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WISCONSIN ACADEMY OF SCIENCES, ARTS, AND LETTERS

MONOGRAPH ON THE AQUATIC GASTROPODA OF WISCONSIN

THE FRESH WATER MOLLUSCA OF WISCONSIN

PART I. GASTRO

By

FRANK COLLIN

Curator, Museum of

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Baker - Fresh Water Mollusca of Wisconsin

Errata. Part I

Page 101. Under Amnicola limosa superiorensis, plate VII, figs. 22, 23, are Cincinnatia emarginata lacustris. (See p. 127)

Page 127. Add the following plate reference, plate VII, figs. 22, 23, under Cincinnatia emarginata lacustris.

Page 476. Twelfth line from bottom, "larger" should read "smaller": "its center tooth being **smaller** than that of any other species".

Page 481. Plate VII, figs. 22, 23 are Cincinnatia emarginata lacustris, not Amnicola limosa superiorensis.

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MONOGRAPH ON THE AQUATIC GASTROPODA OF WISCONSIN

THE FRESH WATER MOLLUSCA OF WISCONSIN

PART I. GASTROPODA

By

FRANK COLLINS BAKER

Curator, Museum of Natural History

University of Illinois

This Monograph constitutes Part I of Bulletin 70 of the Wisconsin Geological and Natural History Survey

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FOREWORD

The Mollusca of Wisconsin have not only a scientific interest as one of the great groups among the aquatic animals of the state, but they have also considerable economic importance, both direct and indirect. The smaller species and the young of all species form a large and valuable element in the bill of fare for the fish. The shells of the larger species of clams are the basis of the pearl button industry and they thus have a direct economic value which is greater than that of any other invertebrate animal of our fresh waters.

The Wisconsin Geological and Natural History Survey determined to include the Mollusca among the groups of aquatic animals on which a report ought to be made which should be a standard contribution to the knowledge of the zoology of the state. In 1920 the Survey fortunately induced Mr. F. C. Baker to undertake the task of preparing such a report.

For many years Mr. Baker has been studying the fresh water Mollusca of the United States and especially those of the North Central States. He has been bringing out the results of his observations ever since 1892, and his publications on the subject are far more extensive than those of any other zoologist, as the literature cited in this report abundantly shows. He made large collections of Wisconsin Mollusca during four field seasons and he has studied the Wisconsin species preserved in numerous collections. He has collated the Wisconsin forms with those from adjacent states. The result is a report which not inadequately illustrates the aquatic molluscan fauna of the northern United States and the adjacent parts of Canada.

Thus the present report is not merely the outcome of the eight years during which Mr. Baker has made it his chief scientific work. It is even more truly the fruit of the many earlier years of study which he has given to the group. It embodies the ripened results of a lifetime largely devoted to this work. It is the good fortune of the Survey that it has been able to secure such a report.

Through the generous aid of the University of Wisconsin and of the Wisconsin Academy of Sciences, Arts, and Letters,

the Survey is able to present the report in a form not unworthy of the labor bestowed upon it and the accumulated results of long and skillfully directed investigation which it contains. The hearty thanks of the Survey are hereby extended to both cooperating institutions. The details of this cooperation are stated in the foreword to Part II of this report.

This volume constitutes a Monograph on the Aquatic Gastropoda of Wisconsin for the Wisconsin Academy of Sciences, Arts, and Letters; and Part I of Bulletin 70 for the Wisconsin Geological and Natural History Survey.

E. A. BIRGE,
In charge, Natural History Division, Wisconsin Geological and Natural History Survey.

Madison, Wisconsin, August 20, 1928.

PREFACE

It is the purpose of the present volume to furnish a reliable guide to a knowledge of the aquatic molluscan fauna of the State of Wisconsin, including descriptions of the shells and animals, the distribution in the State and in general, their ecology (habitat relationships) and their economic importance, both direct and indirect. For this purpose the account of each species is given under several headings, including the shell, animal, parts of its anatomy (genitalia, jaw, radula), its ecology, its distribution by drainage systems in the State, and remarks concerning the chief features of its variation, value, or general interest. The anatomical observations are rather more numerous than is usual in works of this kind. The plate illustrations are photographs of the specimens, often retouched to more clearly bring out details of importance. The cuts of anatomy have been made with great care, often many examinations being made to assure accuracy. All cuts are either camera lucida drawings or have been made from exact measurements in millimeters or microns. The exact size is stated on the cut in most instances.

During the progress of the work many thousands of specimens have been examined making it possible in most cases to ascertain the range of variation and the consequent specific limitation. Collections of Wisconsin Mollusca have been available from the following sources:

Milwaukee Public Museum (collected by Chadwick and others).
Museum of Zoology, University of Michigan.
Chicago Academy of Sciences.
U. S. National Museum.
Dr. Bryant Walker, Detroit, Mich.
Dr. Alvin R. Cahn, University of Illinois.
Mr. D. S. Bullock, Madison, Wis. (now in Museum, University of Wisconsin).
Mr. W. H. Dudley, Madison, Wis.
University of Wisconsin Museum.
University of Illinois Museum.

The very large collection of Mollusca in the collection of the University of Illinois, including material collected by A. A. Hinkley, L. E. Daniels, W. A. Nason, and others, has been constantly referred to and has been of the utmost assistance in determining the distribution of many of the species, besides

affording many records for Wisconsin. One of the most valuable collections of Wisconsin material was included in the collection of Mr. Bullock, whose assiduous collecting in out-of-the-way places has provided many records for the State which would otherwise be missing. The University of Wisconsin material includes collections by Dr. A. S. Pearse, C. E. Brown, Professor Chancey Juday, Professor George Wagner, Mrs. E. C. Wiswall, Mr. W. H. Dudley, and others. Special note should be made of the collection of Mr. George T. Marston, who collected extensively in eastern Wisconsin, and who also acquired much valuable material collected many years ago by P. R. Hoy, Kirtland, and other early Wisconsin Naturalists. The collections of Dr. A. R. Cahn are the most exhaustive that have been made of a single region—southeastern Wisconsin.

Under the auspices of the Wisconsin Geological and Natural History Survey the writer spent three summers (1920–1922) in different parts of the State, during which time extensive collections were made. Between the years 1900 and 1910 the writer also spent several vacations in the State and the collections made at these times (mostly in his personal collection) have been available for study. While much of the State has been covered by these various collectors, there remain very many parts not represented in which many interesting, perhaps unrecorded, species occur.

The material used in preparing the descriptions and illustrations in this work is mostly preserved in the museums of the University of Wisconsin and the University of Illinois. Some few species are in the writer's private collection. All material is cataloged under its appropriate ownership, and is thus available for future workers.

Many references to species published in papers referring to Wisconsin Mollusca are questionable as regards identification, and the great majority of these have been checked up by an examination of the original material where that has been preserved and is at present accessible. This is true of Lapham's, Chadwick's, and Binney's lists, material identified by these authors being in the Milwaukee Public Museum and in the United States National Museum. The collections of the University of Wisconsin also contain much material which has made possible a decision concerning some of these uncertain records.

It may be charged by some that the writer has been too liberal in admitting names of species or varieties as valid which have been thought to be synonymous with other better known species; and also in the matter of new species and varieties it may be thought that too many have been admitted on apparently trivial characteristics. Probably no two authors will exactly agree on what constitutes a species, the matter being largely one of personal opinion. It is generally held that a species is an aggregation of individuals which differ from all other aggregations of individuals by some definite characteristic. It does not matter how small this characteristic may be as long as it is constant and there are no intergradations between the two species. Varieties are aggregations of individuals more or less distinct but connected by intermediate forms. Shell characters do not always afford criteria of definite importance, the genitalia or radula often showing that a species is distinct from another when the shell characteristics are decidedly negative.

Keys to families, genera, and species have been included throughout the work. These are applicable, on the whole, only to the species found in Wisconsin. They will be found to help considerably, it is hoped, in the determination of the species, but there will be many cases where the key will fail owing to similar resemblances between different species. The figures and descriptions should enable anyone at all familiar with freshwater mollusks to readily place any form found in the State.

Acknowledgments for assistance in the preparation of the monograph are due many people. Dr. Bryant Walker, Detroit, Mich., and Dr. H. A. Pilsbry, of the Academy of Natural Sciences of Philadelphia, have given their advice concerning matters of disputed nomenclature and have also added data concerning distribution and kindred subjects. Mr. T. E. B. Pope, of the Milwaukee Public Museum, has kindly transmitted much material from the collection of that institution. Dr. Paul Bartsch, of the U. S. National Museum, has submitted many questionable Wisconsin species from the collection of the National Museum. Dr. Samuel Henshaw, late Director, Museum of Comparative Zoology, Harvard University, loaned material from the Anthony collection in that institution. Mr. P. L. Barney, of the U. S. Bureau of Fisheries, has contributed

considerable material from the Upper Mississippi River, as well as data on the development of several species of Naiades. Dr. Sterki, with his accustomed good nature, has examined and passed upon the entire collection of Sphaeriidae. Dr. Bryant Walker on the Ancylidae. Mr. Calvin Goodrich, of Newark, N. J., has kindly identified most of the Pleuroceridae. Mr. William J. Clench, of the Museum of Comparative Zoology, has given the writer many valuable notes on the Physidae. Dr. Alvin R. Cahn, of the Department of Zoology, University of Illinois, has furnished most of the information concerning the mollusks of southeastern Wisconsin, especially of Waukesha, Jefferson, and Dodge counties, as well as from Vilas County. Mr. D. S. Bullock's contribution of data from Wisconsin has already been mentioned. The staff of the University of Wisconsin, including Dr. A. S. Pearse, Professor Geo. Wagner, and Professor Chancey Juday, have contributed much information on the distribution of Wisconsin mollusks. Mr. W. H. Dudley, of Madison, Miss Mina L. Winslow, of the Museum of Zoology, University of Michigan, Dr. N. M. Grier, of Washington and Jefferson College, Dr. H. J. Van Cleave, of the Department of Zoology, University of Illinois, and Mr. Frank M. Woodruff (deceased) of the Chicago Academy of Sciences, have contributed specimens or information, and my debt to them is hereby acknowledged.

During the periods of field work the writer received many courtesies and much help from a large number of people. To Professor Chancey Juday is due a deep debt of gratitude for assistance in collecting material and for continued help and suggestions during the preparation of this monograph. To Mr. I. H. Boomer and his associates of the fish hatchery at Oshkosh, and to Mr. Clyde B. Terrell of Oshkosh, acknowledgment is due for assistance during the season spent in studying the region of Lake Winnebago.

And finally, the writer is under the deepest obligation to President Emeritus Edward A. Birge, University of Wisconsin, and in charge of the Natural History Survey Division of the Wisconsin Geological and Natural History Survey for the opportunity of carrying on this very interesting investigation of the freshwater molluscan resources of the State of Wisconsin.

FRANK COLLINS BAKER.

University of Illinois,
January 1, 1928.

INTRODUCTION

Wisconsin contains a large and varied aquatic molluscan fauna. The State is favorably located for a diverse fauna, lying within the drainage areas of two of the largest of the Great Lakes and the great Mississippi basin. There are three major drainage areas, Lake Superior on the north, Lake Michigan on the east, and the Mississippi River on the south and west.

These three areas are divisible into several subareas of considerable importance, as noted below:

Lake Superior: There are several small rivers and creeks that drain into this Great Lake.

Lake Michigan: Fox River, Green Bay streams; Lake Michigan streams.

Mississippi River: St. Croix River; Chippewa River; Black River; Wisconsin River; Rock River; Fox River of Illinois.

Though few attempts have been made to prepare lists of the species of fresh water mollusks inhabiting the State, the literature relative to the fauna is extensive, about 50 papers having been published which refer definitely to Wisconsin species. These are indicated by an asterisk in the bibliography. The type localities of 49 species and varieties of aquatic mollusks are located within the state.

In the present monograph 327 species and varieties are recognized of which 40 are described as new. This number of species compares favorably with the fauna of neighboring states and ranks about with that of Michigan (see Winslow, 1926b) from which 316 species and varieties have been recorded. Illinois probably contains almost as many forms, but the last catalog was published many years ago (Baker, 1906) and lists but 240 species and varieties. Many additional species have since been added to the fauna of this state. The last list of Indiana Mollusca (Daniels, 1903) lists 215 species and varieties, but this number is doubtless much larger.

Only four catalogs of the Mollusca of Wisconsin have been published that attempt to list the species of the whole or a

considerable part of the state. In 1852 and 1860, Lapham published a list of the shells of Wisconsin in which 68 freshwater species are recorded. Some of these are synonyms of other species and a few are erroneously included in the state fauna. In 1897, Mrs. E. C. Wiswall published a list of the shells of southern Wisconsin, enumerating 65 aquatic forms. In 1906, Dr. Geo. H. Chadwick published an extended account of Wisconsin Mollusca in which are listed 129 species and varieties of freshwater forms. This is the first attempt to present a modern account of the aquatic molluscan fauna of the State. Several shorter papers by the writer have been published, dealing with restricted areas, the most important being one on the molluscan fauna of Tomahawk Lake Region (1911), in which 44 species are listed, and one on the fauna of the Lake Winnebago Region, in which 113 species are listed. Upwards of 50 papers refer definitely to Wisconsin aquatic Mollusca.

Our knowledge is yet too meager concerning the distribution of the aquatic fauna to form adequate generalizations. Generally speaking, the fauna of the Mississippi drainage is best represented, probably some 60–65 per cent. of the fauna being found here. The Lake Michigan drainage is also well represented, probably containing upwards of 60 per cent. of the total fauna. The Lake Superior drainage is least known, not more than 15 per cent. of the fauna occurring in this part of the State. When more collecting has been done in the unexplored portions of the State it may be possible to know just which species are peculiar to a given drainage.

The 327 species and varieties described and figured in this work are distributed among the following groups: Naiades 95; Sphaeriidae 77; Ctenobranch Gastropods, 62; Pulmoniferous Gastropods 93.

The species with type localities in Wisconsin are recorded below. Many of these are now considered synoynms of other species. The new groups diagnosed for the first time are also listed, together with the species and varieties published herein for the first time.

NEW GROUPS WITH THEIR TYPE SPECIES

Hinkleyia. Type: *Lymneus caperatus* Say.
Nasonia. Type: *Limnaea cubensis* Pfr.

SPECIES WITH TYPE LOCALITIES IN WISCONSIN

Unio undatus Barnes *(Fusconaia undata).* Wisconsin and Fox Rivers.
Unio giganteus Barnes *(Megalonaias giganteus).* Prairie du Chien.
Unio nodosus Barnes (*Quadrula metanevra* Raf.). Wisconsin.
Unio prasinus Conrad *(Quadrula pustulosa prasina).* Fox River at Green Bay.
Unio schoolcraftensis Lea *(Q. pustulosa prasina).* Fox River at Green Bay.
Unio tuberculatus Barnes (*Tritogonia verrucosa* Raf.). Wisconsin.
Unio verrucosus Barnes (*Cyclonoias tuberculatus* Raf.). Wisconsin River.
Unio gibbosus Barnes (*Elliptio dilatatus* Raf.). Wisconsin River.
Unio mucronatus Barnes (*Elliptio dilatatus* Raf.). Wisconsin.
Alasmodonta rugosa Barnes (*Lasmigona costata* Raf.). Fox River.
Alasmodonta complanata Barnes *(Lasmigona complanata).* Fox River.
Utterbackia imbecillis fusca F. C. Baker. Sturgeon Bay, Door Co.
Anodonta footiana Lea *(Anodonta grandis footiana).* Asylum Bay, Lake Winnebago.
Anodontoides birgei F. C. Baker. Sturgeon Bay, Door Co.
Unio cornutus Barnes (*Obliquaria reflexa* Raf.). Fox River.
Unio ellipticus Barnes *(Actinonaias carinata).* Fox River.
Unio carinata Barnes *(Actinonaias carinata).* Fox River.
Unio gracilis Barnes (*Leptodea fragilis* Raf.). Prairie du Chien, Wisconsin River.
Unio planus Barnes (*Leptodea fragilis* Raf.). Prairie du Chien, Wisconsin River.
Paraptera gracilis lacustris F. C. Baker *(Leptodea fragilis lacustris).* Off Plummers Point, Lake Butte des Morts.
Unio parvus Barnes *(Carunculina parva).* Fox River.
Carunculina parva cahni F. C. Baker. Neosho mill pond, Dodge Co.
Unio praelongus Barnes (*Ligumia recta latissima* Raf.). Fox River.
Unio spatulatus Lea (*Ligumia ellipsiformis* Conrad). Rock River.
Unio siliquoideus Barnes *(Lampsilis siliquoidea).* Wisconsin River.
Unio inflata Barnes *(Lampsilis siliquoidea).* Wisconsin River.
Lampsilis siliquoidea pepinensis F. C. Baker. Lake Pepin, Lake City, Minn.
Unio ventricosus Barnes *(Lampsilis ventricosa).* Wisconsin River.
Sphaerium stamineum wisconsinense Sterki. Fox River, Brown Co.
Pisidium compressum limnicolum Sterki. Fox River, Brown Co.
Pisidium punctatum simplex Sterki. Fox River, Brown Co.
Pisidium minusculum Sterki. Fox River, Brown Co.
Pisidium fragillimum Sterki (*Pisidium complanatum* St.). Lake Geneva.
Pisidium abyssorum (Stimpson) Sterki. Off Racine, in Lake Michigan.
Pisidium medianum Sterki. Lakes in Wisconsin.
Amnicola judayi F. C. Baker *(Cincinnatia cincinnatiensis judayi).* Off Doemel Point, Lake Winnebago.

Amnicola sheldoni Pilsbry *(Hoyia sheldoni).* Lake Michigan, off Racine.
Lymnaea stagnalis lillianae F. C. Baker. Tomahawk Lake, Oneida Co.
Lymnaea wisconsinensis F. C. Baker *(L. emarginata wisconsinensis).* Tomahawk Lake, Oneida Co.
Lymnaea winnebagoensis F. C. Baker. *(Stagnicola winnebagoensis).* Oshkosh, Lake Winnebago.
Lymnaea nashotahensis F. C. Baker *(Stagnicola nashotahensis).* Lower Lake, Nashotah, Waukesha Co.
Stagnicola walkeriana F. C. Baker. Madeline Island, Lake Superior, Bayfield Co.
Planorbis bicarinatus striatus F. C. Baker *(Helisoma antrosa striata).* Cold Spring Park, Milwaukee (fossil).
Stagnicola emarginata vilasensis F. C. Baker. Big Muskallonge Lake, Vilas Co.
Helisoma antrosa cahni F. C. Baker. Big Muskallonge Lake, Vilas Co.
Helisoma antrosa shellensis F. C. Baker. Shell Lake, Washburn Co.
Planorbis trivolvis pilsbryi F. C. Baker *(Helisoma).* Tomahawk Lake, Oneida Co.
Planorbis trivolvis winslowi F. C. Baker *(Helisoma).* Little Arbor Vitae Lake, Vilas Co.
Planorbis campanulatus wisconsinensis Winslow *(Helisoma).* Little Arbor Vitae Lake, Vilas Co.
Valvata tricarinata mediocarinata. Lake Winnebago, Lower Asylum Bay.
Lioplax subcarinata wisconsinensis. Fox River, Brown Co.
Campeloma brevispirum. Mirror Lake, Sauk Co.
Viviparus intertextus illinoisensis. Havana, Ill.
Bulimus tentaculatus magnalacustris. Lake Winnebago, near Oshkosh.
Amnicola limosa superiorensis. Bayfield, Shore of Lake Superior.
Amnicola lustrica decepta. Silver Lake, Waukesha Co.
Amnicola lustrica perlustrica. Lake Michigan shore, east of Sturgeon Bay.
Amnicola greenensis. Green Lake, Green Lake Co.
Amnicola walkeri foxensis. Fox River, mile north of Portage, Columbia Co.
Amnicola precursor. Green Lake, Green Lake Co. (fossil).
Cincinnatia emarginata lacustris. Winnebago Lake, near Oshkosh.
Cincinnatia emarginata canadensis. Lake Kakiska, near Great Slave Lake.
Goniobasis livescens michiganensis. Lake Michigan, east of Sturgeon Bay.
Goniobasis livescens barronensis. Red Cedar River, west of Chetek.
Fossaria sayi. Niagara River near Buffalo, N. Y.
Helisoma antrosa sayi. Tomahawk Lake, Oneida Co.
Physella laphami. Hancock, Waushara Co.
Physella latchfordi. Meechs Lake, Ottawa Co., Quebec.
Physella chetekensis. Moose Ear Creek, near Chetek, Barron Co.
Physella bayfieldensis. Pike Creek, near Bayfield, Bayfield Co.

Physella obrussoides. Oshkosh, Winnebago Lake, in hatchery bay.
Fusconaia undata wagneri. Lake Pepin, near Lake City, Minn.
Quadrula quadrula bullocki. Fox River, near DePere, Brown Co.
Pleurobema coccineum mississippiensis. Lake Pepin, near Lake City, Minn.
Lasmigona costata pepinensis. Lake Pepin.
Lasmidonta costata nuda. Red Cedar River, near Chetek, Barron Co.
Alasmidonta calceolus danielsi. Moots Creek, Indiana.
Alasmidonta calceolus magnalacustris. Sturgeon Bay, Door Co.
Alasmidonta marginata variabilis. Red Cedar River, west of Chetek.
Strophitus rugosus winnebagoensis. Long Point Island, Lake Winnebago.
Strophitus rugosus pepinensis. Lake Pepin, near Lake City, Minn.
Strophitus rugosus lacustris. Oconomowoc Lake, Waukesha Co.
Truncilla truncata lacustris. Long Point Island, Lake Winnebago.
Lampsilis siliquoidea chadwicki. Doemel Point, Lake Winnebago.
Lampsilis ventricosa perglobosa. Lake Pepin, near Lake City, Minn.
Lampsilis ventricosa winnebagoensis. Winnebago Lake, near Oshkosh.
Sphaerium solidulum winnebagoense. Lake Butte des Morts, near Plummers Point.
Sphaerium flavum foxense. Lake Butte des Morts, near Plummers Point.
Sphaerium bakeri Sterki. Green Lake.

Species and Varieties Influenced by the Environment

For many years a controversy has existed between different fields of biological science concerning the part played by the environment in the evolution of life and the formation of species. Some biologists deny that the environment has any effect or plays any part in the evolution of species while others, notably the paleontologists, affirm that the environment is the chief factor, and some students, with Lamarck, believe that the acquired characters are inherited. It is now admitted by all biologists that it is the germ plasm that transmits new characters through the genes of the chromosomes. It is held by many zoologists and paleontologists, however, that, while the heredity characters are transmitted through these determinators, the environment performs a directive stimulus and in some manner shapes the new organism so that it is in harmony with its environment.

Paleontologists who have studied the great changes that have taken place during the long period of geological time, and field zoologists who have observed the multitude of living things in their diverse environments, cannot but believe that the en-

vironment has played a large part in the production of this infinite variety of living organisms. The geneticists who confine their studies to laboratory experiments on a few animals, usually under abnormal conditions, are not in as good position to judge of the effect of environmental changes as are the students who have spent years in field observations. The truth of the matter is probably best expressed in a recent statement that the "environment permits and directs evolution but does not cause it" (Coe, Organic Adaption to Environment, p. 147, 1924).

Some zoologists—especially ecologists—may affirm that the environment, in directing evolution, does in large measure cause the change, as for example, when a normal river or creek species is forced to inhabit a lake, and in a sense this may be true, the changed environment *compelling* the organism to change its structure so that it may be in harmony with the changed conditions of its environment. Such reactions between the environment and the organism have been observed in many places in North America and these features must be recognized in attempting to unravel the puzzle of organic evolution.

Everyone who has spent much time studying large quantities of animal life is soon drawn to the conclusion that the most notable and fundamental characteristic of living organisms is their inherent tendency to vary. Gather a few thousand snails from any locality and the first observation made is the great number of different forms included, no two specimens, perhaps, being exactly alike, and many of them being so different as to confuse the observer as to their specific relationship. It logically follows that the conclusion suggested is that the changing of an environment, acting upon or directing this inherent tendency to vary, results in the production of a new variety or species which is better adapted to the changed environment.

During the progress of the field work incident to the preparation of this monograph it has become increasingly apparent that each stream has a faunal facies of its own which is not shared to a similar degree by other streams. It was repeatedly observed, also, that the size of the stream governed in a measure the character of the fauna. The small rivers and creeks, such as the Fox, parts of the Rock, the headwaters of

the Chippewa, and the Red Cedar River, contained a type of mollusks which was different from that of the medium sized rivers, as the Wisconsin and Rock; and these two systems were still different from the large rivers, as the Mississippi and lower Wisconsin Rivers. The fauna of the small lakes, also, was somewhat different from that of Lakes Michigan and Superior, and totally different from that of the streams and rivers. This variation of the fauna, coordinate with the size of the stream and the character of the water body, appears to be a universal law. It has been noted by Ortmann in Pennsylvania and Tennessee, Adams in the Tennessee River system, Grier in the Ohio and Lake Erie systems, and Baker in Illinois and Wisconsin (see Ortmann, 1920, 1924; Grier, 1926, Adams, 1915, Baker, 1926).

The early naturalists, Say, Lea, Haldeman, Tryon, did not pay any attention to the precise habitat relations of species, but separated them on the basis of individual differences, and often these simply represented individual variations in the same species. Species were based on one, two, or a few specimens and the broad relationships of habitat association had not yet been realized. Indeed, it was not possible in these early days to obtain the data for such generalizations, the new species being founded upon specimens picked up by exploring parties and others, usually but slightly interested in the mollusks, and gathering the specimens for conchological friends. At the present time, with transportation available to all parts of the country and with the great interest in ecology it is possible to consider the animals in groups as they bear relationship to certain natural types of territory. This is the natural method and gives the best results in trying to interpret the relationships of varying types of animal life.

Wisconsin is peculiarly well situated for studies of animal life from the standpoint of environmental evolution, having hundreds of lakes of various sizes, streams of all sizes connecting with each other, and each water body having an almost endless combination of ecological characteristics. In this monograph an attempt has been made to interpret some of this habitat variation and all species have been viewed from this standpoint.

In an address given not so long ago, Jennings makes certain statements which should be borne in mind when attempting to

generalize on the laws of evolution from any one series of factors. He says (1927, p. 22) "Different organisms, different societies of organisms, are diverse emergents, showing diverse systems of relations and consequent diverse methods of action. No longer must it be held that what is true for one organism is necessarily true for another. No longer will the investigator expect by a single crucial experiment to settle a question for the whole organic world. Knowledge of the biology of the oyster is practically not a solid basis for judgment of that of the social insects; this practical fact will be recognized as theoretically significant; as a fact typical of biological science; not something to be minimized and explained away. Organic evolution will be seen as emergent evolution in its most conspicuous and manifold display. * * * To generalize will be recognized as the most laborious task in biology, instead of the lightest and simplest. * * * To discover what organisms have in common becomes an object for wide-extended comparative investigation; not a matter for assumptions".

With these statements the writer is in full accord, for it has seemed that to assume that the changes in environmental complexes can be understood by a study of social insects or that any organism other than a creature influenced by the same environmental complex is absurd to the last degree, and generalizations based on such assumptions must, as Jennings remarks, be filled with error. It has been observed that the water breathing mollusks respond to this lake-river-creek ecological complex much more closely than the air-breathing freshwater forms, again clearly demonstrating that an assumption based on one of these organisms will not be entirely true for another. Much light would undoubtedly be thrown on this subject by experimental study of material transferred from one environment to another, or by long-continued examination of animals which have been forced to adapt themselves to a changed environment by the formation of artificial lakes by damming creeks and rivers. Such a condition has been created at Chetek in Barron County, Wisconsin, and a study of the molluscan life of the resulting lakes and the near-by creeks and small rivers has been productive of much information on this point. Attention is called to this particular territory in many places in this monograph (see Baker, Ecology, IX, July, 1928).

It is believed by the writer that the mass variations of the creeks, small rivers, large rivers, etc., should be distinguished as ecological varieties and given definite names, and in this monograph this has been done. In many cases the change has been of a most decided character while in others it is not as distinctly apparent. As systematic zoology is an attempt to interpret the animal life of the earth in its relationship to related forms and to the environment, no other course seems satisfactory.

The freshwater mollusks of Wisconsin have evolved from several different sources at different times during geological time. The ancestral forms were probably all marine. Among the gastropods, the Ctenobranchiata have descended more or less directly from marine forms which became adapted to a freshwater habitat through gradual change from marine through brackish to fresh water. These forms retain the ancestral gills, with, in some groups, the addition of a lung. The freshwater pulmonates (Basommatophora) have descended from terrestrial mollusks through an adaptation to aquatic conditions. In some forms (Planorbidae) there is a secondary gill (pseudobranch) which may exist with the lung, or the secondary gill may replace the lung almost entirely (Ancylidae). All of these adaptations attest the influence of the environment, at least as a directive stimulant.

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PART I

Class GASTROPODA

Mollusca with distinct head, soled or more or less fin-like foot, and undivided mantle, which latter secretes a simple, spirally wound, or saucer-shaped shell. Gastropods differ from Pelecypods in having a more or less distinctly marked head, which usually bears tentacles, eyes, and ears, and contains a large cerebral ganglion. The ventral aspect of the animal is formed by a broad foot, though in some marine forms it may be fin-like or wing-like. The mantle lobe is elevated along the back like a hood, extending as far forward as the head, and usually secretes a shell from its outer surface. The shell covers the intestinal sac and lung cavity, and usually permits of retraction into it of the entire body of the animal. Body and shell are united by muscular attachment; in spiral shells the muscle is fastened to the columella, but in bowl-shaped forms to the inner surface of the shell.

The nervous system consists of two cerebral ganglia, the paired pedal and visceral ganglia, and two or three additional pairs, all of which are united by commissures. A complete crossing of the commissures of the visceral ganglia sometimes takes place (Streptoneura), but in other forms they run parallel (Euthyneura).

The peculiar armature of the mouth, although developed in all classes of Mollusca except the Pelecypoda, is especially characteristic of the Gastropoda. This consists of two jaw-like, horny plates on the upper wall of the oesophagus, opposed to which is a chitinous grating strap, or radula, resting upon the tongue or odontophore, the latter being merely a swelling at the bottom of the buccal cavity. The radula is usually quite long, and beset with few or many small teeth or hooks, placed in transverse and longitudinal rows. The great diversity of the teeth of the radula in different groups of mollusks has formed the basis for a large part of the classification of these animals.

The digestive system consists of an esophagus which leads into a long coiled, intestinal canal, which is surrounded by a

large liver or digestive gland, the kidneys, and numerous glands. The intestinal opening or anus is placed anteriorly. The circulatory system consists of a heart, which may have one, or more rarely two auricles; from the heart there extends a much branched system of blood vessels, reaching every part of the animal. In the Ctenobranchia and Pulmonata, the only gastropods considered in this work, the gills or lungs are placed in front of the heart and the auricles are anterior to the ventricle.

Only a few gastropods breathe through the general surface of the body, and are without distinct organs of respiration; the vast majority possess gills or lungs. The gills are lamellar or tuft-like, sometimes branched or feathered lobes of the integument, and are usually placed in the gill-cavity below the mantle; more rarely they project freely on the back or at the sides. Typically there are two gills, but the left usually becomes completely atrophied, and the right takes up a median position, consequent upon the torsion of the body, or even migrates over to the left side. Air-breathing snails have the gills replaced by a sac-like cavity, the lung occupying the place of the gill-cavity. The walls of the respiratory cavity are covered with a finely branched network of blood vessels. Some groups, like the Ampullariidae and Siphonariidae possess both lungs and gills. The opening of the respiratory cavity is reduced to a round or crescentic aperture, called the breathing pore.*

Gastropods exhibit wide differentiation of the reproductive system; some groups, as the Ctenobranchiates, have the sexes in two individuals while other groups, as the Pulmonata, are hermaphroditic, and have the sexes combined in one individual. The male and female genital ducts open through a common orifice or cloaca in some groups, while in other groups these openings are widely separated. The variation in the form and character of these organs is described under each genus.

The embryonic stages of gastropods are completed in the egg, there being no post-embryonic metamorphosis as in many of the Pelecypoda. In the egg the embryonic shell is formed, consisting of one or more whorls, which often differ radically from the form or sculpture of the post-embryonic shell. In

* Adapted from Eastman's translation of Zittel's Text-book of Paleontology.

our freshwater gastropods, the embryonic shell, called protoconch, is usually retained at the end of the mature shell, though this may become decollated and its place taken by a rounded plug.

The shells of freshwater gastropods fall into two groups, the spiral and the flat or symmetrical. The spiral shells are either of a screw-like character or are discoidal, coiled in the same plane. Most spiral shells of the fresh waters form a widening cone, more or less rapidly increasing in diameter, surrounding a solid pillar, the columella, or a central tube-like cavity, the umbilicus. The umbilical opening is present in some groups and absent in others, and these are said to be perforate or imperforate. There is great variation in the shell; it may be long or short, wide or narrow, with a spire of variable length. The surface markings may consist only of growth lines or there may be in addition coarse or fine spiral lines giving a decussated pattern to the surface. The shell substance is of a chitinous character (conchiolin) infiltrated with calcium carbonate (aragonite). To protect the limy character of the shell from erosion by the carbonic acid in the water, it is covered by a horny substance called the epidermis, which

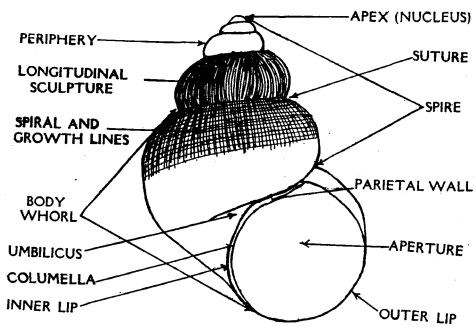

Fig. 1. Parts of Gastropod Shell. *Viviparus.*

varies in color from light yellowish horn to dark green or black. Much of the surface marking of the shell resides in this epidermis or periostracum and is lost when this is removed. The shells of freshwater gastropods may be right handed (dextral) or left handed (sinistral). In left handed shells the genitalia are on the left side (usually) and vice versa in right handed shells. The parts of the shell used in

descriptions are shown in figure 1, and the general anatomical features of the animal in figure 2.

Among freshwater gastropods some groups, as the water-breathing snails Amnicola, Campeloma, etc., have a horny (rarely calcareous) operculum attached to the foot which effectually closes the aperture when the snail has withdrawn into its shell. This may be spiral, subspiral, or concentric, starting from a nucleus which is central or marginal in position. The sculpture of the operculum varies and often gives good characters for distinguishing species or genera. In the air-breathing freshwater snails there is no operculum.

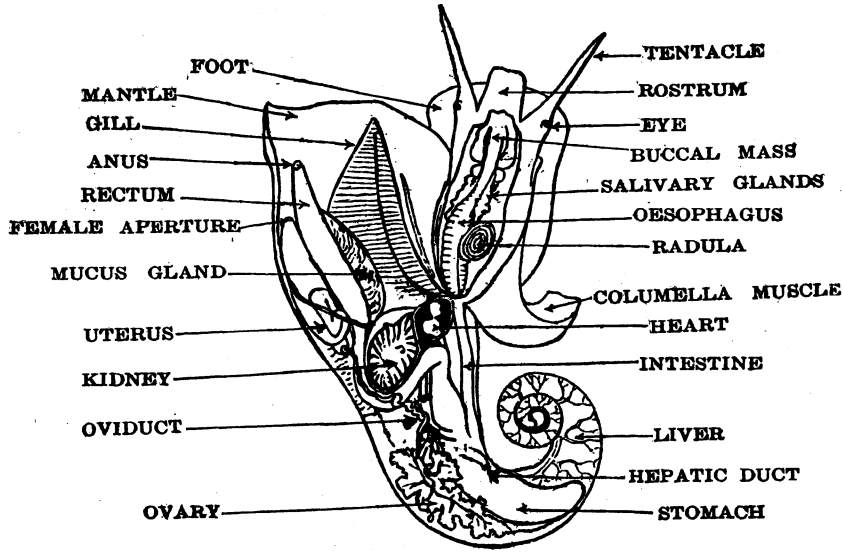

Fig. 2. General Organization of Gastropod. *Littorina obtusata,* female. After Souleyet.

The ecological distribution of freshwater gastropods embraces all kinds of water bodies from the transient pools of woodlands to the great stretches of the Great Lakes; in depth they range from near the surface to the deeper parts of lakes and rivers; and in conditions from quiet pools to wave swept shores. They occupy mud, sand, and rock bottoms, as well as areas thickly covered with aquatic vegetation. Most freshwater mollusks are vegetable feeders, the great quantities of algae, as well as of organic-filled detritus, affording a never-

failing supply. A few species have added carnivorous as well as scavenger habits. Of all animal life, the freshwater mollusks are more dependent upon vegetation than most groups of animals.

CLASSIFICATION

The classification of the freshwater Gastropoda is now undergoing rather rapid and in some cases marked changes. Studies of the genitalia, radula, pallial organs, etc., are bringing to light characteristics heretofore unknown and a mass of data is accumulating (thanks to the work of Pilsbry, Walker, H. B. Baker, and others) which will, in the course of time, make it possible to formulate a much more satisfactory and natural classification than has been possible from characteristics of the shell and what little was known about the animal. As far as possible, the changes in nomenclature and classification caused by this research have been incorporated in this monograph.

The general classification of the Gastropoda and its larger divisions is that of Pilsbry and Dall, in Eastman's translation of Zittel's Text-book of Paleontology.

Economic Importance of Gastropods

Snails are not of direct economic importance, as are the river mussels from which pearl buttons are made. Indirectly they are of great importance as furnishing food for many fish and other animals. About 20 per cent of the species of freshwater fish feed more or less upon mollusks, largely gastropods; the quantity consumed, in comparison with other food, ranges from one to 100 per cent. The sheepshead, lake sturgeon, common red-horse, spotted sucker, and pumpkinseed include from 50 to 100 per cent of mollusks in their food; and the common sucker, common bullhead, and whitefish include more than 25 per cent. A single species of fish often feeds upon several species of mollusks, as the pumpkinseed, 18, whitefish, 17, yellow perch 8, and common bullhead, 11. More than 40 species of mollusks are now known to be used as food by our common food and game fish. Among gastropods, the genera eaten are Amnicola, Valvata, Bythinia, Vivipara, Campeloma, Physella,

Helisoma, Gyraulus, Galba, and Ferrissia. (See Baker, Bull. 4, N. Y. State Coll. Forestry, 1916, for more detailed information on this subject.)

Subclass STREPTONEURA Spengel

Gastropods in which the visceral commissures are crossed, producing an 8-shaped loop; sexes separate; heart behind the gill; a shell almost always developed, and with few exceptions provided with an operculum.

Order CTENOBRANCHIATA Schweigger

Right cervical gill pectinate, very large, and usually transposed to the left side, owing to torsion of the body; the left gill atrophied. Heart with but one auricle. Radula small, variously constructed, but usually armed with few teeth in a transverse series. Shell coiled in a more or less elevated spiral, rarely cup- or cap-shaped.

Suborder PLATYPODA Lamarck

Foot normally developed as described for the Class, never fin-like.

Superfamily TAENIOGLOSSA Bouvier

Teeth of the radula seven in a transverse row. Mainly holostomate forms, but some genera have deeply notched apertures, as in the higher divisions.

KEY TO THE FAMILIES OF TAENIOGLOSSA

1. a. Operculum concentric ---------- *Viviparidae*
   b. Operculum spiral ---------- 2
2. a. Operculum circular, multispiral, gill external ---------- *Valvatidae*
   b. Operculum paucispiral, gill internal ---------- 3
3. a. Animal without external verge, shell large, thick, heavy, no basal denticles on central tooth ---------- *Pleuroceridae*
   b. Animal with external verge, shell small, basal denticles on central tooth ---------- 4
4. a. Foot with vertical and longitudinal sinuses ---------- *Pomatiopsidae*
   b. Foot without sinuses ---------- *Amnicolidae*

Family VALVATIDAE Gray

The family is monotypic including but one genus, *Valvata*. *Orygoceras* of Brusina (1882) included in this family by Fischer, should probably be referred elsewhere.

Genus VALVATA Müller, 1774

Valvata O. F. MÜLLER, Hist. Verm., II, p. 198, 1774. Type: *Valvata cristata* O. F. MÜLLER.

See Dall, 1905, p. 120, for generic synonymy and subgroups proposed.

SHELL small, spiral, dextral, turbinate or subdiscoidal; whorls rounded or carinated; aperture entire, circular; lip simple, sharp; operculum orbicular, multispiral, whorls with a thin elevated ridge.

ANIMAL (Fig. 3) with short, wide foot, rounded behind and distinctly bilobed in front, the lobes forming two finger-like processes. Tentacles long, slender, cylindrical, the eyes sessile at their internal base; rostrum long, cylindrical, capable

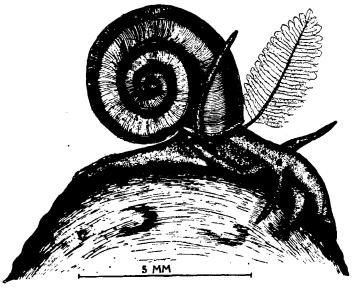

Fig. 3. Animal of *Valvata tricarinata* (Say) crawling on stone. Winnebago Lake.

of considerable extension. Gills external, the left plumose and extended over the back and shell during locomotion, the right (rudimentary) forming a slender appendage which is usually protruded from the shell during locomotion. Otoliths multiple.

GENITALIA (Fig. 4): The genus is monoecious. The external male organ or verge is very long (almost as long as neck and rostrum), slender, and nonretractile; the vas deferens is slender and as long as the verge; the prostate is a pyriform organ, shorter than the verge and joined to the vas

deferens by a tube about as long as the vas deferens. The female opening is on the right side between the right gill and the rectum; the vestibule is wide and short; a large accessory shell gland is present and is a kidney-shaped gland, narrowed above and somewhat contracted where it joins the vestibule; the spermatcheca is an elongated, cylindrical sac two-thirds as large as the shell gland and is joined to the

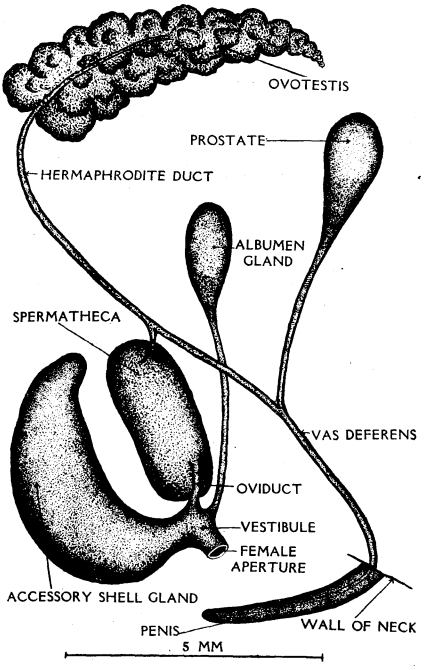

Fig. 4. Genitalia of *Valvata tricarinata.* Modified from Bernard. Winnebago Lake.

vestibule by a very short, narrow oviduct and to the hermaphrodite duct by a short tube; the albumen gland is pyriform, somewhat smaller than the prostate and joined to the vestibule by a long, narrow duct which enters the vestibule near the opening of the oviduct. The hermaphrodite organs consist of a hermaphrodite duct 2½ times as long as the prostate duct, and a large ovotestis. As far as material has been available, the genitalia of the different species are quite uniform.

The hermaphrodite condition of *Valvata* is almost unique among Streptoneurous Mollusca. The sexual organs are similar to those of other members of the superorder excepting that both are placed in the same animal. The generally simple structure is shown by the less complicated organization (as compared with the monoecious Pulmonata) and by the retention of the nonretractile verge, which is characteristic of the dioecious members of the group. It is retractile in the Pulmonata. The animal has been described as dioecious in some works.

Ten to thirty eggs of a more or less green color are laid. The eggs are laid in a single spherical capsule which is attached to aquatic plants or other objects. The young hatch in about 15 days, and the young are usually quite active, often floating shell downward on the surface of the water. The breeding season occurs from March to July.

JAW: There is a rudimentary superior jaw which is covered with very small scales; the lower edges are saw-like, and overlie like shingles on a roof. In some species the scales are placed in vertical rows while in others each scale overlaps parts of two below.

RADULA: In seven vertical rows of 3–1–3 teeth; there are more than 50 rows in a membrane. Central tooth about twice as wide as high, the outer corners produced and angular and strongly bent downward, the base concave and bordered by a thickened ridge; reflection wide, low, multicuspid, 10 to 15 small cusps on either side of a single central larger cusp; there are no basal denticles; lateral teeth somewhat cleaver-shaped, the peduncle being short and very wide; there are usually several ridges extending parallel with the long diameter of the tooth; reflections wide and low, multicuspid, 9–12 small cusps on the summit and 10–15 small cusps on the outer side, separated by a larger cusp at the angle of the reflection: first marginal elongated, narrowed below with a distinct vertical ridge on the center of the body; reflection with 9–13 small cusps on the summit and 20–30 very small cusps on the outer side, usually separated by a larger cusp at the angle of the reflection; the cusps gradually become more minute toward the center of the outer margin of the tooth: second marginal narrower than the first with 11–13 cusps on the summit and 12–30 minute cusps on the outer margin, which gradually be-

come more minute toward the center of the margin; there is usually a small ridge on the lower part of this tooth, The teeth of the radula are remarkably uniform for the American species examined, the variation being in the size of the central tooth and in the number of denticulations.

The radula resembles in some respects certain of the Amnicolidae in which the teeth are multicuspid (as *Clappia, Hoyia*). The published figures do not show the exact form of the central tooth nor the form of denticulation and the ridges of the side teeth.

Valvata may be found under many varying conditions in streams and lakes and the genus is widely distributed, both in America and in other parts of the world. It occurs both in shallow water and in the deeper parts of lakes. These small snails have a distinct economic value as food for many fish, the percentages in many cases being as high as 25 per cent. The several species have been found in the stomach of the following species (see Baker, 1918b) : whitefish, 10 per cent; round buffalo, 12 per cent; lake sturgeon, a large percentage; common sucker, 15 per cent; common red horse; golden shiner; common bullhead; pumpkinseed, yellow perch. In Lake Chetek, Barron Co., *tricarinata* was found in the stomach of the bluegill.

The genus has been divided into several subgenera based mostly on the presence or absence of spiral keels. As the latter all have ecarinate varieties, these divisions are wholly without value, unless characteristics of radula or genitalia should be found, which have not been in evidence during these studies. The group appears from our present knowledge to be monotypic.

KEY TO SPECIES OF VALVATA

1. a. Shell with spiral keels or angulations ---------- 2
   b. Shells with rounded whorls, not angulated ---------- 3
2. a. Spire elevated above last whorl; whorls sloping upward from carina to suture ----------*tricarinata*
   b. Spire usually depressed below last whorl; whorls sloping downward to the suture ----------*bicarinata*
3. a. Spire elevated, whorls accurately and regularly rounded, umbilicus narrow and deep ----------*sincera*
   b. Spire depressed, whorls rapidly enlarging, umbilicus wide and shallow ----------*lewisi*

VALVATA TRICARINATA (Say)

Plate I, figures 1–3

Cyclostoma tricarinata SAY, Jour. Phil. Acad., I, p. 13, 1817.
Valvata tricarinata HALDEMAN, Mon. p. 3, 1844; BINNEY, L. and F. W. Shells N. A., III, p. 9, fig. 13, 1865; WALKER, Nautilus, XV, p. 123, fig. 1, 1902.

TYPE LOCALITY: Delaware River.

WISCONSIN RECORDS:

1860. *Valvata tricarinata* LAPHAM, p. 155. Milwaukee.
1865. *Valvata tricarinata* BINNEY, p. 12. Milwaukee.
1897. *Valvata tricarinata* WISWALL, p. 48. Southern Wisconsin.
1900a. *Valvata tricarinata* BAKER, p. 177. Milwaukee (fossil).
1906. *Valvata tricarinata* CHADWICK, p. 24, 89. Milwaukee River, Mud Creek, Honey Creek, near Leighton Park; Cold Spring Park, Milwaukee Co.; Lake Winnebago near High Cliff (part).
1906. *Valvata tricarinata simplex* CHADWICK, p. 24, 89. Milwaukee.
1918. *Valvata tricarinata* MUTTKOWSKI, p. 474. Lake Mendota.
1920d. *Valvata tricarinata* BAKER, p. 119. Milwaukee (fossil).
1924. *Valvata tricarinata* BAKER, p. 134. Lakes Winnebago and Butte des Morts.
1927a. *Valvata tricarinata* WINSLOW, p. 6. Little Arbor Vitae Lake.

SHELL: Turbinate, thin, translucent, shining; horn colored or pale green; whorls about 4, rapidly enlarging, flattened between the carinae, sloping upward from the carina to the suture on the upper surface; spire elevated, but depressed at the apex; sculpture of coarse lines of growth more or less

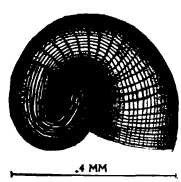

Fig. 5. Nucleus of *Valvata tricarinata.*

equally spaced, with very fine spiral lines to be seen only with high powers; nucleus small, of one-half turn, rounded, and heavily, spirally striated or ridged; these ridges end abruptly and are separated from the following whorls by a distinct vertical ridge; for the next half turn there are both heavy spiral lines and heavy, spaced, vertical ridges, after

which the growth lines remain distinct, rather crowded, and the spiral lines become very faint, but may be seen under high powers, even on the carinae (fig. 5); sutures distinct, well impressed; body whorl large, with three distinct, sharp carinae, one on the shoulder, one on the periphery, and one on the base which encircles the round, deep, funnel-shaped umbilicus; the superior carina persists to the spire but does not begin until one full turn has been completed, the young shell of one whorl being ecarinate; the carinae are usually lighter in color than the body of the shell; aperture circular, modified somewhat by the carinae; lip simple, sharp, continuous, appressed to the body whorl between the basal and peripheral carinae.

L. 2.9; W. 5.1; Ap. L. 2.5; W. 2.5 mm.	Chetek.	(U. of W.,	4554).
L. 3.0; W. 4.5; Ap. L. 2.5; W. 2.1 mm.	"	"	"
L. 2.8; W. 4.5; Ap. L. 2.1; W. 2.0 mm.	"	"	"
L. 3.5; W. 5.0; Ap. L. 2.5; W. 2.2 mm.	"	"	"
L. 4.1; W. 5.0; Ap. L. 2.5; W. 2.1 mm.	"	"	"
L. 4.1; W. 4.5; Ap. L. 2.3; W. 2.2 mm.	"	"	"

OPERCULUM (Fig. 6): Horny, multispiral, of about 10 turns, the nucleus situated in the center, the whorls with a keel or ridge bordering the suture between the whorls; this is

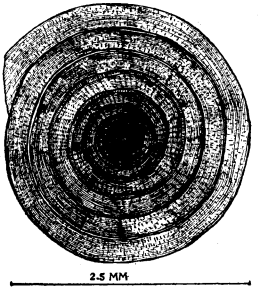

Fig. 6. Operculum of *Valvata tricarinata.*

conspicuous on the earlier whorls but becomes fainter toward the outer turns and wholly disappears on the last whorl in most specimens; sculpture of fine spiral lines, among which may be seen evidences of growth lines which are more apparent on some specimens than on others; the nucleus is slightly punctate.

ANIMAL: See generic description. The color is pinkish-white, sometimes quite pinkish, more or less translucent, with brown blotches on mantle showing through the shell. During locomotion the animal moves steadily along rather slowly but without jerks. The branchial plume may be quite well extended over the back of the shell or it may be represented only by the tip end which protrudes from the edge of the aperture. The bilobed fore portion of the foot is frequently used to examine objects, the attenuated corners forming tentacular-like processes.

GENITALIA: See generic description. Eggs are deposited during March, April, May, June, and July. They are laid in a greenish gelatinous mass on stones or other objects, are about a millimeter in diameter, and contain from 10 to 30 eggs. Lea (Binney, 1865b, p. 10) observed this species depositing ova and also obtained data concerning their development, 15 days elapsing from the deposition of the eggs to the hatching of the embryos. The young were observed to float on the under surface of the water film, like the young and adults of *Physa* and other pulmonates.

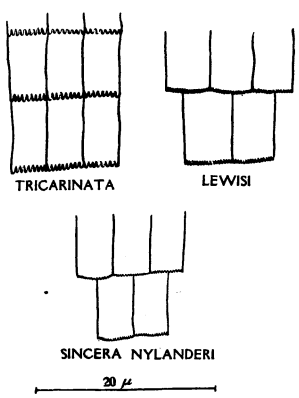

Fig. 7. Jaws of Valvata.

JAW (Fig. 7): The jaw is rudimentary and is covered with long, narrow scales which overlap; the lower edges are distinctly serrated, the serrations being larger than in *lewisi* or *sincera*. See generic description.

RADULA (Fig. 8): See generic description. The formula on the average is: 15–1–15; 12–1–16; 12–1–20; 9–1–25. The

number of cusps varies within small degrees; the smaller ones are difficult to see, apparently the outer edge becomes very finely serrated at the lower part. The cusps near the center cusp are largest and they gradually decrease in size toward the outer or lower side. The radula is very uniform for the different species and varieties of American Valvatae.

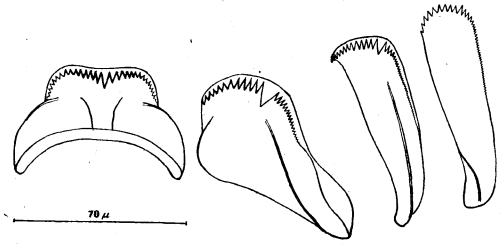

Fig. 8. Radula of *Valvata tricarinata.* Winnebago Lake.

ECOLOGY: In Wisconsin, *tricarinata* is found from shallow water to depths exceeding 9 meters. Dead shells were obtained in Green Lake at a depth of over 39 meters. The general ecological distribution is shown below: Winnebago Lake, near Asylum Bay, sand, .8m., in thick vegetation; on sand-gravel bottom, 2.8 m., no vegetation; Miller Bay, sand, 1-2.2 m., *Vallisneria,* other vegetation; Doemel Point, gravel, sand, rock, 2.5-2.8 m.; Fahney Bay, mud, .6 m., gravel, 1.6 m., no vegetation; Long Point Island, sand-gravel, 1.5 m., vegetation; Roe Point, boulder, .6 m.; open lake, one mile from shore, mud, 5.5 m. no vegetation; east of Oshkosh, gravel, 3.4m., no vegetation. Lake Butte des Morts, Terrell's Point, mud, 1.2 to 2.2 m., vegetation; bullrush and wild rice zones, mud bottom, 1.2 to 1.5 m., vegetation abundant. Omro, Fox River, mud, .9 m.

Lake Chetek on lily leaves *(Castalia)* and in shallow water on mud bottom in vegetation. Bayfield, Big Bay, Madeline Island, in shallow water, sand bottom. Green Lake, sand bottom, 1.2 m. no vegetation. Dredged dead at following depths: 3, 7, 10, 39.5 m. In Silver Creek on floating debris and in vegetation at depths of 2-3 m. Devils Lake, soft clay bottom, 8.5 to 9.5 m., in algae.

GENERAL DISTRIBUTION: Eastern United States west to Iowa; Great Slave Lake south to Virginia and the Ohio River.

DISTRIBUTION IN WISCONSIN: Apparently more abundant in the eastern part of the State, but known from all drainage areas.

REMARKS: *Valvata tricarinata,* in one form or another, is perhaps the most abundant mollusk in many lakes and rivers as well as in Pleistocene deposits. Its round aperture, turbinate, strongly carinated whorls will usually distinguish it from other members of the genus. The only species likely to be confused with it is *Valvata bicarinata,* which is larger, has a more depressed spire and a wider umbilicus, and which exhibits all of the volutions, a feature not found in *tricarinata,* which has a deep, funnel-shaped umbilicus.

Valvata tricarinata is subject to great variation, principally in the development of the carinae. These variations are to be regarded as mutations rather than as distinct varieties; they are not strictly ecological, for many of the variations may be found in any lot from one locality or habitat. There may be, also, angulations on the whorls which later develop into a distinct carina or carinae, and a carina may be reduced to an angulation on a later part of a whorl, or may disappear altogether. Rarely a fourth carina may be formed on the body whorl and still more rarely a specimen may be sinistral (vide Walker, 1902a, p. 124). There are no differences in the radulae of these several mutations. The tricarinate and bicarinate forms are most abundant in Wisconsin. These mutations appear coincident in distribution with the typical form.

A recent study of a large collection of *Valvata* from Waukesha and Jefferson Counties indicates that the strongly tricarinate form is characteristic of rivers while the variations *(simplex, perconfusa,* etc.) are confined chiefly to lakes. A lake habitat apparently causes a reduction of the degree of angulation.

These mutations have been given names and are recognized in the literature. Most of them are found in Wisconsin. The following table will differentiate any of these mutations. In using the key, only distinct carinae are to be recognized, simple angulations are not to be considered.

Upper, middle and lower carinae present ---------- *tricarinata*
Middle carina absent ---------- *perconfusa*
Upper and lower carinae absent ---------- *mediocarinata*
Lower carina absent ---------- *basalis*
Middle and upper carinae absent ---------- *infracarinata*
Middle and lower carinae absent ---------- *unicarinata*
All carinae absent ---------- *simplex*

VALVATA TRICARINATA (Say)

Plate I, figures 1–3

In this form there are three distinct carinae, one on the shoulder of the whorl, one on the periphery, and one encircling the umbilicus. It is a form, principally, of rivers.

VALVATA TRICARINATA PERCONFUSA Walker

Plate I, figure 4

Valvata tricarinata confusa WALKER, Nautilus, XV, p. 124, fig. 2, 1902 (non *V. confusa* West., 1897).
Valvata tricarinata perconfusa WALKER, Nautilus, XXXI, p. 36, 1917.
Valvata tricarinata var. *bicarinata*, authors generally, not of Lea.

TYPE LOCALITY: Not specified.

Middle carina absent and the periphery smooth or but slightly carinated.

DISTRIBUTION IN WISCONSIN: Lake Winnebago, several localities; Green Lake and Spring Lake, Green Lake Co.; Sturgeon Bay, Door Co., 6.3 m. marly clay; Chetek and Prairie lakes, Barron Co.; Devils Lake, Sauk Co., 8.5 m., mud bottom, in algae; lakes in Waukesha and Jefferson Co.

REMARKS: *Perconfusa* is very common in Prairie Lake and Lake Chetek and integrades with the typical form. Of a hundred specimens examined, 55 were *tricarinata*, 40 *perconfusa*, 3 *unicarinata*, and 2 *simplex*.

VALVATA TRICARINATA UNICARINATA De Kay

Plate I, figure 5

Valvata unicarinata DEKAY, N. Y. Moll., p. 118, pl. vi, fig. 129, 1843.
Valvata unicarinata BINNEY, L. & F. W. Sh. N. A., III, p. 11, fig. 16, 1865.
Valvata tricarinata supracarinata BAKER, Nautilus, XXXV, p. 24, 1921.

TYPE LOCALITY: Lake Champlain and Erie Canal *(unicarinata)*; near Morris, Grundy Co., Illinois *(supracarinata)*. Middle and lower carina absent.

DISTRIBUTION IN WISCONSIN: Lake Winnebago and Butte des Morts, Winnebago Co.; Prairie Lake, Barron Co.; lakes in Waukesha Co.

This mutation is less common than *tricarinata* or *perconfusa*, and occurs with any considerable lot of *tricarinata*.

VALVATA TRICARINATA MEDIOCARINATA Nov. Var.

Plate I, figure 7

Differs from the other mutations in having a carina only on the periphery, the shoulder and base being smooth or only slightly angulated.

L. 2.8; W. 4.0; Aperture L. 1.9; W. 1.8 mm. Type. U. of W., 4707.
L. 2.1; W. 3.2; " L. 1.5; W. 1.2 mm. Paratype. U. of Ill., 12773.

TYPE LOCALITY: Lower Asylum Bay, Lake Winnebago.

This mutation occurs sparingly in Lakes Winnebago and Butte des Morts, associated with typical *tricarinata.* It is found on mud and sand bottom from .5 to 3.1 m. usually among vegetation. It did not occur in the deeper part of the lake.

VALVATA TRICARINATA BASALIS Vanatta

Plate I, figures 8, 9

Valvata carinata SOWB., Gen. Shells, XLI, fig. 2, 1834 (part); BINNEY, L. & F. W. Sh. N. A., III, p. 11, fig. 15, 1865.
Valvata tricarinata var. WALKER, Nautilus, XV, p. 124, 1902.
Valvata tricarinata basalis VANATTA, Nautilus, XXVIII, p. 105, fig., 1915.

TYPE LOCALITY: Hudson River, N. Y.

L. 2.56; W. 4.15; aperture L. 1.69; W. 1.74 mm. Type.

The *basalis* mutation is fairly common in Lake Winnebago, associated with typical *tricarinata* and variety *perconfusa.* The base is completely rounded and there is not even a trace of an angulation. By the strict rules of priority this variety should perhaps be given the name *carinata* of Sowb., who gave a very good figure but no description. Vanatta's name is founded on the same form but he both figured and described the variety.

In Lake Winnebago this form occurs in many places, mostly on a sand or sand-gravel bottom, in water .6 to 3.4 m., usually near shore. It was also dredged one-half mile east of Oshkosh in the open lake, on a mud bottom, in water 3.4 .m deep, without vegetation. It was found sparingly in Prairie Lake, Barron Co. and in lakes in Waukesha Co. It has been reported from Vermont.

VALVATA TRICARINATA INFRACARINATA Vanatta

Valvata tricarinata infracarinata VANATTA, Nautilus, XXVIII, p. 104, fig., 1915. Noted by WALKER, Nautilus, XV, p. 124, 1902.

TYPE LOCALITY: White Pond, N. J.

This mutation is distinguished by having a keel only at the base surrounding the umbilicus. It is recorded from Ontario, New York, New Jersey, and Michigan, but has not yet been observed in Wisconsin. It will doubtless be found associated with other forms of *tricarinata.*

VALVATA TRICARINATA SIMPLEX Gould

Plate I, figures 10, 14

Valvata tricarinata var. *simplex* GOULD, Invert. Mass., p. 226, fig. 156, (right hand figure) 1841.
Valvata humeralis MILES, Geol. Surv. Mich., p. 237, 1860 (not of Say).

TYPE LOCALITY: Vermont.

In this mutation there are no keels, the whorls being typically rounded but flattened above. Some specimens have faint angulations, which, with the difference in shape and sculpture, will distinguish it from *sincera* and *lewisi.* In Wisconsin, *simplex* has been found in Winnebago Lake, Green Lake and Spring Lake, Green Lake Co., in Big Bay, Madeline Island, Bayfield Co., Lake Superior, at Milwaukee, and in many lakes in Waukesha Co. In the first mentioned locality it is common in places.

VALVATA BICARINATA Lea

Plate I, figure 6

Valvata bicarinata LEA, Proc. Amer. Phil. Soc., II, pp. 81, 83, 1841; BINNEY, L. & F. W. Sh. N. A., III, pp. 9–10, fig. 14, 1865; WALKER, Nautilus, XV, p. 124, fig. 6, 1902; XX, p. 29, pl. 1, fig. 14, 1906.

TYPE LOCALITY: Schuylkill River, Pa.

WISCONSIN RECORDS: None.

SHELL: Discoidal, flattened above, rather thick, shining; horn-colored or tinged with green; whorls 3½, shouldered, upper surface sloping downward from the carina to the suture, which is deeply impressed; spire greatly depressed, not rising above the carina of the body whorl when viewed from in front; lines of growth faintly marked; body whorl bicari-

nate, superior carina revolving nearly to the apex, periphery rounded or bluntly angulate; carinae sharp, elevated; aperture nearly circular, slightly flattened above and modified by the carinae; lip simple, sharp, appressed to the lower half of the body whorl; umbilicus wide, exhibiting all the whorls. L. 3,5; W 6.5 mm. (Walker).

OPERCULUM: As in *tricarinata.*

ANIMAL: In general the same as *tricarinata.* Lea (1841) gives a few distinguishing characteristics between his species and *tricarinata,* which are noted below: "The head of the *tricarinata* is more cylindrical and enlarged at the termination, where it somewhat resembles the snout of the hog, while that of the *bicarinata* is more conical and without so sudden an enlargement at the end. The color of the *bicarinata* is lighter. In the black markings they also differ. In the *tricarinata* there is a single blotch anterior to the area between the eyes. In the *bicarinata* this extends also behind this area; and in addition may be observed two quite black marks above the mouth, which the *tricarinata* does not seem to have. The tentacular of the *bicarinata* are larger and more filiform. When in motion, the anterior portions of the lobes of the foot are pointed, and recurved or hooked."

GENITALIA: The external organ of the male is the same as in *tricarinata.*

JAW: As in *tricarinata.*

RADULA: See under variety *normalis.*

GENERAL DISTRIBUTION: Eastern Pennsylvania west to Illinois south to Alabama (Walker, 1906b, p. 30). As this species has been confused with *tricarinata* the literature is quite inadequate for data concerning distribution. The typical form has not yet been found in Wisconsin.

REMARKS: "In comparison with *V. tricarinata,* Lea's species is larger, discoidal; the upper surface of the whorls slope downwards from the carina to the sutures, giving a concave appearance to the upper surface as a whole; the spire is depressed, not appearing above the superior carina of the body whorl, the umbilicus is very wide and more shallow, exhibiting all the whorls. In *tricarinata,* on the other hand, the whorls are more closely coiled, making a round, deep, funnel-shaped umbilicus; the penultimate whorl is elevated and only the apex of the spire is depressed" (Walker).

Typical *bicarinata* seems more eastern and southern in distribution, no specimens having as yet been found in Wisconsin. It has been reported from Lake Michigan and the Desplaines River at Joliet, Illinois (Baker, 1902a, p, 351), and it is to be expected in the fauna of southeastern Wisconsin at least.

VALVATA BICARINATA NORMALIS Walker

Plate I, figures 11–13

Valvata bicarinata normalis WALKER, Nautilus, XV, p. 125, fig. 6, 1902.

TYPE LOCALITY: Muscatine, Iowa and Utica, Illinois.

WISCONSIN RECORDS:

1906. *Valvata tricarinata* CHADWICK, p. 89 (part). Lake Winnebago, near High Cliff.

1906. *Valvata bicarinata normalis* CHADWICK, pp. 24, 89. North Milwaukee.

SHELL: "Body whorl tricarinate, otherwise like the type" (Walker).

L. 4.0; W. 6.0; Ap. L. 2.3; W. 2.3 mm.	L. Winnebago	(U. of W.,	4555).
L. 3.9; W. 5.8; Ap. L. 2.3; W. 2.1 mm.	"	"	"
L. 3.5; W. 6.0; Ap. L. 2.2; W. 2.1 mm.	"	"	"
L. 3.5; W. 5.5; Ap. L. 2.2; W. 2.0 mm.	"	"	"

OPERCULUM: As in *tricarinata.*
ANIMAL: See under *bicarinata.*
GENITALIA: Same as *tricarinata.*
JAW: As in *tricarinata.*

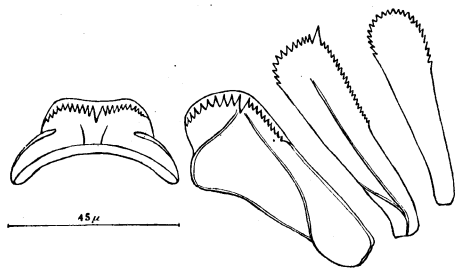

Fig. 9. Radula of *Valvata bicarinata normalis.* Winnebago Lake.

RADULA (Fig. 9) Formula 10-1-10: 9-1-10: 13-1-20: 23. The central tooth is much smaller than that of *tricarinata* and the cusps are smaller and less numerous. The lateral and marginal teeth differ in the relative number of cusps. In the

outer marginal all cusps were apparently subequal without the larger center cusp at the upper angle. Ridges of attachment are more distinctly marked than in *tricarinata.*

GENERAL DISTRIBUTION: Not well known. It has been observed in the states of Iowa, Illinois, and Wisconsin.

DISTRIBUTION IN WISCONSIN: At present known only from Winnebago Lake and vicinity, and from near Milwaukee.

ECOLOGY: In Winnebago Lake; Roe Point, boulder bottom, water .6 m. deep; Libby Point, gravel, 0.3 m.; off Doemel Point, gravel, 3.4 m.; Hatchery Bay, sandy silt, 0.9 m., in vegetation; Butte des Morts: sandy mud bottom, 1.5 m., on Vallisneria.

REMARKS: Walker remarks that the typical *bicarinata* is really a variety of the specific type represented by the variety *normalis.* This is the most distinct and characteristic form of *Valvata* in the State, easily known by its sharp, keel-like carinae and wide, funnel-shaped umbilicus. The spire whorls are not always sunk below the upper carina of the last whorl, but may be almost as elevated as in *tricarinata.* The Winnebago Lake lot contains every gradation between these two extremes. There is no variation in the tricarinate condition of the shell, as in the case of *tricarinata* from Wisconsin, every specimen in the several hundred examined having three sharp, pinched-like keels without any sign of simple angulation.

VALVATA BICARINATA PERDEPRESSA Walker

Plate I, figures 15–18

Valvata bicarinata perdepressa WALKER, Nautilus, XX, p. 30, pl. 1, figs. 15–16, 1906.

Valvata sincera BAKER (part) Moll. Chicago Area, p. 348, pl. 30, fig. 31, 1902.

TYPE LOCALITY: Lake Michigan, at Michigan City, Ind.

WISCONSIN RECORDS: None.

SHELL: "Broadly umbilicated, very much depressed, often planorboid. Ecarinate. whorls regularly rounded, occasionally subangulated around the umbilicus or at the periphery, smooth or obsoletely striate, frequently obscurely malleated, especially on the lower half of the whorl, very pale horn colored or with the apical whorls more or less tinged with dull

purple or red" (Walker). Nuclear whorls with the spiral and growth lines much finer than in *bicarinata* or *normalis*.

L. 3.5; W. 5.0; Ap. L. 2.0; W. 2.0 mm.	Charlotte, N. Y.	(U. of I.,	Z24075).
L. 2.8; W. 4.9; Ap. L. 2.0; W. 2.0 mm.	"	"	"
L. 3.0; W. 4.4; Ap. L. 2.0; W. 1.9 mm.	"	"	"
L. 2.8; W. 4.5; Ap. L. 2.0; W. 1.9 mm.	"	"	"

OPERCULUM: As in *bicarinata normalis*.

ANIMAL: Not examined.

GENITALIA: Not examined.

JAW AND RADULA: As in *bicarinata normalis*.

ECOLOGY: Apparently a lake form and not recorded from other places.

GENERAL DISTRIBUTION: Wisconsin east to New York, principally in Lakes Michigan, Erie, and Ontario; Little Lakes, N. Y.

DISTRIBUTION IN WISCONSIN: Confined to Lake Michigan. Lake Michigan shore near Wisconsin-Illinois line and Lake Michigan shore near Sturgeon Bay, Door Co. The variety is very common in the southern part of the lake on the Illinois and Indiana shore.

REMARKS: "*Perdepressa* would be taken for a smooth form of *Valvata lewisi* were it not for the connecting links with *bicarinata* afforded by occasional subangulated individuals and *bicarinata connectans*. It is very variable in shape, ranging from planorboid with the apex depressed below the level of the body whorl to specimens with the apex quite as much elevated as in the ordinary specimens of *lewisi*. In sculpture it varies from almost perfectly smooth to a striation nearly as strong as that of typical *lewisi*. Indeed, the more elevated and strongly striated examples standing alone would unhesitatingly be referred to that species" (Walker).

Perdepressa somewhat resembles *Valvata lewisi helicoidea*, but is more depressed on the average, has a wider umbilicus, and the surface smoother and more polished. Another variety which should be found among normal *perdepressa* is *Valvata bicarinata connectans* Walker (Nautilus, XX, p. 30, 1906), which is unicarinate, only the superior carina being present, the base rounded or subangulated. The type came from Lake Michigan at New Buffalo, Mich. This form is said to be rare. No specimens have been seen from Wisconsin.

VALVATA SINCERA Say

Plate I, figures 19–22

Valvata sincera SAY, Long's Exped., p. 264, pl. xv, fig. 11, 1824; BINNEY, L. & F. W. Sh. N. A., III, p. 12, fig. 17, 1865; WALKER, Nautilus, XX, p. 26, pl. 1, figs. 1–6, 1906; DALL, Alaska Moll., p. 122, 1905.

TYPE LOCALITY: "Northwest Territory" (Say).

WISCONSIN RECORDS:

1860. *Valvata sincera* LAPHAM, p. 155. Milwaukee.
1865b. *Valvata sincera* BINNEY, p. 13. Madison.
1906. *Valvata sincera* WALKER, p. 28. Milwaukee.
1906. *Valvata sincera* CHADWICK, p. 24, 89. Near Milwaukee.

SHELL: Subglobose-conic, rather solid; yellowish-brown in color; whorls four, evenly rounded, regularly increasing in diameter; sculpture of fine and regular striae; sutures well impressed; nuclear whorls as in *tricarinata* but all lines finer, the spiral lines not apparent after the second whorl or at most very fine; aperture circular, lip continuous, touching but not appressed to the whorl above; umbilicus round and deep exhibiting the volutions almost to the apex.

L. 4.5; W. 5.5; Ap. L. 2.4; W. 2.2 mm. Lake Winnipeg (U. of I., Z24076).
L. 4.0; W. 4.5; Ap. L. 2.0; W. 2.0 mm. High Island Harbor (U. of Ill., Z24077).
L. 4.1; W. 5.1; Ap. L. 2.2; W. 2.2 mm. High Island Harbor (U. of Ill., Z24077).

OPERCULUM: As in the genus.

ANIMAL: Not examined.

JAW: See variety *nylanderi.*

RADULA: As in *nylanderi.* Specimens from High Island Harbor examined.

ECOLOGY: Not specifically reported. Living specimens have for the most part been found in lakes. It has been found in rather deep water in Lake Michigan and Lake Superior.

GENERAL DISTRIBUTION: Anticosti Island and Maine west to Wisconsin, S. E. Keewatin and Lake Winnipeg south to southern Michigan and northern New York. It is a northern species. Not authentically reported from Illinois.

DISTRIBUTION IN WISCONSIN: This species seems rare in the State. Milwaukee, Milwaukee Co. (Chadwick, Lapham, Walker); Sturgeon Bay, Door Co. (Baker); Madison, Dane Co. (Binney, Lapham). Lake Winnebago, Winnebago Co.

(Baker); Outlet of Oconomowoc Lake, Waukesha Co. (Cahn, fossil).

REMARKS: *Sincera* may be known by its accurately rounded whorls, round deep umbilicus, subglobose-conic shape, and finely, regularly striated whorls. From *lewisi* it may be known by its higher spire, smaller umbilicus, and less expanded aperture and last whorl. The form of *sincera* is so characteristic, typically, that it cannot be usually confused with the other ecarinate forms. It is apparently a rare species in Wisconsin.

The name *sincera* has been made to include all of the ecarinate forms of *Valvata- lewisi* and the ecarinate forms of *tricarinata* and *bicarinata*. All of the early authors—Binney, Haldeman, Tryon—confused these several forms and it remained for Walker to clearly indicate the specific characteristics and to give adequate figures (see 1906b, p. 26).

VALVATA SINCERA DANIELSI Walker

Plate I, figures 23–25, 31

Valvata sincera danielsi WALKER, Nautilus, XX, p. 28, pl. 1, figs. 9, 10, 1906.

TYPE LOCALITY: Cannon Lake, Rice Co., Minn.

WISCONSIN RECORDS:

1900a. *Valvata sincera* BAKER, p. 177. Milwaukee (fossil).
1906. *Valvata sincera* CHADWICK, p. 89. Cold Spring Park, Milwaukee (fossil).
1920d. *Valvata sincera* BAKER, p. 119. Milwaukee (fossil).

Shell: "Larger and proportionally higher than the typical form; whorls 4, finely and regularly striate, very convex with deeply impressed suture; aperture entire, scarcely appressed to the body whorl."

L. 6.0; W. 5.7; Ap. L. 0.0; W. 0.0 mm. Type.
L. 4.2; W. 4.2; Ap. L. 2.1; W. 2.0 mm. Milwaukee (fossil. U. of I., Z24078).
L. 3.1; W. 3.5; Ap. L. 1.8; W. 1.5 mm. Milwaukee (fossil. U. of I., Z24078).
L. 2.7; W. 4.0; Ap. L. 1.8; W. 1.5 mm. Milwaukee (fossil. U. of I., Z24078).
L. 4.1; W. 4.9; Ap. L. 2.4; W. 2.3 mm. Green Lake (U. of W., 4558).
L. 3.4; W. 4.5; Ap. L. 2.1; W. 2.0 mm. " "
L. 4.8; W. 5.8; Ap. L. 2.7; W. 2.5 mm. " (U. of W., 4559).

ANIMAL: Not examined.

ECOLOGY: Evidently a lake form, both recent and fossil specimens coming from this kind of a habitat.

GENERAL DISTRIBUTION: At present known in the recent fauna from Minnesota and as a fossil from Wisconsin and Illinois (Crystal Lake).

DISTRIBUTION IN WISCONSIN: This is the common form of *sincera* in the marl deposits of the Pleistocene. All Wisconsin specimens seen are fossils.

Milwaukee, Milwaukee Co. (Baker, Chadwick, Slocum); Green Lake, Green Lake Co. (Baker). Oconomowoc Lake, Waukesha Co. (Cahn).

REMARKS: The characteristics of this variety have been indicated in the race diagnosis. It is quite distinct in most specimens examined. Among the fossil material from Milwaukee, however, there is a tendency to vary toward the depressed *nylanderi* type, though there are no axial ribs as in that variety (see fig. 25).

VALVATA SINCERA NYLANDERI Dall

Plate I, figures 26–27

Valvata (*sincera* var?) *nylanderi* DALL, Alaska Moll., p. 122, pl. 1, figs. 7–9, 1905.

Valvata sincera nylanderi WALKER, Nautilus, XX, p. 28, 1906.

TYPE LOCALITY: Aroostook Co., Maine.

WISCONSIN RECORDS:

1906b. *Valvata sincera nylanderi* WALKER, p. 28. Lake Geneva.

1927a. *Valvata sincera nylanderi* WINSLOW, p. 6. Little Arbor Vitae Lake.

SHELL: Differing from typical *sincera* in having the sculpture consist of axial "thin, sharp, elevated, rather distant lamellae". Otherwise similar.

L. 3.0; W. 3.5; Aperture L. 1.5; W. 1.5 mm. Bayfield (U. of W., 4556).
L. 3.2; W. 4.0; " L. 1.8; W. 1.5 mm. Georgian Bay (U. of Ill., Z24079).

OPERCULUM: As in *sincera.*

ANIMAL AND GENITALIA: Not examined.

JAW (Fig. 7): Of very small plates which overlap and have the lower margins very finely serrated, much finer than in *tricarinata* and somewhat finer than in *lewisi.* The plates overlap horizontally as well as vertically.

RADULA (Fig. 10): Formula 15–1–15: 10–1–15: 9–1–30: 11–1–30. Teeth about the size of *tricarinata,* the central tooth somewhat higher. Denticulations much like *tricarinata* in both number and form.

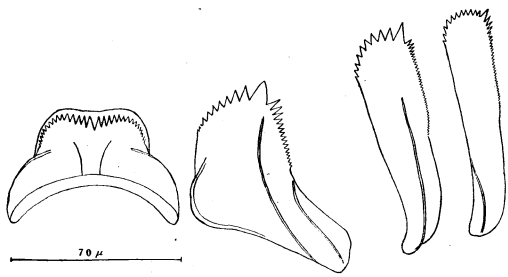

Fig. 10. Radula of *Valvata sincera nylanderi.* Georgian Bay, Ont.

ECOLOGY: Sand bottom, on drift log in shallow water.

GENERAL DISTRIBUTION: Aroostook Co., Maine; Georgian Bay, Ontario, Can.; Marquette Co., Mich., Isle Royale, L. Superior; Little Lakes, N. Y.; Wisconsin.

DISTRIBUTION IN WISCONSIN: Known from widely separated localities. Lake Geneva, Walworth Co. (Walker); mouth of Chicago Creek, Bayfield Co., Lake Superior (Baker); Little Arbor Vitae Lake, Vilas Co. (Winslow).

REMARKS: Typical *nylanderi* is so different from *sincera* as to separate it at once from that species. Walker, however, cites examples from Isle Royale, Lake Superior, which vary from ribbed to striate, and specimens from Georgian Bay, recently examined, also exhibit this variation. As remarked by Dall, the sculpture recalls that of the land shell *Planogyra asteriscus* Morse. It is evidently very rare in Wisconsin. The radula of the Isle Royale specimens is exactly like that of the Bayfield specimens.

VALVATA LEWISI Currier

Plate I, figures 28–30

Valvata striata LEWIS, Proc. Phil. Acad., 1856, p. 260; BINNEY, L. & F. W. Sh. N. A., III, p. 13, fig. 18, 1865 (not of Philippi, 1836).

Valvata sincera HALDEMAN, Mon. VIII, pl. 1, figs. 6–8, 1845.

Valvata sincera BAKER, Moll. Chi. Area, p. 348, pl. 32, fig. 15, 1902 (Part).

Valvata lewisi CURRIER, Kent. Sci. Inst., Miscel. Pub., No. 1, p. 9, 1868 (New name for *V. striata* Lewis); DALL, Alaska Moll., p. 123, fig. 94, 1905.

Valvata lewisii WALKER, Nautilus, XX, p. 29, pl. 1, figs. 12–13, 1906.

TYPE LOCALITY: Little Lakes, N. Y.

WISCONSIN RECORDS:

1897. *Valvata sincera* WISWALL, p. 48. Southern Wisconsin.

SHELL: Turbinate, thin, shining; epidermis brownish, reddish-brown, or greenish-horn; whorls 3½, regularly convex, rapidly increasing in diameter, regularly striate, like the "winding of thread on a spool"; sutures deeply impressed; spire depressed, apex flattened, nuclear whorl similar to that of *sincera,* spiral lines very fine, disappearing on second whorl; growth lines close together; aperture circular; lip simple, continuous, appressed to the body whorl above; umbilicus rather wide, deep, exhibiting interior whorls.

L. 3.5; W. 4.8; Ap. L. 2.3; W. 2.2 mm.	Prairie	Lake	(U.	of	W., 4557).
L. 3.3; W. 5.0; Ap. L. 2.1; W. 2.0 mm.	"	"	"		"
L. 3.1; W. 4.5; Ap. L. 2.1; W. 2.1 mm.	"	"	"		"

OPERCULUM: As in the genus.

ANIMAL: "Head whitish above with a tinge of slate color, increasing posteriorly; mantle pale yellowish; tentacles filiform, whitish, more than 0.2 inch long; eyes minute, black and shining, situated on the upper and outer part of the posterior side of the protuberance at the base of the tentacles; margin of the branchial cavity blackish-brown; pinnatifid branchia semitransparent, consisting of a stem, on each side of which extend at right angles filiform obtuse branches bent in a zigzag, shorter towards the extremity, about 10 on each side, the whole resembling a feather; tentaculiform branchia rather longer than the tentacles, equally slender and obtuse; foot whitish, swelling and regularly rounded posteriorly with the anterior lobes sharply angular, and the middle somewhat contracted (Adams, in lit. Hald. Mon. p. 7).

GENITALIA: Not examined.

JAW: With the scales somewhat larger than *sincera,* the serrations on the lower margin larger than *sincera* but smaller than *tricarinata,* and more numerous.

RADULA (Fig. 11): Formula 9–1–9:9–1–13:10–1–18:23. Teeth like those of *bicarinata normalis,* but central tooth a trifle larger (see measurements). The number of cusps varies within narrow limits.

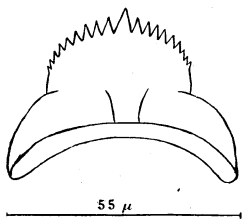

Fig. 11. Radula of *Valvata lewisii.* Lake Butte des Morts.

ECOLOGY: Prairie Lake, shallow water, sand bottom, in vegetation; Lake Butte des Morts, 1 m., mud bottom, on plants. Apparently not found in as deep water as *sincera.* Also a lake species largely.

GENERAL DISTRIBUTION: Northern part of the United States from the Atlantic to the Pacific oceans, northward, in British America, to the upper Mackenzie River. Its southward range is not fully known. It is recorded from La Salle Co., Ill.

DISTRIBUTION IN WISCONSIN: Probably inhabits most parts of the State, and known from drainages of the Chippewa, Rock, Fox rivers and Lake Michigan.

REMARKS: *Lewisi* resembles *sincera;* it may be known from that species by its more depressed spire which appears in normal specimens to be pushed inward, its more rapidly enlarging whorls, wide and shallower umbilicus, and less distinctly marked striae. While some specimens of *lewisi* with high spire somewhat resemble *sincera,* the more rapidly enlarging whorls will usually distinguish it from that species.

There is some variation in sculpture, occasional specimens having coarse striae which approach ribs, while others are almost smooth, resembling *bicarinata perdepressa.* The normal sculpture may be said to be as described by Dall, "fine and close, like the winding of thread on a spool". Specimens from Green Lake, dredged from marl bottom at depths of 7 to 39 m., vary from depressed to turbinate, the sculpture being very fine, almost smooth. No living specimens were found in this

lake and the great variability in form seems due to these Pleistocene fossils having lived in cold, glacial waters. The Prairie Lake specimens are very uniform, more nearly resembling the typical form from New York.

Most previous authors, following Haldeman and Binney, have confused this species with *sincera,* Haldeman, after Adams, referring wholly to the more depressed *lewisi,* which he figures. Dall separates the two forms and Walker both describes and figures a form which is without doubt the *striata* of Lewis (= *lewisi*). *Lewisi* is very common in parts of Wisconsin, while *sincera* is very rare.

VALVATA LEWISI HELICOIDEA Dall

Plate I, figures 32–35

Valvata lewisi var. *helicoidea* DALL, Alaska Moll., p. 123, pl. ii, figs. 1, 2, 1905; WALKER, Nautilus, XX, p. 31, 1906.

TYPE LOCALITY: Not specified. With the type form, to some extent everywhere, but especially toward the northwest (Dall).

WISCONSIN RECORDS: None.

SHELL: "This form resembles *lewisi* but is more depressed, almost flat above, and more or less flattened toward the suture; the whorls are more slender and near the aperture usually rather suddenly expanded; the surface polished, the sculpture frequently obsolete; the umbilicus wide, and its bounding coil peripherally diverted during the growth of the last half whorl" (Dall).

L. 2.5; W. 5.0; Aperture L. 2.0; W. 0.0 mm. Type.
L. 2.8; W. 4.3; " L. 2.0; W. 1.9 mm. Chetek Lake (U. of W., 4560).
L. 2.5; W. 3.6; " L. 1.7; W. 1.4 mm. Bayfield (U. of W., 4561).

OPERCULUM: As in *lewisi.* There are about 12 whorls, the spiral lines are very regular while the growth lines are regular on the inner whorls but become irregular on outer whorls.

ANIMAL: As in *lewisi.*

GENITALIA: Not examined.

JAW AND RADULA: As in *lewisi.*

ECOLOGY: Slough near Chetek, water .3 to .7 m. deep, mud bottom, with abundant vegetation.

GENERAL DISTRIBUTION: Said to occur with the type form throughout its range. Typical specimens have been seen from Oneida Lake; Birch Lake, Horn River, Little Lake, Mackenzie River; St. Anne Lake, near Klutina, Alaska; Lake Winnipeg, Manitoba.

DISTRIBUTION IN WISCONSIN: Known only from the northern part of the State, Chetek Lake, Barron Co., and Bayfield Co., Lake Superior Shore (Baker).

REMARKS: Typically, *helicoidea* is quite distinct from *lewisi,* the sculpture being so reduced as to give a smooth surface. The flattened spire and rapidly enlarging body whorl are also distinctive. The sculpture varies greatly, however, specimens from Bayfield having uniform fine sharp sculpture, resembling *Valvata siberica* Middendorf, to which it is apparently closely related. Mackenzie River specimens, collected by Mr. E. L. Whittaker, show considerable variation in both form and sculpture, connecting the variety with typical *lewisi.* The variety seems rare in Wisconsin.

Of the variation in *Valvata* Walker says: "The difficulty in finding tangible distinction between the more elevated, substriated individuals of this form *(bicarinata perdepressa)* and the obsoletely striated examples of *V. lewisii* is similar to that experienced in attempting to separate *V. tricarinata simplex* from smooth or obsoletely striated forms of *sincera.* And this naturally raises a query as to whether there are really more than two polymorphic species differing constantly in shape, but both varying in sculpture, all the way from tricarinate to smooth, and from smooth to ribbed-striate. Both series are complete and parallelism is absolutely exact". The variations in the radulae bear out this statement. The table below indicates this relationship of shell and of radula (shell after Walker). Center tooth in microns.

Type	Group of tricarinata	Group of bicarinata
Tricarinate	*tricarinata* 70 μ	*bicarinata normalis* 45 μ
Bicarinate	*tricarinata confusa* 70 μ	*bicarinata* 45 μ
Unicarinate	*tricarinata unicarinata* 70 μ	*bicarinata connectans* 45 μ
Smooth	*tricarinata simplex* 70 μ	*bicarinata perdepressa*
Obsoletely striate	*sincera* (Anticosti) 70 μ	*lewisi heloicoidea* 55 μ
Thread-striate	*sincera* 70 μ	*lewisi* (Var.?)
Ribbed-striate	*sincera nylanderi* 70 μ	*lewisi* (typical?) 55 μ

Family VIVIPARIDAE (Gray, 1857) Gill, 1863

SHELL moderately large, turbinate, imperforate or subperforate; whorls convex, often carinated; aperture entire, subcircular or somewhat angled above; lip simple; operculum convex, concentric, nucleus subcentral, spiral in one genus.

ANIMAL with a long rostrum, not divided into tentacular lobes; tentacles rather long and moderately slender, in the male the right one is shorter, wider, truncated, and forms a sheath for the penis; eyes on peduncles on the outer base of the tentacles; mantle with two cervical lobes, the right one often larger, more or less modified to form tubular conduits for respiratory purposes; gill suspended from the mantle cavity, the plates in a single row, each plate being wide at the bottom and narrower at the apex. Jaws two, pear-shaped, placed laterally in the mouth, covered with polygonal plates of small size (see fig. 26); radula with the central tooth broad, without basal denticulations, the reflections broad or narrow, multicuspid; lateral and marginal teeth more or less narrow, the apices narrow or wide and distinctly denticulated. Fig. 25 shows the general position of the digestive system, gills, heart, genitalia, and some ganglia.

GENITALIA with a sausage-shaped or convoluted penis, a large prostate, variously placed on the vas deferens, the penis placed in the right tentacle which forms a penis sheath; female orifice on right side placed in a small papilla which lies to the right of the rectum in the branchial cavity; uterus large, filling much of the last whorl, especially when distended with embryos. Ovoviparous, the young shell in the mid-neanic stage when born.

DISTRIBUTION including the greater part of the northern hemisphere. None are known from South America or Australia, nor at present from west of the Rocky Mountains. Fossil forms have been described from Eocene formations in some of the western states.

KEY TO SUBFAMILIES OF VIVIPARIDAE

1. Shell subconic, aperture regularly rounded; penis large, sausage-shaped; cervical lappets forming tubular conduits for respiratory purposes; central tooth broad, reflection wide, the center cusp usually wide and square, the side cusps sharp;

lateral and marginal teeth narrow with a wide, blunt center cusp ----------*Viviparinae*

2. Shell turreted, aperture subangulated, sinuous or incurved at base; penis forming a narrow, more or less convoluted tube; cervical lappets not forming regular conduits; central tooth narrower than wide, the center cusps as well as side cusps narrow and sharp ----------*Lioplacinae*

Subfamily VIVIPARINAE (Gill, 1871) Baker, 1926

Group *Vivipari* GILL, 1863 (p. 36). Subfamily *Viviparinae* BAKER, 1926, p. 194.

Shell usually large with rounded or carinated whorls; operculum wholly concentric, the inner margin folded in some groups; foot not much larger than shell, not extending beyond end of tentacles; cervical lappets large, forming tubular conduits for respiratory purposes, the right lappet the larger; radula with broad central tooth, the reflection broad and multicuspid, the center cusp usually wide and blunt; lateral and marginal teeth longer than wide, the reflections wide and multicuspid; penis forming an elongated, thick, sausage-shaped sac, behind which the prostate is placed without intervening vas deferens, the latter short and narrow.

This subfamily includes the typical genera, *Viviparus, Tulotoma, Taia, Margarya, Neothauma,* and perhaps some other groups which agree in genitalia, radula, and general form. Many years ago Gill divided the Viviparidae into two groups which he later distinguished as subfamilies, the distinctions being based on the difference in the lingual teeth. The genitalia also give good division differences, and the separation into these two groups appears fully warranted by the facts.

Genus VIVIPARUS Denys de Montfort, 1810

Conchyl. System., II, p. 246, 1810. Type: *Viviparus fluviorum* MONTFORT, = *Helix vivipara* LINN. *Paludina* LAMARCK, 1816.

SHELL: Dextral, spiral, subconoial; rather thin, smooth, imperforate or slightly umbilicate; light green or olivaceous, unicolored or banded with brown or tinged with purple; whorls convex, aperture entire, subcircular; lip simple, acute; columellar and parietal margin not usually thickened. Operculum horny, concentric, with a simple nucleus situated near the

columellar margin, slightly punctate or roughened; inner margin simple, not reflected; there is a border of cuticle surrounding the edge of the horny portion.

ANIMAL (Fig. 12): Foot of moderate size, not extending beyond the rostrum, which is short, wide, and of medium size. Head rather large, the tentacles rather long and pointed in the female, the right tentacle of the male swollen to the size

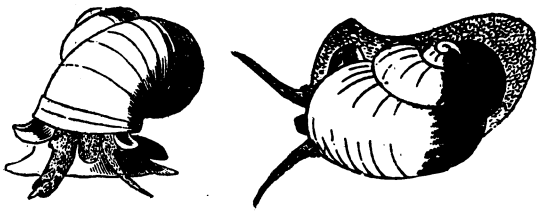

Fig. 12. Animal of *Viviparus intertextus*, Male and Female. Binney, L. & F. W. Sh. N. A., Figs. 30, 31.

of the rostrum to accommodate the male organ. Eyes placed on large swellings near the outer base of the tentacles. Cervical lappets on each side of head, large, folded to form, in connection with the edge of the mantle, two trough-like appendages or tubes for the ingress (right) and discharge (left) of the water used in respiration, the right lappet being larger than the left. Operculigerous lobe very large, on right side of body near the center of the hinder end of the dorsal surface of the foot. Branchiae with numerous crowded laminae

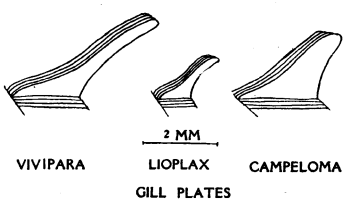

Fig. 13. Gill Plates of Viviparidae.

placed in a single linear row extending from the roof of the mantle cavity. They are wide at the base and rapidly narrow toward the free end, where they are simple and not divided into separate lobes as described by Stimpson (see fig. 13).

GENITALIA (Fig. 25): Female organs consisting of a large gut-like uterus ending in a small tube-like vagina; the spermatheca is large, sac-like, and situated at the upper end of the

uterus; beneath this, in the natural position, is a large albumen gland from which the narrow oviduct leads upward to the small, digitiform ovary. Male organs (fig. 14) consists of a large, cylindrical verge or penis which is lodged in the right tentacle, so modifying this organ as to make it as large as the rostrum, squarely truncated at the tip; the prostate, a large sausage-shaped organ, lies back of the penis, filling a large part of the cavity; from this a short vas deferens leads into the two testicular lobes which are embedded in the liver.

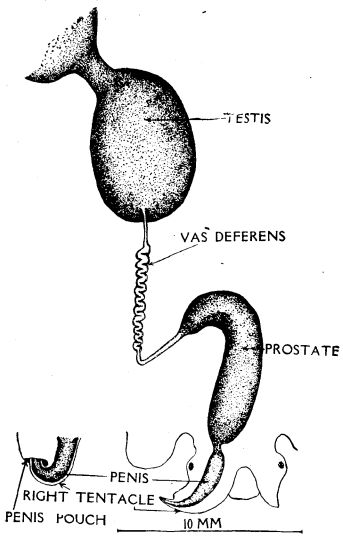

Fig. 14. Genitalia of *Viviparus subpurpureus*, Male. Mississippi River.

JAWS: There are two horny jaws, about twice as long as broad, placed on each side of the mouth. They are elongate-ovate in form.

RADULA: The central tooth is rounded or subquadrate in form, the laterals are long and narrow, and the marginals very much elongated and more or less narrow. The reflection is always multicuspid, the center cusp of all but the outer marginal being broad, short, and blunt. The number of cusps vary in the different species. Stimpson (Binney, III, p. 16) records the central from 7 to 18, the lateral from 7 to 12, the inner marginal from 5 to 10, and the outer marginal from 5 to 16. There is more variation in form and number of cusps than in the genus Campeloma.

Viviparus is of almost world wide distribution (it is not found in Australia or South America), being particularly abundant in northern Europe, Asia, and North America. Attempts to divide the genus into subgroups have not met with great success. The subgenus *Callina* of Hannibal (p. 193) is untenable because the characters given for the separation are non existent, the type cited, *intertexta,* having both an umbilicated and and imperforate form, while the young is distinctly angulated on the periphery. Pilsbry (Phil. Acad., 1901, p. 188) has separated a form from Burma as a subgenus *Idiopoma,* the characters being a differently sculptured operculum. Annandale (Records, Indian Museum, XIV, p. 123, 1918) has described a genus *Taia* with a number of new species from Upper Burma and the Shan Plateau which greatly resembles the American genus *Tulotoma* in the sculpture of the shell. At present, the American species appear to be uniform and to belong to but one group. The species live in both lakes and rivers.

KEY TO SPECIES OF VIVIPARUS

1. a. Shell with four brown bands* ---------- *contectoides*
   b. Shell without brown bands ---------- 2
2. a. Shell thin, whorls convex, spire short, base umbilicate_*intertextus*
   b. Shell thick, whorls flatly-rounded, shouldered, spire long, base imperforate ---------- *subpurpureus*

VIVIPARUS CONTECTOIDES W. G. Binney

Plate II, figures 12–17

Limnea vivipara SAY, Nich. Encyc., (1), pl. ii, fig. 5, 1817 (Paludina of later editions).

Paludina vivipara SAY, Amer. Conch., pl. x, outer fig., 1830; HALDEMAN, Mon. p. 17, pl. vi, 1841; BINNEY, L. F–W. Sh. N. A., III, p. 25, figs. 47, 48, 1865.

Vivipara contectoides W. G. BINNEY, Op. Cit., p. 23, figs. 41–44, 1865; Baker, Moll. Chi. Area, p. 354, pl. xxxvi, figs. 1–3, 1902.

Viviparus contectoides WALKER, Synopsis, p. 124, 1918.

TYPE LOCALITY: Not specified.

WISCONSIN RECORDS:

1906. *Vivipara contectoides* CHADWICK, p. 89. Kinnickinnic River, near Milwaukee.

* Occasional bandless forms of *contectoides* may be known from *intertextus* by the longer spire, less convex whorls, and the smaller umbilical chink which is sometimes wholly absent in *contectoides.*

SHELL: Rather thin, rounded, swollen; color greenish-horn, usually with four revolving brown bands, only two of which appear on the spire whorls; surface shining, sculpture only of growth lines, which are distinct and crowded but not rough; the earlier whorls have very fine spiral lines; one or more brown marks of former peristomes may be present; nuclear whorls large, rounded, rapidly increasing in size, faintly spirally striate or, in mature shells, granular; spire rather long, subconic; whorls almost six, regularly increasing in size, swollen, slightly roundly flattened below the suture, which is deeply impressed; aperture roundly-ovate, somewhat oblique, entire, the inner lip tightly appressed to the body whorl, either entirely closing the umbilicus or leaving a very small chink; the aperture is bluish-white inside and the four bands show clearly on the outer part of the aperture; peristome simple, sharp, sometimes bordered by a black band. Bandless forms occur rarely.

L. 34.0; W. 24.0; Ap. L. 16.5; W. 12.0 mm. Bass Lake, Ind. (U. of I., Z15412).
L. 32.5; W. 25.5; Ap. L. 17.0; W. 13.0 mm. Bass Lake, Ind. (U. of I., Z15412).
L. 32.0; W. 24.0; Ap. L. 16.0; W. 12.0 mm. Morris, Ill. (U. of I., Z15411).
L. 21.0; W. 17.0; Ap. L. 13.0; W. 9.5 mm. Morris, Ill. (U. of I., Z15411).
L. 15.5; W. 13.5; Ap. L. 8.5; W. 6.5 mm. Morris, Ill. (U. of I., Z15411).

OPERCULUM (Pl. X, fig. 30): Roundly-ovate, translucent, rather thick, horny, sculpture concentric; nucleus long-ovate, sculpture granular or scale-like, the concentric markings beginning immediately outside; nucleus placed near the columellar edge about half way between base and summit, the latter being roundly angular; the external border is surrounded by a ring of epidermal matter.

ANIMAL: See generic description. Color dark brown with lighter patches here and there.

GENITALIA: See generic description. It is in all respects like that of *Viviparus subpurpureus.*

EMBRYONIC SHELL (Pl. V, fig. 19): Of good size, hyaline, subglobular, somewhat flattened above, body whorl subangulated at the periphery, 2½ whorls, sutures deeply impressed,

aperture round; whole shell, excepting a portion of the base near the umbilicus, covered with fine, equidistant spiral lines which are raised into epidermal lamellae. Length 2.8; Width, 2.5 mm. (Bass Lake, Ind., coll. Walker). The color bands begin as soon as the young *contectoides* is born. The foot of the young snail is almost black in color, with large, irregular white spots on the under side; they are very active.

JAWS: See generic description.

RADULA (Fig. 15): Formula 5–1–5:4–1–4:3–1–3:7(3–1–3). Central tooth broader than long, roundly quadrate, the base wider than the apex; reflection wide and low, 11-cuspid, 5 small, sharp, triangular cusps on either side of a wide and low, blunt center cusp; lateral tooth much longer than wide,

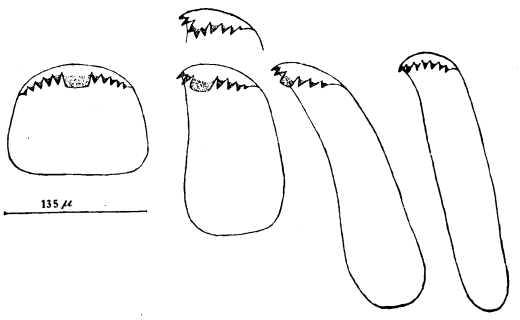

Fig. 15. Radula of *Viviparus contectoides*. Chicago.

with parallel sides, base rounded; reflection with three or four sharp, triangular cusps on either side of a wide and low, blunt, center cusp: first marginal very long, of about equal width, base rounded; reflection with three triangular teeth on either side of a blunt and wide center cusp: outer marginal very long and narrow, the reflection with 7 small, triangular, sharp cusps of equal size. There are 55 or 60 rows of teeth. The center cusp of the lateral tooth is frequently broken up into three or more small, triangular cusps. This was noted in several teeth.

ECOLOGY: Found in both lakes and rivers on a mud bottom in shallow water. In Oneida Lake, N. Y., this species was collected from a mud bottom in water about 3 m. deep, and on a sand bottom in shallow water in protected situations.

GENERAL DISTRIBUTION: Eastern United States from Michigan to New York, south to Florida, and west to Arkansas.

It has been colonized in New York where it is now widely distributed. Also introduced into Boston and Philadelphia, where it is well established. It is abundant in central and northern Illinois.

DISTRIBUTION IN WISCONSIN: At present known only from a single empty shell found in the Kinnickinnic River, near Milwaukee. This may have been brought to its location. As it is common in various parts of Cook County, Illinois, it may ultimately be found in southeastern Wisconsin, especially in some of the small glacial lakes.

REMARKS: This very beautiful species may be at once distinguished by its robust shell and four distinct bands. From *subpurpurea* it may be known by its more rounded whorls, more depressed spire, and color; from *intertexta illinoisensis* it may be distinguished by its higher spire, less rotund whorls, different color, and imperforate base (in the adult). Specimens without color bands occur rather frequently.

The animal moves about rather rapidly, its long tentacles and rounded rostrum extended to their full length, the latter bent downward searching for food, the former feeling about nervously, the shell swaying from side to side during progression.

VIVIPARUS INTERTEXTUS ILLINOISENSIS Nov. Var.

Plate II, figures 18–21

Paludina intertexta (part) of authors, not of Say.
Vivipara intertexta BINNEY, L. F–W. Sh. N. A., III, p. 17 (part), figs. 23, 24, 29–31, 1865.

TYPE LOCALITY: Havana. Illinois River, Illinois.

WISCONSIN RECORDS:

1905c. *Vivipara intertexta* BAKER, p. 256. Mississippi River between McGregor and Prairie du Chien.

SHELL: Subglobose to globosely-ovate; color greenish-horn to brownish; surface shining, sculpture of close-set lines of growth crossed by numerous fine, equidistant spiral lines of brown color which are in the periostracum; rest periods are marked by a longitudinal brown band; nucleus large, of about two whorls, rounded, coiled in almost the same plane with deep sutures, sculpture of very fine spiral lines; the nucleus is sometimes wine-colored; spire somewhat elevated in the adult,

depressed in the young shell; whorls about 5½, wide and low, very convex, flatly rounded near the suture, which is deeply impressed; aperture almost circular, continuous; outer lip sharp, thin; inner lip erect, partly reflected over the umbilical region, leaving a more or less distinct chink or umbilicus; the aperture is appressed to the body whorl for a short distance above, where it is slightly angulate.

L. 27.0; W. 24.0; Ap. L. 14.0; W. 11.5 mm. Havana, Ill. (U. of I., Z18025 holotype).
L. 21.0; W. 20.0; Ap. L. 11.5; W. 10.5 mm. Havana, Ill. (U. of I., Z18245 paratype).
L. 18.0; W. 19.5; Ap. L. 11.0; W. 9.8 mm. Havana, Ill. (U. of I., Z18245 paratype).
L. 15.5; W. 17.0; Ap. L. 10.0; W. 8.5 mm. Havana, Ill. (U. of I., Z18245).

OPERCULUM: Similar to that of *contectoides*. (Pl. X, fig. 29).

ANIMAL (Fig. 12): See generic description.

GENITALIA: As in *V. subpurpureus*. The embryonic shell (pl. V, figs. 20, 21) is rather large, 3.0 mm. wide and 2.5 mm. long, of 2¼ whorls, a much depressed spire, a distinctly carinated periphery, a well-marked umbilicus, the sutures deeply impressed or even channelled; the color is spermaceti-white, transparent; sculpture of heavy, equidistant spiral lines which are raised into elevated lamellae; on the body whorl, near the umbilicus, these lines become absent or very faint and they also disappear on the nucleus, which is minutely punctate, and often rose-colored (specimens from Walker collection, obtained at Davenport, Iowa).

JAWS: As in the genus.

RADULA (Fig. 16): Formula 6–1–6 : 5–1–5 : 6–1 : 6–1 (3–1–3). The center tooth is rounded, the length being about the same as the width, the lower corners are rounded; reflection wide, a large, square center cusp with six sharply pointed cusps on either side; lateral tooth long and rather narrow, the reflection with a wide, rounded center cusp with five sharply pointed cusps on either side; marginals much longer and narrower than lateral, the lower margin rounded, narrowing toward the upper margin where there is a wide reflection with six small, sharp cusps on the inner side of a larger rounded cusp.

It will be noted that this description differs considerably

from that given by Stimpson (Binney, fig. 29), principally in the form of the lower margin of the central tooth. The description here given is of the radula of a specimen from Louisiana, typical *intertexta,* and there may be some slight

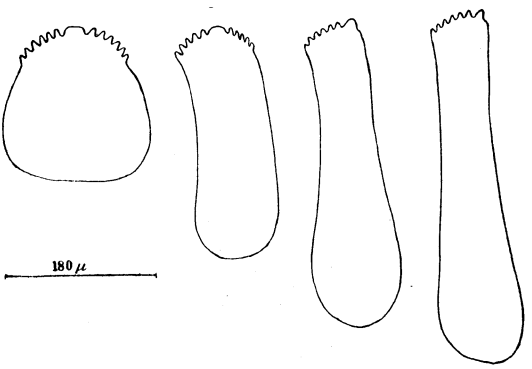

Fig. 16. Radula of *Viviparus intertexus.* Louisiana.

differences. No fresh specimens of the Illinois variety are at hand for study. For the sake of comparison the figure of Binney is reproduced. This was made from specimens obtained at Davenport, Iowa (fig. 17).

ECOLOGY: In Illinois, Iowa, and Wisconsin, this species lives in the bayous of the Mississippi River. No exact ecological notes are available.

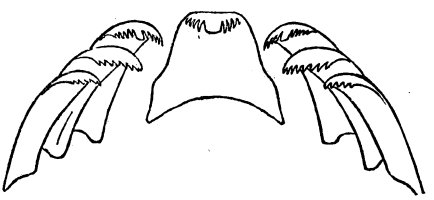

Fig. 17. Radula of *Viviparus intertextus.* Stimpson's Figure.

GENERAL DISTRIBUTION: Mississippi River in Iowa, Minnesota, Wisconsin, and Illinois; Wabash River in Knox and Gibson counties, Indiana; Illinois and Wabash Rivers in Illinois. The southern extension is not known at present as the variety has been confused with the type form from Louisiana. Its extension northward into Minnesota is attested by Dr. U. S.

Grant (1885, p. 123) who quotes it from White Bear Lake and Winona, Mississippi River.

DISTRIBUTION IN WISCONSIN: Mississippi River, between Prairie du Chien and McGregor, Iowa; Winona, Minnesota (Grant); Savanna, Carrol Co., Ill., northward to Grant Co., Wisconsin (Baker).

REMARKS: *Viviparus intertextus illinoisensis* may be known from *contectoides* by its blackish or yellowish-brown color, its wider shell, more depressed spire, very deep sutures and convex whorls; it is also usually rather distinctly umbilicated, while adult *contectoides* is rarely well umbilicated.

Comparison of specimens of Say's *intertextus* from New Orleans with the shells so called from Illinois shows that the two forms are distinct varietally. Typical *intertextus* has a very wide, somewhat globular shell with a broadly depressed spire, the nuclear whorls of which are coiled in the same plane, while in *illinoisensis* the shell is subglobose, the spire rather elevated, the spire whorls are relatively higher than in *intertextus,* the nuclear whorls being more regularly descending, and the sutures are more deeply impressed. The typical *intertextus* from New Orleans has a very minute perforation or umbilical chink while the northern shell is typically widely umbilicated, the inner lip being erect and emargining the umbilicus. Say's original description and figures indicate the type with closed umbilicus; a form is here figured (pl. II, figs. 22–24) from the type locality, New Orleans (Z15415, U. of I.).

Dr. Bryant Walker has very kindly gone over his collection and compared the various lots as to the degree of umbilication. There are 18 lots numbering over 100 specimens. The specimens from Minnesota, Iowa, Illinois, and Indiana are typical of the variety *illinoisensis.* Those from Louisiana, Georgia, Mississippi, Alabama, and Missouri are imperforate or with a small umbilical chink. Specimens from Lake Waccamaw, N. C., divided up as follows: 2 perforate as in *illinoisensis,* 3 practically imperforate, 5 with an umbilical chink. These data, together with those from the author's material, indicate that the variety is a northern race in which the umbilicus is rather widely open, and that this intergrades, in some places (as in North Carolina) with the type, which is either imperforate or with a slight chink. It would be interesting to know the exact limits of the distribution of each type, but

specimens from the region between central Illinois (southern range of *illinoisensis*) and Clinton, Mo., (northern range of *intertexta*) are not at hand for comparison.

VIVIPARUS SUBPURPUREUS (Say)

Plate II, figures 6–11

Paludina subpurpurea SAY, N. H. Dissem., II, p. 245, 1829; Amer. Conch., III, pl. xxx, fig. 2, 1831; HALDEMAN, Mon. p. 28, pl. ix, 1841.
Vivipara subpurpurea BINNEY, L. F–W. Sh. N. A., III, p. 19, figs. 32–36, 1865.

TYPE LOCALITY: Fox River of the Wabash River (Say).

WISCONSIN RECORDS:

1841. *Paludina subpurpurea* HALDEMAN, p. 28. Wisconsin.
1865. *Vivipara subpurpurea* BINNEY, p. 21. Wisconsin.
1905c. *Vivipara subpurpurea* BAKER, p. 256. McGregor, Iowa, near Prairie du Chien, Wis.
1906. *Vivipara subpurpurea* CHADWICK, p. 90. Wisconsin.

SHELL: Elongate-ovate or subovate, rather thick and solid; color olive or yellowish-green with a tinge of purple, especially in the aperture; spire elongated, conic, longer than the aperture; whorls about six, flatly rounded, somewhat roundly shouldered at the upper part near the deeply impressed sutures; penultimate whorl very large and high, especially so when viewed from behind; nucleus of good size, rather pinkish, rapidly enlarging, sculpture of fine raised, epidermal laminae; surface shining, lines of growth diagonal, very heavy, former lip marks occurring in many places on the surface of the shell; there are evidences of very fine spiral lines; aperture rounded, much narrowed above; outer lip simple, sharp; inner lip reflected over the columellar region, leaving a very small, narrow umbilical chink; there is a wash of callus on the parietal wall where the inner lip is appressed to the body whorl. In some specimens the body whorl is flattened forming a rounded angle on the periphery.

L. 32.5; W. 22.0; Ap. L. 15.0; W. 12 mm. Havana, Ill. (U. of I., Z3906).
L. 28.0; W. 19.0; Ap. L. 14.0; W. 11.0 mm. Havana, Ill. (U. of I., Z3906).
L. 29.0; W. 19.0; Ap. L. 13.0; W. 11.0 mm. Havana, Ill. (U. of I., Z3906).

OPERCULUM (Pl. X, fig. 24): Smaller than either *contectoides* or *intertextus*, with a roundly-ovate nucleus, of granular texture, situated near the columellar border; sculpture of annular growth rings in concentric form.

ANIMAL: Generally light bluish or lead color flecked with yellow spots, principally on head, rostrum and tentacles; cervical lappets as in *intertextus* but longer; other characters as in the genus.

GENITALIA: See generic description. The penis is shaped like a small sausage, pointed at the distal end, which is turned over into a small pocket-like depression at the outer part of the right tentacle, when at rest. The prostate is large and sausage-shaped while the vas deferens is small and short. The testes are paired and very large. The genitalia of the American forms as far as examined is exactly like that of the European *Viviparus viviparus* figured by Baudelot (pl. v, fig. 7). *Intertextus* and *subpurpureus* of the American species have been examined. The female organs are also similar. The shell of the female is slightly more rotund than that of the male (see pl. II, figs. 6, 7).

JAWS: As in the genus.

RADULA (Fig. 18): Formula 8–1–8:1–6–1–6:8–1–4:10–4 (3–1–3). Center tooth slightly longer than wide, the base rounded, the reflection wide with a small center cusp on either

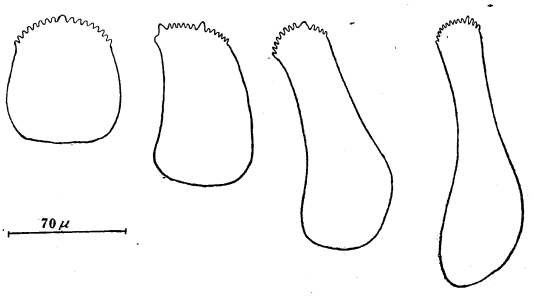

Fig. 18. Radula of *Viviparus subpurpureus*. Mississippi River.

side of which there are eight small, rounded cusps; lateral tooth longer than wide, rounded on ventral border, the reflection wide with a large inner cusp followed by six small cusps, then another large cusp followed by six smaller outer cusps; marginals long and narrow, somewhat bottle-shaped, much

wider on basal part, the reflection narrowed, the inner marginal with eight small inner cusps, then a larger, wider cusp, followed by four small outer cusps; the second marginal has ten small inner cusps and four outer cusps.

This description differs considerably from Stimpson's figures in Binney. High powers were used and many examinations made and there is no doubt of the correctness of the present figures. The differences are due, doubtless, to the use of higher powers than those at the command of Stimpson.

ECOLOGY: At Havana, on the Illinois River, this species lived in the small lake-like bayous, in quiet water on a more or less muddy bottom. This habitat has been changed by the raising of the water level by the Chicago Drainage Canal. In the Mississippi River it lives in similar situations, in the old ox-bows or bayous.

GENERAL DISTRIBUTION: *Subpurpureus* is found from southern Minnesota to Illinois, Iowa, and Indiana. Southward its place is taken by the variety *texanus* Tryon, a much narrower shell, which occurs from Missouri to Texas, Louisiana, and Mississippi. The exact meeting place of these two forms is not definitely known at present. Narrow forms are found in southern Illinois which have been identified as *texanus,* but they are scarcely normal for the variety. It is probable that the two ranges overlap.

DISTRIBUTION IN WISCONSIN: Mississippi River as far north as Winona, Minnesota (vide Walker, in Lathrop collection). It is found near Prairie du Chien in the small bayous of the Mississippi River.

REMARKS: *Subpurpureus* may be known by its purplish or olive-colored shell without bands, narrow form and usually imperforate umbilicus. It is narrower than either *intertextus* or *contectoides,* and is usually thicker and heavier. The penultimate whorl appears to bulge out when viewed from the back, a fact noted by Say in his original description. There is considerable variation in the form of the shell, which ranges from narrow to rather broad. Some of this variation is probably due to sex. This species approaches some forms of Campeloma in form, and it might be taken for a member of this genus at first sight. The animal and radula are, however, quite different.

Subfamily LIOPLACINAE (Gill, 1871) Baker, 1926

Group *Lioplaces* GILL, 1863. Subfamily *Lioplacinae* BAKER, 1926, p. 194.

SHELL turreted, whorls rounded or subcarinated; aperture subangulated, sinuous or incurved at the base; operculum wholly concentric or with subspiral nucleus; cervical lappets small; foot very large, truncated before, rounded behind; radula with narrower teeth than in the Viviparinae, the reflection with sharp cusps, none being wide and blunt, the marginals very long and narrow, wide at the base; penis forming a long, narrow, more or less convoluted tube opening at the end of the right tentacle, which is larger than the left tentacle; prostate placed immediately behind the penis or midway of the vas deferens, either sac-like or made up of several large convolutions.

DISTRIBUTION: Eastern United States and Southern Canada.

The narrow, sharp-pointed cusps of the radula, the large foot, the thin, tube-like penis, the differentiation in the position and form of the prostate, the absence of the conduit form of cervical lappets, together with the more or less sinuated aperture, are sufficient characteristics for separating these snails as a subfamily of Viviparidae. Gill (1863, p. 38) separated these shells on account of the supposed absence of cusps on the reflection of the radula teeth, but an examination of these with high powers shows that cusps are present in all species, though they are small and difficult to see. The group is wholly an American one of more or less restricted distribution. Hannibal's family Lioplacidae (1912, p. 195) is wholly untenable, being founded on a mistaken assumption that the operculum of Campeloma has the same subspiral nucleus as Lioplax. It is an absolute synonym of *Lioplaces* Gill.

Genus LIOPLAX Troschel, 1856

Lioplax TROSCHEL, Gebiss der Schnecken, p. 100, 1856. Type: *Limnaea subcarinata* Say.

Haldemania TRYON, Proc. Phil. Acad., p. 451, 1862. Type: *Limnaea subcarinata* Say.

SHELL: Ovate, turreted, imperforate, spire produced, whorls rounded or carinated; olivaceous green or dark brown; aperture oval, subcircular; lip thin continuous.

ANIMAL (Fig. 19): With the foot very large, extending beyond the shell in all directions when the animal is in locomotion, extending well in front of the tentacles, rounded behind, squarely truncated before; head very small, rostrum short and rather narrow; eyes on distinct peduncles at the outer base of

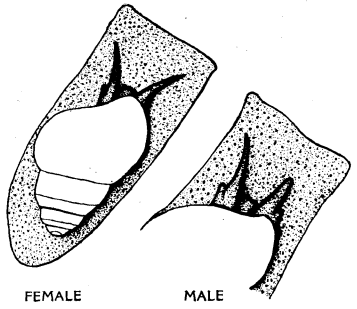

Fig. 19. Animal of *Lioplax subcarinata.* Omro, Fox River.

the tentacles, the latter broad at the base and tapering toward the end; right tentacle modified in the male to serve as a penis sheath; cervical lappet of right side, long, narrow, extending beneath the right tentacle and rostrum to near the base of the left tentacle; left lappet very small; gill plates resembling those of *Viviparus.* Color dark grayish or bluish, the upper surface of the foot thickly spotted with orange.

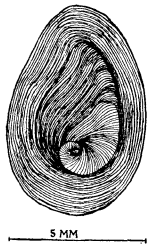

Fig. 20. Operculum of *Lioplax subcarinata.* Omro, Fox River.

OPERCULUM (Fig. 20): Long ovate or pear-shaped in form, the lower margin broadly rounded, the upper margin acutely rounded, the right and left sides broadly rounded; the nucleus placed near the center of the lower third of the operculum, subspiral like *Amnicola,* of a little more than one turn, the sculpture consisting of lines of growth; the subspiral condition

persists for a little more than half the area when the sculpture and growth becomes wholly concentric.

GENITALIA (Fig. 21): Female organs as in *Campeloma* and *Viviparus*. Male organs: Penis in right tentacle which is larger than left tentacle; there is no depression for the reception of the end of the penis, as in *Viviparus;* penis a long, narrow convoluted tube, a short vas deferens portion joining

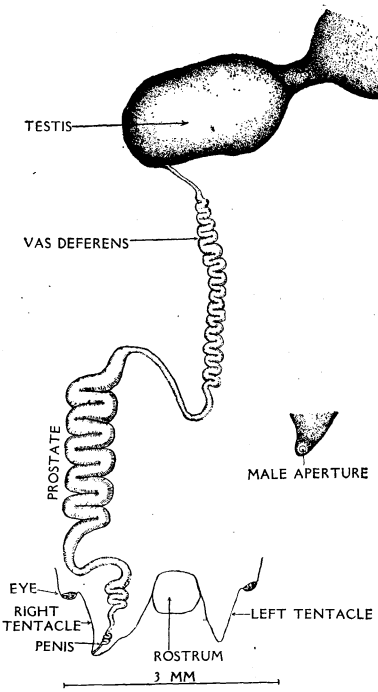

Fig. 21. Genitalia of *Lioplax subcarinata,* Male. Omro, Fox River.

the penis to the prostate, which consists of about ten large folds; the distal end of the prostate narrows into first a straight and then a convoluted vas deferens, which is rather long, and enters the large, double testis which occupies the upper whorls of the shell.

The prostate differs radically from both that of Viviparus and Campeloma, the former being a sausage-shaped organ of glandular nature, while that of Lioplax is like an enlarged vas deferens, the convoluted tube being encased in a thin-walled membrane. In Campeloma the prostate is long and narrow,

of a glandular nature, and situated near the testis, in this respect differing from both Viviparus and Lioplax. The narrow, more or less convoluted penis is quite unlike the sausage-shaped organ of Viviparus and resembles that of Campeloma.

RADULA (Fig. 22): Formula *(subcarinata)* 4–3–4: 4–3–4: 4–3–4: 5–1–5. Central tooth longer than wide, the base square, the reflection broad and 11-cuspid, three large, sharply rounded center cusps with four very small cusps on either side; lateral tooth long and narrow, base rounded, reflection broad and with cusps as in the center tooth; first marginal long and narrow with a sharp, pointed center cusp, a broadly rounded cusp on each side, and four outer cusps on each side; outer marginal very narrow with eleven subequal cusps.

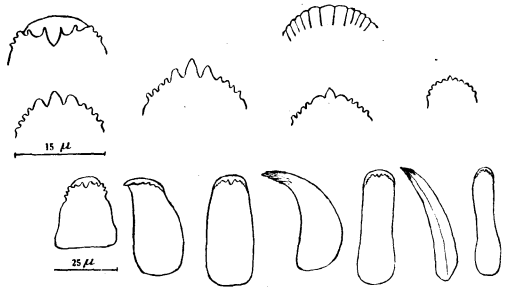

Fig. 22. Radula of *Lioplax subcarinata.* Winnebago Lake.

The description and figures of the radula here given is radically different from that published by Binney (Stimpson), in which the apices of the teeth are said to be smooth. High powers indicate that this is not true, the apices being armed with cusps as in Viviparus, though the cusps are of a different shape, more nearly resembling those of Campeloma.

DISTRIBUTION: Eastern United States and Southern Canada. A species is recorded from Eocene fresh water formations (Tejon beds) in California.

Lioplax is peculiar in having a subspiral nucleus in its operculum. The genitalia is also peculiar, the prostate composed of about ten folds instead of being sac-like as in Viviparus and Campeloma. The penis also differs from that organ as found in Viviparus, being small and tube-like, and the outlet is at the extreme end of the right tentacle, and not at the side, near the end. The radula is in some respects midway between

that of *Viviparus* and *Campeloma,* though nearer the latter. The gill plates are like those of *Viviparus* and not like *Campeloma* (see fig. 13).

LIOPLAX SUBCARINATA (Say)

Limnea subcarinata SAY, olim., Nich. Encyc., Ed. I, 1817; Ed. II, pl. ii, fig. 6, 1818.

Paludina subcarinata SAY, Nich. Enc., Ed. III, pl. i, fig. 7, 1819; HALDEMAN, Mon., p. 8, pl. 2, 1840.

Lioplax subcarinata BINNEY, L. & F–W. Sh. N. A., III, p. 58, figs. 117, 118, 1865; TRYON, Con. Hald. Mon., p. 34, 1870 (part).

Paludina bicarinata POT. et MICH., Gal. des Moll., I, p. 249, pl. xxv, figs. 17, 18, 1838.

TYPE LOCALITY: Delaware River *(subcarinata);* Delaware River *(bicarinata).*

SHELL: Short ovate, thin to rather thick, spire and aperture about equal in length; color light greenish-horn, often tinged with brown; surface dull to shining, lines of growth coarse, somewhat sigmoid, often raised into vertical ridges: sculpture of distinct lines, together with the growth lines forming a distinct microscopic latticed effect; apex sharp and pointed in the young shell, truncated in immature and adult shells; nucleus small, rounded, hyaline, sculpture at first punctate, then spirally lirate, sutures deep; spire broadly conic, short; whorls about four, regularly and rapidly increasing in diameter; the apical whorls are always missing in immature and adult shells, the spire truncated and a rounded, re-entering knob filling the space; sutures very deeply impressed; the spire whorls are usually suncarinate, this carina sometimes being very acute, but disappearing more or less on the body whorl; aperture ovate or roundly ovate, rounded and a little effuse below, somewhat acutely narrowed above; peristome acute, thin, simple; inner lip acute, forming an appressed callus on the parietal wall and emargining the umbilicus, which is narrowly open; aperture bluish-white within.

L. 20.0; W. 13.1; Ap. L. 10.0; W. 7.5 mm. Delaware River, Phil. (U. of I., Z17647).

L. 21.5; W. 15.5; Ap. L. 10.0; W. 7.5 mm. Delano, N. J. (U. of I., Z17632).

This is the common form of *Lioplax* in the Delaware River and the east, which is different from the *Lioplax* in Wisconsin

and of the rivers of Illinois and Indiana, and some southern states.

LIOPLAX SUBCARINATA WISCONSINENSIS Nov. Var.

Plate III, figures 1–9

Lioplax subcarinata of authors generally.

TYPE LOCALITY: Fox River, Brown Co., Wisconsin (Marston collection).

WISCONSIN RECORDS:

1897. *Lioplax subcarinata* WISWALL, p. 48. Southern Wisconsin.
1906. *Lioplax subcarinata* CHADWICK, p. 90. Kenosha; Lake Winnebago, near High Cliff, Calumet Co.
1922. *Lioplax subcarinata* BAKER, p. 20. Lakes Winnebago and Butte des Morts; Omro, Fox River.
1924. *Lioplax subcarinata* BAKER, p. 135. Lakes Winnebago and Butte des Morts; Omro, Fox River.

SHELL: Differing from the typical form in being uniformly smaller, with a rounder aperture and with the body whorl narrower and the aperture not as effuse.

L. 16.2; W. 11.0; Ap. L. 7.5; W. 5.5 mm. Fox River, Brown Co. U. of W., 437). Type.
L. 15.0; W. 9.0; Ap. L. 7.2; W. 4.0 mm. Fox River, Brown Co. (U. of W.,437). Paratype.
L. 16.5; W. 11.0; Ap. L. 7.5; W. 5.0 mm. Winnebago Lake (U. of W., 4576).
L. 14.0; W. 9.0; Ap. L. 7.0; W. 5.0 mm. Omro, Fox River (U. of W., 4574). Male.
L. 14.0; W. 10.0; Ap. L. 7.5; W. 5.5 mm. Omro, Fox River (U. of W., 4574). Male.
L. 11.0; W. 8.0; Ap. L. 6.0; W. 3.5 mm. Omro, Fox River (U. of W., 4574). Male.
L. 16.0; W. 11.0; Ap. L. 7.5; W. 5.0 mm. Omro, Fox River (U. of W., 4574). Female.
L. 15.7; W. 10.6; Ap. L. 7.0; W. 5.0 mm. Omro, Fox River (U. of W., 4574). Female.
L. 13.3; W. 9.0; Ap. L. 6.2; W. 4.5 mm. Omro, Fox River (U. of W., 4574). Female.

OPERCULUM (fig. 20): See generic description.

ANIMAL: See generic description.

GENITALIA: See generic description. Embryonic shell small, of a little more than two full whorls; first whorl rounded, second faintly carinated, third strongly carinated, sutures deeply impressed; apex rounded, punctate, spiral striae begin-

ning at about a third of the first whorl, becoming stronger, and with the lines of growth forming a strongly latticed pattern on the third whorl, which becomes still stronger on the postneanic whorls; the whorls very rapidly increase in diameter. Length and width about 2 mm. Females are slightly more numerous than males, of 24 specimens examined, 14 were females. Specimens collected in early August were gravid, but the young shells not fully formed. Many females were sterile at this time.

JAW: As in *Campeloma.*

RADULA: See generic description.

ECOLOGY: Omro, Fox River, near shore, water 1 m. deep, mud bottom, with much vegetation. Lake Butte des Morts, Plummers Point, boulder bottom, water .5 m. deep; near mouth of Fox River, mud bottom, 3 m. deep; off Sunset Point, mud bottom, water 2.7 to 3.4 m. deep. Lake Winnebago, near Oshkosh, sand bottom, .8 m. deep, sand and gravel bottom, 2.8 m. deep; Roe Point, sand bottom, .8 m. deep, boulder bottom, 2.8 m. deep; Long Point Island, sand bottom, .8 m. deep. Off Long Point Island, mud bottom, 3.7 m. deep. The best habitat is on a mud bottom in about a meter of water.

GENERAL DISTRIBUTION: The typical form is quoted as from Delaware River west to Iowa. In the light of the probable division of the species into several species and varieties the old range will need considerable revision. The Delaware River form, which is typical, has not been seen by the writer in any material from the middle west. All Wisconsin specimens are referable to the new variety, which has not been seen outside of the State.

DISTRIBUTION IN WISCONSIN: Known only from the eastern part of the state.

Fox Drainage: Lakes Winnebago and Butte des Morts; Omro, Fox River, Winnebago Co. (Baker); Lake Winnebago, near High Cliff, Calumet Co. (Chadwick); Fox River, Brown Co.; Little Rapids, Brown Co. (Marston).

Lake Michigan Drainage: Kenosha, Kenosha Co. (Chadwick, Wiswall).

Rock Drainage: Crawfish River, Aztalan; Lake Koshkonong, Jefferson Co. (Cahn).

REMARKS: *Lioplax subcarinata* is readily recognized by its subcarinated spire whorls, which at once distinguish it from

any species of *Campeloma*. The decollated spire is also a characteristic of the form as found in Wisconsin. There appear to be at least two distinct forms referable to the decollated species known as *subcarinata*. The typical form as found in the Delaware River is large and wide. All of the forms found in Wisconsin, whether in rivers or lakes, are uniformly smaller than the eastern form and have a rounder aperture, besides, on the whole, a narrower body whorl. The Fox River shells are rather wider than the Winnebago Lake forms and do not have the sharply truncated spire of the latter, in this respect approaching the unnamed species of Illinois and Indiana. The lake shells, also, have somewhat narrower shells than the Fox River form. The carina of the spire may be very pronounced or it may be almost absent.

Say especially mentions the apex which he described as "truncated and re-entering". This is a peculiar feature which seems to be characteristic of all of the Wisconsin material. This is a physiologic character, the truncation and subsequent replacing of the spire with a rounded plug taking place after the shell has acquired five full whorls. All of the young have perfect spires with regularly coiled, subcarinated whorls. Young shells 8.5 mm. long have five whorls, mature shells 16 mm. long have but 4 whorls; the unmodified adult shell would have 6–7 whorls.

A distinct species of *Lioplax* occurs in Illinois, Indiana, and farther south, which has a larger, wider shell with perfect whorls in the adult which form an acute, pyramidal spire. There are six full whorls. This form is figured by Binney (figs. 119, 120). Tryon, Haldeman, and Call each figure the western form of *Lioplax* and not the true *subcarinata* of Say. It is probable that the Wisconsin small form is a northern race, as it is found in both lakes and rivers. In the American Viviparidae there appears to be a northern and a southern variety of many species, and, also, an eastern and a western form.

Genus CAMPELOMA Rafinesque, 1819

Journ. Phys. Chem. Hist. Nat., LXXXVIII, p. 423, 1819. Type: *Campeloma crassula* RAF.

Melantho of GILL, BINNEY, TRYON, and other authors, not of Bowdich.

SHELL: Usually large, thick and solid, imperforate; olivaceous green, uni-colored; spire produced, turreted; whorls

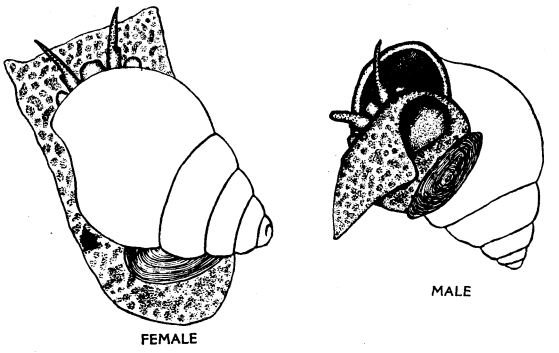

Fig. 23. Animal of *Campeloma rufum.* Winnebago Lake (Female); Salt Fork, near Urbana, Ill. (Male).

smooth, rounded or shouldered; aperture oval, inner lip more or less sinuous; lip simple, columella and parietal wall usually callously thickened.

ANIMAL (Fig. 23): With very large foot, produced beyond the rostrum and much larger than the shell, rounded behind, squarely truncated in front, often auriculated at the corners;

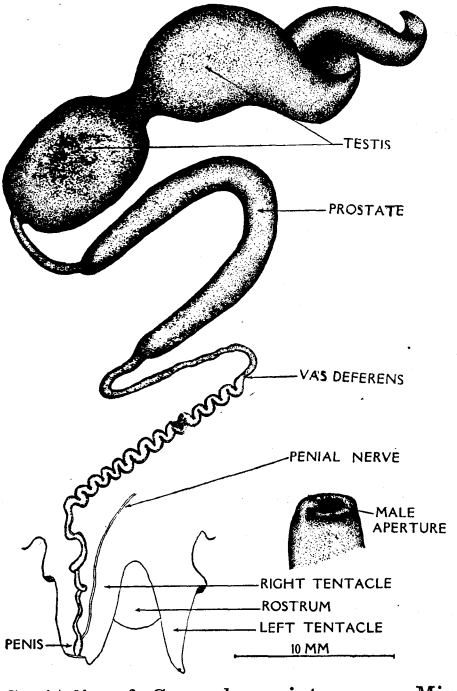

Fig. 24. Male Genitalia of *Campeloma integrum.* Mississippi River.

head small; rostrum short, rather narrow; eyes on peduncles at the outer base of the tentacles, the latter narrow and tapering; right tentacle of male modified to form a penis sheath; cervical lappets not large, not forming tubular conduits for respiratory purposes, the right lappet plicated; gill plates wider and shorter than in either *Viviparus* or *Lioplax* (fig. 13); color dark grayish or bluish with many orange spots on the upper surface of the foot.

OPERCULUM: Wholly concentric, the nucleus situated near the center and a little to the left side, which is straight or but slightly curved, the base and right side rounded, the apex acute; the operculum is thick and horny and fits the aperture snugly.

GENITALIA: Male organs (Fig. 24): Right tentacle forming a sheath for the penis, flattened at the end, the orifice being about in the center; penis long, narrow, tube-like, somewhat convoluted; vas deferens long, narrow, the portion following the penis much convoluted, becoming a straight tube shortly before entering the elongated, sac-like prostate; the prostate

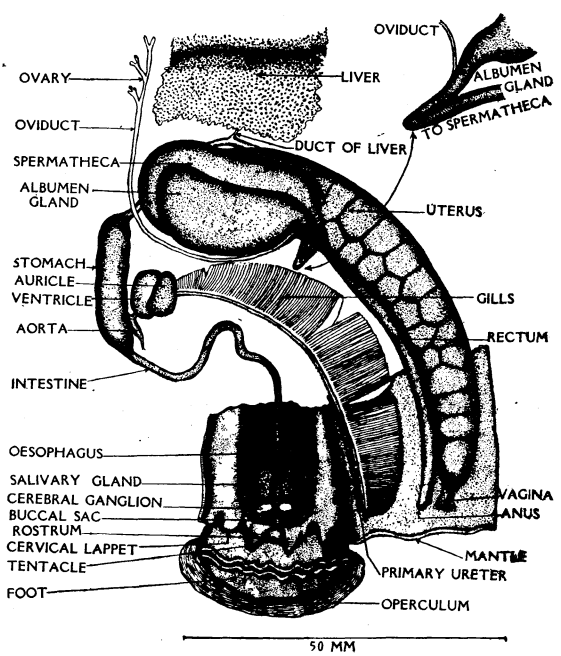

Fig. 25. General Anatomy and Female Genitalia of *Campeloma integrum*. Mississippi River.

and bilobed testis are joined by a short, straight posterior portion of the vas deferens. The right tentacle is about twice the size of the left, the triangular end appearing as a finger-like papilla at the left of the penial aperture; there is a distinct penial nerve. Female organs (fig. 25); generally as in *Viviparus* and *Lioplax*. The uterus is very large.

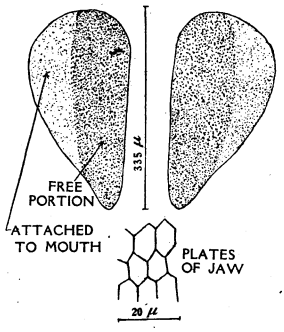

Fig. 26. Jaw of *Campeloma milesii.*

JAWS (Fig. 26): See family description.

RADULA (Fig. 27): In 3–1–3 series as in the family generally. Central tooth usually longer than wide, rounded or square on the base, the reflection narrow, with a long, sharp center cusp and several small side cusps; laterals longer than

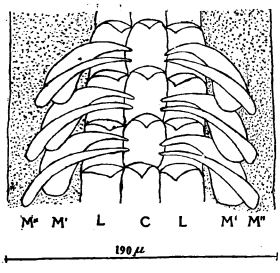

Fig. 27. Radula of *Campeloma decisum.* Three rows of teeth in natural position.

wide, base rounded, reflection moderately wide with a long, sharp center cusp with three smaller pointed cusps on either side; marginals long, widely rounded below, narrowed above, the apex with seven small, sharp cusps arranged as in the lateral tooth.

This description and the figures differ rather radically from those given by previous authors. Gill and Call described the apices as smooth, while Stimpson (in Binney) says that they are smooth or only slightly crenulated. In all specimens examined they are distinctly cusped though the cusps are small and difficult to see clearly. The side view of the marginal teeth gives a somewhat claw-like appearance, but viewed squarely from the face the outline is simply greatly elongated, narrowed above and slightly bulging at the base. The difference in size and shape of the central tooth affords some good criteria for distinction among the species.

DISTRIBUTION: Eastern United States and Southern Canada.

This genus has long been known under the name of *Melantho*, a European fossil genus. For the past thirty years the name *Campeloma* has been in general use, the group having been properly diagnosed by Rafinesque in 1819. Pilsbry (1917a, p. 111) has proposed to substitute *Ambloxis* Rafinesque, 1818, for *Campeloma*. This change seems unwarranted and we agree with Walker (1918, pp. 127, 163) that if "all incompetent evidence is eliminated, there is not sufficient ground to justify the change." The name so long in use will, therefore, be used in this monograph.

The genus *Campeloma* has been monographed by several distinguished American naturalists. Binney, in 1865, under the genus *Melantho*, described and figured the species then known. The well-known conservatism of this author placed many recognizable species in the synonymy. Tryon, in 1870, in continuation of Haldeman's monograph, described and figured those species which had been described subsequent to the publication of Haldeman's monograph. These were included in the genus *Vivipara* under the subgenus *Melantho*, Tryon admitting most of the described forms as species. In 1886, Call monographed the genus under Rafinesque's *Campeloma*, admitting a number of forms as species but including in the synonymy many distinct forms later distinguished by Walker and Pilsbry. Call also published, in 1887, a very good account of the gross anatomy of the genus, which gives about all of the information known at present.

In all of these monographs little or no attention has been given to the radula or internal organs. The radula affords some criteria of specific value, the size and shape of the central

tooth being different in many of the species examined. One of the most reliable features for the determination of the different species is the form and size of the embryonic shell. This has been found to be remarkably uniform and little difficulty has been experienced in separating the Wisconsin species when the embryonic shells were obtainable. In many cases it would have been practically impossible to fix the species without this aid, especially when the spire whorls were eroded. The genitalia are very uniform and no differences of note were observed. Of the dozen or more species and varieties at present known, five have been found in Wisconsin. One new species is described.

KEY TO SPECIES OF CAMPELOMA

1. a. Shell thin and fragile, upper whorls usually eroded; spire acute when present; radula with central tooth higher than wide ---------- 2
   b. Shell more or less solid, thick, not fragile, spire whorls usually present; radula with central tooth as wide as or wider than high ---------- 3
2. a. Whorls flat-sided, especially the body whorl; embryonic shell with apical whorl sunk below the second whorl; central tooth of radula 50 μ wide ----------*decisum*
   b. Whorls rounded, body whorl obese; embryonic shell with apical whorl just appearing above second whorl; central tooth of radula 40 μ wide ----------*milesii*
3. a. Spire acute, longer than aperture, central tooth of radula, 50–55 μ wide ---------- 4
   b. Spire short, depressed, dome-shaped; central tooth of radula 70 μ wide ----------*brevispirum*
4. a. Whorls flatly rounded, with a slight shoulder, body whorl elongated, compressed laterally; shell always white or bluish-white beneath epidermis; embryonic shell narrow, apical whorl raised above second whorl ----------*integrum*
   b. Whorls rounded, body whorl rounded or obese; shell usually pinkish beneath epidermis; embryonic shell globose, apical whorl sunk below second whorl ----------*rufum*

CAMPELOMA DECISUM (Say)

Plate V, figures 1–7

Limnaea decisa SAY, Nich. Encyc., I, 1817; II, pl. iii, fig. 6, 1818; BINNEY, L. F–W. Sh. N. A., III, p. 42, fig. 83, 1865.

Paludina decisa SAY, Nich. Encyc., Amer. Ed., Correc. to Ed. I, pl. iii, fig. 6, 1817; HALDEMAN, Mon., p. 4, pl. i, 1840.

Melantho decisa BINNEY, Op. Cit., p. 41, figs. 79–82, 1865.

Campeloma decisum CALL, Bull. Wash., Coll. Lab. N. H., I, p. 155, 1886; WALKER, Nautilus, XVI, pl. v, fig. 12, 1903.

TYPE LOCALITY: Not stated by Say. Binney says "there can be no doubt that the shell described is the form common in the Delaware River".

WISCONSIN RECORDS:

1911a. *Campeloma decisum* BAKER, pp. 216, 218, 233 (part). Gilmore Creek and Wisconsin River, Oneida Co.

SHELL: Elongate-ovate, subfusiform, thin; color dark green, through olive to brownish; surface shining, lines of growth fine, crowded, often raised into ridges in spots and broken irregularly by black marks of former peristomes; upper whorls and body whorl above periphery covered with heavy brown revolving striae which are epidermal; these are lighter below the periphery; apex of medium size, flat-topped, sutures deeply impressed, color hyaline; spire long and pointed, sharply conic; whorls six, flatly rounded, the upper ones usually eroded; sutures well impressed; aperture elongately-ovate, rounded below, acutely angled above, bluish-white within; peristome acute, simple, usually bordered by a dark band; columellar wall of aperture covered by a callus which is bordered with brown and is tightly appressed to the parietal wall; the lower part of the inner lip forms a flattened projection which is erect and emargines the columellar region, which is less sigmoid than in most species, and is completely imperforate, or there may be a very small chink.

L. 35.0; W. 21.0; Ap. L. 17.0; W. 10.0 mm. Red Cedar River (U. of W., 4562). Female.

L. 27.5; W. 12.0; Ap. L. 14.0; W. 9.0 mm. Red Cedar River (U. of W., 4562). Female.

L. 28.0; W. 19.0; Ap. L. 15.0; W. 9.0 mm. Red Cedar River (U. of W., 4562). Female.

L. 23.0; W. 15.0; Ap. L. 12.5; W. 7.5 mm. Red Cedar River (U. of W., 4562). Female.

L. 13.0; W. 9.0; Ap. L. 7.5; W. 4.7 mm. Red Cedar River (U. of W., 4562). Female.

L. 29.0; W. 18.0; Ap. L. 16.0; W. 9.0 mm. Lake Pokegoma (U. of W., 4563). Male.

L. 31.0; W. 20.5; Ap. L. 16.0; W. 10.0 mm. Moose Ear Creek (U. of W., 4564).

OPERCULUM (Pl. X, fig. 25): Ovate or elongate-ovate, lower margin rounded, apex roundly triangular, right margin rounded, left margin straight or slightly convex; nucleus situated a little below the center near the columellar margin, its

sculpture granular; markings entirely concentric or subconcentric; the operculum is thick and horny, and there are usually four or five dark rest marks at regular intervals. It fits the aperture snugly.

ANIMAL: See generic description. Color of body generally yellowish, lead colored on foot, with tentacles and rostrum bluish. In life the upper surface of the foot is thickly spotted with orange, as are also the head and tentacles. These spots fade out when the animal is preserved in alcohol. There is an absence of black pigment on the mantle.

GENITALIA: See generic description. Embryonic shell (fig. 33) hyaline, of 2¼ whorls, rounded, with well marked sutures; spire flat, planorboid when viewed from above, the apex not appearing above the second whorl when viewed from the side; the apex is granular, the rest of the surface being covered with heavy, equidistant spiral laminae which are epidermal and appear hirsute; there are very fine lines between the equidistant lines. The shell in the uterus is slightly smaller than the shell which is ready for birth. These are shown below:

L. 5.8 ; W. 4.8 mm. 3 full whorls. Shortly after birth.
L. 4.25; W. 4.00 mm. 3 whorls. At birth.
L. 3.25; W. 3.00 mm. 2¼ whorls. In uterus.

Specimens examined in late August, from the Red Cedar River, gave the following data as regards number of young and condition of embryos:

1. Empty; 2. 10 eggs, 5 with shells formed; 3. 21 eggs, 4 with shells formed; 4. 14 eggs, 4 with shells formed; 5. empty; 6. 2 eggs, 7 with shells formed; 7. empty; 8. 4 eggs, 10 with shells formed; 9. 0 eggs, 4 with shells formed. Of 264 embryonic young examined, only 4 were reversed.

JAW: See generic description.

RADULA (Fig. 28): See generic description. The central tooth is relatively narrow. All cusps are of the type characteristic of the family.

ECOLOGY: Red Cedar River in rapid current buried in sand; usually common on sand bars in the middle of the river in water about a foot deep in summer; rocky-sandy bottom in Moose Ear Creek, in shallow water; Chicago Creek, Bayfield, in shallow water on sand bottom near mouth of creek near Lake Superior.

GENERAL DISTRIBUTION: New England and Pennsylvania west to Minnesota, Nova Scotia and Saskatchewan, British America, south to Tennessee and Virginia. Some of the northern distribution may include the related *milesii;* the southern distribution is doubtful because many other species have been identified as *decisum.* The species is very rare in northern Illinois.

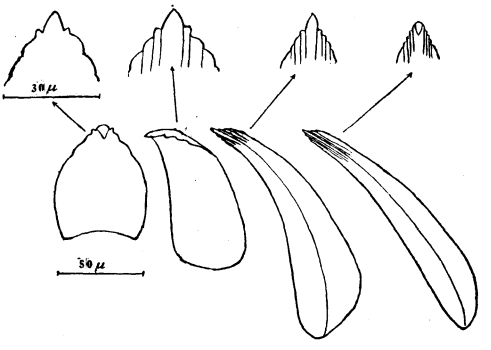

Fig. 28. Radula of *Campeloma decisum.* Red Cedar River.

DISTRIBUTION IN WISCONSIN: The records indicate that *decisum* is to be found over much of the state. It is known from the drainage of the Chippewa, Wisconsin, St. Croix, Fox, Lake Michigan, and Lake Superior.

REMARKS: *Campeloma decisum,* when once understood, is a fairly recognizable species. The shell is quite thin while that of the other species is thick to solid; the spire is pointed when entire, the whorls are well rounded, without shoulder and the aperture is rounder and lacks the characteristic sigmoid curve of other species. The shouldered whorls of *subsolidum (=crassulum)* will at once separate that species; the more solid shell, shorter and wider spire, sigmoid-curved aperture, and larger shell will distinguish *integrum; rufum* is a much wider shell, with a wider spire, a different aperture and, usually a reddish color within the aperture. The thin shell of *decisum* causes the spire to be almost invaribly eroded. Of 100 specimens from Wisconsin, not one has a perfect spire, and many have but three whorls. Reversed specimens are rare, but one immature shell occurring among over a hundred adult specimens and but four among 260 embryonic young. The embryonic shell is different from any other Wisconsin species.

Among Wisconsin specimens, females overwhelmingly predominate, only one male occurring among over 100 individuals examined. These were collected during July and August. Judging by the records, *decisum* in Wisconsin is in large part a river snail, not being found in natural lakes in any large degree. Many of the western lakes, as Chetek, Prairie, Rice, are artificial, caused by the damming of creeks to provide water for lumber operations many years ago (60 years ago at Lake Chetek). Shell Lake contained a few *decisum,* but as far as the records go, this is the only lake in which this species has been found. It would be of interest to know just how general this apparent choice is found to be throughout the range of the species.

CAMPELOMA MILESII (Lea)

Plate II, figures 1–5

Paludina milesii LEA, Proc. Phil. Acad., 1863, p. 156; BINNEY, L. F–W. Sh. N. A., III, p. 47, fig. 94, 1865; TRYON, Con. Hald. Mon., p. 28, pl. 13, fig. 5, 1870.

Campeloma milesii WALKER, Nautilus, XVI, p. 121, pl. v, figs. 1–9, 1903.

TYPE LOCALITY: Branch Lake, Antrim Co., Mich.

WISCONSIN RECORDS:

1911a. *Campeloma decisum* BAKER, p. 204, 206, 208, 209, 233 (part). Tomahawk Lake.

SHELL: Elongate-ovate, thin; color grass-green or yellowish-green; surface as in *decisum;* sculpture of spiral lines as in *decisum;* apex as in *decisum;* whorls about six, the upper ones all eroded in mature specimens, well rounded, especially the body whorl which is globose; sutures well impressed; aperture rounded or roundly ovate, narrowed above; outer and inner lip as in *decisum;* the umbilical region has a more distinct chink than in *decisum.*

L. 33.0; W. 22.0; Ap. L. 18.0; W. 11.0 mm. Yellow River (U. of W., 4565). Female.

L. 28.0; W. 19.0; Ap. L. 14.0; W. 9.0 mm. Yellow River (U. of W., 4565). Female.

L. 27.0; W. 19.0; Ap. L. 14.5; W. 9.0 mm. Yellow River (U. of W., 4565). Female.

L. 16.0; W. 11.2; Ap. L. 10.0; W. 5.7 mm. Yellow River (U. of W., 4565).

L. 8.5; W. 6.5; Ap. L. 6.0; W. 3.0 mm. Yellow River (U. of W., 4565).

OPERCULUM (Pl. X, fig. 21): Differing from that of *decisum* in being more pear-shaped with a pointed and incurved apex. Otherwise similar.

ANIMAL: Color and other characters as in *decisum.*

GENITALIA: See generic description. The embryonic (fig. 33) shell of *milesii* is more elongated than *decisum,* and in the newly hatched young the apex is raised notably above the second whorl, while in *decisum* it only just appears to tip the second whorl. This difference, while small, is constant. Shells still in the uterus are not so markedly different. These differences are shown in the figures. Measurement of shell in uterus, L. 3.50; W. 3.25 mm., 2¼ whorls; young of 3 full whorls, L. 6.1; W. 5.0 mm.

Specimens examined in middle August contained the following number of young, mostly in the egg stage:

1. Entirely empty; 2. 28 with eggs; 2 with shells; 3. 29 with eggs; no shells; 4. 32 with eggs; no shells; 5. 32 with eggs; no shells. Of sixteen specimens examined, all were females. No reversed specimens occurred, either embryonic, young, or mature.

JAW: See generic description.

RADULA (Fig. 29): The radula differs from that of *decisum* in having somewhat smaller teeth, the center tooth being 10 μ smaller than *decisum.* The other teeth are proportionately smaller.

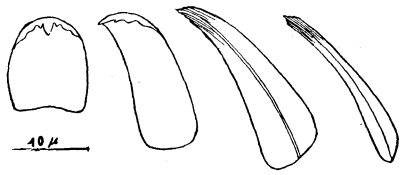

Fig. 29. Radula of *Campeloma milesii.* Yellow River.

ECOLOGY: In Yellow River, *milesii* occurred abundantly in the sandy-mud bottom bordering the river, in water a few inches to a foot in depth, among Typha, Sagittaria, Elodea, and a small Potamogeton. *Milesii* is essentially a lake species, all of the records being of this type of habitat. Yellow River near Spooner is wide and lake-like.

GENERAL DISTRIBUTION: *Milesii* has not heretofore been recorded outside of Michigan, principally in the northern part (North Lake, Beaver Island, Lake Mich.). It now appears to

live also in northern Wisconsin and its distribution will probably be found to include Minnesota and southern Canada as well. It has doubtless been confused with *decisum.*

DISTRIBUTION IN WISCONSIN: At present known only from the northern part of the State.

St. Croix Drainage: Yellow River, near Spooner, Washburn Co. (Baker).

Wisconsin Drainage: Plum and Big Muskallonge lakes, Vilas Co. (Cahn); Tomahawk Lake, Oneida Co. (Baker).

Chippewa Drainage: White Sand Lake, Vilas Co. (Cahn); Lower Gresham Lake, Vilas Co. (Juday).

REMARKS: *Milesii* is closely related to *decisum* but from the material at hand seems sufficiently distinct. "Compared with *decisum* as it is commonly found, *milesii* is a thinner, more elongated shell, with a more acute apex; the upper whorls are more convex and the suture rather more deeply impressed; the aperture is smaller and narrower" (Walker). It may be added that in Wisconsin specimens, the body whorl is usually more globose, the umbilical region more often has a small chink, and the operculum is quite different, being longer in proportion to width and having a more pointed apical end. The embryonic shells also differ, as has been stated on a previous page. Considering all the features, *milesii* is a well characterized species easily recognized when once known. The radula teeth are also somewhat smaller than those of *decisum.*

This interesting species has been considered a synonym of *decisum* by both Binney and Tryon, and as a synonym of *subsolidum* by Call, the last being quite erroneous, *milesii* not having the slightest resemblance to the heavy *subsolidum* of the Mississippi Valley. Walker (1903a, p. 122) was the first author after James Lewis to recognize the true characteristics and relationships of the species. Its distribution suggests a rather northward extension and it may be possible that many of the northern records of *decisum* are based on this species.

CAMPELOMA INTEGRUM (Say)

Plate III, figures 10–18; plate IV, figures 1–8, 10

Paludina integra SAY, Journ. Acad. Nat. Sci. Phil., II, p. 174, 1921; HALDEMAN, Mon., p. 10, pl. iii, fig. 4, 1840; BINNEY, L. & F–W Sh. N. A., III, p. 48, fig. 96, 1865.

Campeloma integrum CALL, Bull. Wash. Coll. Lab. N. H., I, p. 160, pl. v, fig. 9, 1886.

TYPE LOCALITY: Waters of the Missouri.

WISCONSIN RECORDS:

1834. *Paludina ponderosa* COOPER (non Say), p. 154. Wisconsin River.

1905c. *Campeloma subsolidum* BAKER, p. 257. Mississippi River between McGregor, Iowa, and Prairie du Chien, Wis.

1905c. *Campeloma integrum* BAKER, p. 256. Prairie du Chien.

1922. *Campeloma subsolidum* GRIER, p. 18. Lake Pepin near Lake City.

SHELL: Elongated, rather solid, spire longer than aperture in adult; color light green to dark olivaceous, sometimes with reddish longitudinal streaks; surface dull, sometimes shining, lines of growth coarse, raised into more or less conspicuous ridges, especially on the last two whorls, upon which several old peristome marks are visible; spiral lines present and more or less distinct; apex blunt, rounded, of three whorls, with deep sutures, hyaline; spire long, conic, whorls about 6, flatsided, almost perpendicular, in some specimens, with a rounded shoulder bordering the very deep sutures; aperture ovate, rounded and somewhat effuse below, bluntly rounded above, slightly sinuous on the columellar margin, light bluish-white or whitish within, sometimes tinged with dark purple; peristome thin on the edge but somewhat thickened within, simple; inner lip forming a rather heavy white callus on the parietal wall and a wide expansion below which emargines and is reflected over the umbilical region, completely closing the umbilicus.

L. 38.0; W. 22.5; Ap. L. 20.5; W. 12.0 mm. Binney's fig. 96 of Say's type.

L. 37.0; W. 21.0; Ap. L. 19.5; W. 11.0 mm. Fairport, Iowa (U. of I., Z15478). Female.

L. 40.0; W. 23.0; Ap. L. 20.0; W. 12.0 mm. Fairport, Iowa (U. of I., Z18263). Female.

L. 38.0; W. 22.1; Ap. L. 19.0; W. 11.0 mm. Fairport, Iowa (U. of I., Z18263). Female.

L. 25.0; W. 17.0; Ap. L. 15.0; W. 8.0 mm. Fairport, Iowa (U. of I., Z18263). Female.

L. 31.0; W. 22.0; Ap. L. 17.5; W. 10.5 mm. Fairport, Iowa (U. of I., Z18262). Female.

L. 32.0; W. 19.5; Ap. L. 16.0; W. 9.5 mm. Fairport, Iowa (U. of I., Z15477). Male.

OPERCULUM (Pl. X, fig. 26): Long-ovate, rounded below, acutely rounded above but not pointed; right side broadly rounded; left side almost straight; nucleus a little below the center near the left or columellar side; sculpture concentric.

ANIMAL: Color of foot bluish-white or lead color, the foot, tentacles, and operculiferous lobe covered with irregularly placed bright yellowish or orange dots, which are arranged on the tentacles and rostrum in somewhat regular transverse rows giving a barred appearance.

GENITALIA: As in the genus. The embryonic shell (fig. 33) is of good size, of three rounded whorls, regularly increasing in diameter; spiral sculpture rather fine but distinct; the first whorl is rounded, the second flatsided, and the third slightly shouldered; the nuclear whorl is bent inward, the tip seemingly buried beneath the beginning of the second whorl, and the first turn is upward, appearing slightly above the second whorl; when viewed from above the nuclear whorl seems to be coiled in the same plane. Length 3.1, width 3.0 mm. Female shells are larger and wider than male shells. In 20 female specimens examined, the number of embryonic young varied from 25 to 64. This is a much larger number than has been observed in any other species.

JAW: As in the genus.

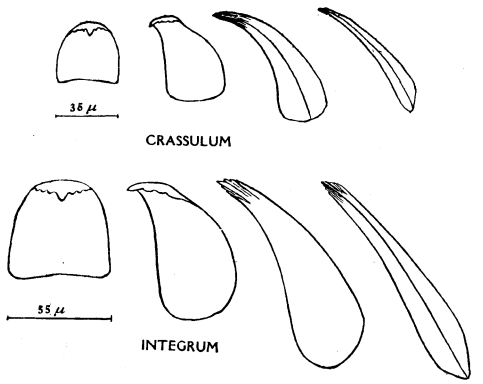

Fig. 30. Radula of *Campeloma integrum*, Sauk Co.; *C. crassulum*, Illinois River.

RADULA: (Fig. 30): Similar in general form and denticulation to the other members of the genus. The radula is about the same as that of *rufum*, the size being the same and the variation in width of the central tooth being the same.

ECOLOGY: In the Mississippi River found on a mud bottom, near shore, in shallow water. In the Wisconsin it lives on a mud bottom near shore in shallow water.

GENERAL DISTRIBUTION: As this species has been confused with *rufum* and *subsolidum* its distribution is not well known. As herein understood, it has been seen from the Mississippi River from Red Wing, Minn., south to Fairport, Iowa, and west to Missouri and Nebraska. In the Wisconsin River it extends as far up as the lower Dells at Kilbourn. It inhabits some of the rivers of Illinois and probably Indiana. No authentic specimens have been seen from eastern localities. Say's original locality is Missouri River, possibly between Iowa and Nebraska. It is highly probable that most of the *Campeloma* from west of the Mississippi are referable to this species.

DISTRIBUTION IN WISCONSIN: Known only from the Mississippi and Wisconsin rivers.

Wisconsin Drainage: Merrimack, Sauk Co. (A. T. Poole); Dell Creek, Sauk Co.; Wisconsin River, Columbia Co. (Baker).

Mississippi Drainage: Near Prairie du Chien, Crawford Co. (Baker); Lake Pepin, Pierce Co. (Grier); Mississippi River and Lake Pepin (Wiebe). La Crosse, La Crosse Co. (U. S. Nat. Mus.).

REMARKS: *Integrum* bears a superficial resemblance to some forms of *decisum* and many monographers have considered it a synonym of that species. Call distinguished it as a separate species but gave De Kay as describer. Binney, Tryon, and the majority of foreign writers have listed it as a synonymn of *decisum*. It is, however, very distinct from *decisum;* it is larger, much more solid, the spire is nearly always entire, not decollated, the aperture is longer and narrower and more sigmoid, and the sutures are more deeply impressed. From *rufum* it is separated by its more flatsided whorls, its absence of pink color, and particularly by the embryonic shell which in *rufum* is larger and wider with the apical whorl sunk below the second whorl, not raised above as in *integrum*.

Integrum appears to be more nearly related to *crassulum* than to any other member of the genus. From this species it may be known by the much deeper sutures, more shouldered whorls, with straighter sides, and the body whorl not as flatsided as in *crassulum*. The latter also has a longer spire and a proportionally smaller aperture, and seven full whorls while there are but six in *integrum*. The whorls of *crassulum* are also rather longer than those of integrum. The central tooth of the radula of *crassulum* is much smaller than in *integrum* (see fig. 30).

There has been some controversy over just what shell Say had before him when he described *integrum.* Call seems in doubt (1886, p. 160) and gives the species to De Kay. Binney's figure of Say's type specimen it would appear leaves no doubt concerning what kind of shell is referred to. The measurement of Say, ¼ inch, is evidently a typographical error and 1¼ inch was probably meant, as this corresponds with dimensions of the shell referred to this species. The original locality has been questioned, waters of the Missouri, but this appears to be correct and not an error. Some of the shells Say described came from the Missouri River, especially near Council Bluffs. At any rate, the shells from the Mississippi River, and from farther west, are exactly like Say's figure in Binney, and the species is certainly a valid one. It is the only *Campeloma* seen from the Mississippi River, south of Lake Pepin.

Males seem rare, nearly all specimens examined being females. The males are quite different from the females in form, being smaller and with a much thicker shell (see figures on plate). Animals examined in July were empty of embryos or contained a small number, one specimen having 20 embryos. Reversed specimens are very rare, only one being seen among 160 adult and none were seen as embryos.

Campeloma crassulum Raf. (*subsolidum* Anthony) is not found in Wisconsin. The type is said to have come from Illinois, but nothing approaching the measurements of Anthony has been seen from this state. Specimens from the Ohio River, at Lawrenceburg, are exactly like Anthony's figure and measurements. Specimens from the Illinois River are much narrower, with a sharply pointed spire. These narrow specimens may be the males of the wider form, and as they are also common in the Wabash River, where the wide form is also found, this disposition seems best until fresh specimens with the animal are available for study. The narrow Illinois form is figured for comparison with *integrum* (see pl. III, figs. 19–21).

The *Campeloma obesum* ("Lewis" Tyron) appears to be more nearly related to *rufum* than to *integrum,* taking the Mississippi River form as typical *integrum.* Whether it is a variety of *rufum* or a distinct species can only be determined by an examination of the radula and embryonic shell. It is not found in Wisconsin.

CAMPELOMA RUFUM (Haldeman)

Plate IV, figures 9, 11–22

Paludina rufa HALDEMAN, Mon. III, p. 3 of wrapper, pl. iii, fig. 1, 1841; BINNEY, L. F.–W. Sh. N. A., III, p. 49, fig. 102; p. 50, fig. 103, 1865.
Vivipara rufa TRYON, Con. Hald. Mon., p. 22, pl. 12, fig. 12, 1870.
Campeloma rufum CALL, Bull. Wash. Coll. Lab. N. H., I, p. 158, pl. v, figs. 5–7, 1886.

TYPE LOCALITY: Ohio.

WISCONSIN RECORDS:

1860. *Viviparus decisus* LAPHAM, p. 1. Milwaukee.
1865. *Melantho decisa* BINNEY, p. 51. Milwaukee and Racine; Aztalan.
1870. *Vivipara rufa* TRYON, p. 22. Wisconsin.
1897. *Melantho integra* WISWALL, p. 48. Southern Wisconsin.
1906. *Campeloma rufum* CHADWICK, p. 90. Okauchee Lake, Waukesha Co.; Little Cedar Lake, Washington Co.; Lake Winnebago, near High Cliff, Calumet Co.; Beasley Brook, Waupaca Co. Same references, 1905, p. 24.
1906. *Campeloma decisum* CHADWICK, p. 90. Lake Winnebago, near High Cliff; East Twin River, at Two Rivers, Manitowoc Co. Same references 1905, p. 24.
1924. *Campeloma rufum* BAKER, p. 135. Lakes Winnebago and Butte des Morts; Omro, Fox River.

SHELL: Ovate, more or less elongated, rather solid in most specimens; color olive-green, apple-green or brownish, with more or less of a pink tinge on various parts of the shell; beneath the epidermis the shell is normally pinkish; surface shining, polished, lines of growth very fine crossed by fine spiral lines; there are always one or more previous peristome marks of black; apex small, rounded, flattened, lirate, often pink but also many times simply hyaline; spire typically elongated, conic, but also depressed and broadly conic; whorls 6 to 7, flatly rounded, slightly shouldered at the deep sutures; the spire may be as long as or longer than the aperture; aperture ovate, narrowed above, slightly channelled, broadly rounded below, slightly effuse in some specimens; interior of aperture usually rosy or pinkish but also light blue; peristome thin, sharp, simple; inner lip broad and tightly appressed to the columellar and parietal walls, slightly emargining the umbilical region, which is usually completely imperforate; inner margin of aperture more or less sinuous.

L. 37.0; W. 24.0; Ap. L. 20.5; W. 17.0 mm. Portage, Fox River (U. of W., 4567). Female.
L. 35.0; W. 21.5; Ap. L. 17.5; W. 10.5 mm. Portage, Fox River (U. of W., 4567). Female.
L. 32.5; W. 19.0; Ap. L. 16.0; W. 9.0 mm. Portage, Fox River (U. of W., 4567). Female.
L. 26.0; W. 18.0; Ap. L. 15.5; W. 9.0 mm. Portage, Fox River (U. of W., 4567). Female.
L. 19.0; W. 13.0; Ap. L. 11.5; W. 6.5 mm. Portage, Fox River (U. of W., 4567). Female.
L. 10.5; W. 8.0; Ap. L. 6.5; W. 3.5 mm. Portage, Fox River (U. of W., 4567). Female.
L. 29.0; W. 18.5; Ap. L. 15.0; W. 9.0 mm. Winnebago L. (U. of W., 4568).
L. 27.5; W. 19.0; Ap. L. 15.5; W. 9.0 mm. Winnebago L. (U. of W., 4568).
L. 37.0; W. 23.0; Ap. L. 23.0; W. 12.0 mm. Yahara River (U. of W., 4569). Female.
L. 28.5; W. 18.0; Ap. L. 15.0; W. 9.5 mm. Yahara River (U. of W., 4569). Female.
L. 44.0; W. 25.0; Ap. L. 20.5; W. 12.0 mm. Sturgeon Bay (U. of W., 4570).
L. 39.5; W. 24.5; Ap. L. 18.5; W. 12.0 mm. Winnebago L. (U. of W., 4571).

OPERCULUM (Pl. X, fig. 22): Elongate-ovate, much longer than wide, upper border acutely rounded, base and right side broadly rounded, left side almost straight; nucleus granular, ovate, large, placed below the middle near the left or columellar margin; sculpture of concentric growth lines.

ANIMAL (Fig. 23): As in the genus. The colors are much darker than in *decisum,* the body being yellowish-white with much dark pigment over the breeding organs and gill and the foot is darker, in alcoholic specimens almost black.

GENITALIA: As in *decisum.* Embryonic shell (fig. 33) large, hyaline, subglobose, whorls 3, rounded, sutures deeply impressed; apical whorl sunk below the second whorl producing a very deep suture; the nucleus is flat-topped, the first 1½ whorls being wound in the same plane; it is frequently heavily malleated or punctate; sculpture of heavy, equidistant spiral lines which extend well on to the nucleus; the aperture is large and roundly ovate. The operculum measures 2.4 by 2 mm., is transparent and hyaline, and is completely covered with spiral concentric lines, which are much finer on the large nucleus.

Of sixty specimens examined for the genitalia, all but one were females. Specimens examined in July contained mostly

eggs, more or less advanced toward the shell stage; nine specimens contained the following: 30 eggs; 40 eggs; 20 eggs; 10 eggs, 2 young with shells; 14 eggs; 30 eggs; 15 eggs; 10 eggs; empty. The last three were half grown females. Four specimens from the Yahara River, collected on August 17, contained the following: 24 young with well-formed shells; 32 eggs, 2 shells; 16 shells partly formed; 20 shells partly formed. The young when ready for birth are hyaline or spermaceti-white in color and consistency, transparent, the eyes jet black, a grayish pigment beginning to show where the oviduct will be in the adult animal; the upper part of the foot is well marked with small golden spots.

JAW: As in *decisum.*

RADULA (Fig. 31): Similar in form and size to that of *integrum.*

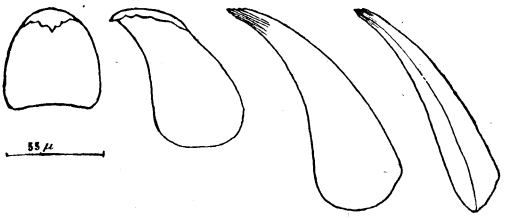

Fig. 31. Radula of *Campeloma rufum.* Fox River, Portage.

ECOLOGY: *Rufum* occurs in both lakes and rivers, and does not show the very marked difference in these environments, as would be expected as judged by the effect on other species. On the whole, the lake shells are larger, the whorls more tightly coiled, the spire is longer and the aperture somewhat rounder. The shell is inclined to be more solid and thicker. In any large number of species, a student with experience could tell fairly well which came from rivers and which from lakes (See the figures on plate IV). The following specific habitats have been observed:

Rivers: Fox River, near Omro, sand bottom, water .5 m. deep; mud bottom, 2.1m. deep; Fox River, below Portage, sand bottom, shallow water near shore.

Lakes: Lake Winnebago, sand bottom, water .3 and .8 m. deep; mud bottom with vegetation, .9m. deep; Lake Butte des Morts, mud bottom,

1.2 m.; sandy mud bottom, 1 m.; boulder bottom, .5 m.; Green Lake, sand bottom, shallow water near shore; Devils Lake, sand bottom, shallow water near shore.

GENERAL DISTRIBUTION: Said to extend from New England west to Iowa, Michigan and Wisconsin south to Alabama. Some of the outlying territory to the south may include other species or varieties. It is a common species in the Middle West. The distribution of *integrum* and *rufum* is very interesting. *Integrum* ascends the Mississippi River as far as Red Wing, Minn. Above this part of the river, especially at Minneapolis, the form is *rufum*. The differences in the species here are clearly shown by the form of the embryonic shells. In the Wisconsin River, *integrum* ascends as far as the dam at Kilbourn, but the Campeloma above the dam is *rufum*. The preference of each species for a particular type of river, *integrum* the larger, *rufum* the smaller, is especially noteworthy.

DISTRIBUTION IN WISCONSIN: Known at present only from the southeastern part of the State. In some of the streams of the northwestern part of Wisconsin, *rufum* is replaced by *decisum* and *milesii*. In the large Mississippi it is replaced by *integrum*. It has been recorded from the following drainages: Wisconsin, Fox, Rock, Fox of Illinois, Lake Michigan.

REMARKS: *Rufum* has been confused with *integrum*, and many specimens of the shells are difficult to separate from that species. The surface of *rufum*, however, is smooth and polished while that of *integrum* is rough, both growth and spiral lines being coarser. The color of *integrum* is usually rather a deep dark apple green, while that of *rufum* is light yellowish green often with much reddish on the surface, and the substance of the shell is frequently, though not always, pinkish. The aperture of *integrum* is more elongated than that of *rufum*, which has a more sigmoid columellar lip; the interior of the aperture of *rufum* is also often pinkish or reddish. The whorls of the spire are also rounder in *rufum* and the body whorl is rounder and not flat-sided, as in *integrum*. The embryonic shell is larger and the apical whorls are sunk below the second whorl. *Rufum* is quite distinct from *integrum*. *Decisum* has a smaller shell, usually with a decollated apex, the shell is thinner, the aperture rounder, the columellar lip scarcely sigmoid, and the central tooth of the radula is narrower. The embryonic shell is also different.

Rufum is very variable in both form and coloring. In form it varies from narrow and elongated, like Haldeman's type, to a form with short spire and wide, obese body whorl. Some of this variation is to be correlated with environment. Thus the small stream form, so common in Waukesha County and in parts of Illinois, has a large, wide shell, the body whorl being especially expanded. The immature forms of this variety have a short, wide shell like Binney's figure of *obesum*. Shells from the larger rivers, as the Wisconsin near Kilbourn, have a long, narrow shell which resembles the typical specimen figured by Haldeman. In the lakes, and especially in Sturgeon Bay, the shell is narrow but the spire is turreted, or even somewhat scalariform, and resembles some forms of *integrum*, but the shell is decidedly pinkish. These variations are responses to changes of environment. The largest shells, 48 mm. in length, are found in the small streams and creeks.

In color the shells vary from deeply pink-tinged to entirely white without a suggestion of color, and this variation may occur in the same lot of shells. The radula is also variable, the central tooth varying 5 μ in width. The embryonic shell, however, appears to be always the same, judging by the material at hand. *Rufum* is the most variable species of the genus.

The *Campeloma obesum* ("Lewis" Tryon) may be a variety of *rufum*, rather than of *integrum*. Binney's figure is probably not correct and may represent an immature *rufum* without color (Binney, 1865, fig. 95). Lewis correctly described and figured his species in 1875 (Proc. Phil. Acad. Sci., p. 336, pl. 22, figs. 5, 6) and these figures are different from Binney's figure and also are the same as that figured by Tryon in 1870 (Con Hald., pl. 13, fig. 6). Nothing like this has been seen from Wisconsin. De Kay's *heros* is related to *rufum* rather than to *integrum* and may be the same creek form as that recorded above from Wisconsin and Illinois. If so, all of these forms should be called variety *heros*, as the form is sufficiently distinct, ecologically, for recognition. Haldeman's figure 2 is doubtless referable to *rufum* and not to *integrum*, Ohio specimens of *rufum* being exactly like it, though they are not all with a rufous tinge.

CAMPELOMA RUFUM GIBBUM (Currier)

Plate V, figures 8–12

Melantho gibba CURRIER, Amer. Journ. Conch., III, p. 112, pl. 6, fig. 3, 1867.

Vivipara gibba TRYON, Con. Hald. Mon., p. 27, pl. 12, figs. 3–7, 1870.

TYPE LOCALITY: Grattan, Mich.

WISCONSIN RECORDS: None.

SHELL: Differing from typical *rufum* in having the body whorl rather rhombic in form, the periphery subangulate and the aperture rhombic or forming a rounded elipse; the spire is normally depressed, the sutures deeply impressed and the sculpture rather coarser than in *rufum;* the nuclear whorls are like *rufum* in form and sculpture; the whole shell is thinner than is usual with *rufum;* the color is light greenish or citrine with much red on the surface; the aperture is pinkish, like that of *rufum.* The post-embryonic whorl is rather wider and more gibbous than in typical *rufum.*

L. 28.5; W. 18.5; Ap. L. 14.5; W. 9.5 mm. Detroit Harbor (U. of W., 4572).
L. 28.0; W. 19.5; Ap. L. 14.5; W. 9.0 mm. Detroit Harbor (U. of W., 4572).
L. 25.0; W. 16.0; Ap. L. 13.0; W. 8.0 mm. Detroit Harbor (U. of W., 4572).
L. 13.5; W. 10.5; Ap. L. 7.5; W. 5.0 mm. Detroit Harbor (U. of W., 4572).

OPERCULUM (Pl. X, fig. 27): Differing from that of typical *rufum* in being wider as compared with height, with the upper margin less angular and pointed; the nucleus is more nearly in the center of the left side.

ANIMAL AND GENITALIA: Not examined.

ECOLOGY: Not known.

GENERAL DISTRIBUTION: Originally described from Michigan, and quoted by Tryon from Mohawk, N. Y. It may be a northern form of *rufum.*

DISTRIBUTION IN WISCONSIN: At present known only from Detroit Harbor, Door Co. (Bullock).

REMARKS: The chief distinguishing characteristic of *gibbum* is its gibbous body whorl with the peripheral angulation. There are a dozen specimens in the Door County lot and all

but one show some angulation. The young are more bulbous than those of *rufum*. It has been suggested as a monstrosity of *rufum,* but more extended study is needed. It appears to be a recognizable variety.

CAMPELOMA BREVISPIRUM Nov. Sp.

Plate V, figures 13–18

TYPE LOCALITY: Mirror Lake, Sauk Co., Wisconsin.

WISCONSIN RECORDS: None.

SHELL: Ovate, neither solid nor thin; color dark olivaceous or lighter greenish; surface dull, rather rough, lines of growth distinct, often accentuated to form small ridges; spiral lines distinct, hirsute; the last part of the body whorl is frequently heavily marked with distinct spiral ridges; former peristome marks present but not conspicuous; apex flattened, nuclear whorls rounded, with a distinct, deep suture and heavily spirally lined, light horn color, not pinkish; spire short, broadly conic, shorter than the aperture; whorls about 5, flatly rounded, the body whorl rather rounded, slightly shouldered near the deeply impressed suture; the nuclear whorls are eroded in all excepting post embryonic individuals; aperture ovate, rounded below, rather acutely narrowed and angled above; peristome and inner lip as in *rufum;* the umbilical region is completely imperforate and the inner lip forms a rather heavy callus; the interior of the aperture is slightly pinkish in some specimens and bluish white in others.

L. 33.5; W. 23.0; Ap. L. 19.0; W. 11.0 mm. Mirror Lake (U. of W., 4573). Type. Female.
L. 27.5; W. 19.0; Ap. L. 16.5; W. 11.0 mm. Mirror Lake (U. of W., 4573). Paratype. Female.
L. 19.0; W. 13.5; Ap. L. 11.5; W. 6.0 mm. Mirror Lake (U. of W., 4573). Paratype. Female.
L. 13.5; W. 9.5; Ap. L. 8.5; W. 4.5 mm. Mirror Lake (U. of W., 4573). Paratype. Female.
L. 7.0; W. 6.0; Ap. L. 5.0; W. 2.5 mm. Mirror Lake (U. of W., 4573). Paratype. Female.
L. 27.0; W. 19.5; Ap. L. 16.0; W. 9.5 mm. Delton (U. of W., 4574). Female.
L. 23.0; W. 15.5; Ap. L. 14.0; W. 8.5 mm. Delton (U. of W., 4574). Female.

OPERCULUM (Pl. X, figs. 23, 28): Broader than *rufum* in comparison with length, the apex broadly rounded instead of sharply pointed; otherwise similar.

ANIMAL: As in the genus. Color similar to that of *rufum.*

GENITALIA: Same as *rufum.* The embryonic shell (fig. 33) is similar to that of *rufum* in general form but differs markedly in details; it is narrower and the aperture is longer and narrower, as is also the second whorl; the spiral sculpture is much coarser and distinct; the apical whorl is not as flat, quite rounded, slightly raised above the second whorl, not regularly coiled as in *rufum,* but forming a long oval in outline with a conspicuous space between the nucleus and the rest of the first whorl, forming a deep pit where the suture begins. Dimensions, L. 4.0; W. 3.5 mm.

Of fifty adult specimens examined none were males and but three females contained eggs or young, the rest were not gravid. One contained 9 eggs and one shell; one no eggs and four shells; and one 9 eggs. The material was collected on July 28 and 29.

JAW: As in the genus.

RADULA (Fig. 32): In general similar to that of *rufum.* The center tooth, however, is very much larger than that of *rufum,* and is wider than high while in *rufum* it is squarish. It measures 70 μ in width while that of *rufum* measures 55 μ.

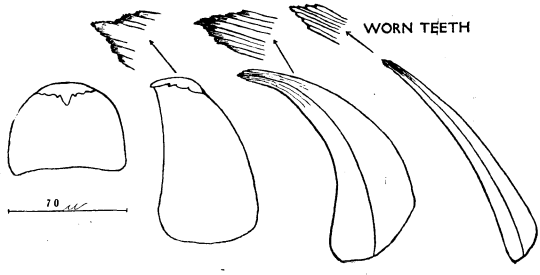

Fig. 32. Radula of *Campeloma brevispirum.* Mirror Lake.

The lateral and marginal teeth are also larger than those of *rufum.* The cusps of many of these teeth were much worn, very jagged from wear.

ECOLOGY: Mirror Lake (type locality) on firm sand bottom, in water from shore to 1 m. deep; in Lake at Delton, a widening out of Dell Creek, they occurred on a mud bottom in very

shallow water; Dell Creek, below Mirror Lake dam, water shallow, bottom covered with stones with slight covering of mud. The habitats seem somewhat diversified but all are in quiet water.

GENERAL DISTRIBUTION: At present known only from Wisconsin.

DISTRIBUTION IN WISCONSIN: Mirror Lake at Fern Glen; Delton, in small lake in Dell Creek; below Mirror Lake dam in Dell Creek, all Sauk Co. (Baker).

REMARKS: *Brevispirum* is related to both *rufum* and *integrum* but may be separated from these species by its shorter, wider spire whorls, its more cylindrical shape, generally more distinctly shouldered whorls; it is not as bulbous as short-spired forms of *rufum,* or *integrum.* A rufous color is only indistinctly shown on a very few specimens. The more tangible differences are in the embryonic shell, which has a rounded nucleus with a small pit between the apex and the rest of the first whorl, while *rufum* has a very flat nucleus without this pit. The center tooth of the radula is also very much larger and of a different shape. The surface is rough as in *integrum.*

It is with some hesitation that a new species is added to the already large number of this genus. The differences are so great in the radula and embryonic shell, as well as in the general form of the shell, that the novelty seems warranted. About a hundred specimens were collected from the Lake and Dell Creek, only one of which was reversed. The *Campeloma* living in the lower part of Dell Creek is *integrum* as is also the species in the Wisconsin River below the dam at Kilbourn. Mirror Lake is of artificial derivation, Dell Creek having been dammed for mill purposes many years ago. Whether this species is one evolved after the building of the dam or whether it was a form already inhabiting the upper part of Dell creek cannot now be determined. The form is found abundantly only in Mirror Lake and a small lake or pond formed by a widening of the creek at Delton. Between these two points *Campeloma* is rare but is *brevispirum* and not *integrum.* Whatever its derivation, it is quite distinct from *rufum* or *integrum,* both in form of shell as well as in radula, embryonic shell, and operculum.

Family AMNICOLIDAE (Tryon, 1862) Gill, 1863

SHELL: Small, spiral, dextral, conical or elongated, imperforate or umbilicated; unicolored; aperture entire, lip simple, usually acute; operculum concentric, spiral, or subspiral, with or without spiral striae.

ANIMAL: With a long rostrum; tentacles long, cylindrical or tapering, with the eyes at their outer base; foot oblong, truncate before, rounded behind, undivided by sinuses; operculigerous lobe well developed; gills pallial, the right gill (the only one developed) short and wide, composed of a few laminae which are broader than high; verge external, placed on the back behind the right tentacle and usually consisting of a penis and a flagellum sheath, the flagellum being semi-independent. There is a cartilaginous stylet in connection with the stomach similar to that found in some Pelecypods. Faeces forming small oblong pellets.

JAWS: Two, somewhat pear-shaped, composed of small imbricated plates.

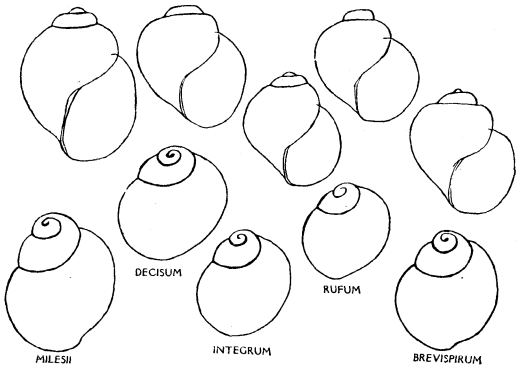

Fig. 33. Embryonic shells of Campeloma.

RADULA: With 2–1–1–1–2 teeth placed on a narrow membrane in slightly arcuate, transverse rows, about 60 rows being developed on a membrane; central tooth usually wider than high, 7–11 denticulate, the lateral angles with a ridge upon which one or more basal denticles are developed; laterals hatchet-shaped, with a long peduncle, a reflection usually wide and low, few denticulate or multidenticulate; marginals fal-

cate, long and narrow, slender, the reflections multicuspid. All teeth bear vertical or transverse ridges which interlock the individual teeth. Animal oviparous. Living in marine, fresh or brackish water in all parts of the world.

Little attention has been given to the study of the internal organization of this family since the classic studies made by William Stimpson in 1865. Many additions have been made to the number of species, and a few American forms have been studied anatomically, notably by Pilsbry. Stimpson laid the foundation for all subsequent work on the classification of the family, although his work seems to be unknown or ignored by many of the European students. Recently, however, Annandale, in the Records of the Indian Museum (1922) has made a study of the Amnicoloid fauna of India, based on characters of the radula, operculum, and in some cases the genitalia.

The classification of these small snails is based largely on the form and denticulation of the teeth of the radula, and on the presence or absence of certain appendages. To clearly see these structures requires powers of from 500 to 700 diameters. There are three foci to be observed in these teeth; first, the reflected portion with its cusps or cutting points; second, the ridge on the lateral angles with its denticulations; and third, the form of the base of the tooth with its appendages. It is necessary to study the different parts by adjusting the focus to meet these different levels and the light from the mirror must be varied so as to cast a shadow from the cutting points or appendages to clearly see their form and mode of attachment. Some figures of Amnicoloid radulae, including those of Stimpson, fail to show the exact form of the cutting points because of a desire to show the tooth just as seen under one focus. This feature is indicated by Stimpson who clearly stated that the shape of the cusps were slightly different under varying foci.

In the figures of radulae accompanying this monograph, each figure is drawn to represent the tooth as it actually is, all of the cusps and appendages being shown as though in one focus, the more clearly to indicate the exact form and relation of the different parts. The cutting points are also shaded to differentiate their form and relation to the body of the tooth. To assure accuracy, several radulae have been examined of each species and dozens of teeth studied from ruptured membranes.

The individual characteristics of the teeth cannot be seen until each tooth is completely isolated and clearly separated from the rhachis, when the shape and form of appendages and cutting points are clearly visible. The cutting points, also, appear sharp and acute when viewed from some angles and blunt and short when viewed from the edge when the tooth is tilted upward. Careful manipulation is also necessary to clearly observe the proper relation of the lobes and ridges to the body of the tooth.

The central tooth of this family has been called the rhachidian, the lateral the admedian or intermediate, and the marginals have been called laterals. For the sake of uniformity with the usage in descriptions of the radula of the Pulmonata, these teeth are named in this monograph the central, lateral, and marginal.

The genitalia, principally the verge or male generative organ, offer some excellent points of interest, which are of diagnostic value. In most of the groups the verge has a secondary lobe which forms the external opening of the flagellum. As this lobe seems not to have been named we have called it the flagellum sheath. This sheath varies in form and is said to be absent in some groups, although a careful anatomical search may lead to its discovery in some form. The operculum offers some characters, both in form, sculpture, and method of growth. It may be deeply striated spirally or marked only by growth lines. Opercula have been examined under a power of 75 diameters after being cleaned in oxalic acid and scraped of all foreign matter. The shell is not in all cases sufficiently characteristic to correctly place a species in a genus without the aid of the radula and other anatomical features. In most of the systematic discussions of the family only the shell has been used, some authors believing that the radula is not sufficiently varied to afford differential characters of importance.

The classification of the Amnicolidae is somewhat involved in the literature. All early authors placed the fresh water and brackish water forms in the family Rissoidae (Binney and Stimpson, 1865; Tryon, 1883). Fischer (1887) separates the fresh water forms in the family Hydrobiidae. European authors generally use the family name Paludestrinidae in place of Hydrobiidae. In recent work on the Indian fauna, Annan-

dale uses the family name Hydrobiidae and several species and genera are differentiated on anatomical grounds.

In 1862 (p. 452) Tryon proposed the name Amnicolidae for the American fresh water Rissoids but did not publish a diagnosis. In 1863 (p. 35) Gill diagnosed the family suggested by Tryon, although, as stated by Stimpson (1865b, p. 9) the characteristics assigned were not all correctly designated. For some reason Tryon later failed to use the family name which he had suggested (see 1883, p. 259) although it appears in his Continuation of Haldeman's Monograph (p. 44). Walker (1918, p. 27) uses the name Amnicolidae for this group, adopting the classification of Stimpson for the subfamilies. See also Tryon, 1866b, p. 155. American authors now uniformly use this name.

As Tryon and Gill were the first authors to definitely separate the fresh-water Rissoids as a family their name should be used in place of Hydrobiidae or Paludestrinidae. The family is indeed closely related to Rissoidae, differing mainly in the position of the basal denticles on the central tooth (on the inferior margin, not on the anterior surface), the operculum, with a notably excentric nucleus, the young with a free-swimming veliger stage, and the presence of certain appendages on the foot. The Rissoidae are all marine while the Amnicolidae are mainly fresh or brackish water in habitat, the great majority inhabiting fresh water rivers and lakes.

The family, which includes some 80 generic names and hundreds of species, is in need of a thorough revision, which can only be satisfactorily accomplished by the examination of the genitalia and radula of all genera and many species. The shell alone cannot be depended upon. The species found in Wisconsin fall into three of the four subfamilies recognized in America. These are characterized below:

KEY TO THE SUBFAMILIES OF AMNICOLIDAE

1. a. Operculum concentric ---------- *Buliminae*
   b. Operculum paucispiral ---------- 2
2. a. Shell thin, subglobose to elongate; columella not thickened-- ---------- *Amnicolinae*
   b. Shell thick, short, body whorl large; columella thickened---- ---------- *Lithoglyphinae*

Subfamily BULIMINAE Hannibal, 1912

Bythiniinae STIMPSON, 1865.

Shell ovate, large for the family, spiral, conical or turbinate, spire produced; operculum calcareous, spiral when young, concentric when adult. Animal with simple foot; right cervical lobe well developed, forming water conduit; central tooth of the radula with several basal denticulations; tentacles long, pointed, tapering.

In 1871 Gill, (p. 7) elevated the Bythiniinae of Stimpson to family rank, and in 1912 Hannibal performed the same office for Buliminae; but this seems hardly necessary or advisable, the radula and animal being similar to the Amnicolidae in general. Only the operculum differs in any large degree and this begins as a paucispiral.

Genus BULIMUS Scopoli, 1777

Bulimus SCOPOLI, Introductio ad Historiam Naturalem, p. 392, 1777. Included *Helix putris, fragilis, stagnalis,* and *tentaculata* of Linnaeus. Type by designation (Pilsbry, Bull. A. M. N. H., LIII, p. 214, 1927), *Helix tentaculata* Linnaeus. Hannibal (1912, p. 184) used the name *Bulimus,* but did not designate the type.

Bithynia LEACH, in Abel, Narrative of a Journey in the Interior of China, p. 362, 1818. *Bythinia* of authors.

Animal and shell as described for the subfamily. Egg capsules laid in groups, originally rounded, but rendered polygonal by mutual pressure.

BULIMUS TENTACULATUS MAGNALACUSTRIS Var. Nov.

Plate V, figures 22, 23, 26–31

TYPE LOCALITY: Winnebago Lake, near Oshkosh, Wis.

WISCONSIN RECORDS:

1902a. *Bythinia tentaculata* BAKER, p. 330. Wisconsin.
1906. *Bythinia tentaculata* CHADWICK, p. 88. Wisconsin.
1924. *Bythinia tentaculata* BAKER, p. 134. Lakes Winnebago and Butte des Morts.
1928. *Bithynla tentaculata* BAKER, p. 58. Various localities cited below.

SHELL: Globosely turbinated, rather thick, transparent to opaque; color ranging from yellowish to greenish, with thin brownish epidermis; surface shining, lines of growth fine, crossed by numerous very fine incised spiral lines; sutures

deeply impressed; whorls 5½, convex, the last rapidly enlarging and equalling all the others combined; spire elevated, broadly conic; epiconch or nucleus small, round, without striae, reddish brown; aperture broadly rounded-ovate, narrowed above; peristome continuous, rounded, simple, thickened a little on the inside, bordered all around with yellowish; inner lip appressed to the columelar wall, thickened at the edge; the base may be imperforate or there may be a small umbilical chink.

L. 12.2; D. 7.0; Ap. L. 6.0; D. 3.1 mm. Winnebago Lake. Holotype. (U. of I., Z18637).
L. 11.0; D. 7.1; Ap. L. 5.8; D. 2.9 mm. " " Paratype. (U. of I., Z18638).
L. 11.0; D. 6.4; Ap. L. 4.7; W. 3.0 mm. ♂ Win. L. (U. of W., 4523).
L. 11.0; W. 6.0; Ap. L. 4.0; W. 2.5 mm. ♂ Win. L. (U. of W., 4523).
L. 9.5; W. 6.1; Ap. L. 4.0; W. 2.5 mm. ♂ Win. L. (U. of W., 4523).
L. 9.8; W. 6.0; Ap. L. 4.0; W. 2.5 mm. ♀ Win. L. (U. of W., 4524).
L. 10.0; W. 5.5; Ap. L. 4.0; W. 2.5 mm. ♀ Win. L. (U. of W., 4524).
L. 10.3; W. 6.6; Ap. L. 4.8; W. 3.0 mm. ♀ Win. L. (U. of W., 4524).
L. 8.0; W. 5.0; Ap. L. 3.5; W. 2.0 mm. Win. L. (U. of W., 4525. Age set).
L. 7.0; W. 4.9; Ap. L. 3.5; W. 2.3 mm. Win. L. (U. of W., 4525. Age set).
L. 6.6; W. 4.0; Ap. L. 2.9; W. 2.0 mm. Win. L. (U. of W., 4525. Age set).
L. 4.0; W. 3.0; Ap. L. 2.0; W. 1.5 mm. Win. L. (U. of W., 4525. Age set).
L. 11.8; W. 7.0; Ap. L. 5.0; W. 3.8 mm. Green Bay (U. of W., 4526).

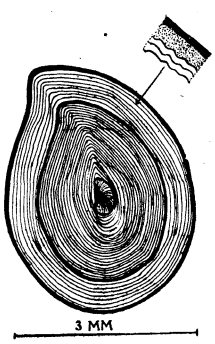

Fig. 34. Operculum of *Bulimus tentaculatus magnalacustris.* Lake Winnebago.

OPERCULUM (Fig. 34): Roundly ovate, narrowed above, regularly rounded elsewhere, calcareous, thick, lines of growth concentric. under a high power seen to be wavy; there is a

border of dark epidermal material. Attachment to operculigerous lobe indicated by a dark line about a third of the distance from nucleus to border and this border is raised above the general level of the operculum. As noted by Sterki (1907, p. 386) the first whorl, or a part of it, is spiral or subspiral, not concentric, the latter condition being assumed later.

ANIMAL (Fig. 35) : Color yellowish-white on foot and body; head and rostrum black with several yellow or golden-yellow spots, the tip yellowish-white; spire whorls pinkish through shell, mottled black and yellowish through body whorl; rostrum large, long, rounded; tentacles filiform, about half as long

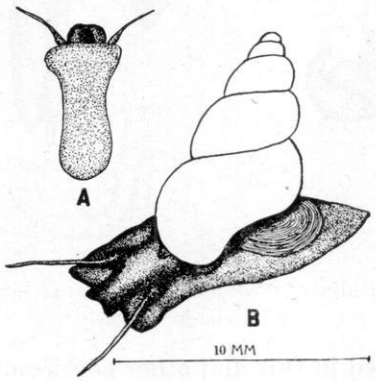

Fig. 35. Animal of *Bulimus tentaculatus*. Winnebago Lake.

as the shell, the black eyes placed on swellings at their outer base. Foot wide, rather short, slightly auriculated in front, roundly pointed behind, whitish on edge with a yellowish part near the center and toward the anterior end; cervical lobes (lappets) round, wide, short, rather fully extended. Operculum placed toward the posterior part of the foot, on a large operculigerous lobe which is wider than the foot.

GENITALIA (Fig. 36) : Male A. Verge very large, situated on the back just behind the right tentacle. It consists of a penial portion and a second projection which forms a sheath for the flagellum, which is very long, a blind diverticulum, and is semi-independent, having no internal connection with the vas deferens (see B) : the vas deferens is very long, narrow, a wide prostatic portion occupying a long area, just behind the penis; testes large. The flagellum sheath has caused the penis to be

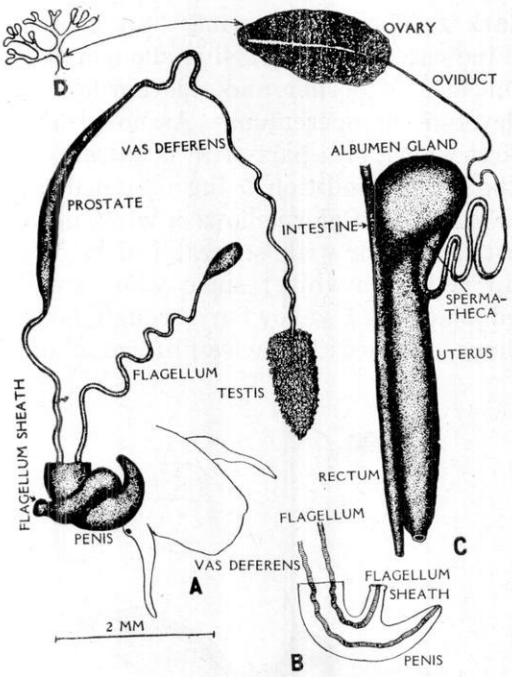

Fig. 36. Genitalia of *Bulimus tentaculatus magnalacustris.* Winnebago Lake.

described as bilobed in this and other species of the family; the sheath may be shorter than the penial portion, or it may be as long as the whole penis from body to tip. In fig. B it is shown in the short condition and in A in the elongated condition, in

Fig. 37. Verge of Bulimus during breeding season.

which it is usually curved around the penial portion. Fig 37 shows the flagellum sheath as it appears during the breeding season, much elongated and bulbous.

Female, C. The uterus lies beside the rectum in the right angle of the mantle and body; it is rather long and wide; the albumen gland is large, balloon-shaped; the spermatheca is somewhat long, pear-shaped; the oviduct is a long, thin, convoluted tube; the ovary is large, and is composed of many small lobules (D).

Of fifty specimens examined, the males somewhat exceeded the females, the males comprising 55 per cent. The egg capsules are large (1 mm. in diameter) and are laid in clusters of from four to 17 (fig. 38, A, B). In Lake Winnebago all eggs

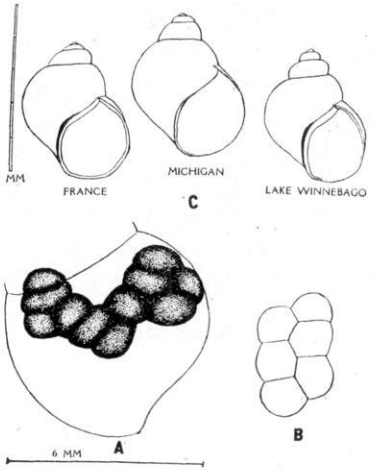

Fig. 38. Bulimus. A, B. Egg capsules. Winnebago Lake. C. Young shells of Bulimus from America and Europe.

appeared to be laid on the shells of neighboring living individuals (A), as many as four clusters being found on one shell. The clusters on ten shells were counted with the following result: the figures indicating the number of eggs in each cluster, the semicolon separating the number of clusters on each shell: 17, 8:4, 9:13, 7:6:5:6:4, 10:5, 15:11, 6:6, 6, 5, 7. Breeding was most active in August but was also observed in July.

JAWS (Fig. 39): Two in number, transparent, very thin, somewhat pear-shaped, made up of minute more or less hexagonal plates, which are but slightly pectinated.

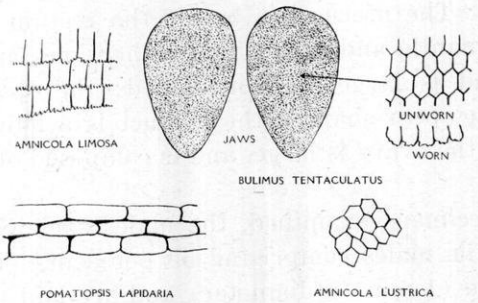

Fig. 39. Jaws of Amnicolidae.

RADULA (Fig. 40) : Formula 12:14:3–1–3:$\frac{3}{6}\frac{1}{6}\frac{3}{6}$:3–1–3:14:12. Central tooth large, 2/3 as high as wide, lateral angles produced, lower margin concave, with a large, rounded tongue-shaped process extending from the anterior base; lateral ridge wide, with six denticles, the upper one large the lower ones much smaller, a rounded lobe connecting the ridge with the lower angle of the tooth; reflection wide and low, 7-cuspid, the center cusp large and roundly pointed, the lateral cusps smaller and more sharply elongated: lateral tooth higher than wide,

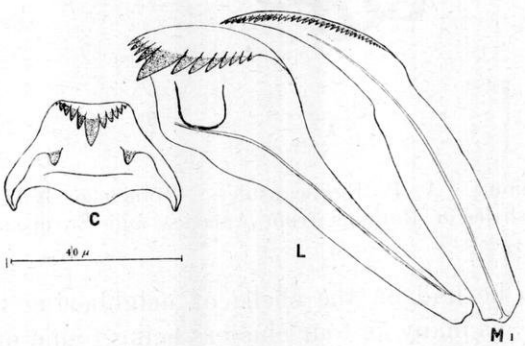

Fig. 40. Radula of Bulimus. Lake Winnebago.

with a wide peduncle which narrows rapidly toward the end and bears a strong ridge extending downward from the center of the tooth; there is a large, rounded lobe on the inner basal part of the body of the tooth and above this a large pit-like depression; reflection wide, 7-cuspid, the center cusp large, the side cusps much smaller, all quite sharp: first marginal falcate,

with a long and narrow body which has a heavy ridge parallel with the long axis; reflection 15-cuspid: second marginal somewhat spoon-shaped, narrowing ventrally, with a vertical ridge, the reflection 12-cuspid, the cusps as large as in the first marginal.

The above descriptions, and the figures, differ somewhat from that published by Troschel in the denticulation and form of the lateral and marginal teeth. The rounded ventral lobe of the lateral tooth as well as the ventral lobe on the central tooth (which is slightly tongue-shaped) are the principal differences. The figure in the Moll. Chi. Area (fig. 117, p. 329) is incorrect. The teeth of the new genus *Hydrobioides,* Nevill, figured by Annandale (1918) are more like the present figure of *tentaculatus,* though differing in the form and denticulation of the marginal teeth. The basal ridge of the central tooth appears to be a folding over of the lateral margin of the base. It also appears to be thicker than the body of the tooth.

ECOLOGY: *Bulimus tentaculatus magnalacustris* is an inhabitant of the large lakes, as a rule. Some of its Wisconsin habitats are indicated below: Winnebago Lake: Hatchery Bay, Oshkosh, sand, .9 m., in vegetation; Asylum Bay, boulder, .4 m., veg.; Doemel Point, boulder, .6 m., veg.; Long Point Island, sand-gravel, 1.5 m., veg.; Miller Bay, sand-gravel, 2.2 m., veg.; mile east of Oshkosh, in open lake, mud, 3.4 m. Lake Butte des Morts; various places, sand and mud bottom, 1 to 4.6 m., mostly in veg. Sturgeon Bay: sandy or marly clay, 2 m., veg. This species is preeminently a mollusk of vegetation, and is seldom found away from it. It is a vegetable feeder, being particularly fond of filamentous algae, among which it is usually found in abundance.

GENERAL DISTRIBUTION: This species is at present known in the Great Lake region from Albany west to Winnebago Lake, and is recorded from the following states: New York, Penn., Ohio, Indiana, Illinois, Michigan, Wisconsin. It is also known from several places in the St. Lawrence and Ontario, and the Ottawa River, in Ontario, Canada (see Baker, 1928, for list of occurrences of the American form).

DISTRIBUTION IN WISCONSIN: Winnebago Lake, Calumet and Winnebago counties; Lake Butte des Morts; Sturgeon Bay, Door Co. (Baker); Green Bay (Pearse); Kenosha Co., Lake Michigan (Baker).

REMARKS: *Bulimus tentaculatus magnalacustris* may at once be identified by its large size, turbinated shell, and particularly by its calcareous, concentric operculum. As in all the Amnicolidae, the shells are dimorphic, the males being slightly narrower than the females. Economically, this species furnishes food for the pumpkinseed *(Eupomotis gibbosus)* and probably other bottom-feeding fish. In Chicago, many years ago, these small shells became a nuisance by choking up the water pipes in residences, as much as a glass full of snails being removed from a single faucet. Such conditions prevail at various times, and are due to the eggs being drawn into the mains through the small meshes of the protecting screens at the intakes in the lakes. These eggs hatch and in a short time an epidemic of snails results.

It has been confidently thought by most students of the Mollusca that this species was an alien to our fauna, introduced from Europe. Of it Dr. Bryant Walker says, "there is no doubt but that this common European species was introduced into America from Europe in the ballast of the timber ships that used to carry long, squared timber from Holland, Saginaw and other Lake Michigan ports, directly to Europe. The species was detected at these points as early as 1891". Recently, Dr. Alvin R. Cahn, of the Department of Zoology, University of Illinois, collected a number of *Bulimus* from excavations in Chicago at depths of 15 and 25 feet below the present surface of the street, the locations being at southwest corner of Tower Court and Pearson Street, and corner Michigan Boulevard and Walton Place. These are apparently in old Pleistocene deposits, sandy, and the time of their deposition would be, probably, the Toleston stage of Glacial Lake Chicago, this point being at about the mouth of old Wilmette Bay, south of the Graceland Bar (See Baker, 1920d).

These fossils are like the species (though somewhat smaller) now living in Lake Michigan and elsewhere in Wisconsin and Illinois and indicate that this species has been in America for some thousands of years. This would suggest that *Bulimus* is another circumboreal form, like *Stagnicola palustris* and *Aplexa hypnorum,* though not as wide-spread as those species, perhaps more like *Margaritana margaritifera,* in distribution, restricted. That these *Bulimus* were not found in the deposits studied in the drainage canal is perhaps not strange as the

southernmost point studied, Bowmanville, is some five miles north of the present location of this species. There seems to be no question concerning the geological horizon of the specimens found by Dr. Cahn, and the fact of the inclusion of this species in the Pleistocene of North America. Associated with *Bulimus* are *Fusconaia undata* and *Elliptio gibbosus,* species not now found in Lake Michigan, and this fact, together with the depth of the deposits, seems to preclude any thought of later filling by recent lake material.

A study of European and American specimens seems to indicate that the latter is slightly different from the former. Comparisons of young shells (fig. 38, c) with four whorls show that the European form has a somewhat depressed apex and rather flat-sided whorls, as well as a more expanded aperture, while the American form has more rounded whorls with deeper sutures and an apex that stands well above the second whorl. The Lake form is also usually heavier than the European form. The European shell is usually somewhat narrower and more elongated than the American lake form, which is disposed to be somewhat obese and very thick. European figures also show some differences in the radula, but this may be due to differences in drawing the teeth. The differences in the apical whorls and in the ecological distribution suggest the advisability of recognizing the American lake form as a geographic race.

That there was an introduction of European material in the manner indicated by Walker is true without doubt and parts of the Great Lakes were stocked in this way. In specimens from Muskegon Lake, Michigan, recently examined, the young were found to be exactly like the young of the European form in the shape of the spire whorls and not like the form living in Lake Winnebago (see fig. 38, c). This suggests the theory that the introduced form may be living in some parts of the area of distribution and the native form in another; or the two may have interbred producing the present large lake form. It is to be noted that all of the fossil specimens are slightly smaller than recent specimens. Additional fossil material should be found in Pleistocene lake deposits.

Subfamily AMNICOLINAE Gill, 1871

Shell small, dextral, subglobose to elongate, thin, imperforate or umbilicated; columella and parietal wall not callously thickened; operculum corneous, subspiral or paucispiral.

Foot simple, without sinuses; tentacles cylindrical with blunt ends; verge rounded, with flagellum sheath; no cervical lobe; central tooth of radula wide and low, lateral ridge with one or more denticulations.

KEY TO GENERA OF AMNICOLINAE

1. a. Shell carinated or subcarinated on the periphery ---- *Pyrgulopsis*
   b. Shell with periphery rounded ---------- 2
2. a. Shell umbilicated ---------- 3
   b. Shell rimate or imperforated ---------- 4
3. a. Central tooth with tongue-shaped projection from base; basal teeth two in number; lateral tooth with rounded basal lobe; apex of shell flattened ---------- *Amnicola*
   b. Central tooth with tongue-shaped projection; only one basal tooth; no distinct lobe on base of lateral tooth; apex of shell pointed ---------- *Marstonia*
   c. Central tooth without tongue-shaped projection; one basal tooth; no lobe on base of lateral tooth; lateral teeth multicuspid ---------- *Cincinnatia*
4. a. Central tooth with tongue-shaped projection; one large basal denticle; lateral teeth 7-cuspid, with lobe on base of tooth; shell long and acute ---------- *Stimpsonia*
   b. Central tooth without tongue-shaped projection; 4 basal denticles; lateral teeth multicuspid; shell with blunt apex ---------- *Hoyia*

Genus AMNICOLA Gould and Haldeman, 1841

Invert. Mass., p. 228, 1841. Type: *Paludina porata* SAY.

Shell small, ovate-conic to elongate, spire subacute; whorls 4–6, convex; aperture oval or roundly oval; peristome continuous; lip simple, sharp; columella not thickened; umbilicus narrowly or widely open; operculum thin, corneous, paucispiral, usually spirally and longitudinally striated.

Animal with short foot auriculated before, rounded behind; rostrum short, wide; tentacles cylindrical, blunt at tips; verge short, consisting of penis and flagellum sheath; egg capsules semilenticular in form, with a membranous appendage encircling the unattached side. These capsules are always attached

to some object and each contains but one egg. For the radula see below.

The radula teeth of *Amnicola* are similar in general form. The central teeth are about twice as wide as high, the reflected portion about as wide as the height of the tooth; the outer angles are much produced and sharply triangular; the lateral ridge (which seems to be a part of the lateral margin turned over) on the anterior face of the tooth carries one or two denticles of which the upper one is always the larger. A tongue-shaped appendage extending from the lower part of the tooth appears to be attached near the lower third or fourth of the body of the tooth; the reflection is broad and varies from 9 to 11 cuspid, the center cusp being always much larger and frequently more blunt than the smaller side cusps.

The lateral tooth is hatchet-shaped with a square body from which projects inferiorly and laterally a long peduncle, on the face of which there is a long, distinct ridge extending its whole length; in the center of the body of the tooth there is always a space which appears like a pit and has been described as a perforation; beneath this there may be a tongue-shaped lobe extending from the ventral border of the tooth or simply a broad swelling of this border; the reflection is wide and low and there are usually 2–3 inner and 3–4 outer cusps on either side of a large central cusp (which may be three times the size of the side cusps), all cusps being rather sharply spade-shaped.

The first marginal is somewhat falcate, with a long and narrow body, which bears one or more distinctly marked vertical ridges; the reflection is low, wide and multicuspid, the cusps being rather long and sharply triangular. The second marginal is narrower than the first, somewhat spoon-shaped, the ventral part of the narrow body much narrower than the upper part, and with a ridge extending the length of its long axis; the reflection is very wide, narrow, and multicuspid, the cusps being smaller than those of the first marginal. The ridges or lobes of the teeth appear to be for the purpose of interlocking the teeth on the radula membrane or rhachis. These ridges have not been previously shown in figures of Amnicoloid radulae.

Amnicola is separable into several subgenera. Paulucci, many years ago, separated the Palaearctic Amnicoloids in a genus called *Pseudamnicola,* distinguished by the different structure of the operculum. The radula also differs from that

of *Amnicola*. Annandale and Prashad (1919, p. 23) have instituted the subgenus *Alocimna* (type *Amnicola sistanica* A. & P.) for the Indian, Persian, and Mesopotamian *Amnicola*, distinguished by the long rostrum, lunate penis, and very large and characteristic operculum. The radula resembles *Amnicola* S. S., though the denticulation of the lateral tooth is more like *Cincinnatia*. To these the writer has added a fourth in this monograph.

KEY TO SPECIES AND VARIETIES OF AMNICOLA AND CINCINNATIA

1. a. Shell with strongly truncated apex, the first 2 or 2½ whorls coiled in the same plane ---------- 2
   b. Shell with apex slightly flattened on top, the first whorl partly hidden by the second whorl ---------- 3
   c. Shell with apex projecting and not concealed by the second whorl ---------- 8
2. a. Two whorls visible in side view; top of spire wide, of 2½ whorls with deeply separating sutures; umbilicus wide ---------- *lacustris*
   b. Three whorls visible in side view; top of spire narrow, of two whorls; umbilicus narrow ---------- *emarginata*
3. a. Shell 4 mm. long ---------- 4
   b. Shell 2½ mm. long ---------- 7
4. a. Shell elongate-ovate, umbilicus narrow ---------- *limosa*
   b. Shell globose, spire elevated, umbilicus wide ---------- 5
5. a. Spire elevated, sutures deep, shell thin or slightly thickened 6
   b. Spire depressed, sutures shallow, shell and lip thickened ---------- *superiorensis*
6. a. Apical whorls ¾ mm. in diameter, aperture rounded --- *porata*
   b. Apical whorls ⅓ mm. in diameter, aperture ovate --- *leightoni*
7. a. Shell globose, whorls flat-sided, sutures shallow, umbilicus narrowly open ---------- *parva*
   b. Shell globose, whorls convex, sutures deep, umbilicus wide ---------- *pilsbryi*
8. a. Shell slender, spire elongated, width 68% or less of length ---- 9
   b. Shell subglobose or ovate-conic, width 70% or more of length ---------- 12
9. a. Whorls of adult shell about 5 ---------- 10
   b. Whorls of adult shell about 6 ---------- 11
10. a. Umbilical region with small chink or closed ---- *lustrica; perlustica*
    b. Umbilical region with wide umbilicus ---------- *decepta*
11. a. Aperture more or less sharply angled above ---------- *gelida*
    b. Aperture rounded above ---------- *oneida*
12. a. Adult shell less than 4 mm. in length ---------- 13
    b. Adult shell more than 4 mm. in length ---------- 15
13. a. Umbilicus wholly or partly closed ---------- *foxensis*
    b. Umbilicus widely open ---------- 14

14. a. Whorls low, spire depressed, width 84% of length------*walkeri*
    b. Whorls high, scalariform, spire long, width 75% of length ----------*precursor*
15. a. Shell elongated, spire considerably longer than aperture, whorls 6, apex acute ----------*greenensis*
    b. Shell globose, spire not much longer than aperture, whorls 5, apex blunt ---------- 16
16. a. Shell 5.5 mm. long, whorls shouldered, body whorl large, outer lip effuse below ----------*cincinnatiensis*
    b. Shell 4.5 mm. long, whorls rounded, aperture oval, not effuse ----------*judayi*

Subgenus AMNICOLA ss.

Apex of shell blunt, nuclear whorl partly concealed by the second whorl; central tooth of radula large, slightly more than twice as wide as high; basal ridge with two cusps, the upper one larger; lateral teeth with large tongue-shaped appendage on lower, inner margin.

TYPE: *Paludina limosa* Say.

This group differs from the other species referred to *Amnicola* in the form of the apex. It includes *limosa, porata, parva, borealis, pallida, bakeriana,* and *nimia.*

AMNICOLA LIMOSA (Say)

Plate VI, figures 1–6

Paludina limosa SAY, Journ. Phil. Acad., I, p. 125, 1817.
Amnicola limosa BINNEY, L. & F. W. Sh. N. A., III, p. 84, fig. 166, 1865.

TYPE LOCALITY: Delaware and Schuylkill rivers, Pa.

WISCONSIN RECORDS:

1865b. *Amnicola limosa* BINNEY, p. 84. Milwaukee (teste Lapham).
1897. *Amnicola limosa* WISWALL, p. 48. Southern Wisconsin.
1905. *Amnicola limosa* DALL, p. 117. Wisconsin.
1906. *Amnicola limosa* CHADWICK, p. 88. Lindwurm, Milwaukee River.
1924. *Amnicola limosa* BAKER, p. 134. Omro, Fox R.; Lake Butte des Morts.

SHELL: Conic, somewhat inflated, narrowly perforate; color light yellowish or dark horn, without color bands, or marks; surface shining, lines of growth numerous, fine, crowded; sutures deeply impressed; whorls 4½, more or less inflated, turbinate, regularly increasing, body whorl globose; spire wide, obtusely conic; apex flat-topped, the first (nuclear) whorl small, rounded, minutely granular and bordered by the

second whorl, which begins to descend after making about one fourth turn; aperture orbicularly-ovate, rounded below and but slightly angled above; peristome sharp, simple, a little thickened within; inner lip sharp, joining the parietal wall at the umbilical region but not appearing on the parietal wall which is without callus or the callus is very thin; base of shell rounded.

L. 4.0; W. 3.0; Ap. L. 2.1; W. 1.6 mm.	Bayfield	(U. of W.,	4527).
L. 4.0; W. 3.1; Ap. L. 2.0; W. 1.5 mm.	"	("	).
L. 4.1; W. 3.0; Ap. L. 2.0; W. 1.6 mm.	"	("	).
L. 4.0; W. 3.4; Ap. L. 2.3; W. 1.6 mm.	"	("	).
L. 3.5; W. 3.1; Ap. L. 2.1; W. 1.5 mm.	"	("	).

OPERCULUM (Fig. 41): Horny, thin, subspiral, of about 2½ whorls, almost straight on the left margin, regularly rounded at base and on right side; spirally and longitudinally striated with very fine, close-set lines, the growth lines being much finer; the last half of the last whorl heavily striated with

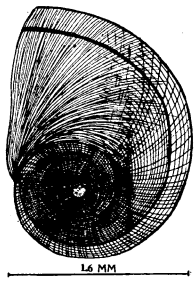

Fig. 41. Operculum of *Amnicola limosa porata.* Winnebago Lake.

fine, subparallel striae running transversely to both the longitudinal and spiral lines of the older part, obliterating these on the last third of the last whorl; there is no sharp demarcation where these lines meet, all being fused and indistinct; nucleus at about the center of the lower third of the operculum; a very dark line (or ridge) inside of the outer border indicates the attachment to the operculigerous lobe; the outer border of the operculum may also be marked by a dark line.

ANIMAL (Fig. 42): Body generally whitish or pinkish and translucent; there is a streak of dark brown extending down the side of the tentacles, a patch of brown between the eyes, and black and brown markings on the rostrum; foot short, about three times as long as wide, rounded behind, auriculated before and somewhat concave in the middle of the sides; the

auriculated portion may be prolonged t· ıntacle-like processes; operculigerous lobe rounded ɔroader than the foot, over the sides of which it p , rostrum short,

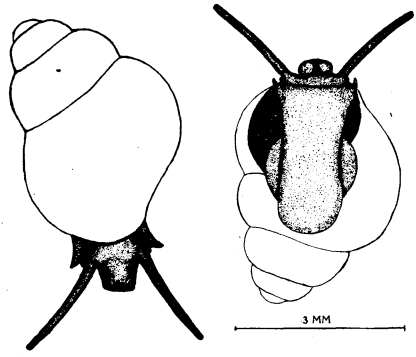

Fig. 42. Animal of *Amnicola limosa porata.* Winnebago Lake.

broad, emarginate in the middle of the anterior end; this feature is particularly noted when the animal is crawling up the glass side of a jar; tentacles slender, cylindrical, not tapering,

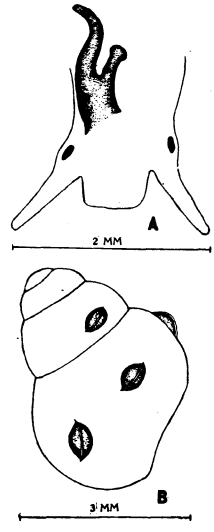

Fig. 43. *Amnicola limosa porata.* A. Verge. B. Egg capsules. Devils Lake.

about two-thirds as long as foot when extended, blunt at tips; eyes placed at the inner base of the tentacles, on the anterior side of a small swelling; mantle simple on edge.

GENITALIA: Generally, as in *Bulimus*. Verge (fig. 43, A) situated on the right side of the neck behind the right tentacle; penis rather long, usually making a half coil about the flagellum sheath, which is short and cylindrical with a truncated extremity. Female organs as in *Bulimus* as far as can be seen.

BREEDING SEASON: Egg capsules (fig. 43, B) have been observed in July and August. Stimpson records them also in April and May. A single egg is laid in a semilenticular, corneous capsule, somewhat longer than broad, attached to objects by what may be termed the base. Encircling the capsule at the upper edge, and extending from one end to the other, is a thin, ribbon-like appendage. Each capsule is attached separately to some object, as on the shell of a neighboring *Amnicola* or on vegetation or other object, and contains the egg or embryo which floats in the fluid contained in the capsule. As many as five capsules have been counted on a single shell of *Amnicola*. (See Baker, 1918a, p. 21, for observations on the egg capsules of *Amnicola*). Females are more numerous than males, the ratio sometimes being 10 to 1.

JAW (Fig. 39): Oblong-ovate or somewhat pear-shaped, composed of many scale-like plates with the lower edges serrated or imbricated.

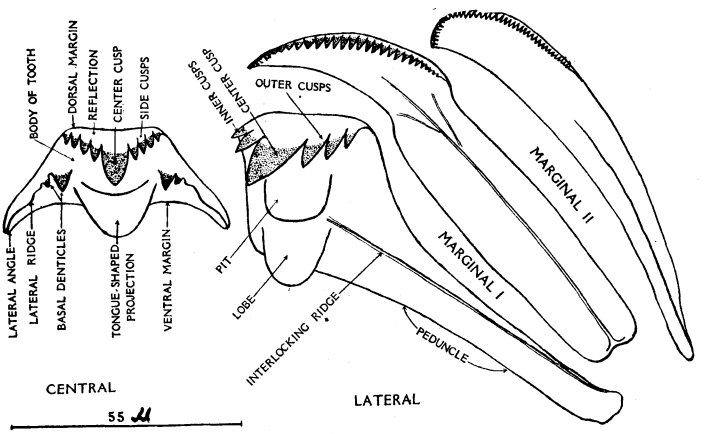

Fig. 44. Radula of *Amnicola limosa porata*. Winnebago Lake.

RADULA (Fig. 44): Formula 40:30:2–1–3:$\frac{4-1-4}{2-2}$:2–1–3:30:40. The general form and denticulation of the radula is as described under the description of the genus. The figures and descriptions differ somewhat from those of Stimpson (1865b, p. 14).

Under high magnification and with different degrees of lighting, the cusps are seen to be longer than those shown by Stimpson, and to be rather spade-shaped. This difference was, indeed, mentioned by this author, but his figures all fail to show the sharp cutting points, which differ in various species. The denticulations on the basal ridge are but 2 in number, not 4, the lower apparent cusps being simply swellings of the ridge. The central tooth is also 9-cuspid, not 7-cuspid. The lateral teeth are 6-cuspid, as noted by Stimpson, but there is also a pit in the center of the body of the tooth. The first marginal has 30 cusps (not 18) and the second marginal 40 or more, so minute that they are difficult to count accurately. Specimens examined from New York, Illinois, and Wisconsin.

ECOLOGY: *Limosa* is a species, generally, of rivers, streams, and quiet bodies of water. The following specific habitats have been noted in Wisconsin: Fox River at Omro, mud bottom, 2.1 m. deep; Red Cliff Creek, Bayfield Co., on vegetation in shallow water; swamp behind beach, west shore of Lake Pokegoma, Chetek, mud bottom, shallow water; outlet of Lake Chetek, rock bottom, shallow water, in vegetation; Yellow River, near Spooner, mud bottom, shallow water, in vegetation; Mirror Lake, near Kilbourn, mud bottom, .2 m. deep, in *Myriophyllum;* Green Lake, off Spring Grove Hotel, 2.5 m. deep, clay bottom; Lake Butte des Morts, mud bottom, .6 to 2.2 m., in vegetation; Devils Lake, sand bottom, 7.5 m., mostly in algae and other vegetation.

Of the type locality Say remarks: "extremely numerous on the muddy shores of the rivers Delaware and Schuylkill, between high and low water marks".

GENERAL DISTRIBUTION: New England and New Jersey west to Utah, Manitoba south to Texas. In Illinois, *limosa* is recorded from the northern part of the state, especially in the northeastern part bordering Wisconsin. Lack of authentic material from other parts of the state prevents a knowledge of its distribution in the southern part.

DISTRIBUTION IN WISCONSIN: Apparently widely distributed in scattered localities over much of the State, in all drainage areas.

REMARKS: Under the name *limosa* almost all of the globose *Amnicolas* have been listed and the literature is quite unsafe to supply data for geographic distribution. When its distinc-

tive characteristics are once understood it is a species easily recognized. The flat-topped spire (the first and a part of the second whorls being coiled in the same plane), the elongate, turbinate form, and the narrowly open umbilicus will at once distinguish it from all related species and varieties. There is some variation in the convexity of the whorls, the length of spire, and the size of umbilicus, these variations occurring among groups of shells closely related to the variety *porata.*

In Lake Butte des Morts a form occurs which has the long spire of *limosa* and the wide umbilicus of *porata.* These are intermediate forms, forcefully indicating the relation of the two forms. Some of the Devils Lake *limosa* are also of this intermediate character. Under *porata* a supposed change from *limosa* to *porata* is described.

The *pallida* of Haldeman is apparently closely related to *limosa* but if the shells from the Erie Canal at Mohawk, N. Y., identified by James Lewis (ex. Walker) are correctly placed, it seems distinct, being much heavier and with a somewhat differently shaped spire. This species has not been seen from Wisconsin.

The animals of both *limosa* and *porata* glide more or less rapidly about carrying the shells with a wabbly motion. They have also been observed to float on the under surface of the water film, shell downward. *Amnicola* is a widely used food by some fish, including whitefish, common sucker, pumpkinseed, and the smaller fish, the Manitou and tessellated darters, which are eaten by larger food and game fishes. The total food of the whitefish includes 26 per cent of molluscan animals, consisting largely of *Amnicola.*

AMNICOLA LIMOSA PORATA (Say)

Plate VI, figures 7–8, 18; plate VIII, figures 1–3

Paludina porata SAY, Jour. Phil. Acad., II, p. 174, 1821.
Amnicola porata W. G. BINNEY, L. and F. W Sh. N. A., III, p. 82, fig. 164, 1865.
Amnicola orbiculata LEA, Trans. Amer. Phil. Soc., IX, p. 16, 1844; Obs., IV, p. 16.
Amnicola orbiculata W. G. BINNEY, Op. Cit., p. 87, fig. 172, 1865.
Amnicola porata PILSBRY, Nautilus, XII, p. 44, 1898.

TYPE LOCALITY: Lake Cayuga, N. Y. *(porata);* Springfield, Ohio, and Schuylkill River, near Philadelphia, Pa. *(orbiculata).*

WISCONSIN RECORDS:

1865b. *Amnicola limosa* BINNEY, p. 84. Madison (Lapham).
1906. *Amnicola limosa* CHADWICK, p. 88. Lake Winnebago, west of High Cliff, Calumet Co.
1911. *Amnicola cincinnatiensis* BAKER, p. 233. Tomahawk Lake.
1918. *Amnicola limosa* MUTTKOWSKI, p. 474. Lake Mendota.
1924. *Amnicola limosa porata* BAKER, p. 134. Lake Winnebago.
1927a. *Amnicola limosa porata* WINSLOW, p. 6. Little Arbor Vitae Lake.
1927a. *Amnicola* sp. WINSLOW, p. 6. As above.

SHELL: Differing from *limosa* in having more swollen whorls, a shorter spire, more deeply impressed sutures, and a more widely umbilicated base, the umbilicus roundly open: the height and diameter are more nearly equal than in *limosa*. The apex of the spire is flat-topped, as in *limosa*.

L. 4.2; W. 3.4; Ap. L. 2.3; W. 2.0 mm. Chetek Lake (U. of W., 4528).
L. 4.5; W. 3.5; Ap. L. 2.3; W. 2.0 mm. " " (" ").
L. 4.4; W. 3.4; Ap. L. 2.2; W. 1.8 mm. Devils Lake (U. of I., Z18362). Male.
L. 4.5; W. 4.0; Ap. L. 3.5; W. 2.0 mm. Devils Lake (U. of I., Z18362). Female.
L. 4.5; W. 4.0; Ap. L. 2.5; W. 2.1 mm. Devils Lake (U. of I., Z18362). Female.
L. 4.1; W. 4.0; Ap. L. 2.5; W. 2.0 mm. Devils Lake (U. of I., Z18362). Female.
L. 5.2; W. 4.0; Ap. L. 2.6; W. 2.1 mm. Little Arbor Vitae Lake (U. of I., Z19349).

OPERCULUM: Like that of *limosa*, but somewhat rounder.

ANIMAL AND GENITALIA: As in *limosa*.

JAW AND RADULA: As in *limosa*.

ECOLOGY: *Porata*, in Wisconsin, at least, is the lake manifestation of *limosa* and inhabits quite a different habitat. The following records cover the greater variety of ecological situations:

Lake Winnebago: Stony Point, sand bottom, vegetation, .3 m.; Libby Point, gravel, vegetation, .3 m.; Miller Bay, sand, veg., .6 m.; Roe Point, boulder, veg., .6 m.; Long Point Island, gravel, veg., .8 m.; Hatchery Bay, sandy silt, veg., .9 m.; Asylum Point, boulder, 1.5 m.; Moreley Point Bay, sand-gravel, 2.5 m.; Lower Asylum Bay, gravel in mud, 3.1 m.; Doemel Point, gravel, 3.4 m.; in open lake, one mile east of Oshkosh, mud, 5.5 m.

Bayfield: Mouth of Chicago Creek, sand bottom, .1 m.

Lake Chetek and Vicinity: Mud and sand bottom, among plants, .3 to .6 m.

GENERAL DISTRIBUTION: Apparently the same as typical *limosa.* It is probable that many records of *limosa* are based on *porata.* In Illinois, the variety is recorded from many places in the northern part of the state, but records are lacking from the southern part (Baker, 1906b, p. 92).

DISTRIBUTION IN WISCONSIN: *Porata* covers about the same area as *limosa.* At present known from the drainages of the Rock, Fox, Wisconsin, and Chippewa rivers.

REMARKS: *Porata* is a wide, umbilicated form of *limosa,* with which it intergrades in many places. The radula is also identical, as is the verge and operculum. The globular shell and wide umbilicus will easily distinguish it. While typically *limosa* is a species of slow moving bodies of water, quiet creeks, rivers, and shallow ponds, *porata* is typically a form of large lakes where there is heavy wave action. As in *limosa,* there is great variation in the obesity of the whorls and in the character of the umbilicus. Specimens from Lakes Winnebago and Chetek are very large with wide body whorl and umbilicus; but with these are always some forms more nearly resembling the *limosa* type. The peristome is more often continuous in *porata* than in *limosa.*

Specimens from Lake Chetek are large and globular, though some individuals vary toward *limosa.* These Chetek forms give an excellent example of a variety developed by a change of environment. The lake was originally a small river, similar to the Red Cedar River nearby, but somewhat smaller. About sixty years ago this stream was dammed for the purpose of providing deep water to float logs to a mill. The dam is about 16 feet in height and has ponded the waters for a distance of some 10 miles, forming a chain of beautiful lakes ranging in depth from two or three to about twelve feet. The *Amnicola,* which were originally *limosa,* have changed to the wide bulbous form of *porata,* which is found only in these lakes. This is the most striking change in a species produced by the environment that has come under the writer's observation, the entire evolution taking place in the space of 60 years. A similar change is taking place in *Amnicola* and other mollusks in Mirror Lake, near Kilbourn, where the *limosa* are varying toward the wide

porata type, though the change has not yet progressed far enough for the form to be included in the variety.

In many lakes, especially in Vilas and Oneida Co., but also observed elsewhere, there is a marked sexual variation or dimorphism, the males having longer, more scalariform spires than the females (see pl. VIII, figs. 1–3). The majority of the Wisconsin references to *limosa* seem based on the wide *porata* form, which is characteristic of the many lakes in the State. Pilsbry (1898, p. 44) states that *orbiculata* is completely synonymous with *porata*. Lea gives as type localities Springfield, Ohio, and Schuylkill River, Pa. Pilsbry states that *porata* is common near Philadelphia. It would appear that perhaps *orbiculata* is composite, including the river form from Springfield and the lake-like form near Philadelphia. In the west the two types are not usually found associated in the same habitat. I have followed Pilsbry in considering *orbiculata* a synonym of *porata*. Lea's types of *parva* also came from Springfield, Ohio, and his *orbiculata* from this locality might be a variation of this type of shell. Lea himself suggested this in his description of *parva*.

AMNICOLA LIMOSA SUPERIORENSIS Var. Nov.

Plate VI, figures 9–11; plate VII, figures 22, 23

TYPE LOCALITY: Bayfield, Bayfield Co., on shore of Lake Superior.

WISCONSIN RECORDS:

1906. *Amnicola limosa* CHADWICK, p. 88. Sandy beach of Lake Michigan.
1906. *Amnicola limosa porata* CHADWICK, p. 88. As above.

SHELL: Differing from variety *porata* in being usually larger, with a thicker, more solid shell, a more depressed spire, especially in the female, a more globose form, and a wider umbilicus. The immature shell is larger than that of *porata*.

L. 4.8; W. 4.0; Ap. L. 2.5; W. 2.1 mm. Bayfield (U. of W., 4529). Type, female.
L. 4.2; W. 4.0; Ap. L. 2.3; W. 2.0 mm. Bayfield (U. of W., 4529). Paratype, female.
L. 4.4; W. 3.5; Ap. L. 2.3; W. 2.0 mm. Bayfield (U. of W., 4529). Paratype, male.

ECOLOGY: Rough shores of the Great Lakes.

GENERAL DISTRIBUTION: Probably occupies the whole of the Great Lakes area. Specimens have been seen from Lakes Superior, Michigan (Millers, Ind.), and Ontario (Charlotte, port of Rochester, N. Y.).

DISTRIBUTION IN WISCONSIN: Lake Michigan shores near Sturgeon Bay, Door Co. (Baker); near Milwaukee, Milwaukee Co. (Chadwick); near line between Illinois and Wisconsin (Baker); Shore of Lake Superior near Bayfield, Bayfield Co. (Baker).

REMARKS: *Superiorensis* is the Great Lakes manifestation of the *limosa* type of *Amnicola,* characterized by a large, thick shell, which is usually more globose than the variety *porata* of the smaller lakes. The males are more elongated and narrower than the females. While there are intermediate forms between *superiorensis* and *porata,* it appears quite appropriate to recognize the large *Amnicola* of the Great Lakes region, which is abundant on the shores in many places. The three forms, *limosa, porata,* and *superiorensis,* are direct responses to differences in environment.

AMNICOLA LIMOSA PARVA Lea

Plate VI, figures 12–14

Amnicola parva LEA, Proc. Amer. Phil. Soc., II, p. 34, 1841.
Amnicola parva BINNEY, L. & F. W. Sh. N. A., III, p. 87, fig. 171, 1865.
Amnicola parva PILSBRY, Nautilus, XII, p. 44, 1898.

TYPE LOCALITY: Springfield, Ohio.

WISCONSIN RECORDS:

1906. *Amnicola limosa parva* CHADWICK, p. 88. North bank Milwaukee River at Lindwurm; Menomonee River, Castalia Park, Wauwatosa, in stream drift.

SHELL: Somewhat smaller than *limosa,* with obtuse apex and narrow umbilicus; the whorls are tumid below the suture, producing a distinct shouldered appearance; the aperture is like that of *limosa,* the inner lip not forming a callus on the parietal wall, hence not continuous.

L. 3.8; W. 3.2; Ap. L. 0.0; W. 0.0 mm.	Lea's type (vide Pilsbry).
L. 3.0; W. 2.5; Ap. L. 1.7; W. 1.4 mm.	Pettis Co., Mo. (U. of I., Z14285).
L. 3.2; W. 3.0; Ap. L. 2.0; W. 1.5 mm.	" "
L. 3.2; W. 1.5; Ap. L. 2.0; W. 1.5 mm.	" "
L. 2.7; W. 2.3; Ap. L. 1.5; W. 1.2 mm.	Milwaukee (Mil. Mus., 5074).
L. 3.2; W. 2.6; Ap. L. 1.8; W. 1.2 mm.	" "

ANIMAL: No living or alcoholic specimens have been available for study and the characters of *operculum, radula,* and *genitalia* have not been ascertained.

GENERAL DISTRIBUTION: Atlantic and Middle States. Its exact distribution is imperfectly known; it is reported authentically from Ohio (Sterki), Indiana (Daniels), Illinois (Baker), Iowa (Pilsbry) and Missouri (Walker, specimens). Its distribution may be coincident with that of *limosa.*

DISTBIBUTION IN WISCONSIN: Only a few scattered records are known.

Lake Michigan Drainage: Milwaukee River, Lindwurm, and Wauwatosa, Milwaukee Co. (Chadwick, specimens seen).
Rock Drainage: Lake Mendota, Dane Co. (Walker).

REMARKS: *Parva* appears to be a small variety of *limosa,* having the same form of umbilicus and flat-topped spire. It is wider than *limosa* on the average and resembles in general shape some forms of *porata.* Lea, in fact, compares it with his *orbiculata,* which is considered a synonym of *porata.* The shouldered whorls seem distinctive and with the diminutive size, flat-topped spire, and narrow umbilicus should readily distinguish it. Specimens from Pettis Co., Missouri, are figured, as these seem more typical than the Milwaukee specimens.

Pilsbry (1898, p. 44) remarks, after a study of Lea's type of *parva:* "Whether it is a stunted form of *limosa* due to unfavorable station, or is constantly distinguishable I have not ascertained, but it is at all events recognizable". Many small specimens of *limosa* are like *parva* but they lack the shouldered whorls. *Parva* seems to be a dwarf-like variety of *limosa,* related to both the typical form and to *porata.*

Subgenus MARSTONIA Baker, 1926

Marstonia BAKER, Trans. Wis. Acad. Arts, Sci. Lett., XXII, p. 195, 1926. Type: *Amnicola lustria* PILSBRY.

Apex of shell acute, nuclear whorl not flat-topped, emerging well above the second whorl; the nuclear whorl is only half the size of that of *Amnicola* typical. Central tooth of radula about two-thirds as large as that of *Amnicola;* basal ridge with but one large denticulation; reflection usually with more than 9 denticulations; lateral teeth without a distinct lobe at the inner ventral border which is replaced by a broad swelling. All

cusps usually longer and sharper than in *Amnicola* typical. The second marginal is peculiarly expanded on the lower part of the body of the tooth, differing from that in *limosa.*

The *lustrica* group of *Amnicola* differs sufficiently in both shell and animal to entitle it to group rank. This group will include *lustrica, gelida, oneida, walkeri, pilsbryi, greenensis, winkleyi,* and probably some others not examined.

The group is dedicated to Mr. Geo. T. Marston, who lived for many years in Eastern Wisconsin, and who accumulated a large collection of Wisconsin Mollusca which has been invaluable in the preparation of this monograph.

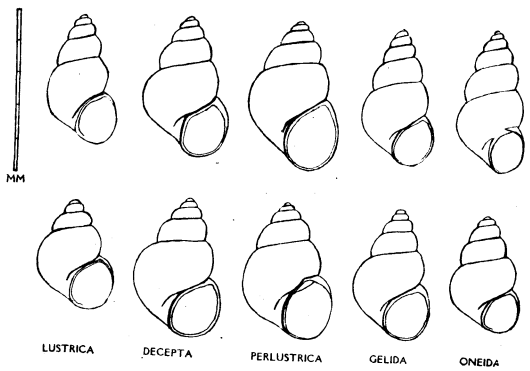

Fig. 45. Species and varieties of Amnicola. *Lustrica,* Mason Co., Ill. (U. of I., Z17761); *lustrica decepta* Var. Nov., Silver Lake, Wis., type and paratype (U. of I., Z22501); *lustrica perlustrica* Var. Nov., Sturgeon Bay, Wis., type and paratype (U. of I., Z18635a); *gelida,* Morris, Ill., type and paratype (U. of I., P926, P927); *oneida,* Oneida Lake, type locality (U. of I., Z22513). Upper figs. males, lower figs. females. Camera lucida drawings.

AMNICOLA LUSTRICA Pilsbry

Plate VI, figures 16, 17, 26, 27; text figure 45

Amnicola lustrica Pilsbry, Nautilus, IV, p. 53, 1890. Not *A. lustrica* Say = *Pomatiopsis lapidaria.*

TYPE LOCALITY: Not specifically given. "New York to Illinois and Minnesota" (Pilsbry).

WISCONSIN RECORDS:

1906. *Amnicola lustrica* CHADWICK, p. 88. Honey Creek, near Layton Park, Milwaukee.

1924. *Amnicola lustrica* BAKER, p. 134. Lake Winnebago (part).

SHELL: Small, thin, turreted, translucent; color varying from greenish to light brownish, often waxy; surface smooth and shining, lines of growth distinct, regular; spire elevated, conic, somewhat longer than aperture; whorls 5, rather convex, regularly but not rapidly increasing in diameter; sutures well impressed; nucleus small, minutely granular, of about one whorl, waxy or greenish, sometimes stained with reddish; the post-nuclear whorl immediately begins to descend; aperture roundly ovate, more or less distinctly angled above, waxy inside; peristome continuous, thin, appressed to the body whorl for a short distance near the upper terminations; base of shell broadly rounded, with a small, narrow umbilical chink.

L. 4.0; W. 2–2½. Pilsbry's type.
L. 4.0; W. 2.2; Ap. L. 1.6; W. 1.1 mm. Mason Co., Ill. (U. of I., Z17761). Male.
L. 3.4; W. 2.4; Ap. L. 1.5; W. 1.3 mm. Mason Co., Ill. (U. of I., Z17761). Female.
L. 4.0; W. 2.5; Ap. L. 1.7; W. 1.3 mm. Lake Chetek (U. of W., 4533).
L. 3.7; W. 2.6; Ap. L. 1.6; W. 1.2 mm. " "
L. 4.5; W. 3.1; Ap. L. 2.0; W. 1.5 mm. " "
L. 5.7; W. 3.5; Ap. L. 2.5; W. 2.0 mm. Mukwonago River (U. of I., Z22503).

OPERCULUM (Fig. 46): Horny, thin, subspiral, of about 2½ whorls, all sides regularly rounding upward to the sharply pointed apex; spirally and longitudinally striated with very fine

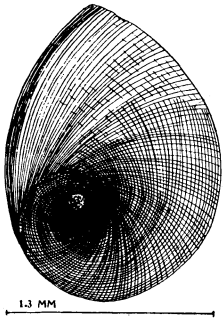

Fig. 46. Operculum of *Amnicola lustrica.* Winnebago Lake.

lines, the spiral lines being obscured on the last whorl by the lines of growth; there is no sharp demarcation between these several kinds of striae; attachment to operculigerous lobe occupying all but a small margin of the under side. The oper-

culum of *lustrica* differs from that of *limosa* in shape and in general surface markings.

ANIMAL AND GENITALIA: Not differing materially from *limosa.* The egg capsules (fig. 56, B) are similar to those of *limosa* but are often found on vegetation, especially *Vallisneria.*

JAW: As in *limosa.*

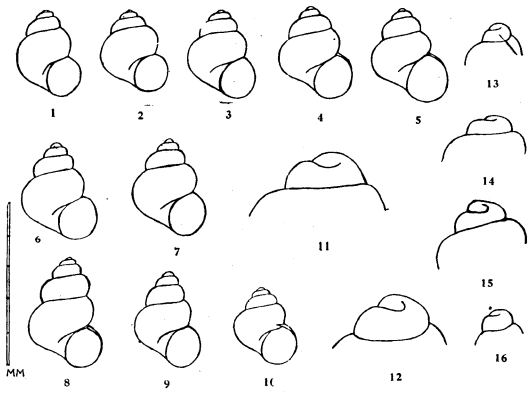

Fig. 47. 1, 2. *Amnicola walkeri foxensis* Var. Nov. Types (U. of I., Z18374); 3. *Amnicola walkeri,* High Island Harber, type locality. 4, 5. *Amnicola walkeri,* Bayfield (U. of I., Z13368); 6. *Amnicola precursor* Sp. Nov., Green Lake, type; 7–9. *A. precursor,* paratypes (U. of I., Z22508); 10. *Amnicola pilsbry,* Brown Co., Wis. (U. of W., 433); nuclear whorls of; 11, *walkeri;* 12, *precursor;* 13, *greenensis;* 14, *porata;* 15, *leightoni;* 16, *lustrica.* Figures 11–16 greatly enlarged. Camera lucida drawings.

RADULA (Fig. 48): Formula 30:24:3–1–4:$\frac{5}{1}\frac{1}{1}\frac{5}{1}$:3–1–4:24:30. The teeth of *lustrica* differ from the *limosa* group in being smaller, with finer, sharper cusps. The central tooth is higher in proportion to width and there is but one large denticulation on the basal ridge. The central and lateral teeth also bear a larger number of cusps. The lateral tooth also lacks the distinct lobe which is present on the lateral tooth of *limosa.*

ECOLOGY: *Lustrica* is usually an inhabitant of vegetation and is particularly abundant in filamentous algae. In Wisconsin it has been found in the following situations: Winnebago Lake, Asylum Bay, sand bottom, .8 m.; sand and gravel bottom, 2.8 m. Chetek Lake, shallow water among vegetation.

GENERAL DISTRIBUTION: New York west to Minnesota. The northern and southern limits of distribution are not defi-

nitely known. It has been authentically reported from Indiana, Illinois, New York, Minnesota, Michigan, Ohio, Pennsylvania, and southern Ontario.

DISTRIBUTION IN WISCONSIN: Rather widely distributed over a large part of the State, both in the Great Lakes and Mississippi drainages.

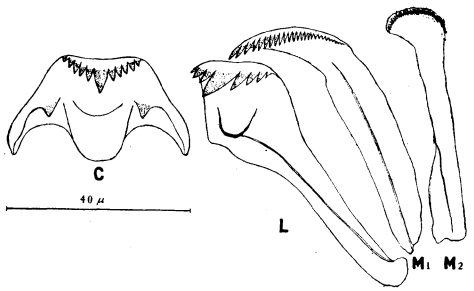

Fig. 48. Radula of *Amnicola lustrica.* Winnebago Lake.

REMARKS: *Lustrica* may be distinguished by its narrow shell and acute spire. It is narrower than *cincinnatiensis* or *judayi* and the umbilicus is narrower. From *gelida* and *oneida* it is separated by its shorter, wider spire and more flat-sided whorls. It is wider and has more flat-sided whorls and a narrower umbilicus than the lake variety described below. While there is some variation in length of spire and convexity of whorls, the present form is fairly uniform. Specimens from Mukwonago Creek are the largest observed.

The name *lustrica* has been made to include all narrow species of *Amnicola* with an acute spire. Pilsbry (1917b, p. 46) has differentiated several species from Oneida Lake, N. Y., and the writer has separated several fossil forms as distinct species. Pilsbry's original description included two forms which appear recognizable, a lake and a river form. As Pilsbry did not indicate the habitat of his *lustrica* I have selected the river form with the narrow umbilicus to represent the type form and have separated the lake form with the wider umbilicus, as an ecological variety. The parallel is duplicated in *Amnicola limosa,* which has a river, small lake, and Great Lake form. *Lustrica* is believed to be quite distinct from both *oneida* and *gelida.*

AMNICOLA LUSTRICA DECEPTA Var. Nov.

Text figure 45

TYPE LOCALITY: Silver Lake, Waukesha Co., Wis.

WISCONSIN RECORDS: Probably recorded as *lustrica.*

1924. *Amnicola lustrica* BAKER, p. 134. Lake Winnebago (part).

SHELL: Larger and more solid than *lustrica,* with a wider spire, deeper sutures, rounder whorls, wider and deeper umbilicus, and 5–5½ whorls; the posterior part of the aperture is often more sharply angled.

L. 4.5; W. 2.6; Ap. L. 1.8; W. 1.3 mm. Silver Lake (U. of I., Z22501). Type, male.

L. 4.2; W. 3.0; Ap. L. 1.9; W. 1.5 mm. Silver Lake (U. of I., Z22501). Paratype, female.

L. 4.0; W. 3.0; Ap. L. 1.8; W. 1.5 mm. Silver Lake (U. of I., Z22502). Paratype.

L. 4.5; W. 3.0; Ap. L. 1.8; W. 1.5 mm. Silver Lake (U. of I., Z22502). Paratype.

L. 4.1; W. 3.0; Ap. L. 2.0; W. 1.5 mm. Silver Lake (U. of I., Z22502). Paratype.

ANIMAL: As in *lustrica.*

RADULA: As in *lustrica.*

ECOLOGY: A form of smaller lakes. In Silver Lake found on a clear sand bottom in water several feet deep. Oconomowoc Lake, among weeds and algae, water 304 m. deep., vegetation *Vallisneria* and *Potamogeton.* Golden Lake, sand bottom without vegetation, water 1 m. deep. Ashippun Lake, soft sand bottom, water less than 1 m deep.

GENERAL DISTRIBUTION: At present known from Minnesota east to Michigan. Probably occurs in other states where lakes abound.

DISTRIBUTION IN WISCONSIN: Northern and eastern part of the State, as far as known.

Lake Michigan Drainage: Lake Noquebay, Crivitz, Marinette Co. (Bullock, Walker).

Wisconsin Drainage: Little Arbor Vitae Lake, Vilas Co. (Winslow). Plum Lake, Vilas Co. (Cahn).

Fox Drainage: Green Lake, Green Lake Co., Lake Winnebago, Winnebago Co. (Baker).

Rock Drainage: Lake Mendota, Dane Co. (Hinkley); Lakes Oconomowoc, Genesee, Lower Nashotah, Dutchmans, Ashippun, Cooks, Silver, Golden, Waukesha Co. (Cahn); Lake Wingra, near Madison, Dane Co. (Bullock).

REMARKS: This variety of *lustrica* is larger, has a wider spire, deeper sutures and a wider umbilicus than the typical form. It is especially characteristic of the small lakes and is doubtless an ecological variation. In the group of lakes in southeastern Wisconsin it is the predominating form, occurring in some localities in countless numbers. It resembles the form found in the Great Lakes, differing in its larger umbilicus and shorter body whorl. In some lots there is variation toward the typical form, especially in Green Lake, and in some river forms there is variation toward *decepta.*

In Lake Chetek, the *Amnicola* is referable to typical *lustrica,* having the small umbilicus, but the whorls are rounder and the sutures deeper than in the typical form, showing the effect of a lake environment. Lake Chetek is of artificial origin, made by damming the Chetek River.

AMNICOLA LUSTRICA PERLUSTRICA Var. Nov.

Plate VI, figure 15; text figure 45

TYPE LOCALITY: Michigan shore east of Sturgeon Bay, Door Co., Wis.

WISCONSIN RECORDS:

1920d. *Amnicola lustrica* BAKER, p. 120. Milwaukee (fossil).

SHELL: Differing from *Amnicola lustrica* in its larger size, wider spire, and more flat-sided whorls; from *Amnicola lustrica decepta* in its smaller umbilical opening, and its relatively longer whorls, especially the body whorl, and its larger aperture; the whorls are also slightly more shouldered.

L. 4.5; W. 2.0; Ap. L. 1.6; W. 1.5 mm. Lake Mich., Sturgeon Bay (U. of I., Z18365a). Type.
L. 4.3; W. 1.9; Ap. L. 1.9; W. 1.5 mm. Lake Mich., Sturgeon Bay (U. of I., Z18365a). Paratype.
L. 4.5; W. 3.0; Ap. L. 2.0; W. 1.5 mm. Lake Mich., Sturgeon Bay (U. of W., 4535). Paratype.

ANIMAL: Not examined.

ECOLOGY: Shores of Great Lakes.

GENERAL DISTRIBUTION: Probably in nearly all of the Great Lakes. Specimens examined from Lake Superior, Lake Michigan, and Lake Erie.

DISTRIBUTION IN WISCONSIN: Shores of Lakes Superior and Michigan.

Lake Superior: Near Bayfield, Bayfield Co. (Baker).
Lake Michigan: Lake Michigan shore east of Sturgeon Bay, Door Co.; Milwaukee, Milwaukee Co., fossil (Baker).

REMARKS: The *lustrica* of the Great Lakes differs from both the river and small lake form of the species in the manner indicated in the diagnosis. The smaller umbilicus shows its relation to typical *lustrica* and its wide spire indicates its relationship to *decepta.* This variety is a common form on the shores of Lake Michigan and Lake Superior. The fossil forms from Milwaukee are somewhat smaller than specimens in the recent fauna.

The *lustrica* of the Wisconsin region provide an interesting study in ecological variation, each type of shell,—rivers, small lakes, Great Lakes,—being characteristic and typically quite distinct from those of the other habitats. The fact that there are many forms intermediate between each of these variations only serves to more forcibly indicate the plasticity of molluscan life and its response to changing conditions.

AMNICOLA GELIDA F. C. Baker

Plate VI, figures 19–23; text figure 45

Amnicola lustrica var., BAKER, Journ. Geol., XXVIII, p. 448, 1920.
Amnicola lustrica gelida BAKER, Nautilus, XXXV, p. 22, 1921.

TYPE LOCALITY: Morris, Grundy Co., Ill., in Pleistocene deposits.

WISCONSIN RECORDS: None.

SHELL: Rather solid, elongated, narrow; spire elongated, turreted, twice as long as aperture; whorls 6, convex, separated by deep, almost channelled sutures; body whorl comparatively small; aperture roundly ovate, slightly angled above, usually thickened within; peristome continuous, in many cases completely separating the aperture from the body whorl; umbilicus narrow but distinct.

L. 4.9; W. 2.2; Ap. L. 1.2; W. 1.0 mm. Morris, Ill. (U. of I., P926). Topotype.
L. 4.3; W. 2.3; Ap. L. 1.4; W. 1.2 mm. Morris, Ill. (U. of I., P927). Paratype.
L. 4.0; W. 2.5; Ap. L. 1.5; W. 1.3 mm. Morris, Ill. (U. of I., P927). Paratype.
L. 4.9; W. 2.4; Ap. L. 1.7; W. 1.4 mm. Spring Lake (U. of W., 4537).
L. 4.1; W. 2.1; Ap. L. 1.5; W. 1.3 mm. Spring Lake (U. of W., 4537).
L. 3.1; W. 2.0; Ap. L. 1.3; W. 1.1 mm. Spring Lake (U. of W., 4537).

GENERAL DISTRIBUTION: Known from states of Wisconsin, Illinois, and Ohio.

DISTRIBUTION IN WISCONSIN: Known only from Spring Lake, east of Green Lake, Green Lake Co. (Baker).

REMARKS: *Gelida* is a well-marked species of the *lustrica* group, distinguished by its elongated spire, deep sutures, rounded whorls, and small aperture with its thickened peristome. It has been confused with *lustrica,* differing in its narrower spire, smaller aperture and one more whorl in mature specimens. It differs from *oneida* in its angulated aperture, that of *oneida* being rounded above. The Spring Lake specimens have deeper sutures and hence more globose whorls, especially the body whorl, than the typical form from Illinois, but it is doubtless a variation of the *gelida* type. Specimens from Milwaukee, previously referred to *gelida,* are the Great Lake form *lustrica (perlustrica).*

AMNICOLA ONEIDA Pilsbry

Plate VI, figures 24–25, 28–31; text figure 45

Amnicola oneida PILSBRY, Nautilus, XXXI, p. 46, 1917; N. Y. State Coll. For., Tech. Pub. 9, p. 246, 1918.

Amnicola oneida BAKER, Tech. Pub., Coll. For., 9, p. 170, 1918.

TYPE LOCALITY: Lower South Bay, Oneida Lake, N. Y.

WISCONSIN RECORDS: None.

SHELL: Typically slender, thin, conic, turreted; spire elevated, conic, about twice as long as aperture; color corneous to greenish, surface with minute striae of growth; whorls 6, well rounded; sutures deeply impressed or channelled; whorls slowly increasing in diameter; nuclear whorl rounded, slightly granular, somewhat obtuse, corneous, of about one volution, projecting well above the second whorl; the nucleus appears a trifle larger than that of the *lustrica* group; aperture ovate or roundly ovate, small, upper extremity narrowly rounded; peristome thin, continuous, very briefly in contact with the body whorl; base rounded, umbilicus narrowly open.

L. 4.0; W. 2.0; Ap. L. 1.2; W. 1.0 mm. Oneida Lake (Pilsbry's type).
L. 4.3; W. 2.0; Ap. L. 1.4; W. 1.0 mm. " (U. of I., Z22513). Male.
L. 3.2; W. 2.1; Ap. L. 1.4; W. 1.1 mm. " (U. of I., Z22513). Female.

L. 3.0; W. 1.8; Ap. L. 1.2; W. 1.0 mm. Devils Lake (U. of W., 4540). Male.
L. 3.3; W. 1.9; Ap. L. 1.1; W. 1.0 mm. Devils Lake (U. of W., 4540). Male.
L. 2.7; W. 2.0; Ap. L. 1.1; W. 1.0 mm. Devils Lake (U. of W., 4540). Female.

ANIMAL: As in *lustrica.*

JAW: As in *lustrica.*

RADULA (Fig. 49): Formula 30:24:2–1–3:$\frac{4}{1}\frac{1}{1}\frac{4}{1}$:2–1–2:24:30. *Oneida* differs from *lustrica* in the lesser number of cusps on central and lateral teeth.

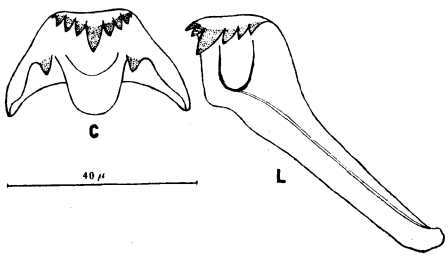

Fig. 49. Radula of *Amnicola oneida.* Oneida Lake.

ECOLOGY: In Oneida Lake this species is abundant among algae, in bays and coves in water of various depths, but principally within the 2 m. line. In Wisconsin it has been found in Devils Lake, sand bottom, 2 m. and 7.1 m. depth, among algae.

GENERAL DISTRIBUTION: Recorded from New York, Michigan, and Wisconsin. Probably the area between these points also contains this species.

DISTRIBUTION IN WISCONSIN: Known only from Devils Lake, Sauk Co. (Baker).

REMARKS: It is surprising to find typical *oneida* in eastern Wisconsin, some hundreds of miles west of its original locality. The Devils Lake specimens are exactly like the New York specimens, though most of the material is immature, and the specimens are thin and fragile, as would be expected in a lake surrounded by quartzite rock.

Certain very narrow specimens of an *Amnicola* were found in Winnebago and Butte des Morts lakes which were thought to be referable to *oneida.* These, however, have an angulation of the upper part of the aperture, and seem referable to *lus-*

trica, probably males, which are much narrower than females. This graceful species is constantly separable from any form of *lustrica* by its very narrow shell and its rounded upper termination of the aperture, which is angled in the *lustrica* group. This distinction also separates it from *gelida,* which has the same number of whorls and a narrow spire. *Gelida* may be ancestral to *oneida.*

AMNICOLA GREENENSIS Var. Nov.

Plate VI, figures 32, 33; text figures 47, 13

TYPE LOCALITY: Off Sherwood Forest Hotel, Green Lake, Green Lake Co., Wis., 10 m. depth.

WISCONSIN RECORDS: None.

SHELL: Large for the genus, rather solid, turreted; surface smooth, with rather coarse lines of growth; spire elevated, conic, longer than aperture; whorls 5½, flatly rounded, somewhat shouldered just below the suture, which is deeply impressed or even channelled; whorls rapidly and regularly increasing in diameter; nucleus small, finely granular, rounded, of one whorl, well raised above the second whorl; aperture ovate or roundly ovate, angled above, the peristome continuous, thin, appressed to the body whorl near the upper part of the aperture; base rounded, with a well-marked, narrow and deep umbilicus.

L. 5.0; W. 3.5; Ap. L. 2.2; W. 1.6 mm.	Type (U. of W., 4544).
L. 4.8; W. 3.0; Ap. L. 2.0; W. 1.5 mm.	Paratype (U. of W., 4545).
L. 5.2; W. 3.2; Ap. L. 2.0; W. 1.5 mm.	" (U. of I., Z16222).
L. 5.3; W. 3.5; Ap. L. 2.3; W. 1.6 mm.	" "

ANIMAL: An extinct species.

ECOLOGY: Unknown.

GENERAL DISTRIBUTION: Not at present known outside of Wisconsin.

DISTRIBUTION IN WISCONSIN: East end Green Lake, Green Lake Co., at depths of 3, 7, 10, and 47 m. (Fox drainage), Baker; Oconomowoc Lake, Waukesha Co., 12 m. (Rock drainage) Cahn.

REMARKS: This fossil species resembles *lustrica* and at first sight appears to be a large form of that species. It differs, however, in its much greater size, longer, more turreted spire, and deeper sutures, hence more convex whorls, and the umbili-

cus is larger and deeper in proportion. It appears almost to have the spire of *gelida* and the body whorl of *lustrica*. It is the largest of the *lustrica* group.

AMNICOLA WALKERI Pilsbry

Plate VII, figures 1–4; text figure 47, 3–5

Amnicola walkeri PILSBRY, Nautilus, XII, p. 43, 1898.
Amnicola walkeri WALKER, Nautilus, XIX, p. 117, pl. v, fig. 12, 1906.

TYPE LOCALITY: High Island Harbor, Beaver Islands, Lake Michigan.

WISCONSIN RECORDS:

1924. *Amnicola walkeri* BAKER, p. 134. Lakes Butte des Morts, Winnebago.
1927a. *Amnicola walkeri* WINSLOW, p. 6. Little Arbor Vitae Lake.

SHELL: Small, thin, conic, translucent; color yellowish-corneous; surface smooth, shining, growth lines very faint, crowded; spire broadly conic, longer than aperture; whorls 4, very convex, regularly and rapidly increasing in diameter; sutures deeply impressed; apex obtuse, the nuclear whorl small, rounded, granular in texture, light corneous or waxy, elevated above second whorl; aperture almost circular, very slightly angled above; peristome continuous, in contact with the body whorl for but a short distance; base rounded, umbilicus wide and deep.

L. 3.0; W. 2.0; Ap. L. 1.2; W. 1.1 mm. Type.
L. 3.0; W. 2.1; Ap. L. 1.2; W. 1.0 mm. Bayfield (U. of W., 4541). Male.
L. 2.5; W. 2.1; Ap. L. 1.2; W. 1.0 mm. " " Female.
L. 2.6; W. 2.0; Ap. L. 1.1; W. 1.0 mm. Winnebago Lake (U. of W., 4542). Male.
L. 2.4; W. 2.1; Ap. L. 1.1; W. 0.9 mm. Winnebago Lake (U. of W., 4542). Female.

OPERCULUM: Similar to that of *lustrica* but rounder with coarse longitudinal and fine spiral striae.

ANIMAL: As in *lustrica*.

JAW: As in *lustrica* and *limosa*.

RADULA (Fig. 50): Formula $30:25:2\text{–}1\text{–}3:\frac{5\text{–}1\text{–}5}{1\quad 1}:2\text{–}1\text{–}3:25:30$. The radula is essentially that of *lustrica*, indicating that the two species group together. The principal differences are in the number of cusps on the central and lateral teeth. The teeth are smaller than those of *limosa*.

ECOLOGY: Winnebago Lake. Miller Bay, gravel bottom, .8 m. deep, among vegetation; Hatchery Bay, sand, .9 m. in veg.; Asylum Bay, mud, .9 m., veg.; Moreley Point Bay, sand-gravel, 2.6 m.; Fahney Bay, gravel, 1.6 m. Lake Butte des Morts, sandy mud, 1.2 m.; mud, 1.2 m., veg. Bayfield, pond behind beach, .3–1 m.; Pike Creek entrance, sand, .3–1 m.

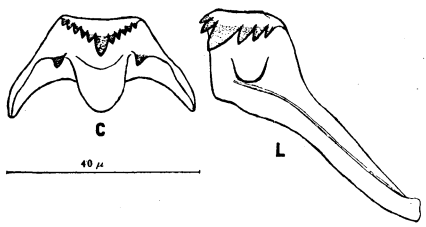

Fig. 50. Radula of *Amnicola walkeri.* Lake Winnebago.

GENERAL DISTRIBUTION: Upper St. Lawrence drainage from Ottawa, Ontario to Lake Michigan (Walker). Also in Mississippi River drainage.

DISTRIBUTION IN WISCONSIN: Localities scattered, but mostly in the eastern part of the State.

Lake Superior: Pond behind beach, mile north of Bayfield; Pike Creek near Salmo, and Chicago Creek entrances, Bayfield Co. (Baker).

Fox River Drainage: Lakes Butte des Morts and Winnebago, Winnebago Co. (Baker).

Wisconsin Drainage: Little Arbor Vitae Lake, Vilas Co. (Winslow); Big Muskallonge Lake, Vilas Co. (Cahn).

Rock Drainage: Lake Wingra, near Madison, Dane Co. (Bullock).

REMARKS: *Amnicola walkeri* may be known by its small size (it is, with *pilsbryi,* the smallest of Wisconsin Amnicolae) and particularly by its very convex, deep-sutured whorls, round aperture, conspicuous umbilicus, and short spire. Male shells are narrower than female shells, but aside from sex variation the shells are remarkably uniform. Small specimens of both *lustrica* and *oneida* are likely to be confused with this species but the aperture of these species is not as round and the whorls are not as convex. Mature shells of each species are easily distinguished by the longer spire and larger size. It should be more widely distributed than the records indicate and it has probably been taken for the young of related species. It should be found in bays on Lake Michigan and in smaller lakes.

AMNICOLA WALKERI FOXENSIS Var. Nov.

Text Fig. 47, 1, 2.

TYPE LOCALITY: Fox River, 1 mile north of Portage, Columbia Co., Wis.

WISCONSIN RECORDS: None.

SHELL: Differing from typical *walkeri* of the lakes in having a smaller, narrower umbilical opening and a relatively narrower form.

L. 2.5; W. 1.9; Ap. L. 1.1; W. 1.0 mm. Type (U. of I., Z18374). Male.
L. 2.4; W. 2.0; Ap. L. 1.1; W. 1.0 mm. Paratype (U. of I., Z18374). Female.

ANIMAL: As in *walkeri.*

RADULA: As in *walkeri.*

ECOLOGY: Margin of river among vegetation in shallow water; Mud Lake, between Okauchee and Forest lakes, Waukesha Co., very soft mud bottom with decomposing vegetation.

GENERAL DISTRIBUTION: Unknown; probably in Michigan, Wisconsin, Illinois, and Indiana, in rivers and associated small lakes.

DISTRIBUTION IN WISCONSIN: Known only from the eastern part of the State.

Fox Drainage: Fox River, 1 mile north of Portage, Columbia Co.; Silver Creek, 1 mile above Green Lake; beach pool, Green Lake, Green Lake Co. (Baker).

Rock Drainage: Mud Lake, near Okauchee Lake, Waukesha Co. (Cahn).

REMARKS: The river form of *walkeri* differs uniformly in the smaller and narrower umbilicus and should be recognized, as in the case of *limosa* and *porata,* the variation being parallel. *Walkeri* is not normally a species of rivers, apparently, for it appears to be rare in such places. The Mud Lake specimens vary toward the widely umbilicated form but are on the whole, more like the river than the lake form.

AMNICOLA PRECURSOR Sp. Nov.

Plate VII, figure 5; text figure 47, 6–9

TYPE LOCALITY: Green Lake, Green Lake Co., 7 m.

WISCONSIN RECORDS:

1913b. *Amnicola walkeri* BAKER, p. 68. Waukesha, Waukesha Co.
1920d. *Amnicola walkeri* BAKER, p. 120. Waukesha.

SHELL: Small, conic; rather thick, surface with rather coarse, close-set growth lines; spire broadly conic, elevated, much longer than aperture; whorls 5½, very convex, regularly but not rapidly increasing in diameter; sutures very deeply impressed; apex obtuse, flattened, the nuclear whorl small, rounded, finely granular in texture, slightly elevated above second whorl; aperture almost circular, slightly angled above; peristome continuous; base rounded, umbilicus wide and deep.

L. 3.0; W. 2.3; Ap. L. 1.4; W. 1.2 mm. Type (U. of I., Z22508). Female?
L. 3.4; W. 2.2; Ap. L. 1.2; W. 1.0 mm. Paratype (U. of I., Z22508). Male?
L. 4.0; W. 2.3; Ap. L. 1.4; W. 1.2 mm. Paratype (U. of I., Z22508). Female?
L. 3.0; W. 2.1; Ap. L. 1.3; W. 1.1 mm. Paratype (U. of I., Z22508). Male?
L. 3.4; W. 2.2; Ap. L. 1.3; W. 1.1 mm. Paratype (U. of W., 4543).

ANIMAL: An extinct species.

GENERAL DISTRIBUTION: Material has been seen only from Illinois and Wisconsin, but it should occur in the Pleistocene deposits of Michigan and Indiana.

DISTRIBUTION IN WISCONSIN: Apparently confined to the eastern part of the State.

Lake Michigan: Canal, Sturgeon Bay, Door Co.; Waukesha, Waukesha Co. (Baker).
Fox Drainage: Green Lake, Green Lake Co. (Baker).
Rock Drainage: Lakes La Belle, Silver, and Oconomowoc, Waukesha Co. (Cahn).

REMARKS: *Precursor* differs from *walkeri* in its larger size, longer spire, which is in many specimens scalariform, rounder whorls and deeper sutures. The apical whorl of *walkeri* is more depressed and half buried in the second whorl, while that of *precursor* is elevated above the second whorl (see fig. 47, 11, 12). The umbilicus is larger than in *walkeri*.

This Pleistocene species is apparently the ancestor of *walkeri*, which has not been observed among Pleistocene fossils from Wisconsin or Illinois. It is abundant in Green Lake, associated with *greenensis* and *leightoni*, both extinct species. It also occurs plentifully in the marl deposits of Waukesha Co., and was evidently a dominant species during late Pleistocene (Wisconsin) time. The whole Amnicoloid fauna of this region has changed materially in late Wisconsin (Wabash) time.

AMNICOLA PILSBRYI Walker

Plate VII, figures 6–8; text figure 47, 10

Amnicola parva MARSH, Conch. Exch., II, p. 91, 1888.
Amnicola pilsbryi WALKER, Nautilus, XIX, p. 116, pl. v, figs. 11, 16, 1906.

TYPE LOCALITY: Rockford, Ill.

WISCONSIN RECORDS: None.

SHELL: Small, globosely conic; color light or brownish; surface dull to shining, lines of growth fine; sutures well impressed, whorls 4–4½, rounded, somewhat globose and slightly shouldered; spire broadly conic, body whorl large; apex flattened, the first two whorls similar to those of *limosa;* sculpture of nuclear whorl as in *limosa;* aperture subcircular, slightly angled above; Peristome thin, continuous, appressed to the body whorl only for a very short distance; base rounded, umbilicus well marked, round, deep.

L. 2.2; W. 2.0; ----------	Type.
L. 2.3; W. 2.0; Ap. L. 1.0; W. 1.0 mm.	Brown Co. (U. of W., 433).
L. 2.5; W. 2.1; Ap. L. 1.1; W. 1.0 mm.	" "
L. 2.5; W. 2.1; Ap. L. 1.1; W. 1.0 mm.	" "

OPERCULUM (Fig. 51): Resembling that of *limosa,* but rounder, with a sinuous left margin.

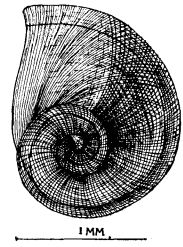

Fig. 51. Operculum of *Amnicola pilsbryi.* Brown Co.

ANIMAL: Not examined.

RADULA (Fig. 52): Formula 30:25:2–1–3:$\frac{4-1-4}{1-1}$:2–1–3:25:30. The teeth of *pilsbryi* are much smaller than those of *lustrica, oneida,* or *walkeri,* the central tooth being about two-thirds as large as that of these species. The cusps are also smaller and finer. Aside from the difference in size the radula is the same as in the species mentioned.

ECOLOGY: In quiet lakes and sloughs.

GENERAL DISTRIBUTION: Wisconsin east to New Philadelphia, Ohio, south to northern Illinois.

DISTRIBUTION IN WISCONSIN: Lawtons Slough, De Pere, Brown Co. (Marston).

REMARKS: This is the smallest species of *Amnicola* found in Wisconsin. It is much like a small *limosa,* as noted by Walker, the umbilicus being like the variety *porata.* It also resembles *walkeri,* differing in its smaller size, less rounded or convex whorls, which are shouldered. The nuclear whorls of the two species are quite different, *pilsbry* having a flattened nuclear whorl while *walkeri* has this whorl well raised above the second whorl. The umbilicus is also narrower than the typical form of *walkeri* but resembles the river form *(foxensis),* which has a smaller umbilicus. *Pilsbryi* is common in Brown

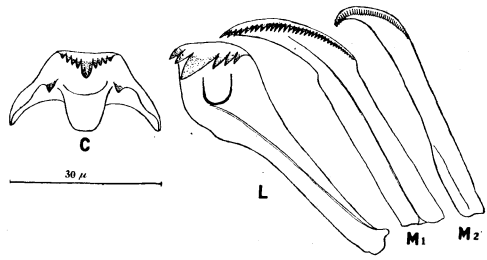

Fig. 52. Radula of *Amnicola pilsbryi.* Brown Co.

County but has not been seen from any other part of the State. In Illinois it is known from the type locality, Rockford, and from Sand and Fox lakes, in Lake Co. Its small size has doubtless caused it to be overlooked or thought to be the young of some other species.

GROUP OF AMNICOLA LEIGHTONI

This extinct species does not seem to group with any of the recent species. It resembles the *limosa* group to some extent, but the nuclear whorl is smaller and not as flat-topped as in that species. It does not group with *winkleyi,* its nuclear whorl being quite different. For the present it must stand in a group by itself. The flat-topped spire, though different from that of the *limosa* group, might admit it to this group.

AMNICOLA LEIGHTONI F. C. Baker

Plate VI, figures 34–39

Amnicola winkley leightoni BAKER, Nautilus, XXXIII, p. 125, 1920.
Amnicola leightoni BAKER, Nautilus, XXXV, p. 23, 1921.

TYPE LOCALITY: Pleistocene deposit near Rush Lake, Logan Co., Ohio.

WISCONSIN RECORDS:

1920d. *Amnicola limosa* BAKER, p. 120. Milwaukee.
1920d. *Amnicola cincinnatiensis* BAKER, p. 120. Milwaukee.

SHELL: Bulbous, conic, turreted, widely umbilicated; surface shining, with fine and crowded lines of growth; sutures deeply impressed; whorls 4½ to 5, inflated, turbinate, well rounded, rapidly increasing in diameter, body whorl large and quite globose; the whorls are frequently somewhat flat-sided just below the suture and this feature is especially marked on the last whorl of some specimens; spire more or less sharply conic, usually elevated and considerably longer than the aperture; nucleus of one whorl, rather flat-topped, but well elevated above the second whorl; aperture roundly ovate, rounded acutely above and broadly below, peristome continuous, sharp, simple, only slightly thickened within the edge; inner lip rather sharp, erect, forming a heavy callus on the parietal wall, from which it is sometimes completely separated; base of shell well rounded; umbilicus widely open.

L. 5.0; W. 3.7; Ap. L. 2.5; W. 2.0 mm.	Topotype (U. of I., P598).
L. 5.0; W. 3.5; Ap. L. 2.3; W. 1.7 mm.	Green Lake (U. of W., 4546).
L. 4.9; W. 3.5; Ap. L. 2.3; W. 2.0 mm.	" (" ").
L. 4.6; W. 3.8; Ap. L. 2.3; W. 2.0 mm.	" (" ").
L. 5.0; W. 3.7; Ap. L. 2.4; W. 2.0 mm.	" (" ").
L. 4.5; W. 3.5; Ap. L. 2.0; W. 1.6 mm.	" (" ").

ANIMAL: Apparently an extinct species.

ECOLOGY: Probably a lake species. In Green Lake it occurs on a marl bottom at depths of 3, 7, 10, 15, and 39 m.; these deposits may have been washed into the lake after the level was raised five or more feet, as the region is underlain by an extensive marl deposit.

GENERAL DISTRIBUTION: Marl deposits in Wisconsin, Michigan, Illinois, Indiana, and Ohio.

DISTRIBUTION IN WISCONSIN: All records are in the eastern part of the State. All are in marl deposits.

Fox Drainage: Silver Creek, Spring Lake, and Green Lake, Green Lake Co. (Baker).

Rock Drainage: Oconomowoc, Ashippun rivers; Lakes Oconomowoc, Dutchmans, Cooks, La Belle, and Silver, Waukesha Co.; Crawfish River, Jefferson Co. (Cahn).

Lake Michigan Drainage: Sturgeon Bay, near Ship Canal, Door Co. (Baker); City of Milwaukee and Bay View, Milwaukee Co. (Slocum).

REMARKS: *Leightoni* may be known from *porata* by its strongly turbinated whorls and particularly by its nuclear whorl which is raised well above the second whorl while in *porata* it is flattened and much smaller (see fig. 47, 14, 15). It is more globose than either *cincinnatiensis* or *judayi,* besides having a differently shaped nucleus. The nuclear whorls are much wider than either *greenensis* or *lustrica* (fig. 47, 13, 16).

This *Amnicola,* first recorded from Ohio marl deposits, proves to be widely distributed in the central west. It is so abundant in the bottom deposits of Green Lake that a single haul of the dredge may bring up two liters of shells, consisting largely of this species. *Leightoni* was at first thought to be a variety of *winkleyi* Pilsbry, a New England species, but the flattened apical whorl is quite different and the whole shell indicates relationship rather with *limosa,* to which group it perhaps belongs. It, with *gelida, precursor,* and other forms, is an extinct species characteristic of late Pleistocene time.

Genus CINCINNATIA Pilsbry, 1891

Cincinnatia PILSBRY, Proc. Phil. Acad. Sci., p. 327, 1891. Type: *Paludina cincinnatiensis* ANTHONY.

SHELL: Large, whorls well rounded, sutures deeply impressed, base widely umbilicated. Animal generally as in *Amnicola.*

Radula much smaller than that of *Amnicola* or *Stimpsonia,* the central tooth two-thirds as wide, high and about half as high as wide, without the ventral tongue-shaped projection of *Amnicola,* the ventral margin being simply broadly lobed; lateral angles produced and sharply triangular; lateral ridge with but one large denticulation, reflection about half as wide as width of tooth, low, denticulations 11, the center cusp three times the size of side cusps, all long, sharp, spade-shaped; lateral teeth with a squarish body and a long, narrow peduncle, almost twice as long as body of tooth, but basal margin of tooth

without tongue-shaped lobe; but there is a slight swelling in this region; there is a distinct ridge parallel with the long axis of the peduncle, and a large pit in the center of the body of the tooth; reflection wide, rather low, and multicuspid, 4–5 cusps on the inner side and 7–9 cusps on the outer side of a large central cusp, all cusps being long and very narrow and sharp: first marginal falcate, long and narrow, with a ridge extending parallel with the long axis; reflection very wide, multicuspid, the cusps small, narrow, sharp; second marginal somewhat spoon-shaped with a narrow body, the reflection multicuspid, the cusps being very small.

By most authors *Cincinnatia* has been considered a section or subgenus of *Amnicola*. The radula is so different, however, from either *Amnicola* or *Stimpsonia* as to forbid its reference to either. Several authors have raised the group to generic rank without giving any reasons, and without even quoting the diagnostic criteria given by Pilsbry. The radula is unlike that of any other American group published, approaching *Prygulopsis* in some respects.

Group of Cincinnatiensis

Nuclear whorl well raised above the second whorl, spire acute.

CINCINNATIA CINCINNATIENSIS (Anthony)

Plate VI, figures 40, 41; plate VII, figures 15–17

Paludina cincinnatiensis Anthony, Bost. Jour. Nat. Hist., III, pt. 1–2, p. 279, pl. iii, fig. 3, Jan. 1840.

Amnicola cincinnatiensis Haldeman, Monograph, p. 9, pl. i, fig. 4, 1844.

Amnicola cincinnatiensis W. G. Binney, L. & F. W. Sh., N. A., III, p. 85, 1865.

Amnicola scarboroughii Tryon, MS, Con. Hald. Mon., p. 54, 1870.

Type Locality: Canal at Cincinnati, Ohio.

Wisconsin Records:

1906. *Amnicola cincinnatiensis* Chadwick, p. 88. Milwaukee River at Lindwurm; Menomonee River dredgings.

Shell: Of good size, umbilicated, rather solid; color ranging from greenish to yellowish brown, sometimes darker; surface smooth and shining, lines of growth well developed,

crowded, rather coarse, sutures deeply impressed; nucleus very small, rounded, granular, brownish, well raised above the second whorl; spire broadly conic, elevated; whorls 5–6, rapidly increasing in diameter, rounded, somewhat shouldered below the suture, the last somewhat loosely coiled so that the aperture is continuous and separated from the body whorl; aperture roundly ovate, narrowed above, bluish-white within; peristome continuous, simple, sharp, touching the body whorl only at the upper part for a short distance; base rounded, with a rounded, deep umbilicus.

L. 4.7;	W. 3.4;	Ap. L. 2.3;	W. 2.0 mm.	DePere	(U.	of	W.,	474).
L. 4.6;	W. 3.4;	Ap. L. 2.2;	W. 2.0 mm.	"	(	"		").
L. 4.2;	W. 3.1;	Ap. L. 2.0;	W. 1.8 mm.	"	(	"		").
L. 5.2;	W. 3.6;	Ap. L. 2.5;	W. 2.0 mm.	"	(	"		439).
L. 5.0;	W. 4.0;	Ap. L. 2.5;	W. 2.0 mm.	"	(	"		439).

OPERCULUM: Similar to that of *limosa,* but without spiral striation.

ANIMAL: Generally as in *limosa* externally. Color yellowish-white above, lighter on base of foot; subtransparent; rostrum short; tentacles, eyes, and verge as in *Amnicola limosa.*

JAW: As in *limosa.*

RADULA (Fig. 53): Formula 40:30:5–1–9:$\frac{5-1-5}{1-1}$:5–1–9:30:40. See generic description.

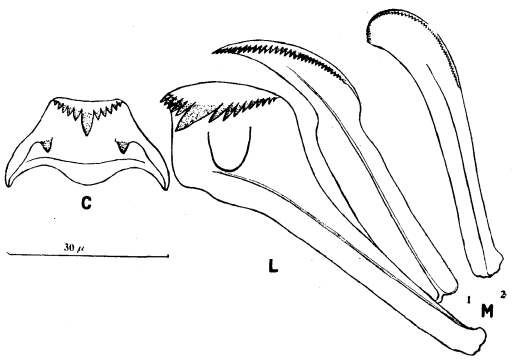

Fig. 53. Radula of *Cincinnatia cincinnatiensis.* Joliet, Ill.

ECOLOGY: *Cincinnatiensis* is largely a species of rivers. It appears to be rare in Wisconsin and ecological data are not extensive. Mukwonago River, gravel bottom, swift current, water few cm. to .5 m. deep. Mukwonago Creek, gravel bottom,

water clear, water about 15 cm. deep. Ashippun River, gravel bottom with some silt, water about .5 m. deep (Cahn).

GENERAL DISTRIBUTION: New York and eastern Penn., west to Utah, Wisconsin south to Texas. Inhabits nearly the whole of Illinois.

DISTRIBUTION IN WISCONSIN: At present known only from the eastern part of the State.

Lake Michigan Drainage: Milwaukee and Menomonee rivers, Milwaukee Co. (Chadwick).

Fox Drainage: Lower Fox River, near De Pere, Brown Co. (Marston).

Rock Drainage: Ashippun and Oconomowoc rivers, Waukesha Co.; Crawfish River, Jefferson Co. (fossil); Neosho mill pond, Dodge Co. (Cahn).

Fox Drainage (Illinois): Mukwonago River and Mukwonago Creek, Waukesha Co. (Cahn).

REMARKS: *Cincinnatia cincinnatiensis* is the largest of the Amnicoloid group, specimens from the Pecatonica River, Illinois, attaining a length of 6 mm. Wisconsin specimens are somewhat smaller. This species is easily known by its large size, solid shell, elongated, conic spire with shouldered whorls, and deep umbilicus. As suggested by Haldeman, it resembles a miniature *Campeloma ponderosum,* or, more nearly, perhaps, some forms of *Campeloma subsolidum.*

CINCINNATIA CINCINNATIENSIS JUDAYI (F. C. Baker)

Plate VI, figures 42, 43

Amnicola judayi BAKER, Nautilus, XXXVI, p. 19, 1922.

TYPE LOCALITY: Off Doemel Point, Lake Winnebago.

WISCONSIN RECORDS:

1906. *Amnicola cincinnatiensis* CHADWICK, p. 88. Lake Winnebago, west High Cliff, Calumet Co.

1922b. *Amnicola judayi* BAKER, p. 20. Off Doemel Point, Lake Winnebago.

1924. *Amnicola judayi* BAKER, p. 134. Lakes Winnebago and Butte des Morts.

SHELL: Ovate-conic, rather wide, widely umbilicated, with rather more than 5 very convex whorls separated by deeply channelled sutures; whitish or corneous, sometimes light brown, lightly striate longitudinally; apex acute; nuclear whorls as in *cincinnatiensis;* aperture roundly ovate, a trifle ob-

lique; peristome continuous, somewhat flattened where it is in contact with the preceding whorl.

L. 5.0; W. 3.3; Ap. L. 2.0; W. 1.6 mm. Lake Winnebago (U. of I., Z12561). Male.
L. 4.4; W. 3.1; Ap. L. 2.0; W. 1.6 mm. Lake Winnebago (U. of I., Z12561). Female.
L. 4.2; W. 3.0; Ap. L. 2.0; W. 1.5 mm. Lake Winnebago (U. of W., 4549).
L. 4.8; W. 3.5; Ap. L. 2.1; W. 1.7 mm. Lake Winnebago (U. of W., 4549).
L. 4.1; W. 3.0; Ap. L. 2.0; W. 1.4 mm. Lake Winnebago (U. of W., 4549).

OPERCULUM: As in *cincinnatiensis.*

ANIMAL: As in *cincinnatiensis.*

JAW: As in *cincinnatiensis.*

RADULA: Formula 40:30:4–1–9:$\frac{6}{1}\frac{1}{1}\frac{6}{}$:4–1–9:30:40. Form generally as in *cincinnatiensis.* The cusps on the second marginal are so small as to be seen only with very high powers (600 diameters). The figure of *cincinnatiensis* in the Mollusca of the Chicago Area (p. 336) is quite inaccurate and could not have been made from the radula of this species, which is different from any other type of Amnicoloid found in America.

ECOLOGY: Lake Winnebago habitats are as follows: off Doemel Point, fine gravel bottom, 2.8 m., 3.4 m.; Miller Bay, sand, 2.2 m.; off Long Point Island, gravel, 1.5 m.; Moreley Point Bay, gravel and sand, 2.5 m.; half mile from shore, off Oshkosh, sand and gravel with detritus, 2.8 m. In Lake Butte des Morts, mostly on mud bottom, 1 to 1.5 m. In the latter lake the specimens were among vegetation, but in Lake Winnebago they were collected from the bottom where there was no vegetation but considerable detritus, which probably provided food.

GENERAL DISTRIBUTION: Not known outside of eastern Wisconsin.

DISTRIBUTION IN WISCONSIN: At present known only from the Fox River drainage. Lakes Butte des Morts and Winnebago, Winnebago Co. (Baker); west of High Cliff, Lake Winnebago, Calumet Co. (Chadwick).

REMARKS: *Judayi* appears to be a lake form of *cincinnatiensis,* distinguished by being smaller, with more rounded whorls, deeper sutures, and a wider umbilicus. In many specimens the whorls are quite turban-shaped, separated by deeply

channelled sutures. This Amnicoloid was at first thought to be a distinct species, but the presence of intermediate forms in the lower Fox River, near DePere, indicate its relationship to *cincinnatiensis,* with which it also agrees in its radula. *Judayi* is one of the handsomest and most graceful of the species of this interesting genus. It is dedicated to Professor Chancey Juday, of the University of Wisconsin.

GROUP OF EMARGINATA

Spire sharply truncated, the three first spire whorls coiled in the same plane and resembling a small *Planorbis* when viewed from above. This species is so very unlike the other American species that it demands a place in a group by itself.

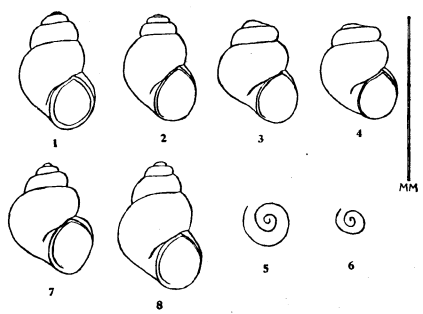

Fig. 54. 1, 2. *Cincinnatia emarginata,* Posey Co., Ind. (U. of I., Z17764); 3, 4. *Cincinnatia emarginata lacustris* Var. Nov. Lake Winnebago. Type and paratype (U. of W., 4531); 5, Apex of *lacustris* from above; 6. Apex of *emarginata* from above; 7, 8. *C. emarginata canadensis* Var. Nov. Lake Kakiska. Type and paratype (U. of I., Z22510). Camera lucida drawings.

CINCINNATIA EMARGINATA (Küster)

Text figures 54, 1, 2

Paludina obtusa LEA, Proc. Amer. Phil. Soc., II, p. 34, 1841 (non Phil. 1837).

Paludina emarginata KÜSTER, Paludina, Conch. Cab., p. 50, pl. x, figs. 3, 4, 1852.

Paludina emarginata BINNEY, L. & F–W., Sh. N. A., III, p. 86, fig. 169, 1865.

Bythinella obtusa BINNEY, Op. Cit., p. 70, fig. 138, 1865.

Cincinnatia emarginata WALKER, Nautilus, XV, p. 30, 1901.

Cincinnatia binneyana HANNIBAL, Proc. Mal. Soc., X, p. 190, 1912.

TYPE LOCALITY: Ohio *(obtusa)*; North America *(emarginata)*.

WISCONSIN RECORDS: None.

SHELL: Elongate-ovate, rather solid; color greenish or brownish horn; surface smooth, shining, lines of growth very fine; spire broadly conic, appearing truncated at the apex; whorls about 5, three full turns showing in lateral view, flatly convex, separated by deep sutures; apex and first whorl coiled in the same plane forming a flat apex resembling a small *Gyraulus*, the whorls separated by deep sutures; nucleus of about one small whorl, rounded, granular; aperture ovate, slightly angled above; peristome continuous, thin to very thick on the inside, tightly appressed to the parietal wall; base rounded with a narrow umbilicus which the inner lip sharply emargines.

L. 3.7; W. 2.2; Ap. L. 1.6; W. 1.1 mm. Posey Co., Ind. (U. of I., Z17764).
L. 3.2; W. 2.2; Ap. L. 1.6; W. 1.2 mm. " "

ANIMAL: See under lake variety.

ECOLOGY: Typical *emarginata* is a species of rivers.

GENERAL DISTRIBUTION: New York west to Iowa, Winnepeg and Hudson Bay south to Kentucky and Arkansas. This range may be enlarged, especially to the south. In Illinois, it occurs in the northern part of the state.

REMARKS: *Emarginata* is easily distinguished by its peculiarly truncated flat-topped spire. The species has been little understood by the majority of students, Binney, placing *emarginata* as a synonym of *cincinnatiensis* and *obtusa* as a species of *Bythinella*. Walker (1901, p. 30) first properly differentiated the species and indicated that *emarginata* and *obtusa* were founded upon the same type of shell. The typical river form has not yet been found in Wisconsin. Specimens from the Mohawk River in New York are the largest seen, measuring 5 mm. in length.

CINCINNATIA EMARGINATA LACUSTRIS Var. Nov.

Plate VII, figures 20, 21; text figure 54, 3, 4

TYPE LOCALITY: Winnebago Lake, near Oshkosh.

WISCONSIN RECORDS:

1906. *Amnicola emarginata* CHADWICK, p. 88. North shore Lake Winnebago, west of High Cliff.

1924. *Amnicola emarginata* BAKER, p. 134. Lakes Winnebago and Butte des Morts.

SHELL: Differing from typical *emarginata* in being more globose, the truncated spire is twice as wide, (see fig. 54, 5, 6) exhibits one more whorl in the plane and the sutures are much deeper; from a lateral view *lacustris* shows but two full whorls, *emarginata* shows three; the body whorl is wider and more globose and the umbilicus is quite wide, deep, and conspicuous.

L. 3.5; W. 2.5; Ap. L. 1.6; W. 1.3 mm. Lake Winnebago (U. of W., 4531). Type.
L. 3.8; W. 2.5; Ap. L. 1.9; W. 1.4 mm. Lake Winnebago (U. of W., 4531). Paratype.
L. 3.0; W. 2.4; Ap. L. 1.5; W. 1.1 mm. Lake Winnebago (U. of W., 4531). Paratype.

OPERCULUM: Like that of *limosa* with spiral lines.

ANIMAL AND GENITALIA: Similar to *limosa*. The animal has been observed to elongate the auricled front of the foot to such an extent as to cause the two lobes to resemble tentacles, as shown in fig. 56 A. This feature has been noted in species of *Amnicola*.

JAW: As in *limosa*.

RADULA (Fig. 55): Formula $40:30:4\text{–}1\text{–}7:\frac{5\text{–}1}{1\text{–}1}:\frac{5}{4\text{–}1\text{–}7}:30:40$. The radula is like that of *cincinnatiensis*, the central tooth, however, being higher and larger, and the lateral tooth relatively larger. Otherwise the teeth are similar and the species is correctly referred to *Cincinnatia*.

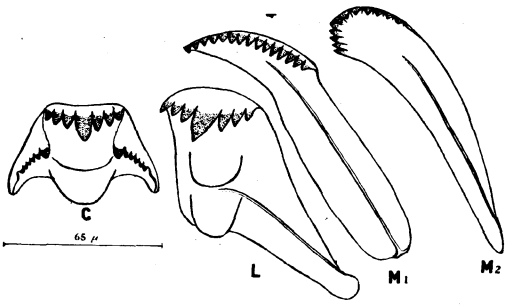

Fig. 55. Radula of *Cincinnatia emarginata lacustris*. Winnebago Lake.

ECOLOGY: *Lacustris*, as its name signifies, is a lake form. Some specific habitats are listed below: Winnebago Lake; Off Doemel Point, gravel bottom, 3.4 m.; off Asylum Point, sand and gravel, 2.8 m.; Miller Bay, sand and gravel, 2.2 m.; Fahney Bay, mud, 0.6 m.; Long Point Island, gravel, 0.8 to 1.5 m.;

Moreley Point Bay, sand and gravel, 2.5 m.; in Lake Butte des Morts, boulder bottom, 0.5 m., and mud bottom with vegetation, 1.9 m.

GENERAL DISTRIBUTION: The variety has been seen only from Wisconsin. It doubtless occurs in many other places.

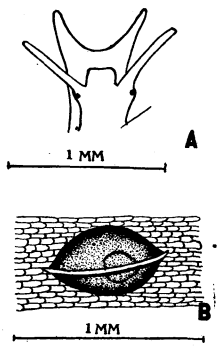

Fig. 56. A, Head of *Cincinnatia emarginata lacustris*, Winnebago Lake. B, Egg capsules of *Amnicola lustrica*. Winnebago Lake.

DISTRIBUTION IN WISCONSIN: Apparently confined to Lake Winnebago.

Fox Drainage: Lakes Winnebago and Butte des Morts, Winnebago Co. (Baker); west of High Cliff, Lake Winnebago, Calumet Co. (Chadwick); Fox River, near DePere, Brown Co. (Marston).

REMARKS: *Emarginata lacustris* may be at once known by the peculiar truncated appearance of the spire and the coiling in one plane of the first two or three whorls. This feature is slightly developed in the *Amnicola limosa* group, but only the first whorl is affected. This form is the most characteristic and easily determined Amnicoloid in the state. The radula allies this species with *cincinnatiensis*, but the shell is very distinctive and quite different from that of any other *Cincinnatia*.

Emarginata is apparently divisible into several forms. One, the typical form, known as *emarginata* Küster (= *Bythinella obtusa* Lea, preoccupied), has a rather long spire which regularly tapers to a blunt, truncated apex, the shell is rather narrow with flattened whorls, and the umbilicus is either a very small chink or but slightly open. This form is abundant in rivers and creeks. Another form is wider, has rounder whorls,

is shorter, the apex is more flatly truncated and the whorls at the truncation are notably wider, the sutures are deeper, and the umbilicus is rather widely open, the aperture being attached to the body whorl only for a short distance above, while it is tightly connected at this place in the typical form. Viewed from the apex, the truncation of the spire is twice as wide as in the typical form (fig. 54, 5, 6). This variety occurs in lakes. It is another example of the ecological law that river species and lake species differ in form, reflecting the change in the environment. The differences here are rather distinct and striking and few intermediate forms have been seen. The variety will probably be found in all the Great Lakes and in some smaller ones which have a wave-beaten shore, which appears to be the normal habitat of *lacustris*. There is some variation in size in both type form and variety, but this is to be considered as individual variation. See Walker, 1901, p. 30 for notes on *emarginata*. Walker was the first student to properly differentiate the species and the relationship of *obtusa* and *emarginata*.

In the northern part of the Mackenzie River district in British America there occurs a large form of *emarginata* which differs from both the river and lake forms of the United States. The shell is larger, with three full whorls showing in lateral profile; the apex is narrower than in *emarginata*, the nuclear whorl being raised somewhat above the second whorl; the whorls are rounder; and the umbilicus is large like the lake form. This variety may be known as

CINCINNATIA EMARGINATA CANADENSIS Var. Nov.

Text figures 54, 7, 8

TYPE LOCALITY: Lake Kakiska near mouth of Beaver River, west of Great Slave Lake, about latitude 61°.

L. 4.0; W. 2.6; Ap. L. 1.8; W. 1.3 mm. Type (U. of I., Z22510). Male?
L. 3.4; W. 2.8; Ap. L. 1.8; W. 1.3 mm. Paratype (U. of I., Z22510). Female?

DISTRIBUTION: Specimens have been seen from Beaver Lake and Little Lake, Mackenzie District. It is possible that some of the data of Dall (Alaska, Moll., p. 118) may belong to this variety.

This large form of *emarginata* differs notably from the river form of the northern part of the United States and should be

differentiated. It is a lake form, apparently, in which the umbilicus has become larger and the spire relatively lengthened, instead of shortening up, as in the shells from Winnebago Lake. All of the localities are in the water shed of Great Slave Lake, hence in the Mackenzie River drainage to the Arctic Ocean. The specimens were collected by Mr. E. J. Whittaker, of the Canadian Geological Survey.

Genus STIMPSONIA Clessin, 1878

MALAK. BLATTER, XXV, p. 151, 1878. Type: *Paludina nickliniana* LEA.

SHELL: Small, elongately ovate or turreted, smooth and shining, usually with an elevated spire; apex usually pointed; aperture ovately rounded, peristome continuous; slightly rimate or imperforate. Operculum corneous, paucispiral, the nucleus large and placed at the left near the basal margin.

Animal with a narrow foot, rounded behind; tentacles tapering, but blunt; verge trifid, with a long flagellum and a sausage-shaped blind sac. Radula with a high, wide central tooth, a single basal denticle, a distinct tongue-shaped projection on the lower margin, and a reflection with rather small denticulations; lateral teeth large, with distinct ventral lobe and a wide peduncle, and large, pointed cusps on the reflection; marginals falcate, multicuspid.

The nomenclature of the group including the shells variously referred to *Hydrobia, Bythinella,* and *Paludestrina* is greatly involved. As stated by Pilsbry (1899, p. 335) there will probably be a number of recognizable genera when the penes of the various groups are examined. *Stimpsonia* with *nickliniana* as type has been relegated to the synonymy of *Paludestrina* by most recent authors and the shell does not differ materially from any of the various forms referred to this genus. A number of species have been found to differ radically in the genitalia. The type of *Paludestrina* (*Paludina acuta* Drap.) has a bifid penis as in *Bulimus,* and therefore *Stimpsonia* with the curious trifid penal organ cannot be referred to this genus. *Paludestrina minuta* (Totten) is said to have a simple penis, but the flagellum sheath may be found to be present on more careful examination. The common European species *P. jenkinsi* has been observed to be parthenogenetic which would remove it from the genus *Paludestrina.* Possibly it should be

placed in *Potamopyrgus,* as suggested by Pilsbry (1920, p. 72; see also Boycott, 1919, p. 54; Quick, 1919, p. 97). No other species known to the writer has the trifid verge.

STIMPSONIA NICKLINIANA (Lea)

Plate VII, figures 9–12

Paludina nickliniana LEA, Trans. Amer. Phil. Soc., VI, p. 92, pl. xxii, fig. 109, 1839.

Bythinella nickliniana BINNEY, L. & F–W., Sh. N. A., III, p. 68, fig. 133, 1865; STIMPSON, Researches, p. 19, 1865.

Paludestrina nickliniana BAKER, Moll. Chi. Area., p. 338, pl. xxvi, fig. 11, 1902.

TYPE LOCALITY: Hot Springs, Virginia.

WISCONSIN RECORDS: None.

SHELL: Elongately ovate, turreted; color greenish-horn, or whitish under a black coating; surface shining, lines of growth numerous, crowded, rather rough in some specimens; whorls 5, very convex, separated by deep sutures; spire elevated, rather sharply conical; nucleus small, flattened, granular, partly concealed by the second whorl; aperture roundly ovate, only slightly narrowed above; peristome continuous, sharp, a little thickened on the inside, appressed to the parietal wall for a considerable distance; inner lip somewhat rounded over the umbilical region; base of shell rounded, umbilical region rimate and indented, but not umbilicated.

L. 4.1; W. 2.1; Ap. L. 1.7; W. 1.3 mm. Michigan City, Ind. (U. of I., Z16524).

L. 4.1; W. 2.1; Ap. L. 1.6; W. 1.3 mm. Michigan City, Ind. (U. of I., Z16524).

L. 3.2; W. 1.8; Ap. L. 1.4; W. 1.0 mm. Michigan City, Ind. (U. of I., Z16524).

L. 3.3; W. 1.9; Ap. L. 1.2; W. 1.0 mm. Michigan City, Ind. (U. of I., Z16524).

OPERCULUM (Fig. 57): Corneous, paucispiral, ovate, very broad, lower and right side convex, rounded upward into a sharp apex, the left side almost straight; rather more than two volutions; sculpture consisting only of growth lines, which are heavy and more or less equidistant; nucleus large, apparently without striae, more or less granular, placed about a third of the distance from base to apex, somewhat toward the left side.

The attachment to the operculigerous lobe shows as a faint ridge on the under surface of the operculum.

ANIMAL: With small foot, about as long as last whorl, rounded behind, somewhat squarish before, light gray blotched with dark spots; rostrum long, capable of great extension when feeding, black, somewhat lighter at the distal end; tentacles

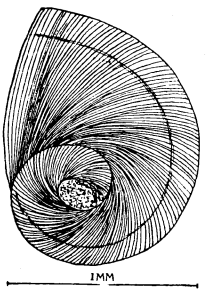

Fig. 57. Operculum of *Stimpsonia nickliniana.* Chicago.

rather long, cylindrical, slightly tapering, blunt at the end, gray and translucent; eyes placed on large swellings at the outer side of the base of the tentacles, black, with a white streak around each eye; the foot can be doubled longitudinally, producing a deep trough. Progression is rather slow and jerky, the snout or rostrum always in action feeling about for food, somewhat in a rooting fashion.

GENITALIA (Fig. 58): Male organs. Verge trifid, consisting of a penis sheath, flagellum sheath, and a sheath for a blind sac; vas deferens long and of large diameter, entering the largest of the sheaths which is at the right side; at the left side there is a long flagellum, emerging from the sheath as a very small, delicate tube, but gradually enlarging until it forms a sac-like organ; between these two organs—the vas deferens and the flagellum—there is a large, blind-sac, which is as long as the entire verge and much wider than the vas deferens, and enters its sheath by a very wide duct. All three organs are independent, having no visible connection. What may be the function of the blind-sac between the penis and the flagellum is not clear. Nothing like it has been seen in any member of the Amnicolidae. The verge is always trifid, but the shape of the three sheaths may vary greatly, as shown in the figures. Dissections were made in late April and about twenty-five specimens examined.

Female organs. Apparently the same as in *Bulimus,* excepting that the uterus is very wide, occupying a large part of the last whorl of the shell. At the time of examination, all organs were much enlarged, indicating breeding activity.

JAW: Of small imbricated plates as in *Amnicola.*

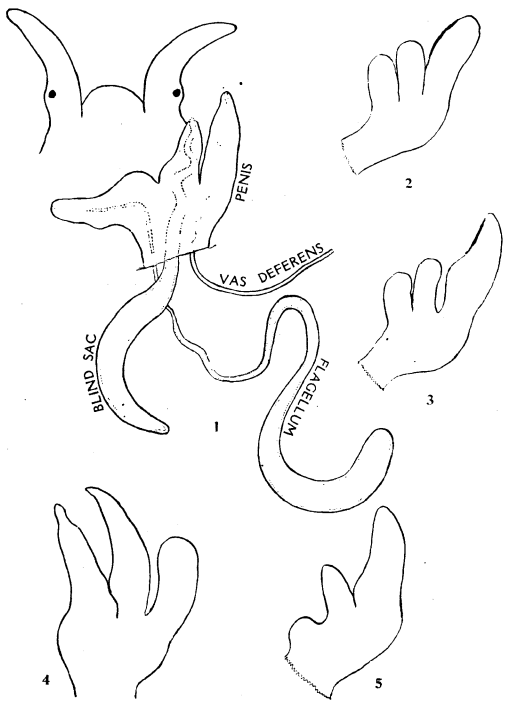

Fig. 58. Genitalia of *Stimpsonia nickliniana.* Champaign Co., Ill.

RADULA (Fig. 59) : Formula 40 :25 :2–1–4 :$\frac{4-1-1-4}{1-1}$:2–1–4 :25 :40. Central tooth twice as wide as high, lateral angles produced, lower margin with a distinct, narrow, tongue-shaped projection as in *Amnicola;* lateral angles and sides with a ridge bearing a single large cusp near the upper part (there is sometimes a small, indistinct cusp below) ; reflection wide and low, 9-cuspid, center cusp about three times as large as side cusps, all cusps sharply spade-shaped; lateral teeth subquadrate, longer than wide, with a wide peduncle about twice as long as the body of the tooth, and with a sharply rounded lobe below the tooth and on the upper part of the body; there is a distinct ridge which

extends parallel with the long axis of the peduncle, and a large pit in the center of the tooth; reflection wide, with two inner and four outer cusps bordering a large central cusp: first marginal falcate, with a long and narrow body on which are several ridges; reflection wide and very low, with about 25 small, acute cusps: outer marginal very narrow with about 40 very fine denticulations; there is a wide expansion of the lower part of the body of this tooth.

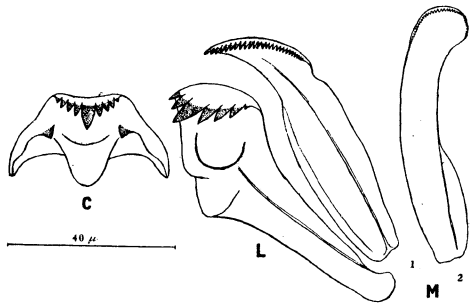

Fig. 59. Radula of *Stimpsonia nickliniana*. Chicago.

The radula of *nickliniana* differs from that of *Amnicola* in the shape of the central tooth, which has but one large denticle on the lateral ridge, the lateral tooth has a somewhat differently shaped peduncle, and the lobe is differently situated. The two types of teeth, however, are similar. The figure given in this monograph differs somewhat from that of Stimpson (1865, fig. 9). The central tooth has a central tongue-shape appendage, not indicated by Stimpson, and the peduncle of the lateral tooth differs slightly. Stimpson's formula is $0:12:6:\frac{3-1}{1-1}\frac{3}{}$ which is quite different from the specimens examined by the writer.

ECOLOGY: *Nickliniana* is a species of small ponds, creeks, and streams among water plants, especially water cress, where they are usually very abundant. Lea's types came from a "rivulet where the channel is supplied by the waters of a hot and cold spring".

GENERAL DISTRIBUTION: Eastern part of the United States from Michigan south to Florida. Recorded from the northern part of Indiana and Illinois.

DISTRIBUTION IN WISCONSIN: *Nickliniana* has not yet been seen in any collections from Wisconsin, nor is it recorded by

any student. As it occurs in the Chicago Area it should be found in southeastern Wisconsin.

REMARKS: *Stimpsonia nickliniana* may be distinguished from narrow forms of *Amnicola* (as *lustrica, oneida, gelida*) by its rimate or imperforate base. The radula is also different from that of *Amnicola.* This tiny species is usually very abundant in small streams and ditches, where it congregates by thousands on such plants as the water cress, a single mass of cress frequently being black with these shells. They are a nuisance to the housewife, who usually thinks they are harmful, and takes the utmost pains to eradicate every specimen from the plants before preparing the cress for the table. The absence of this species from Wisconsin collections is noteworthy and should stimulate search in favorable localities. It was not observed by the writer in any of his field work in the State.

The peculiarity of the trifid verge removes this species from the genus *Paludestrina* where it has been placed by most recent writers. The breeding habits of this species are unknown and are probably of great interest. The function of the peculiar blind sac is not easily accounted for. It may be an additional stimulating organ, as in the case of the flagellum. The most noteworthy feature is the independent opening of each organ at the end of a separate division of the verge. It is evident that there are many interesting and unique features of the genitalia of the Amnicolidae which are yet to be disclosed by anatomical examination.

STIMPSONIA NICKLINIANA ATTENUATA (Haldeman)

Plate VII, figures 13, 14

Amnicola attenuata HALDEMAN, Mon. pt. 4, p. 3 of wrapper (1842); Mon. p. 22, pl. 1, fig. 13, 1844 (named *elongata* on plate).
Bythinella attenuata BINNEY, L. & F–W. Sh. N. A., III, p. 68, fig. 132, 1865.

TYPE LOCALITY: Montgomery Co., Virginia.

WISCONSIN RECORDS: None.

This variety of *nickliniana,* distinguished by its long spire with deep sutures, and well rounded whorls, almost round and continuous aperture, and more numerous whorls (6–7), has not yet been found in Wisconsin. A tray of this variety is in the

Hinkley collection of the University of Illinois marked Illinois, a location much west of its recorded distribution. That the form may be known, if seen in Wisconsin, the Illinois variety is figured. It seems to be undoubted *attenuata*. Measurements are shown below:

L. 5.5; W. 2.3; Ap. L. 1.7; W. 1.3 mm. Illinois (U. of I., Z16525).
L. 4.4; W. 2.0; Ap. L. 1.5; W. 1.1 mm. " "

Genus PYRGULOPSIS Call and Pilsbry, 1886

Pyrgulopsis CALL and PILSBRY, Proc. Daven. Acad. Nat. Sci., V, p. 9, 1886. Type: *Pyrgula nevadensis* STEARNS.

SHELL: Ovate-conical or turreted, imperforate, whorls usually having a single strong carina at the periphery, which may or may not be concealed on the spire; apex acute, whorls 4½ to 6; aperture ovate, peristome usually continuous; operculum ovate, thin, corneous, subspiral, without spiral striae.

Animal not described. Radula with central tooth about twice as broad as high, with a rounded lobe on the ventral border, sharply attenuated lateral angles, a single large basal denticle, a high, wide reflection with 4 small cusps on either side of a very large, long cusp the point of which is opposite the end of the basal denticles or near the margin of the ventral border; lateral teeth hatchet-shaped with a long, narrow peduncle which bears a distinct ridge extending its entire length, with a small, acutely rounded lobe at the inner base and with a wide, rather high reflection, which bears 2–3 inner and 4–5 outer cusps on either side of a large central cusp, all cusps being long and sharp; there is a distinct pit in the center of the body of the lateral tooth; marginals more or less falcate, multicuspid, both with heavy ridges extending parallel with the long axis of the tooth.

Pyrgulopsis appears to be a very characteristic genus quite distinct from any other group of Amnicolidae. As far as known it is restricted to America.

KEY TO SPECIES OF PYRGULOPSIS

1. Shell with distinctly carinated or angulated periphery--*scalariformis*
2. Shell with but a slight indication of angulation on the periphery ---------- *letsoni*

PYRGULOPSIS SCALARIFORMIS (Wolf)

Plate VII, figures 24–27

Pyrgula scalariformis WOLF, Amer. Jour. Conch., V, p. 198, pl. 17, fig. 3, 1869.

Pyrgulopsis scalariformis SHIMEK, Bull. Lab. Nat. Hist., State Univ. Iowa, II, p. 168, pl. xiii, figs. 3a–d, 1892.

Pyrgulopsis mississippiensis CALL and PILSBRY, Pr. Davenport Acad. Sci., V, p. 13, pl. 13, figs. 14–16, 1886; WALKER, Nautilus, XIX, p. 116, pl. 5, fig. 15, 1906.

TYPE LOCALITY: *Scalariformis,* Illinois River, Tazewell Co., Ill.; *mississippiensis,* Rock River, near Mississippi River, Rock Island Co., Ill.

WISCONSIN RECORDS: None.

SHELL: Small, conic, imperforate, solid, thick; color yellowish horn; surface with coarse lines of growth; whorls 5½ to 6, flattened, with a well marked carina on lower third, which becomes central on the periphery of the last whorl; body whorl equal to half the entire length of shell and bluntly angled at position of carina; sutures distinct, deeply impressed only at commencement of last whorl and below, above last whorl covered by carina; spire acute; aperture narrowly ovate, broadly rounded below acutely angled above, very oblique; peristome sharp, continuous, slightly separated from the parietal wall; columellar lip thickened; base of a shell angular, umbilical region imperforate.

L. 3.58; W. 1.6; Ap. L. -- W. --	Types (Call & Pilsbry, p. 13).
L. 3.38; W. 1.5; Ap. L. -- W. --	" " "
L. 3.50; W. 1.6; Ap. L. -- W. --	" " "
L. 3.40; W. 1.6; Ap. L. -- W. --	" " "
L. 3.5 ; W. 1.4; Ap. L. 1.1; W. 1.0 mm.	Rock R. (U. of I., Z16523).

OPERCULUM (Fig. 60): Ovate, thin, paucispiral; basal and right margins rounding upward to meet a sharp apex; left side only slightly convex; sculpture of coarse growth lines, without spiral striation; rather more than two complete turns in mature operculum; nucleus situated about a third of the distance from base to summit, near the left or columellar margin; nucleus rather small.

ANIMAL: Not examined or described (as far as known).

JAW: Thin, with pectinated plates, as in *Amnicola.*

RADULA (Fig. 61) : Formula 30 :18 :3–1–5 :$\frac{4-1}{1-1}$:4 :3–1–5 :18 :30. The central tooth is about the size of that of *Amnicola lustrica* and smaller than that of *Amnicola limosa.* Description generally as in the generic diagnosis. As *scalariformis* is an extinct species, as far as the original material is concerned, it is impossible to know what the radula may have been. A *Pyrgu-*

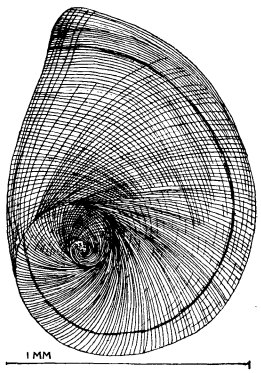

Fig. 60. Operculum of *Pyrgulopsis scalariformis.* Shoal Creek, Ala.

lopsis from Alabama, identified as *mississippiensis,* and evidently conspecific, affords information on this point and is here figured. It resembles the type of the genus, *nevadensis;* the central tooth is somewhat differently shaped but this is probably due entirely to the personal equation in making the drawing. The lateral tooth, however, differs somewhat radically from the figure of *nevadensis,* there being a distinct, rounded lobe on the base and a distinct pit in the body. The marginals differ in form and in the number of denticulations.

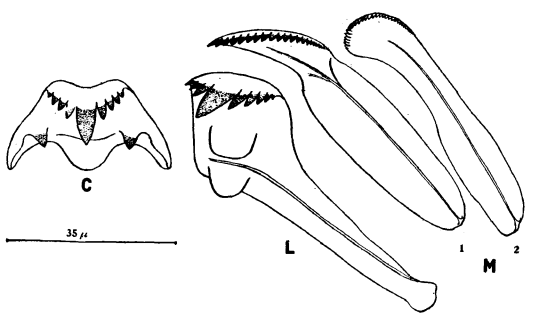

Fig. 61. Radula of *Pyrgulopsis scalariformis.* Alabama.

ECOLOGY: Not known in Illinois as the species is probably extinct. The Alabama form is found in Shoal Creek, near Florence, on a rock bottom, a few being found in algae.

GENERAL DISTRIBUTION: At present known only from the type locality in Tazewell Co., Ill., and from the shore of Rock River near Rock Island. It probably occurs in other places. The Alabama locality is far to the south.

DISTRIBUTION IN WISCONSIN: No records have been seen of the occurrence of this species in Wisconsin. As it occurs in Illinois some distance below the state line it is more than likely that it will ultimately be found farther north in Wisconsin territory. No careful collecting in Pleistocene deposits has been done north of the Wisconsin–Illinois line.

REMARKS: *Pyrgulopsis scalariformis* may be known by its solid shell and the strong keel which encircles the upper whorls and the periphery. It is much larger than *letsoni.*

Shimek (1892, p. 168) has shown that *mississippiensis* is a Pleistocene fossil and synonymous with Wolf's *scalariformis,* described from Pleistocene deposits on the Illinois River in Tazewell Co. (1869, p. 198). Shimek's figures on pl. 13 show a wide range of variation in carination which is toward the Tazewell shell, and it seems evident that the Rock Island form and the Tazewell form represent the same species.

The discovery of living examples of *scalariformis* in Alabama by Mr. Hinkley is of the greatest interest (Walker, 1906a, p. 116), affording data concerning the operculum and radula. The Alabama shells and those from the Pleistocene deposits appear to be the same species, there not being even varietal differences, as is the case between many recent and Pleistocene mollusks. The fossil specimens have a more continuous aperture as a rule but this feature is not constant. This is another example of a Pleistocene species living far to the south or southwest of the region where it lived during glacial times.

PYRGULOPSIS LETSONI (Walker)

Plate VII, figures 28, 29

Amnicola letsoni WALKER, Nautilus, XIV, p. 113, 1901; LETSON, Bull. Buffalo Soc. Nat. Sci., VII, p. 241, fig. 165, 1901.

TYPE LOCALITY: Goat Island, Niagara River, N. Y., in Pleistocene deposits.

WISCONSIN RECORDS: None.

SHELL: Small, elongated, solid, thick; surface with fine growth lines; color dark corneous; whorls 4½ to 6, somewhat flattened laterally and shouldered below the suture in many specimens; body whorl sometimes roundly angular near the periphery; sutures deeply impressed; spire conic, longer than aperture; apex obtuse; nuclear whorl small, rounded, flatly coiled, apparently finely granular in sculpture; aperture small, ovate, rounded below, angled above, flattened on the parietal margin which is oblique to the axis; peristome thick, continuous, in adult specimens entirely free from contact with the body whorl; umbilical region subimperforate or rimate.

L. 3.5; W. 2.2; Ap. L. 1.5; W. 1.0 mm.	Type.
L. 3.2; W. 1.5; Ap. L. 1.1; W. 1.0 mm.	Chicago (U. of I., P280).
L. 3.1; W. 1.4; Ap. L. 1.0; W. 0.9 mm.	" (" ").
L. 3.0; W. 1.6; Ap. L. 1.2; W. 1.0 mm.	" (" ").

ANIMAL: No soft parts of the living forms of *letsoni* have been available for study, hence the genitalia, jaw, radula, and operculum are at present undescribed. An examination of these features will settle conclusively the relationship of *letsoni* to *Pyrgulopsis*.

ECOLOGY: Not recorded.

GENERAL DISTRIBUTION: Goat Island, Niagara River, N. Y., and Chicago, Ill., in Pleistocene deposits. Found living in the following localities: Port Dover, Ont.; Kingsville, Ont.; Sandusky Bay, Ohio; Lake Erie, Monroe Co., Mich.; Raisin River, Dundee, and Huron River, Milford, Mich. (Walker). It will probably be found to be rather widely distributed over the Great Lake region when search is carried on for it. Its diminutive size has doubtless caused it to be overlooked.

DISTRIBUTION IN WISCONSIN: *Letsoni* has not been found in Wisconsin, but from its abundance in Michigan living and in the Chicago deposits as a Pleistocene fossil there seems little doubt but that it will sooner or later be discovered in Wisconsin.

REMARKS: *Letsoni* may be known by its small size, flat-sided whorls, which are somewhat shouldered below the suture, its deeply impressed sutures, and imperforate or subimperforate base and oblique aperture. Its narrower shell and flattened whorls will distinguish it from *Hoyia sheldoni*, which is a wider shell with rounded whorls. It is a very characteristic little species, easily known when once seen.

Walker (1918, p. 139) places this species, originally described as an *Amnicola,* in *Pyrgulopsis,* and the shell certainly resembles this genus, as suggested by Goodrich.

Genus HOYIA F. C. Baker, 1926

Hoyia BAKER, Trans. Wis. Acad. Arts, Sci. Lett., XXII, p. 195, 1926. Type: *Amnicola sheldoni* PILSBRY.

SHELL: Small, elongate-ovate, solid; apex abtuse; nuclear whorl partly concealed by the second whorl; spire short, sutures shallow; whorls convex, flattened above; aperture ovate, not continuous; columella lip thickened; base rounded, rimate or very narrowly perforate. Operculum elongate-ovate, nucleus large, about a third of the distance from base to summit; sculpture of growth lines except on the last turn where there are faint traces of spiral lines.

Animal not examined. Radula (fig. 62), with central tooth two-thirds as wide as high, somewhat trapezoidal in form, the reflection less than half as wide as the width of the tooth; base with sharp lateral angles, but only a slight basal swelling; basal denticles four in number, the uppermost about twice as

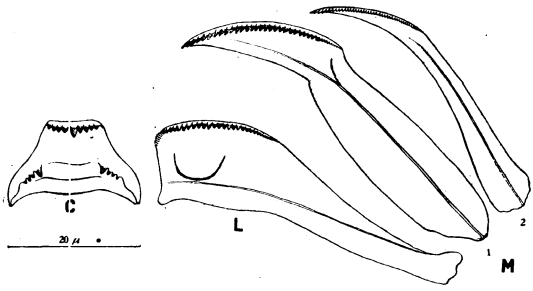

Fig. 62. Radula of *Hoyia sheldoni.* Lake Michigan.

large as the three lower ones, placed on a ridge situated rather low on the body of the tooth; reflection very low, 9-cuspid, the middle cusp about twice as large as the side cusps; lateral teeth with quadrangular-shaped body from which a rather narrow peduncle, almost twice as long as the body, extends laterally in an almost straight direction, being but slightly bent downward; there is a large pit in the body, a long ridge extending parallel with the long axis of the peduncle, and a small lobe at the lower, inner corner of the base of the tooth; reflection very wide and

very low, with about 30 very small cusps of equal size: first marginal falcate with a rather wide body and a heavy central ridge; reflection wide and low, with 30 or more cusps of equal size which are almost twice as large as those of the lateral tooth: second marginal falcate, with a long and narrow body, a distinct ridge, and a swelling of the body at the lower part; reflection wide and low with about 40 very minute cusps.

The radula of *Amnicola sheldoni* is totally unlike that of any other American Amnicoloid observed or published. The teeth are all very small, about a third the size of those of *Amnicola limosa,* and the denticulations are very fine, all teeth beyond the central being multicuspid, with the cusps of equal size. The genus most nearly resembling *Hoyia* is *Potamopyrgus* Stimpson, in which the central tooth has four basal denticles and the reflection is 9-cuspid. However, the lateral tooth is quite different in that there are 30 very fine cusps of equal size, while Stimpson's type has but 11 "numerous equal teeth".

Specimens of *Potamopyrgus coronatus nicaraguanus* Ancey, collected by Hinkley in Lake Izabel, Jocolo, Quatemala, were examined for the radula. The formula is 25:20:3–1–5:$\frac{4}{4}$–$\frac{1}{4}$–$\frac{4}{4}$: 3–1–5:20:25 (fig. 63). The central tooth is twice as large as

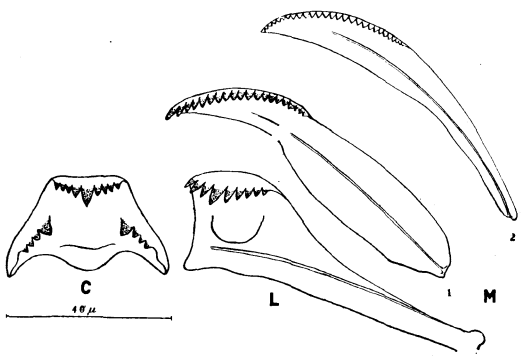

Fig. 63. Radula of *Potamopyrgus coronatus nicaraguanus.*

that of *sheldoni* but is otherwise similar. The lateral is of nearly the same shape, but the denticulations are strikingly different, being larger and less numerous with a somewhat larger central cusp. The marginals are larger and have fewer cusps, the second marginal being differently shaped. The only radula approaching that of *sheldoni* is that of *Clappia* Walker, which

has more than 20 small cusps, but there is a markedly larger cusp in the center which is lacking in *sheldoni.*

The shell is also different from that of *Potamopyrgus,* resembling *Paludestrina* somewhat. The very different and characteristic radula and the deep water habitat (30 fathoms, or about 55 meters) seem to fully justify the reference of this species to a new genus, there being none at present known that will permit its reception. The genus is dedicated to Dr. P. R. Hoy, a pioneer naturalist and molluscan student of Wisconsin, who did much to advance the knowledge of the Molluscan fauna of Wisconsin waters.

It may be observed that it is quite possible that *Potamopyrgus* and some other forms may be separated ultimately from the Amnicolidae to form a separate family, Potamopyrgidae. Some species have been found to be viviparous and all are dimorphic, having a smooth and a spiny form inhabiting the same locality (See Pilsbry, 1891, p. 327; 1920, p. 72). Other characters will possibly also be found to separate these forms from *Amnicola.* They are principally New Zealand, Australian, West African, and Tropical American in distribution.

HOYIA SHELDONI (Pilsbry)

Plate VII, figures 30–32

Amnicola sheldoni PILSBRY, Nautilus, IV, p. 52, 1890.
Pyrgulopsis sheldoni WALKER, Synopsis, p. 140, 1918.

TYPE LOCALITY: Lake Michigan, off Racine, Wis.

WISCONSIN RECORDS:

1890. *Amnicola sheldoni* PILSBRY, p. 52. Lake Michigan, Racine.
1918. *Pyrgulopsis sheldoni* WALKER, p. 140. Lake Michigan, Racine.

SHELL: Small, elongate-ovate, solid, thick; color grayish or light corneous, surface with coarse striae of growth; whorls 4 to 5, slightly convex, somewhat flattened above, slightly impressed below the shallow sutures; apex obtuse, nucleus small, rounded, finely granulate, flattened, coiled in the same plane, partly embraced by the second whorl; aperture ovate, slightly narrowed and angled above, rounded below; peristome thickened, flatly adherent to the parietal wall for a short distance and not continuous; columellar lip thickened; base rounded, rimate or narrowly subperforate.

L. 3.5; W. 2.2; Ap. L. 0.0; W. 0.0 mm. Type.
L. 3.0; W. 2.0; Ap. L. 0.0; W. 0.0 mm. Type.
L. 3.5; W. 2.4; Ap. L. 1.8; W. 1.2 mm. Racine (U. of W., 397a).
L. 3.1; W. 2.2; Ap. L. 1.6; W. 1.2 mm. " (" 397a).

OPERCULUM (Fig. 64): Elongate ovate, base and right side rounding upward to an acute apex, left side almost straight; sculpture of coarse growth lines with faint indications on the last coil of spiral lines; these are nowhere strong; nucleas rather large, granular, placed about a third of the distance from base to summit, well toward the left side; coiling of slightly more than two turns.

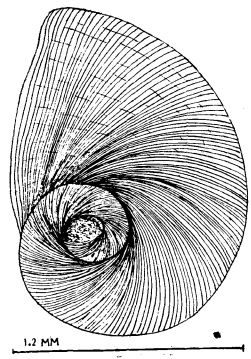

Fig. 64. Operculum of *Hoyia sheldoni.*

ANIMAL: Not examined.

GENITALIA: Not examined.

JAW: As in *nickliniana.*

RADULA (Fig. 62): Formula 40:30:30:$\frac{4-1}{4-4}$:30:30:40. See generic description.

ECOLOGY: Off Racine, in Lake Michigan, 30 fathoms.

GENERAL DISTRIBUTION: Not known at present outside Wisconsin.

DISTRIBUTION IN WISCONSIN: Not known from any part of the State except the original locality. Collected by Dr. P. R. Hoy, of Racine, and later acquired by Mr. Geo. Marston. Dredgings in Lake Michigan should discover this species in other parts of the lake.

REMARKS: "The shallow sutures and heavy texture are the more important characters of this shell. In these points a resemblance to *Hydrobia ulvae* and other species of that group

may be traced. From *Amnicola lustrica* the more flattened whorls at once separate this form" (Pilsbry). The elongated spire and rimate umbilical region separate *sheldoni* from *Amnicola limosa,* which it somewhat resembles in its obtuse apex, and its obtuse apex and lack of distinct umbilicus will distinguish it from *Amnicola lustrica* or any other related Amnicoloid.

Walker (1918, p. 140) suggests that this species seems to be a *Pyrgulopsis* rather than an *Amnicola.* An examination of the radula of specimens from the type lot shows that it cannot be referred to either genus and that it must be included in a new genus. The teeth of the radula are smaller than those of any species yet examined and the multicuspid character of the lateral is unlike anything yet described in this subfamily. Stimpson's remark that species of this family cannot be safely referred to a genus by the shell alone is well illustrated by the history of this species. It is much to be desired that the animal should be examined to determine the form of the verge.

Subfamily LITHOGLYPHINAE Fischer, 1885

Shell small, spiral, dextral; spire short, body whorl large, forming most of the shell; columella usually callously thickened; operculum corneous, subspiral. Animal with simple foot, without sinuses; central tooth of radula with several basal denticles; verge bifid or simple, compressed.

Key to Genera of Lithoglyphinae

1. Adult shell less than 6 mm. in length; lateral teeth of radula without lobe; basal denticles numerous ---------- *Somatogyrus*
2. Adult shell more than 6 mm. in length; lateral teeth of radula with lobe; basal denticles 3 ---------- *Birgella*

Genus SOMATOGYRUS Gill, 1863

Somatogyrus Gill, Proc. Phil. Acad., p. 34, 1863. Type: *Amnicola depressa* Tryon.

Shell usually rather thick and solid, smooth, imperforate or narrowly perforate; spire usually short; apical whorl spirally punctate or lirate; body whorl large, more or less inflated; aperture very oblique; lip sharp, projecting above; columella cal-

lously thickened. Operculum corneous, subspiral, nucleus small whorls rapidly increasing in size.

Animal with broad, flat, truncated rostrum; tentacles rather short and flattened; verge simple, broad, compressed without flagellum. Teeth of radula with many cusps; basal denticles on central tooth 5–6; lateral tooth with a very long peduncle and a pit in the center of the body, the reflection cusps variable in number; marginals falcate, multicuspid.

KEY TO SPECIES OF SOMATOGYRUS

1. Shell with distinct umbilical chink, the columella slightly thickened in old specimens; lateral tooth with formula 2–1–4 ---------- *depressus*
2. Shell imperforate or rimate, the columella with a heavy callus forming a thickened, continuous peristome, lateral tooth formula 6–1–6 ---------- *tryoni*

SOMATOGYRUS DEPRESSUS (Tryon)

Plate VII, figures 33–39

Amnicola depressa TRYON, Proc. Phil. Acad., p. 276, 1862.
Somatogyrus depressus GILL, Proc. Phil. Acad., p. 34, 1863.
Somatogyrus depressus BINNEY, L. & F. W. Sh. N. A., III, p. 77, fig. 150, 1865.
Somatogyrus depressus TRYON, Con. Hald. Mon., p. 61, pl. 17, fig. 12, 1870.

TYPE LOCALITY: Mississippi River, Davenport, Iowa.

WISCONSIN RECORDS:

1897. *Somatogyrus depressus* WISWALL, p. 48. Southern Wisconsin.
1906. *Somatogyrus depressus* CHADWICK, p. 89. Kenosha.

SHELL: Suborbicular, somewhat elongated, rather solid; color whitish corneous, subhyaline; sculpture of fine, close-set striae of growth; whorls about 4, convex, somewhat turban-shaped, rapidly increasing in diameter; sutures well impressed; spire broadly conic, a trifle shorter than the aperture; apex rather blunt, slightly everted above the second whorl; nuclear whorl rounded, obliquely flattened, not constricted by the suture, the sculpture punctate or malleated, without lirae; body whorl large, convex; aperture roundly ovate, very slightly constricted above, where it projects forward conspicuously; peristome continuous, appressed to the parietal wall for a short distance above; inner lip flattened, rather wide, reflected over the small, narrow umbilical chink which it emargines.

L. 4.8; W. 3.7; Ap. L. 2.5; W. 1.5 mm. Davenport, Ia. (Walker coll., 76694).
L. 4.7; W. 4.0; Ap. L. 3.0; W. 1.5 mm. Davenport, Ia. (Walker coll., 76694).
L. 5.2; W. 4.3; Ap. L. 3.1; W. 2.5 mm. De Pere (U. of W., 4550).
L. 5.0; W. 4.1; Ap. L. 3.0; W. 2.2 mm. " "
L. 4.8; W. 3.6; Ap. L. 2.5; W. 2.1 mm. " "
L. 5.0; W. 4.0; Ap. L. 3.0; W. 2.5 mm. " "
L. 4.1; W. 3.3; Ap. L. 2.5; W. 2.0 mm. " "
L. 4.0; W. 4.0; Ap. L. 2.5; W. 2.0 mm. " "

OPERCULUM (Fig. 65): Subspiral, thick, all margins rounding upward to a blunt point, the left side flatly rounded; sculpture of distinct growth lines, but apparently no spiral lines; body consisting of about two complete turns; nucleus at the left side about a third of the distance between base and apex, sculpture punctate.

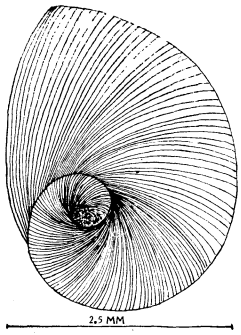

Fig. 65. Operculum of *Somatogyrus depressus*. Winnebago Lake.

ANIMAL: Not examined alive.
GENITALIA: Not examined.
JAW: As in *Amnicola*.
RADULA (Fig. 66): Formula 21:21:2–1–4:$\frac{3}{6}\frac{1}{1}\frac{3}{6}$:2–1–4:21:21. Central tooth about two-thirds as high as wide, the lower angles produced and roundly triangular, the lower border with a large central lobe; basal ridge with six denticles, the innermost largest, the others gradually decreasing in size, the lower part of the ridge being broadly rounded; reflection broad and low with seven denticulations, the center one larger and longer. Lateral tooth with body slightly wider than high, with a distinct central pit; peduncle long and narrow, about twice as long as body of tooth, with a long ridge parallel with the long

axis; reflection with two small inner cusps, then a large cusp, followed by four outer cusps, diminishing in size toward the edge of the tooth. First marginal falcate, very long and narrow with a distinct central ridge; reflection with 21 small cusps, the outer ones very small. Second marginal somewhat spoon-shaped with 21 small denticulations.

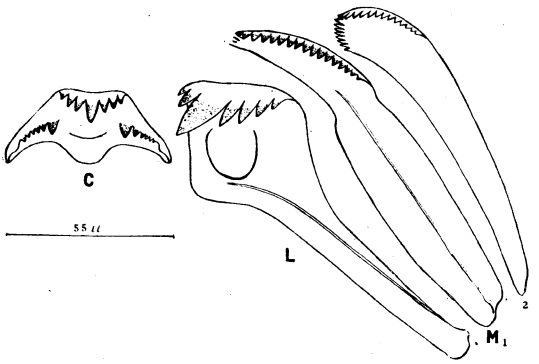

Fig. 66. Radula of *Somatogyrus depressus*. Winnebago Lake.

The radula of the Wisconsin *depressus* agrees with the figure of Stimpson excepting in the number of denticulations of the marginal teeth. These are difficult to see and count.

ECOLOGY: On a mud bottom in shallow water (Miller Bay).

GENERAL DISTRIBUTION: Not clearly known. Authentic material has been seen from Wisconsin, Iowa, and Illinois.

DISTRIBUTION IN WISCONSIN: The distribution is scattered and discontinuous, probably on account of confusion with the next species.

Fox Drainage: Fox River, De Pere, Brown Co. (Marston); Miller Bay, Winnebago Lake, Winnebago Co. (Baker).
Lake Michigan Drainage: Kenosha, Kenosha Co. (Chadwick).
Wisconsin Drainage: Prairie du Sac, Sauk Co. (Hinkley, Walker).
Mississippi Drainage: New Richmond, St. Croix Co. (Bullock).

REMARKS: *Somatogyrus depressus* may be known by its turbinated shell, large body whorl, and subhyaline color. It is smaller and much narrower, with a less ample body whorl, than *Birgella subglobosa* or its variety *isogona,* and the nucleus is smooth or lightly punctate while *subglobosa* has a lirate nucleus. Its nearest relative is the next species, which is of about the same size, but has a very heavily calloused lip margin, espe-

cially the columellar region, which completely closes the umbilicus or leaves a rimate condition. The radulae of the two species are strikingly different. Both of these species are distinct from the *Somatogyrus interger* Say, common in the Ohio and its tributaries. *Depressus* in Illinois appears to be confined to the western part of the state, in streams tributary to the Mississippi, while *integer* is confined to eastern Illinois in streams tributary to the Ohio River.

The distribution of this species is peculiar in Wisconsin. It appears to have migrated up the Wisconsin River, possibly crossed over via the old glacial outlet at Portage into the Fox River, and thence to Lake Winnebago and the lower Fox River.

SOMATOGYRUS TRYONI Pilsbry and F. C. Baker

Plate VIII, figures 13–18

Somatogyrus currierianus TRYON, Con. Hald. Mon., p. 62, pl. 17, fig. 13, 1870 (not description).

Somatogyrus tryoni H. A. PILSBRY and F. C. BAKER, Nautilus, XLI, p. 1927.

TYPE LOCALITY: Pipersville Rapids, Rock River, Jefferson Co., Wis.

WISCONSIN RECORDS:

1870. *Somatogyrus currierianus* TRYON, p. 62. Milwaukee.
1909a. *Somatogyrus depressus* WALKER, p. 90. Watertown.

SHELL: Globosely-conic, very solid; color light yellowish olive, brownish or greenish horn, rarely hyaline, excepting in young; sculpture of distinct growth lines and very fine spiral lines, more marked in immature shells; whorls 4½, convex, rapidly increasing in diameter; sutures well impressed; spire broadly conic, shorter than aperture; apex blunt, not much raised above second whorl; nuclear whorl rounded, flattened, punctate or malleated; body whorl very large, convex or globular; aperture roundly ovate or ovate, slightly narrowed above, whitish or bluish-white within; peristome continuous, appressed to the parietal wall; inner lip and whole columellar region greatly thickened by a heavy callus which forms a wide deposit either completely closing the umbilicus or leaving a very narrow chink, or even a rimate condition; the outer lip is also thickened within, but has a sharp edge; the whole aperture border is thickened and frequently a second apertural border

is formed within the first; in very old specimens there is a delicate keel bordering the flattened columellar area.

L. 6.2; W. 5.3; Ap. L. 4.0; W. 2.5 mm. Pipersville (U. of I., Z22511).
L. 5.8; W. 4.1; Ap. L. 3.1; W. 2.1 mm. " "
L. 5.1; W. 4.1; Ap. L. 3.2; W. 2.1 mm. " "
L. 6.0; W. 5.5; Ap. L. 4.0; W. 3.0 mm. " "
L. 8.6; W. 7.3; Ap. L. 6.0; W. 4.0 mm. Milwaukee specimen of Tryon (A. N. S. P. 57023).

OPERCULUM: Resembling that of *depressus* in form, but there are distinct, though very fine, spiral lines.

GENITALIA (Fig. 67): Male organs. Verge large, simple, apparently without flagellum and with no external flagellum sheath, much compressed and very wide, placed immediately back of the right eye and tentacle. It is scarcely of the same form in any two animals, the most frequent being somewhat

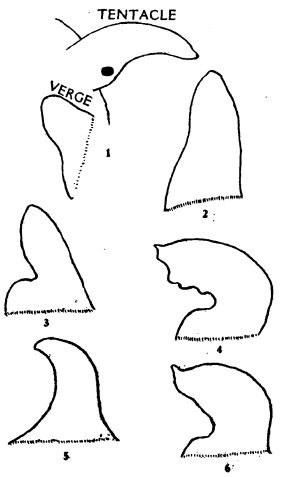

Fig. 67. Verge of *Somatogyrus tryoni.* 1, Portion with head and verge; 2–6. Different forms assumed by verge.

sickle-shaped; when extended it is tongue-shaped (2) and when greatly contracted it is very wide at the base and simulates a secondary lobe (see figures). The verge is quite unlike that of *Birgella,* which has a secondary sheath, though it is compressed as in *Somatogyrus.* In some specimens the verge appears like that of *Gillia* as figured by Stimpson (1865b, p. 27, fig. 19). Female organs: not differing from those of other Am-

nicolidae; the uterus is very wide. Females greatly predominate, only four males being found in a lot of 25 specimens.

JAW: As in *Amnicola.*

RADULA (Fig. 68) : Formula 28 :28 :6–1–6 :$\frac{6-1-6}{6-6}$:6–1–6 :28 :28. Central about two-fifths as high as wide, the lower angles produced and bluntly rounded; lower border of tooth with a large central lobe; basal denticles 6, the upper, inner one large, the others gradually decreasing in size, all placed on a wide, low lateral ridge; reflection broad and low, 13-cuspid, six cusps on either side of a large central cusp, the cusps rather sharp. Lateral tooth with a body slightly wider than high with a central

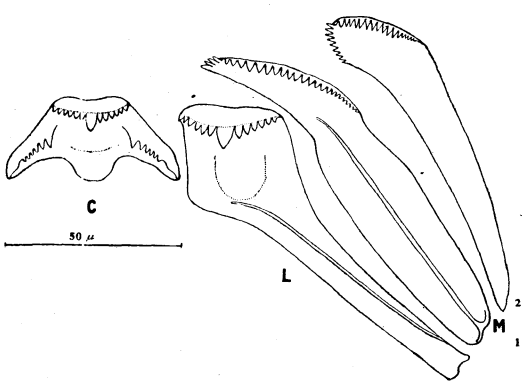

Fig. 68. Radula of *Somatogyrus tryoni.* Pipersville, Rock River.

pit; peduncle long and narrow, about twice as long as body of tooth, with a long ridge parallel with the long axis of the peduncle; reflection 13-cuspid, six cusps on either side of a central cusp, the latter much larger and wider than the side cusps, all spade-shaped. First marginal falcate, with rather wide body which bears a distinct vertical ridge in the center; reflection with 28 cusps, those near the inner edge of reflection large and acute, those on lateral margin becoming smaller. Second marginal spoon-shaped, with 28 cusps similar in size and character to those of the first marginal, but rather sharper. The marginal cusps are difficult to see and count.

The radula of *tryoni* is quite different from that of *depressus,* especially in the denticulation of the center and lateral teeth, which resemble *Clappia* in their number and position, and also some species of *Potamolithus* (Pilisbry, 1899, fig. 14). A

number of examinations of radulae have been made from specimens from Mukwonago and Pipersville, Rock River. The form of the teeth and the denticulation are alike in all specimens. The notable characteristic is the equal number of small denticulations on each side of the larger central tooth in the lateral.

ECOLOGY: Rock River, Pipersville Rapids, water .5 to 1 m. deep, heavy gravel bottom, little vegetation; Mukwonago River, water few cm. deep, gravel bottom, swift current, some vegetation; Mukwonago Creek, gravel bottom, water clear, very shallow, shells rare (Cahn). At Pipersville the rocks are peppered with snails like *Littorina* on the ocean shore.

GENERAL DISTRIBUTION: Not observed outside of Wisconsin.

DISTRIBUTION IN WISCONSIN: Apparently confined to the southeastern part of the State.

Lake Michigan Drainage: Milwaukee, Milwaukee Co. (Tryon).

Rock Drainage: Ashippun River east of Mapleton; Bark River, Highway 67, Waukesha Co.; Crawfish River, Aztalan; Bark River at Rome; Pipersville Rapids, Rock River, Jefferson Co. (Cahn); Watertown, Jefferson Co. (Walker).

Fox Drainage (Illinois): Mukwonago River and Creek, Waukesha Co. (Cahn).

REMARKS: *Tryoni* is at once distinguished from *depressus* by its closed or rimate umbilical region and especially by its very heavily calloused columellar lip and aperture. The dentition is also very different. It is a larger shell when mature and the body whorl is larger, more like *Birgella subglobosa,* from which it differs in its smaller size, heavy columellar callus, and different dentition. It differs from the Ohio River *integer* in its longer spire, rounder whorls of the spire, deeper sutures, more globose body whorl, and its very narrow umbilical opening which is rarely completely closed as it is in *integer.* The unique specimen from Milwaukee figured by Tryon is evidently a shell which has added another season's growth to an already adult condition, for a distinct brown outer lip mark is visible on the last part of the body whirl. The shell would measure about L. 7.0; W. 6.0 mm. if this last portion had not been added, which is about the size of the largest specimens of the Pipersville material.

First figured as a form of *currierianus* by Tryon, this distinct

species has been known only from the original specimen in the Philadelphia Academy of Science for upwards of 50 years. Pilsbry many years ago recognized its distinctness but its absence from more recent literature of Wisconsin and the failure of later collectors to find it raised a question as to the correctness of its habitat in Milwaukee. The abundant material collected by Dr. Cahn definitely settles the question of its distinctness and gives it a place in the fauna of Wisconsin.

Genus BIRGELLA F. C. Baker, 1926

Birgella BAKER, Trans. Wis. Acad. Arts, Sci., Lett., XXII, p. 196, 1926.
Type: *Paludina subglobosa* SAY.

Shell large for the family, spiral, dextral, narrowly umbilicated; spire short; body whorl very large; whorls very convex with deeply channelled sutures; aperture very large; lip simple; columellar lip thin, tightly appressed to the parietal wall; operculum subspiral, nuclear whorl large, sculpture of spiral lines in the type.

Animal with a compressed verge, the penis being much longer than the flagellum sheath which is short and conical or compressed; head wide, tentacles rather short and flattened, pointed; rostrum wide, squarely truncated. Central tooth of radula with a long pointed central cusp which reaches nearly to the base of the tooth, the lateral ridge with but one large denticle and two smaller ones below; lateral teeth with a large rounded lobe on the inner base of the body, with a wide peduncle and a reflection with 8 denticulations; marginal teeth with relatively few denticulations (10–12).

In his study of the Hydrobiinae, Stimpson called attention to the great difference in the dentition between the *isogonus* of Say and the *depressus* of Tryon (1865b, p. 23), though he did not think that this difference was great enough to separate the two groups, in the light of the knowledge at that time. The genitalia at that time were also unknown. The verge of *Somatogyrus* has been found to be simple, not bifid, as in the present species, and the radula is quite different, more so than Stimpson imagined, if all species are like *depressus*. The center cusp of the center tooth is very much longer and reaches well toward the base of the tooth and the lateral ridge has but three denticulations while *Somatogyrus* has six without as marked

difference in size. The lateral tooth is very different in denticulation and in the presence of a distinct lobe on the base of the tooth. Taking into consideration the genitalia and the radula, *subglobosus* differs generically from *Somatogyrus*. It resembles *Gillia* somewhat in the denticulation of the lateral ridge, but the verge of that group is simple, as in *Somatogyrus*, and not bifid.

The genus is dedicated to President Emeritus Edward A. Birge, of the University of Wisconsin, who was director of the Wisconsin Geological and Natural Survey for many years, and who has also been a pioneer in the study of fresh water faunas and in limnological investigations.

BIRGELLA SUBGLOBOSA (Say)

Plate VIII, figures 4–9; plate VII, figures 40, 41

Paludina subglobosa SAY, Jour. Phil. Acad., V, p. 25, 1825; HALDEMAN, Mon., pl. x, figs. 7, 8, 1844; BINNEY, L. & F. W. Sh. N. A., III, p. 78, fig. 155, 1865.

Somatogyrus subglobosus TRYON, Con. Hald. Mon., p. 60, pl. 17, fig. 10, 1870; BAKER, Moll. Chi. Area, p. 340, fig. 123, 1902.

TYPE LOCALITY: Northwestern Territory (Say).

WISCONSIN RECORDS:

1870. *Somatogyrus subglobosus* TRYON, p. 60. Wisconsin.
1902a. *Somatogyrus subglobosus* BAKER, p. 341. Wisconsin.
1906. *Somatogyrus subglobosus* CHADWICK, p. 88. Lake Winnebago west of High Cliff, Calumet Co., Kenosha.
1924. *Somatogyrus subglobosus* BAKER, p. 134. Lakes Winnebago and Butte des Morts.

SHELL: Subglobose to globose, rather solid, depressed; color yellowish-horn to grayish under a corneous periostracum; sculpture of fine to coarse, oblique, crowded growth lines; whorls four, convex, separated by deep sutures, rapidly increasing in diameter, the last whorl very large, ventricose; spire broad, depressed-conic, much shorter, usually, than the aperture; apex slightly raised above the second whorl, the nuclear whorl rounded, sculpture at first wrinkled or malleated, then punctate, punctate-lirate above and lirate below; aperture roundly ovate, somewhat angular above, somewhat produced below; peristome sharp, thin continuous, flattened and appressed to the parietal wall above; the columellar lip forms a

sharp, erect emargination to the narrow but distinct and deep umbilicus.

L. 9.5; W. 7.0; Ap. L. 5.0; W. 3.9 mm.	Butte des Morts (U. of W., 4552).
L. 7.5; W. 6.5; Ap. L. 5.0; W. 3.5 mm.	L. Winnebago (U. of W., 4553).
L. 7.5; W. 6.2; Ap. L. 5.0; W. 4.0 mm.	" " "
L. 6.5; W. 5.5; Ap. L. 4.5; W. 3.5 mm.	" " "
L. 6.0; W. 5.5; Ap. L. 4.4; W. 3.4 mm.	" " "
L. 5.4; W. 4.3; Ap. L. 3.2; W 2 6 mm.	" " "
L. 5.0; W. 4.2; Ap. L. 3.3; W. 2.6 mm.	" " "

OPERCULUM (Fig. 69): Corneous, subspiral, rather thick; base and right side rounding upward to a semiacute apex; left or columellar side only slightly rounded; sculpture of distinct growth lines crossed by equally distinct spiral lines forming a

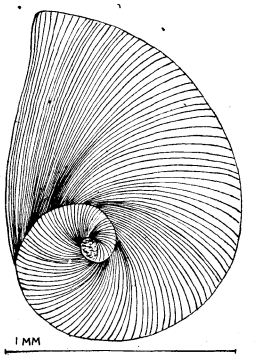

Fig. 69. Operculum of *Birgella subglobosa*. Winnebago Lake.

decussated pattern on the early and the last part of the last volution; but this sculpture is indistinct on the central part of the operculum; attachment to operculigerous lobe indicated by a heavy line which borders the margin; nucleus at left side near the border and about a third of the distance between base and apex; there are rather more than two full turns or volutions.

ANIMAL: Foot short: head wide; rostrum rather short and wide and bluntly truncated at the end; tentacles long and pointed, somewhat flattened; eyes on the upper side of swellings at the outer base of the tentacles.

GENITALIA (Fig. 70): Verge much compressed laterally, consisting of a flattened, pointed penial portion and a wide, lobe-like flagellum sheath. It is situated on the neck at some

distance behind the right tentacle. The female orifice is in a similar position. The verge does not appear the same in different individuals (in spirit) and these probably represent different degrees of contraction. Figure B is probably the most natural and figure D the least.

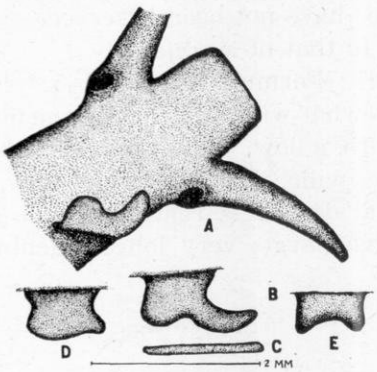

Fig. 70. Head and verge of *Birgella subglobosa*. A. Verge in natural position on back of neck; B, D. E. Different form assumed by verge. C. Verge viewed from above showing its flatness.

Stimpson (1865b, p. 22) figures the verge of *isogona* which is somewhat different from that seen in *subglobosa*, the penial portion being longer and more pointed and the flagellum sheath very short but pointed, not lobed (fig. 71). The whole verge also greatly exceeds that of *Birgella* in size. It is probable that this figure represents a verge which is little contracted

Fig. 71. Verge of *Birgella subglobosa isogona*, after Stimpson (fig. 13).

and possibly in more normal condition, a fact indicated by the variation of the forms of verge found in *subglobosa*. Stimpson mentions the much compressed condition, which is so marked in *subglobosus*. It will be seen, by comparing this figure with the verge of *Amnicola limosa* (fig. 43) and that of *Bulimus* (fig.

37), that the two groups of Amnicolidae differ greatly, in *Amnicola* the verge being long and cylindrically conical and the flagellum sheath round and with an almost bulbous termination, a feature not observed in *Birgella*. The verge of *Amnicola* is comparatively larger than in *Birgella subglobosa*, but is shown relatively as large in Stimpson's figure of *Somatogyrus isogonus*. Egg capsules have not been observed.

JAW: Similar to that of *Amnicola*.

RADULA (Fig. 72): Formula 10:13:2–1–5:$\frac{4}{3}\frac{1-4}{-3}$:2–1–5:13:10. Central tooth somewhat wider than high, the lower outer angles expanded, and with a low, widely rounded basal projection; lateral ridge large, wide, with one large, long, sharp, and two smaller outer basal denticles; reflection wide and high, 9-cuspid, the center cusp large, very long, reaching nearly to the

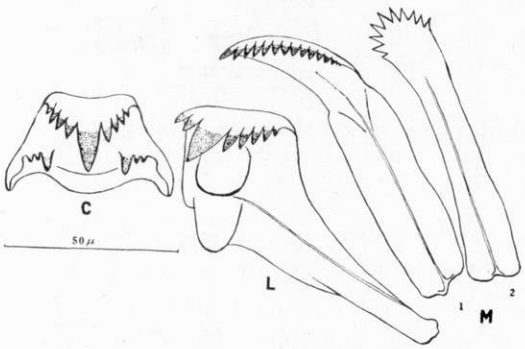

Fig. 72. Radula of *Birgella subglobosa*. Winnebago Lake.

base of the central tooth, side cusps smaller, all cusps very long and sharp: lateral teeth with a quadrate body and a wide peduncle somewhat less than twice as long as the body of the tooth; there is a long, rounded lobe on the inner side of the ventral border of the tooth, a pit in the center of the body, and a long ridge parallel with the long diameter of the peduncle; reflection wide and low, 8–cuspid, the third cusp from the inner border being three times as large as the side cusps, all long, pointed, narrow: first marginal falcate with wide body and long ridge; reflection 13–cuspid, the cusps large, narrow, sharp; second marginal with wide body and long ridge, the reflection 10–cuspid, the cusps almost as large as those of the first marginal.

It will be noted that the figure of the radula of *subglobosa* differs somewhat from that given by Stimpson (1865a, fig. 14)

in the form and number of the cusps and in the possession of a lobe on the lateral teeth, which may be represented by the so-called "door" near the central pit in Stimpson's figure. In all essential details the two figures are similar.

ECOLOGY: *Subglobosa* is a lake form. It has been found under the following conditions:

Lake Butte des Morts, on boulder bottom, in .5 m.; mud bottom in 3 m.; sand bottom in .8 m. Lake Winnebago: Lower Asylum Bay, boulder bottom in .4 m.; sand in .8 m.; near Oshkosh, sand bottom in .6 m.; sand and gravel in 2.2 m.; off Doemel Point, sand and gravel in 2.8 m.; near Long Point Island, gravel in 1.5 m.; middle of lake, mud bottom in 3.4 m.

GENERAL DISTRIBUTION: Probably confined to the Great Lakes region. Typical *subglobosa* has been seen only from Lake Michigan, Lake Erie, Lake Ontario, Oneida Lake, and Lake Winnebago. References to the river form belong under the next variety.

DISTRIBUTION IN WISCONSIN: Found only in the Lake Winnebago region and in Lake Michigan.

REMARKS: *Birgella subglobosa* may be known by its large size, globular form, and distinct umbilicus. The body whorl is very large and distinctly shouldered, the deep sutures also causing the whorls to appear much rounded at this point. It is double the size of *Somatogyrus depressus* and *S. tryoni* and the whorls and columellar region are different. *Birgella subglobosa* is very uniform, the principal differences being correlated with sex, the males being somewhat narrower than the females. The young are not particularly different from large adult shells and at this stage show some difference in sex, as shown in figs. 40, 41, pl. VII.

It is not known just where Say's specimens came from but it is likely that they were picked up on some lake shore. This species is very abundant in Lake Winnebago and is common in drift on the shore of Lake Michigan.

BIRGELLA SUBGLOBOSA ISOGONA (Say)

Plate VIII, figures 10–12

Melania isogona SAY., New Harm. Dissem., II, p. 227, 1829.
Somatogyrus isogonus BINNEY, L. & F–W., Sh. N. A., III, p. 77, figs. 151, 152, 1865.

TYPE LOCALITY: Bear Grass Creek, near Louisville, Ky.

WISCONSIN RECORDS:

1860. *Leptoxis isogona* LAPHAM, p. 155. Rock River.

1906. *Somatogyrus subglobosus* CHADWICK, p. 88. Root River, at Loomis Road, Town Franklin, Milwaukee Co.; Kinnickinnic River, near 11th Ave., Milwaukee; Cudahy, Milwaukee Co.

1924. *Somatogyrus subglobosus* BAKER, p. 134. Omro, Fox River.

SHELL: Differing from that of *subglobosa* in having a very narrow umbilical chink, often completely closed, and in the inner lip which is heavier, often forming a distinct callus over the columellar region.

L. 9.1; W. 8.0; Ap. L. 6.0; W. 5.0 mm.	Near Elizabethtown, Ill. (U. of I., Z17967).
L. 9.1; W. 7.5; Ap. L. 7.0; W. 4.5 mm.	Near Elizabethtown, Ill. (U. of I., Z17967).
L. 7.0; W. 6.5; Ap. L. 5.1; W. 4.0 mm.	Fox River, Wis. (U. of W., 473a).
L. 6.5; W. 6.2; Ap. L. 5.0; W. 4.0 mm.	" "

OPERCULUM: As in *subglobosa.*

ANIMAL: As in *subglobosa.*

JAW: Of imbricated plates as in *Amnicola.*

RADULA: As given by Stimpson the formula is: $12:12:1\text{–}1\text{–}5:\frac{3-1-3}{3-3}:1\text{–}1\text{–}5:12:12$. This is somewhat different from that found in *subglobosa.* Specimens of *isogona* from Illinois and Mississippi, however, show that the radula is identical with that of *subglobosa* as figured in this monograph. Stimpson's figures fail to show the inner cusps of the lateral tooth, which can only be seen when it is completely isolated from the membrane and the cusps spread out. The central tooth also has four cusps on each side of the long center cusp. The so-called door-like appendage is seen to be a rounded lobe bearing the same relation to the peduncle as the appendage on the lateral tooth of *Stimpsonia.*

ECOLOGY: *Isogona* is a river and creek form, living on a muddy bottom in Illinois. The Fox River habitat is also on a mud bottom.

GENERAL DISTRIBUTION: Ohio west to Iowa, Michigan south to Alabama and Arkansas.

In Illinois it is common over the state but has been recorded as *subglobosa.*

DISTRIBUTION IN WISCONSIN: Apparently confined to the southeastern part of the State.

Fox Drainage: Fox River, Brown Co. (Marston). Omro (Baker).
Rock Drainage: Aztalan, Crawfish River, Jefferson Co. (Cahn).
Lake Michigan Drainage: Various places in Milwaukee Co. (Chadwick).

REMARKS: *Isogona* has usually been considered a synonym of *subglobosa* but it differs in its umbilical region and in the much heavier columellar callus. In some specimens of *isogona* the umbilical region is simply rimate. This distinction holds good for a very large series of both forms. Say calls the umbilicus linear in *isogona* and narrow in *subglobosa*. The Illinois specimens are much more typical, the Fox River form intergrading with *subglobosa*. Milwaukee specimens are nearer typical. The lower Fox River is more a lake than a river which may influence the shells in this direction. Lea's *pallida* is said by Tryon to be probably the young of *subglobosa* but it looks more like a form of *Somatogyrus integer*. It does not appear to be *isogona*.

Family POMATIOPSIDAE Stimpson

Subfamily POMATIOPSINAE STIMPSON, 1865.

Shell elongated, turreted, thin to thick, smooth, umbilicated; aperture expanded; peristome continuous, thin or slightly reflected; operculum corneous, subspiral, with spiral sculpture. Animal shorter than the shell, foot broad, truncated before, rounded behind, with a transverse sulcus at about its anterior third; verge simple; central tooth of radula with but one large basal denticle; denticles of the lateral and marginal teeth very large and few in number, proportionally much larger than in Amnicolidae.

Pomatiopsinae would seem to rank as a family rather than as a subfamily of Amnicolidae. The sinuses of the foot, the radula with its few cusps of large size and the two large denticles on the base of the central tooth, as well as its terrestrial habits, all mark this genus as separable taxonomically from Amnicolidae. The verge, also, is simple, without flagellum sheath, and is of large size. This opinion is strengthened by the fact that Gill in 1871 (p. 7) and Pilsbry in 1907 (p. 565) raised the group to family rank. The resemblance of the species to the European genus *Pomatias* suggested the generic

name *Pomatiopsis,* resembling *Pomatias.* Its resemblance to the land operculates suggested the reference to *Cylclostoma* by Say and other early students.

What other groups may be referred to this family cannot be determined at present. There are a number of amphibious Amnicoloids in the Old World, but these may be referred to other families when examined for genitalia and radula. Pomatiopsidae may prove wholly American. The radulae of only *lapidaria* and *cincinnatiensis* have been examined, but it is no doubt probable that *Bythinella binneyi* Tryon, *Pomatiopsis californica* Pilsbry, *P. hinkleyi* Pilsbry, and *P. robusta* Walker are congeneric with the two species already examined (See Walker, 1918, p. 148).

Genus POMATIOPSIS Tryon, 1862

Pomatiopsis TRYON, Proc. Phil. Acad., p. 452, 1862. Type: *Cyclostoma lapidaria* SAY. *Chilocyclus* GILL, Proc. Phil. Acad., p. 34, 1863. Type: *Cyclostoma cincinnatiensis* LEA.

Shell elongated, turreted, thin, smooth, umbilicated; aperture expanded, peristome continuous, thin or slightly reflected; operculum corneous, subspiral, with spiral sculpture.

Animal shorter than the shell, foot broad, truncated before, rounded behind, with a transverse sulcus at the anterior third; tentacles short and subulate, shorter than the long, large, round, bluntly pointed rostrum; verge large, broad, flattened, simple, scythe-shaped. Radula with few and large denticulations, a single tooth on the lateral ridge. A genus of amphibious snails.

KEY TO SPECIES OF POMATIOPSIS

1. Shell elongated, whorls 6–7, adult 7 mm. long ---------- *lapidaria*
2. Shell broadly conic, whorls 5, adult 5 mm. long------ *cincinnatiensis*

POMATIOPSIS LAPIDARIA (Say)

Plate VII, figures 42–45

Cyclostoma lapidaria SAY, Jour. Phil. Acad., I, p. 13, 1817.
Amnicola lapidaria HALLEMAN, Mon., p. 18, pl. i, fig. 10, 1844.
Pomatiopsis lapidaria BINNEY, L. & F. W. Sh. N. A., III, p. 93, figs. 187, 188, 1865.
Paludina lustrica SAY., Jour. Acad. Nat. Sci., II, p. 175, 1821.
Pomatiopsis lustrica BINNEY, Op. Cit., p. 94, fig. 189, 1865; Tryon, Con. Hald., p. 57, pl. 17, fig. 7, 1870.

TYPE LOCALITY: Locality not given by Say *(lapidaria)*: Cayuga Lake *(lustrica)*.

WISCONSIN RECORDS:

1860. *Amnicola lustrica* LAPHAM, p. 155. Milwaukee.
1865b. *Pomatiopsis lustrica* BINNEY, p. 95. Four Lakes, Madison Lapham).
1906. *Pomatiopsis lustrica* CHADWICK, p. 89. Four Lakes.
1897. *Pomatiopsis lapidaria* WISWALL, p. 48. Southern Wisconsin.
1906. *Pomatiopsis lapidaria* CHADWICK, p. 89. Castalia Park, Wauwatosa; near Cement Mills, Milwaukee Co. (W. M. Wheeler); Richland City; Kenosha.

SHELL: Elongated, turreted; color dark brownish horn or chestnut; surface dull to shining, lines of growth crowded, slightly wrinkled in some specimens, rather fine; apex rounded, flattened, depressed; nuclear whorl not emergent, partly embraced by the second whorl, not much constricted by the suture, sculpture very finely granular, almost smooth; whorls 7, well rounded, slowly and regularly increasing in diameter; sutures deeply impressed; spire acute, about three times as long as

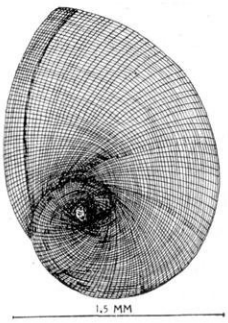

Fig. 73. Operculum of *Pomatiopsis lapidaria*. Homer Park, Ill.

aperture; aperture elongate ovate, somewhat narrowed and angled above, rounded below, slightly expanded, somewhat purplish within; peristome simple or slightly thickened within, upper terminations connected on the parietal wall by a callus of greater or less thickness; umbilicus well marked, emargined by the inner lip which is slightly reflected over the umbilical region; base rounded.

L. 7.0; W. 3.1; Ap. L. 2.1; W. 1.9 mm. Homer Pk., Ill. (U. of I., Z11346a).
L. 6.0; W. 3.0; Ap. L. 2.0; W. 1.5 mm. " "
L. 5.5; W. 2.0; Ap. L. 1.9; W. 1.5 mm. " "

OPERCULUM (Fig. 73): Ovate, all margins rounding upward to an acute apex, the left margin the least rounded; about two and a quarter turns are visible; the nucleus is rounded, of medium size, and the whorls rapidly enlarge; the nucleus is placed near the left or columellar side about a third of the distance between base and summit; sculpture of distinct, impressed spiral and growth lines, producing a latticed effect.

ANIMAL (Fig. 74): With a short, broad foot, broadly rounded before, rounded behind, with three sinuses, of which one separates the foot into an anterior and posterior part, and above this a sinus at right angles to the first, which separates

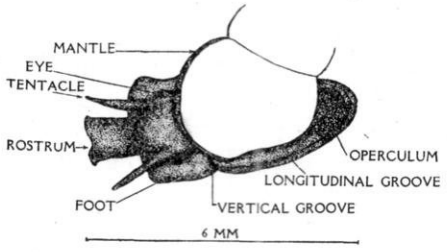

Fig. 74. Animal of *Pomatiopsis lapidaria.*

the foot from the body, the upper fold of which merges into the operculigerous lobe posteriorly; above this there are two folds, one extending from the lower base of the rostrum to the base of the tentacle, and the other from the former point to and beyond the constricted portion called the neck; rostrum blunt, longer than the tentacles, wrinkled transversely, except when fully extended; tentacles short, pointed, tapering; eye situated on the outer side of a swelling at the base of the tentacle; there is a conspicuous white spot of color on the inner side of the protuberance. General color of animal pale yellowish or horn.

GENITALIA (Fig. 75): Verge very large, simple, situated some distance behind the right tentacle a little to the right side of the center of the neck. It is very long, somewhat sickle-shaped, and tapers gradually to a point. In contracted specimens preserved in alcohol or other media, the verge appears smooth and rounded on the outer margin and sharp and somewhat wrinkled on the inner margin; in living specimens or those freshly killed the whole verge is regularly rounded and

tapering. Female organs essentially as in Amnicolidae. The verge of *Pomatiopsis* somewhat resembles that of *Valvata*.

The male organ of Pomatiopsidae is peculiar in being without a flagellum, which has been found in most of the Amnicolidae examined. It is also of large size as compared with the verge in the Amnicolidae, and is situated so far backward on

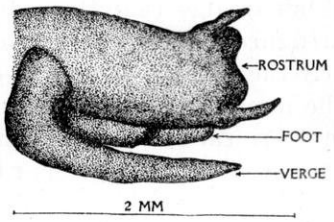

Fig. 75. Head and verge of *Pomatiopsis lapidaria*.

the neck as to be entirely concealed within the branchial cavity and is not exposed beyond the edge of the shell. Stimpson's figure shows the verge as spirally convoluted, but this form has not been observed in the specimens examined (1865b, fig. 23).

JAW (Fig. 39): Smaller than that of Amnicolidae, the plates being much wider than high.

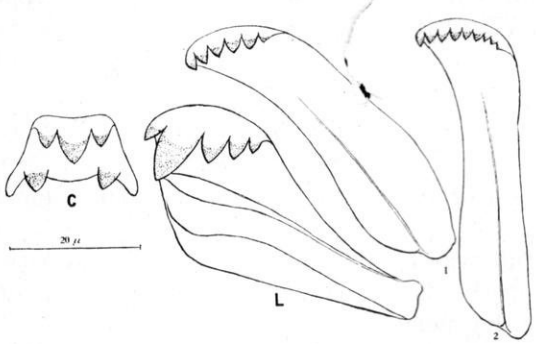

Fig. 76. Radula of *Pomatiopsis lapidaria*.

RADULA (Fig. 76): Formula $9:6:1\text{–}1\text{–}3:\frac{1\text{–}1\text{–}1}{1\text{–}1}:1\text{–}1\text{–}3:6:9$. Central tooth broader than high with curved ventral margin which bears two large basal denticulations pointed inward; reflection broad with three large, wide cusps, the center cusp being about twice as large as the side cusps: lateral teeth some-

what longer than wide with a wide peduncle about as long as the body of the tooth; there are several transverse ridges extending down the long diameter of the peduncle and tooth; reflection 5-cuspid, the second cusp from the left being twice as large as the side cusps, which also vary somewhat in size: first marginal with wide body, the reflection 6-cuspid, the cusps large and wide: second marginal also wide with 8 or 9 denticulations of large size but smaller than those of the first marginal.

The radula here figured differs from that of Stimpson in showing more clearly the form of teeth and cusps and the presence of ridges. The number of cusps also differ, especially on the marginal teeth. Several of these are small and difficult to observe unless the tooth is completely separated from the membrane.

ECOLOGY: *Pomatiopsis lapidaria* is distinctly an amphibious snail, though seemingly in many localities to prefer wet ground to actual immersion in water. Though essentially a terrestrial animal, the gill is of the usual pectinated form as found in the Amnicolidae. Few specimens have been personally collected in water but it has been found in many places under leaves and on damp or wet mud in places more or less subject to overflow from streams and rivers. When in the water it glides along with a somewhat hesitating motion, quite unlike the steady movements of *Amnicola* and other members of this family (fig. 77). It is able to remain for a longer or shorter

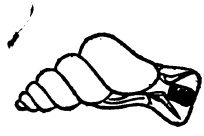

Fig. 77. Animal of *Pomatiopsis lapidaria* in water. Binney, fig. 187.

period without water by withdrawing far within the aperture and shutting the latter tightly with the operculum. Many thus survive dry periods.

GENERAL DISTRIBUTION: New York to Iowa, Michigan and Wisconsin south to Missouri, Alabama, and Georgia.

DISTRIBUTION IN WISCONSIN: Reported scatteringly over a wide area in eastern Wisconsin.

Lake Michigan Drainage: Castalia Park, Wauwatosa; Cement mills near Milwaukee, Milwaukee Co. (Chadwick); Kenosha, Kenosha Co. (Chadwick, Wiswall).

Wisconsin Drainage: Richland, Richland Co. (Chadwick).
Rock Drainage: Four Lakes (near Madison), Dane Co. (Binney, Chadwick, Lapham).

REMARKS: *Pomatiopsis lapidaria* may be known by its elongated, brownish shell, convex and deeply sutured whorls, and reflected rim of the aperture. Its habitat is also different, being rarely found in water but numerously under wet leaves and in places subject to overflow from creeks and streams. Usually it is associated with *Succinea retusa, Helicodiscus lineatus,* and often other land shells, all of which have selected the same locality for the sake of moisture. There is some variation in the form of the shell, mostly correlated with sex, the males having a much wider body whorl to accommodate the very large verge, the female shell being usually much narrower.

The method of progression is so unlike that of any member of the Amnicolidae, due to the sinuses of the foot, that it has been called by Stimpson a stepping mode of progression. Stimpson's description and figures are so graphic that they are here reproduced.

"During this motion the foot is so contracted that its two parts are distinct. In what may be called the *first motion,* the anterior part being firmly fixed upon the ground, the posterior part is drawn up to it, by a sliding movement;—in the accompanying cut (fig. 78, A) it is by exaggeration represented

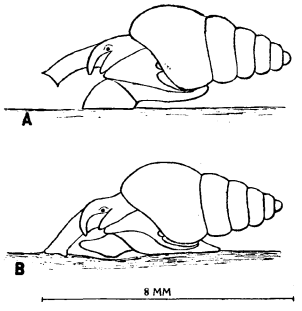

Fig. 78. *Pomatiopsis lapidaria,* Stimpson's figures showing method of progression.

a little raised from the ground, in order better to indicate its movement. At the same moment the snout is thrust forward, and its disk-like extremity affixed to the ground as far ahead as possible. Then comes the *second motion* (fig. 78, B) ; in which,

the snout and the posterior part of the foot being firmly affixed and supporting the body, the anterior part of the foot becomes free, and is thrust forward to the disk of the rostrum where it is again planted. The operations of the first motion are then repeated. Thus the animal moves by regular steps, upon three points of support, of which alternately two and one are used. During the movement the lateral folds of the body and foot are seen sliding upon each other, showing how their arrangement contributes to the facility with which this kind of progression is effected. The surface of the animal is constantly lubricated with mucus apparently much greater in amount than is seen in the Helicidae and other pulmonates. The foot is capable of adhering with considerable tenacity" (1865b, pp. 33–34).

Lapidaria is apparently rare in Wisconsin, judging from the paucity of records. This may be due, however, to its peculiar habitat, which has rendered it less sought for than other fresh water species.

POMATIOPSIS CINCINNATIENSIS (Lea)

Plate VII, figures 18, 19

Cyclostoma cincinnatiensis LEA, Proc. Amer. Phil. Soc., I, p. 289, 1840; BINNEY, L. & F. W. Sh. N. A., p. 82, fig. 163, 1865.

Amnicola sayana (ANTHONY) HALDEMAN, Mon., p. 19, pl. i, fig. 11, 1844; BINNEY, Op. Cit., p. 81, fig. 161, 1865.

Pomatiopsis cincinnatiensis WALKER, Synopsis, p. 148, 1918.

TYPE LOCALITY: Vicinity of Cincinnati, Ohio.

WISCONSIN RECORDS: None.

SHLL: Conical, turreted, elongated; color greenish or brownish horn; surface more or less shining, lines of growth crowded, distinct; apex somewhat flattened; nuclear whorls 1½, rounded, hyaline, with fine granular texture; spire shorter than in *lapidaria,* wider in the male than in the female; sutures deeply impressed and whorls well rounded, rather more than five in number, the body quite ventricose in the male; aperture orbicular; peristome continuous, thickened, slightly reflected; base well rounded; umbilicus rather wide, deep.

L. 4.4; W. 2.0; Ap. L. 1.8; W. 1.5 mm. Kankakee River Female (U. of I., Z16621).

L. 4.5; W. 3.2; Ap. L. 2.0; W. 1.5 mm. Kankakee River Male (U. of I., Z16621).

L. 5.0; W. 3.0; Ap. L. 1.9; W. 1.5 mm. Kankakee River Male (U. of I., Z16621).

OPERCULUM: As in *lapidaria,* but wider and rounder, not pointed above.

ANIMAL: Not differing essentially from *lapidaria.*

GENITALIA: As in *lapidaria.*

JAW: As in *lapidaria.*

RADULA (Fig. 79): Formula $3:4:1\text{–}1\text{–}3:\frac{1}{1}\text{–}\frac{1}{1}\text{–}\frac{1}{1}:1\text{–}1\text{–}3:4:3.$ Central and lateral teeth as in *lapidaria,* excepting that these teeth are slightly smaller than in that species: first marginal similar in shape but with four large cusps which are three or four times as large as those of *lapidaria:* second marginal

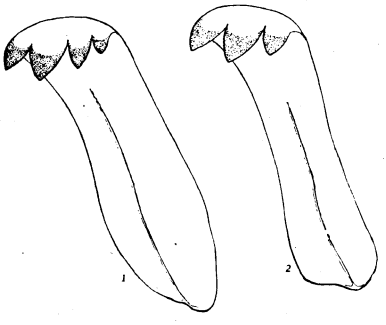

Fig. 79. Radula of *Pomatiopsis cincinnatiensis.* Joliet, Ill.

of similar shape and with three large cusps, differing widely from that of *lapidaria* which has nine small cusps. The radula is practically the same as that figured by Troschel for *Amnicola sayana,* which is a synonym of *cincinnatiensis.* The difference between the marginal teeth of the two species is only what would be expected to occur in two distinct species, such as these undoubtedly are.

ECOLOGY: Similar to that of *lapidaria.* Haldeman describes it as "found on wet earth and roots of trees on the margin of a small stream near Cincinnati". Its habitat in Illinois is similar.

GENERAL DISTRIBUTION: Western New York west to Iowa and Minnesota, Michigan south to the Ohio River. Common in North and Central Illinois.

DISTRIBUTION IN WISCONSIN: Although not yet reported from Wisconsin territory there is not the slightest doubt but that it will sooner or later be found on Wisconsin soil. Its

abundance in Northeastern Illinois suggests that it is to be looked for in Southeastern Wisconsin.

REMARKS: *Cincinnatiensis* differs from *lapidaria* in being shorter and wider, with fewer, wider whorls and deeper sutures. The umbilicus is also wider and deeper. The more ample body whorl of the male (for the reception of the very large verge) as well as the less ample but wider body whorl of the female will easily distinguish it. The radula of the two species are quite different. This species is not to be confused with *Amnicola cincinnatiensis,* a quite different species of the family Amnicolidae.

Family PLEUROCERIDAE

SHELL dextral, elongated or globose, thick and solid; aperture entire or more or less canaliculated below; operculum corneous, subspiral.

ANIMAL with large rostrum, small, squarish foot, elongated, tapering tentacles with the eyes placed on swellings at the outer base; edge of mantle smooth; no external verge, genital duct composed of two laminae forming a closed canal; oviparous. Rhachidian tooth large, broader than long, rounded below, 7–9 cuspid, the central cusp very large; laterals subrhomboidal, 4–6 cuspid, one cusp very large; marginal teeth elongated, more or less sole-shaped, multicuspid.

The shells of this family are infinitely variable and a large number of species have been described. Some of these are undoubtedly synonyms; but there are a large number that are recognizable and still others that have not yet been differentiated. The soft parts do not seem to show the differences indicated by the shells. The genitalia are remarkably uniform in those species examined, not even a difference being recorded between the sexes in the same species. This, of course, may be due to lack of observation, but in the species examined by Stimpson (and also by the writer) there was a remarkable uniformity of structure. The radula, also, as far as examined, shows little variation, save in the number of cusps or cutting points.

The operculum offers some excellent points of differentiation and careful studies of this organ are a desideratum. Good-

rich (1922, p. 9) has given the best published notes on the opercula of this group and his figures and descriptions of the *Anculosae* are about all that is available on this subject. Usually, the opercula are examined uncleaned, with low powers, and thus little differentiation is observed. Careful cleaning will reveal sculpture markings of specific, and certainly of generic value. The family presents a prolific field for the study of anatomy in a group which appears to differ from all other members of the suborder in its reproductive organs, a fine subject for a master's thesis, or even a doctor's dissertation.

KEY TO GENERA OF PLEUROCERIDAE

1. Aperture canaliculate below, shell elongated; no callus thickening on parietal wall, columella twisted ----------*Pleurocera*
2. Aperture not canaliculate, parietal wall with callus, columella smooth, not twisted ----------*Goniobasis*

Genus PLEUROCERA Rafinesque, 1818

Pleurocera RAF., Amer. Monthly Magazine, p. 355, 1818. No type designated. Type: Designated by B. Walker, *Pleurocera acuta* RAF., (see Walker, 1917).

SHELL usually lengthened, conic or cerithiform, spiral, dextral, imperforate; smooth, tuberculate, spirally striate, or carinate; aperture moderate in size, subrhomboidal, prolonged into a short canal below; columella smooth, twisted, not callously thickened (Pl. IX, Fig. 13); lip simple, sharp, sinuous, somewhat expanded. Animal as described under *Pleurocera acuta.*

PLEUROCERA ACUTA Rafinesque

Plate IX, figure 14

Pleurocera acuta RAF., Enumeration and Account, p. 3, 1831; Walker, Oc. Papers, Mus. Zool., No. 38, p. 8, 1917.

Melania subularis LEA, Trans. Amer. Phil. Soc., IV, p. 100, pl. 15, fig. 30, 1834; Obs., I, p. 110, pl. 15, fig. 30, 1834.

Melania intensa ANTHONY, REEVE, Conch. Icon., Melania, pl. xlix, fig. 371, 1860.

Trypanostoma pallidum LEA, Proc. Phil. Acad., p. 174, 1862; Journ. Phil. Acad., V, p. 275, pl. 36, fig. 90.

Pleurocera subulare Goodrich, Nautilus, XXX, p. 122, 1917.

TYPE LOCALITY: *Acuta,* Lake Erie: *subularis,* Niagara River; *intensa,* United States; *pallidum,* Niagara Falls, N. Y. and St. Lawrence at Montreal.

WISCONSIN RECORDS: None for the typical form.

SHELL: Elevated, acute, turreted; color pale brownish horn to dark chestnut, sometimes with a yellowish band encircling the whorls just below the suture; nuclear whorls 1½ to 2, smooth, rounded, wine colored, rapidly increasing in diameter, the apex bent inward; surface dull to shining, lines of growth oblique, crowded, here and there more elevated than the average; sculpture of fine incised spiral lines, which are more deeply impressed on the upper carinated whorls; whorls 15 in perfect specimens, 7–10 usually represented, very flat-sided, regularly increasing in diameter, the upper 7–11 carinated just above the suture, the last four either without carina or with a slight ridge just above the suture; the body whorl is distinctly angulated with a sharply defined carina and there may be one or more small carinae encircling the base of the body whorl; aperture subrhomboid, narrowed above, white, bluish-white or purple within, the spiral ridges on the base sometimes showing through as white lines; produced and canaliculate below near the columella where there is sometimes a purplish spot; peristome acute, smooth, rather thick; columella bluish-white, twisted, terminations of peristome and columella joined by a thick, somewhat spreading callus.

L. 28.0; W. 10.0; Ap. L. 8.0; W. 4.5 mm. Cedar Pt., Lake Erie (U. of I., Z15504).
L. 30.0; W. 10.0; Ap. L. 9.0; W. 5.0 mm. Cedar Pt., Lake Erie (U. of I., Z15504).
L. 33.5; W. 11.5; Ap. L. 9.5; W. 5.0 mm. Macatawa, Mich. (U. of I., Z17297).
L. 31.5; W. 9.5; Ap. L. 8.4; W. 4.2 mm. Bayfield, Wis. (U. of W., 4522).
L. 28.0; W. 9.8; Ap. L. 9.0; W. 4.2 mm. " "

ANIMAL: See river variety below.

ECOLOGY: Typical *acuta* is a species of the Great Lake shores where wave action is strong.

GENERAL DISTRIBUTION: Shores of the Great Lakes, from Ontario to Superior.

DISTRIBUTION IN WISCONSIN: At present known only from the shore of Lake Superior at Bayfield, Bayfield Co. (Baker).

REMARKS: Typical *acuta* should be restricted to the shells found in the Great Lakes, the type coming from Lake Erie. This type has very flat-sided whorls, usually without spiral ridges above the strongly angulated body whorl, but there may be several spiral ridges below this peripheral carina. The

body whorl is also flat-sided. There is, of course, variation in these respects, toward the river variety, but on the whole the lake form is easily distinguishable from the river and small lake form discussed below.

The synonymy indicated under *acuta* seems entirely warranted and is in general that suggested by Goodrich (1917, p. 122). *Tracta* Anth., however, appears to be a recognizable form and should be retained as a river race. All of the other names appear to have been founded on the Great Lake form. Its apparent absence from the west shore of Lake Michigan is noteworthy and probably indicates that more extensive collecting should be done in this area. The Bayfield specimens vary toward the river form.

PLEUROCERA ACUTA TRACTA (Anthony)

Plate IX, figures 1–13

Melania tracta ANTHONY, Proc. Bost. Soc. N. H., III, p. 361, 1850.
Melania neglecta ANTHONY, Ann. Lyc., N. Y., p. 128, pl. 3, fig. 29, 1854.

TYPE LOCALITY: Ohio.

WISCONSIN RECORDS:

1860. *Melania elongata* LAPHAM, p. 155. Milwaukee.
1906. *Pleurocera subulare* var *pallidum* CHADWICK, p. 87. North shore Lake Winnebago, west of High Cliff.
1906. *Pleurocera elevatum* CHADWICK, p. 87. Milwaukee River at Lindwurm and below Schlitz ice house, Milwaukee River.
1918. *Pleurocera elevatum* MUTTKOWSKI, p. 474. Lake Mendota.
1922. *Pleurocera acuta* GRIER, p. 28. Straight slough, between Monona Minn., and Fountain City, Wis.
1924. *Pleurocera acuta* BAKER, p. 134. Lake Winnebago.

SHELL: Differing from typical *acuta* in having a more rounded body whorl, with, usually, a less distinct angulation, and with several distinct spiral ridges encircling the whorls above the peripheral carina; the color is from light horn to dark chestnut, but in many specimens is dark purplish; the sculpture varies from smooth to heavily marked with spiral ridges, in many specimens a heavy ridge appearing just above the carina which encircles the suture, causing a double carina; many specimens have the body whorl well rounded without distinct angulation.

L. 26.0; W. 10.0; Ap. L. 8.5; W. 5.2 mm. Lower Dells, Wis. R. (U. of W., 4517).
L. 26.0; W. 10.1; Ap. L. 9.0; W. 5.0 mm. Bark River (U. of I., Z15334).

L. 25.0; W. 9.0; Ap. L. 7.5; W. 5.0 mm. Yahara River (U. of W., 4515).
L. 23.0; W. 8.0; Ap. L. 6.0; W. 3.5 mm. Lake Pepin (U. of W., 4516).
L. 24.0; W. 10.0; Ap. L. 7.4; W. 4.1 mm. Lake Winnebago (U. of W., 4514).
L. 17.0; W. 7.0; Ap. L. 6.0; W. 3.5 mm. Lake Winnebago (U. of W., 4514).
L. 13.0; W. 5.0; Ap. L. 4.0; W. 2.1 mm. Lake Winnebago (U. of W., 4514).
L. 10.0; W. 4.0; Ap. L. 3.5; W. 2.0 mm. Lake Winnebago (U. of W., 4514).
L. 6.5; W. 3.0; Ap. L. 1.5; W. 1.0 mm. Lake Winnebago (U. of W., 4514).

OPERCULUM: (Fig. 80) Thin, reddish-brown, left margin almost straight, basal and right margins broadly and regularly curved, apex more or less roundly acute; growth lines rather

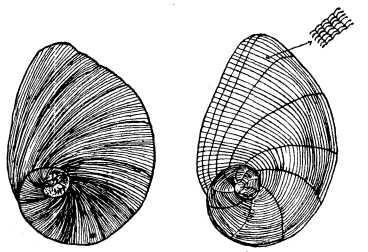

Fig. 80. Operculum of *Pleurocera acuta* and *Goniobasis livescens*. Winnebago Lake.

fine, numerous, rest scars well-marked by dark lines; nucleus sunken, about a third of the distance from base to apex, nearer the left margin; whorls three in adult animal; area of attachment occupying about half of the anterior side.

ANIMAL: (Fig. 81) with wide, short, thick foot, truncated before and rounded behind; color blackish above, yellowish underneath; the top of the rostrum is marked by black transverse bands or spots; side of body and foot streaked with black; mantle dark gray or blackish; operculigerous lobe conspicuous; head prominent, with large, somewhat elongated proboscis or rostrum, subconical in form, which is capable of considerable extension when the animal is in motion; mouth placed at tip of rostrum, disk-like, and represented by a long longitudinal slit which divides the snout-like end into a double disk (C); the radula may be plainly seen in the mouth when the

animal is feeding; tentacles rather long, tapering, very narrow; eyes black, placed on swelling at the outer base of the tentacles; mantle simple, folded on the right side to form the respiratory

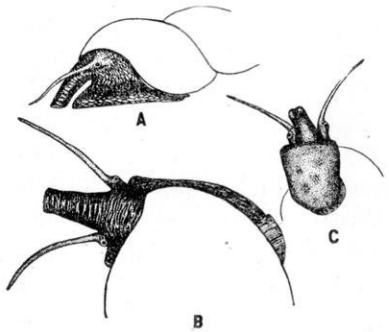

Fig. 81. Animal of *Pleurocera acuta*. Winnebago Lake.

cavity; on the right side of the body there is an impressed line which extends along the body in a parallel direction and curves to the margin of the foot behind the right tentacle; gills as usual in this group, the primary gill being very narrow.

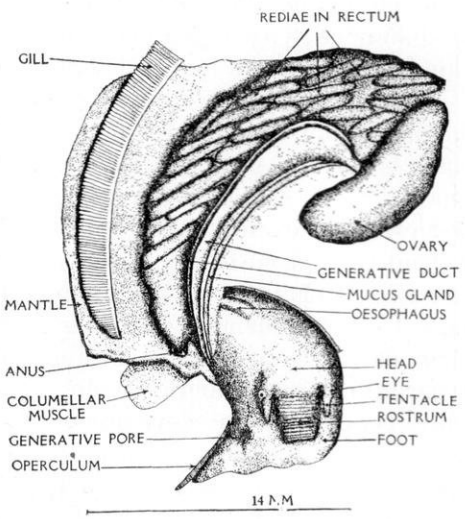

Fig. 82. Animal and genitalia of *Pleurocera acuta*. Oconomowoc River.

GENITALIA (Fig. 82): Generative duct (oviduct or vas deferens) on right side near the rectum; it is composed of two long, narrow laminae, about as broad as the rectum, placed

close together (the two edges joined to the back below) and forming a canal or channel through which the generative products are discharged. This canal-like duct opens into the mantle cavity at the angle formed by the mantle and body wall. There is no apparent opening into the body near the head (as in most forms of this group) and the products would seem to be discharged into the general mantle cavity. Posteriorly the two laminae become a single, short tube, which enters the gonads (ovaries or testes) which lie near the stomach. There is no external organ (penis) in the male. The only apparent difference between the sexes appears to be the presence of a pit or sinus on the neck between the right tentacle and the operculigerous lobe, which is present in the female (with ova) and absent in the male (with sperm). This aperture or slit is so large in the fresh animal that a pin may be passed into it for a long distance. A canal descends toward the base of the foot from this opening and becomes lost in the muscular tissue. This opening was found in those snails containing ova but not in those containing sperm, hence the inference that it is connected with the reproductive system. The left or inner lamina is smaller than the outer (right) lamina. In *Io fusiformis* the inner lamina is distended with generative products while the outer one is folded over this like a sheath (Stimpson, Op. Cit., p. 53).

Since the time of William Stimpson (1864, p. 41) apparently no additional observations have been made concerning the genitalia of these snails. Half a hundred specimens of *Pleurocera* and *Goniobasis* have been examined without finding anything essential not indicated by this careful student. This subject is worthy of the efforts of some of the anatomists who have time and patience to make serial sections and thus definitely solve the problem of the reproductive system of this group which differs from all other members yet described. Nothing is know apparently concerning the development of this family, its nidification, or breeding season.

JAW (Fig. 83): Elongately ovate, the surface covered with a multitude of small, rounded or polygonal scales which are serrated on the lower margin and lie on the membrane like shingles on a roof.

RADULA (Fig. 84): Formula $\frac{1}{8-9}+\frac{1}{6-7}+\frac{1}{3+1+3}+\frac{1}{4+1+4}+\frac{1}{3+1+3}+\frac{1}{6-7}+\frac{1}{8-9}$ (3–1–3); central tooth with a low, wide base of

attachment, the reflected portion 9-dentate, the central cusp very large and long, the side cusps very small; lateral teeth with a somewhat pear-shaped base of attachment, the lower portion acutely pointed, and with a triangular lobe or appendage on the upper part of the base of attachment; reflection wide, low, 7-dentate, three small cusps on either side of a very

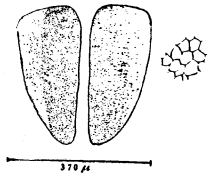

Fig. 83. Jaw of *Pleurocera acuta.* Oconomowoc River.

large, spade-shaped cusp; first marginal elongated, sharply pointed below, reflection wide, low, with 6–7 small cusps; second marginal longer than first marginal, wide above, narrowed below, the base rounded, reflection 8–9 cuspid, the cusps small. Marginals and lateral teeth all bordered by a line or faint ridge, just within the margins. In one membrane the lateral tooth was abnormal, the inner cusps being of the usual form, but the outer very irregular in size, and with several small accessory cusps.

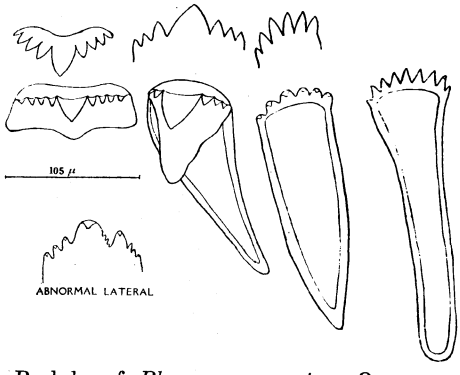

Fig. 84. Radula of *Pleurocera acuta.* Oconomowoc River.

The figure of the radula of *acuta* differs from that in the Moll. Chi. Area (p. 324). The latter is incorrect.

ECOLOGY: *Pleurocera acuta tracta* occupies many kinds of habitats, apparently, differing little in its general form in each habitat. The following embrace the variations of station in

Wisconsin: Lake Winnebago, on boulder and gravel bottom on exposed shores, in .3–1m. of water; Neenah Park, margin of Fox River, on stones in rapid current; off Randall Point, gravel bottom, water 1.5m. deep; northeast of Oshkosh, gravel bottom, 2.5m. deep; south of Oshkosh, sand bottom, 1m. deep; Long Point Island, sand bottom with vegetation (bulrush zone), 1500 feet from shore, water 1.6m. deep. Green Lake, rocky shores, water .3–.6m. deep; outlet of Green Lake, below dam, on rock ledge bottom, water shallow, swift current; Fox River at Omro, sand and mud bottom, near shore, water .3–.5m. deep (Baker). Outlet of Oconomowoc Lake (Oconomowoc River), below dam, on rocks in .3–.6m. of water, rocks well covered with algae, current moderately swift, vegetation *Potamogeton* and *Elodea* (Cahn).

This Pleurocera appears to be rare on sand and mud bottom in slow current, but common and abundant on rocky shores in a swift current or on shores subject to violent wave action. It is decidedly a shallow water form, becoming rare in water deeper than .5m.

GENERAL DISTRIBUTION: Western New York to Great Lakes Region; Canada south to Ohio River drainage.

DISTRIBUTION IN WISCONSIN: *Tracta* is distributed over the entire State, but appears to be best represented in the Fox–Wisconsin region. It is known from the following drainages: Mississippi, Chippewa, Wisconsin, Rock, Fox, Lake Michigan.

REMARKS: *Pleurocera acuta* is the only species of the genus, apparently, found in Wisconsin. It is widely distributed, very abundant in most places, and quite variable in form and coloring. Shells from the Yahara River near Madison are elongated with rounded whorls and but few or no spiral carinae on the last two whorls (fig. 8); Lake Winnebago shells are rounded and embrace all variations from rounded body whorl to rather strongly spirally ridged or carinated (figs. 1–7); Bark River and Oconomowoc River shells are very acute, of a rich dark chestnut color, and with the body whorl entirely destitute of a carina or ridge (fig. 9); Lake Pepin shells are narrow and much elongated with rounded whorls (fig. 10); shells from the Wisconsin River near Kilbourn are heavily spirally ridged or carinated and approach some of the forms called *lewisii* found in Illinois (fig. 11). Variation is so great and irregular that stable varieties are difficult to recognize.

It appears feasible to separate the river and small lake form of *acuta* from the more flat-sided Great Lake form, the whorls being rounder and the sculpture more marked. Anthony's name *tracta* appears to be available for this purpose. A large river form which occurs abundantly in the rivers of Illinois may also be referable to *tracta* (figs. 12–13). The genus *Pleurocera* is in need of a thorough revision and this must largely be done by the study of river systems. The genus appears to reach its minimum in number of species in Wisconsin.

The animal of *acuta* is somewhat sluggish in movement, when active slowly ploughing its way along, the rostrum extended like an elephant's trunk or a hog's snout and waving about from side to side, examining the bottom and objects on the bottom. When in progression the shell hangs over the left side showing the operculum attached to the top of the foot. Many of the movements of *acuta* remind one of a dog on the scent. The tentacles usually act as feelers and touch every object in the vicinity. Many individuals spend hours on the bottom with the body but partly extended from the shell and the rostrum and tentacles slowly moving about. In their natural habitat they occur in small colonies, frequently clustered about a stone or, if on a gravel bottom, in small clusters in scattered locations. When progressing, the animal glides along for a short distance, then pulls the shell after it, thus advancing by a succession of jerks.

Some of the *acuta* from the outlet of Lake Oconomowoc (Oconomowoc River) are heavily infested with rediae of a Trematode worm. The parasites completely fill the rectum of the animal causing it to be greatly distended (fig. 82). The infested snails were found only in certain parts of the river, other colonies being quite free from the parasite. Dr. A. R. Cahn, who discovered the colonies, is studying the parasite and will publish details.

Genus GONIOBASIS Lea, 1862 .

Goniobasis LEA, Proc. Acad. Nat. Sci. Phil., p. 262, 1862. No type designated. Hannibal (1912, p. 179) has designated *Melania osculata* LEA as type.

Shell thick, solid, ovate-conic to more or less elongated, dextral, spiral, imperforate; smooth, longitudinally plicate, trans-

versely striated, or tuberculated; aperture subrhomboidal, subangular at the base but not canaliculate; columella smooth, not twisted; lip simple, acute (Pl. IX, fig. 28). Animal similar in all essential details to *Pleurocera.*

GONIOBASIS LIVESCENS (Menke)

Plate IX, figures 15–26

Melania livescens MENKE, Syn. Méth., p. 135, 1830.
Melania niagarensis LEA, Proc. Amer. Phil. Soc., II, p. 12, 1841; Trans. Amer. Phil. Soc., VIII, p. 173, pl. v, fig. 21.
Melania napella ANTHONY, Proc. Bost. Soc., N. H., III, p. 362, 1850.
Melania milesii LEA, Proc. Phil. Acad., p. 154, 1863.

TYPE LOCALITY: Lake Erie, N. Y., *livescens;* Falls of Niagara, *niagarensis;* Ohio, *napella;* Tuscola Co., Mich., *milesii.*

WISCONSIN RECORDS:

1860. *Melania depygis* LAPHAM, p. 155. Milwaukee.
1906. *Goniobasis livescens* CHADWICK, p. 87. Milwaukee River at Lindwurm and near Cony Island; Menomonee River; Kenosha.

SHELL: Varying from elongate to ovate-acuminate, frequently turreted on the upper whorls; color varying from bluish-flesh to light corneous, sometimes greenish, and frequently with two dark brown bands; apex small, sharp, rounded, turned inward, brown or wine colored, of about 1½ whorls; surface shining, with very faint spiral lines; a carina encircles the center of the spire whorls which becomes obsolete on most individuals on the last two whorls; lines of growth wrinkled, crowded, conspicuous; sutures well impressed; whorls 7 to 9, more or less rounded, regularly increasing in size; spire elevated, usually sharply conic; the last whorl may be somewhat bulbous.

Aperture large, ovate or subrhomboidal, slightly produced at the lower part, brownish-purple to purplish inside; peristome sharp, thin on the edge, but thickened by a callosity within the outer lip, more or less sinuate; columella thick, solid, tinged with blue or purple, and reflected over the columellar region and lip.

L. 17.0; W. 7.3; Ap. L. 7.0; W. 3.6 mm. Sturgeon Bay, head (U. of W., 4518).
L. 15.6; W. 7.0; Ap. L. 7.0; W. 3.0 mm. Sturgeon Bay, head (U. of W., 4518).

L. 15.6; W. 7.6; Ap. L. 7.0; W. 3.5 mm. Sturgeon Bay, head (U. of W., 4518).
L. 10.6; W. 5.6; Ap. L. 5.5; W. 2.7 mm. Sturgeon Bay, head (U. of W., 4518).
L. 7.5; W. 4.1; Ap. L. 3.5; W. 2.1 mm. Sturgeon Bay, head (U. of W., 4518).
L. 17.4; W. 7.0; Ap. L. 6.0; W. 3.7 mm. Sturgeon Bay, Chara (4521).
L. 21.9; W. 11.6; Ap. L. 9.5; W. 5.2 mm. Sturgeon Bay, outer (Baker, 4519).
L. 20.5; W. 10.0; Ap. L. 8.0; W. 5.0 mm. Sturgeon Bay, outer (Baker, 4519).
L. 19.0; W. 9.6; Ap. L. 9.0; W. 5.0 mm. Sturgeon Bay, outer (Baker, 4519).
L. 15.7; W. 8.0; Ap. L. 7.3; W. 4.0 mm. Sturgeon Bay, outer (Baker, 4519).
L. 13.2; W. 7.0; Ap. L. 6.3; W. 3.5 mm. Sturgeon Bay, outer (Baker, 4519).
L. 10.0; W. 5.6; Ap. L. 5.0; W. 2.5 mm. Sturgeon Bay, outer (Baker, 4519).

OPERCULUM (Fig. 80): Long-ovate, thin, reddish brown; left margin almost straight, right margin broadly curved, base rounded, apex acute; growth lines rather coarse; under a high power very fine spiral lines may be seen; these appear like wrinkled ridges, as in the sculpture of many fresh water shells; nucleus sunken, placed at the lower quarter or third of the long diameter, near the left margin; there are nearly three whorls; area of attachment occupying the upper two-thirds of the length of the operculum and the right edge of the inner-face, which is thickened outside of the area.

ANIMAL: Similar in form to *Pleurocera*. Body yellowish-white with lines of black; orange or yellowish on neck; rostrum orange near tip, darker on upper part; under side of foot bluish white, flecked with dark spots. The whole body is sometimes lemon-yellow.

GENITALIA: Not differing from *Pleurocera*.

JAW: Similar to that of *Pleurocera*.

RADULA (Fig. 85): Formula $\frac{1}{8-9}+\frac{1}{5-6}+\frac{1}{5}+\frac{1}{4-1-4}+\frac{1}{5}+\frac{1}{5-6}+\frac{1}{8-9}$ (3–1–3). The teeth are similar in form to those of the radula of *Pleurocera acuta*. The teeth are larger than in *Pleurocera acuta* and the number of cusps on the lateral and marginal teeth are different.

ECOLOGY: Sturgeon Bay, above bridge, marly clay bottom, water .3–1.3m. deep, among Chara, the shells being heavily en-

crusted with lime. West of bridge (below), sand bottom, water 2m. deep, shells without lime deposit.

GENERAL DISTRIBUTION: New York to Great Lakes region, Canada south to Ohio River drainage.

DISTRIBUTION IN WISCONSIN: *Goniobasis livescens* is not found outside of the region of Lake Michigan in the State. It was not found in Lake Superior.

Sturgeon Bay, Door Co. (Baker); Detroit Harbor, Door Co. (Bullock); Marinette, Marinette Co. (Bullock); Menomonee and Kinnickinnic River, Milwaukee Co.; Kenosha, Kenosha Co. (Chadwick); Southern Wisconsin (Wiswall); De Pere, Fox River, Brown Co. (Marston); Milwaukee River, 1 m. east of Brown Deer, Milwaukee Co. (Clench).

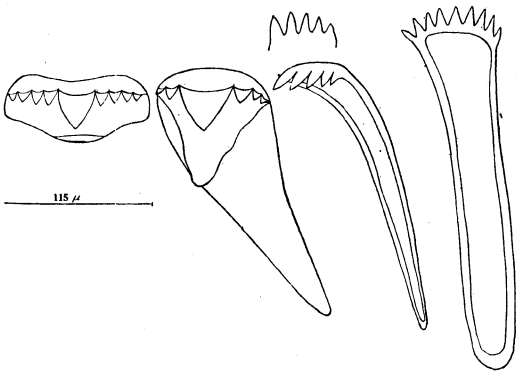

Fig. 85. Radula of *Goniobasis livescens.* Sturgeon Bay.

REMARKS: *Livescens* is the only species of *Goniobasis* found in Wisconsin. It may be distinguished from *Pleurocera acuta* by its shorter shell, more bulbous body whorl and less canaliculate aperture. Like *acuta* it is subject to great variation, certain forms being narrow and much turreted while others are short, wide, with depressed spire. Young shells are strikingly conical with the body whorl encircled by a broad, raised keel which in some individuals persists to the body whorl (figs. 17, 18, 24–26).

The synonymy cited includes forms which seem but individual variations for the most part. (See Goodrich, 1924, p. 43) Near Sturgeon Bay two forms are found which seem worthy of separation varietally. One is with long, narrow spire, short aperture, and more or less compressed body whorl. This may represent typical *livescens,* as figured by Tryon

(1873, p. 248; my pl. IX, figs. 19–21). This form is found in the upper part of the bay where the water is more or less calm. The other form is larger, more bulbous, with short, wide, spire and longer aperture. This is found on the Lake Michigan shore where the water is very rough. These seem, in Wisconsin, to be ecological variations, and the latter is separated below for this reason.

In the Chicago Area Mollusca a shell was figured as *Pleurocera subulare (acuta)* on pl. XXXV, figs. 1, 2, which is very acute, with narrow shell and long spire. This is typical *livescens* and occurred in the quiet waters of Wolf Lake, along the shore of Lake Michigan. These are similar to Lake Erie shells. They are a peculiar white form which has been observed only in this region. Mr. Goodrich stated that he had not before seen anything of this kind.

The animal of *Goniobasis* is more rapid in its movements than is *Pleurocera.* In an aquarium it will glide up the side of the glass jar with as much celerity as a *Lymnaea* or *Physa,* though not as rapidly. When at rest on the bottom it moves more or less slowly, pushing its foot forward a short distance and drawing the shell after it, a sort of stepping process. While in motion, the rostrum is constantly in motion searching for food, the action of the radula being plainly seen as it scrapes the stones and other objects. The mouth may be opened widely and the radula seems to be used in a lapping manner. The long tentacles are constantly in motion, being used as tactile organs feeling and testing all objects within reach. Sight is apparently deficient, the tentacles performing the function of this sense.

GONIOBASIS LIVESCENS MICHIGANENSIS Nov. Var.

Plate IX, figures 27–32

TYPE LOCALITY: Lake Michigan shore, east of Sturgeon Bay, north of Ship Canal, Door Co.

WISCONSIN RECORDS:

1906. *Goniobasis livescens* CHADWICK, p. 87. Lake Michigan, Milwaukee.

SHELL: With usually wider, shorter spire whorls, a bulbous or inflated body whorl, not flatly rounded as in typical *livescens,* a wider and more ovate aperture, a much heavier columella lip

and parietal callus, and a heavier and more solid shell. Color various shades of purple. The number of whorls is also usually less than in the typical form.

L. 19.0; W. 10.1; Ap. L. 7.8; W. 4.5 mm. Lake Michigan, Holotype (U. of W., 4520a).
L. 17.0; W. 9.0; Ap. L. 7.5; W. 4.4 mm. Lake Michigan Paratype (U. of W., 4520b).
L. 16.1; W. 9.0; Ap. L. 8.3; W. 4.3 mm. Lake Michigan Paratype (U. of W., 4520b).
L. 13.6; W. 7.8; Ap. L. 6.5; W. 3.8 mm. Lake Michigan, Paratype (U. of W., 4520b).

ANIMAL AND RADULA: As in typical form.

ECOLOGY: Rocky, wave-beaten shore of Lake Michigan. In the type locality (east of 100 acre swamp) the shore is bordered by heavy ledges of limestone rock.

GENERAL DISTRIBUTION: Lake Michigan. It probably also occurs in the other Great Lakes.

DISTRIBUTION IN WISCONSIN: Seen only from Lake Michigan shore south of Door County peninsula. Lake Michigan, Door Co. (Baker); Milwaukee, Lake Michigan shore (Chadwick).

REMARKS: *Michiganensis* is the Great Lake form of *livescens,* characterized by a bulbous body whorl, a wider spire, and a thick shell and lip. It is an ecological form, the heavier shell, wider body whorl, and larger aperture being a response to the rough environment of the lake shore. The Lake Michigan shells exhibit little variation, but the Sturgeon Bay shells vary from typical *livescens* to heavy forms like *michiganensis.* (See pl. IX, figs. 15–17, 25, 26, 29.) The Sturgeon Bay shells, which can scarcely be referred to *michiganensis,* are excellent examples of the effect of changing environment, from the quiet waters of the upper part of the bay, with marly clay bottom, above the bridge, to the rocky, wave-swept shore of the outer part of the bay. An occasional heavy individual among the typical, upper bay forms, indicates migration from the outer bay or a tendency to vary toward the heavy form.

Specimens of the heavy variety were submitted to Mr. Calvin Goodrich, who has made a special study of the Pleuroceridae, who says "you can safely give your Lake Michigan shells a varietal name".

GONIOBASIS LIVESCENS CORRECTA (Brot)

Plate XVI, figures 1–5

Melania cuspidata ANTHONY, Proc. Bost. Soc. N. H., III, p. 362, 1950.
Melania occulta ANTHONY, Proc. Phil. Acad., p. 58, 1860.
Melania correcta BROT., List, p. 39 (for *cuspidata*, preoccupied in Melania).

TYPE LOCALITY: Maumee River, Ohio *(cuspidata);* Wisconsin *(occulta).*

WISCONSIN RECORDS:

1860. *Melania occulta* ANTHONY, p. 58. Wisconsin.
1860. *Melania occulta* LAPHAM, p. 155. Wisconsin.
1873. *Melania occulta* TRYON, p. 248. Wisconsin.
1897. *Melania livescens* WISWALL, p. 48. So. Wisconsin.

SHELL: Differing from typical *livescens* in being usually smaller (in Wisconsin), shorter, with a less elongated spire, 6–8 whorls, a narrower, more elongated aperture, and a rounded, scarcely bulbous body whorl. There may be two distinct brown bands on the body whorl and one on the spire or the shell may be without bands.

L. 15.2; W. 8.0; Ap. L. 7.0; W. 4.0 mm. Neosho Lake (U. of I., Z22512).
L. 13.5; W. 7.0; Ap. L. 6.2; W. 3.5 mm. " "
L. 13.5; W. 6.5; Ap. L. 6.2; W. 3.5 mm. " "

ANIMAL: As in *livescens.*

GENERAL DISTRIBUTION: Ohio to Wisconsin.

DISTRIBUTION IN WISCONSIN: Known only from the southeastern part of the State.

Rock Drainage: Crawfish River, Aztalan, Jefferson Co.; Neosho Lake, Dodge Co. (Cahn).

REMARKS: A small river form of *livescens* appears referable to Anthony's *cuspidata (correcta).* It is always much smaller with fewer whorls and usually two brown bands. The Wisconsin specimens are like the *Goniobasis* from the Maumee River answering to the diagnosis of *cuspidata. Occulta* is apparently referable to the river form, which appears to be rather restricted in its distribution.

GONIOBASIS LIVESCENS BARRONENSIS Var. Nov.

Plate IX, figures 33–36

TYPE LOCALITY: Red Cedar River, west of Chetek, Barron Co.

WISCONSIN RECORDS: None.

SHELL: Differing from typical *livescens* in having the body whorl more flatly rounded, with several spiral ridges, more or less well developed, the aperture more roundly ovate, the inner lip heavier; the whorls are wider than in *livescens* and all are more flat sided, almost straight in some specimens, the sutures more impressed and forming a sharply defined v-shaped depression, giving the effect of having had a cord tightly wound about the shell; color dark chestnut, lighter at the sutures, the aperture purple, bordered on the lips by darker purplish brown. The young shell is heavily ridged on all whorls.

L. 18.0; W. 8.0; Ap. L. 7.0; W. 3.8 mm.	Holotype.	(U. of W., 4722a).
L. 18.5; W. 8.1; Ap. L. 7.0; W. 3.5 mm.	Paratype.	(U. of W., 4722b).
L. 16.2; W. 7.5; Ap. L. 6.2; W. 3.1 mm.	Paratype.	(U. of W., 4722b).
L. 16.5; W. 7.5; Ap. L. 6.0; W. 3.0 mm.	Paratype.	(U. of W., 4722b).

ANIMAL: As in *Goniobasis livescens.*

GENITALIA: As in *livescens.*

RADULA: Not differing particularly from *livescens.*

ECOLOGY: Red Cedar River, one mile west of Chetek, shallow water, on rocks in swift current.

GENERAL DISTRIBUTION: Known only from Wisconsin at present.

DISTRIBUTION IN WISCONSIN: Known only from the Red Cedar River, Chippewa Drainage, Barron Co.

REMARKS: This variety of *livescens* is characterized by its elongated shell with very flat-sided whorls and raised spiral ridges on the body whorl. The character of the sutures is also distinctive. The young shells are narrower than those of *livescens* and there are several distinct spiral ridges which are absent in the young shell of *livescens.* It appears to be an ecological variety, found in small, swiftly flowing rivers. It differs markedly from typical *livescens,* which has a smooth, acute shell, with narrow whorls. None of the names placed in the synonymy fit this variety and it is necessary to bestow a new name. Specimens of *barronensis* were submitted to Mr. Calvin Goodrich, who suggested their novelty.

The four forms of *livescens* in Wisconsin divide apparently on ecological grounds: *livescens* in bays and rivers entering the Great Lakes; *michiganensis* on exposed lake shores; *correcta* in quiet rivers and their pond-like expansions; and *barronensis* in swiftly flowing rivers of small size. The latter is almost distinctive enough to constitute a separate species.

Subclass EUTHYNEURA Spengel

Gastropods in which the visceral commissures are not crossed, but form a simple loop; sexes united in the same individual (hermaphroditic); heart often in front of the gill; shell spiral or saucer-shaped, frequently vestigial or absent; operculum generally wanting; radula generally multiserial.

Order PULMONATA Cuvier

Euthyneura in which the gill cavity is transformed into a lung for breathing free air.

Suborder BASOMMATOPHORA A. Schmidt

Animal with two tentacles which are flattened triangular or subcylindrical, contractile but not evertible, the eyes sessile at their base; a shell is invariably present and is covered with a corneous epidermis; no operculum present; mostly aquatic in habitat.

Superfamily LIMNOPHILA

Teguments smooth; living in fresh or, more rarely, in slightly brackish water; genital orifices separated, the male orifice near the tentacle, the female at the base of the neck, near the respiratory orifice; respiration by a lung, to which is added, in several families, a more or less complicated pseudobranch, or accessory branchia; jaw simple or composed of three pieces; radula with distinct lateral and marginal teeth in numerous rows; eggs enclosed in a gelatinous, transparent capsule; habits usually phytophagous, but some forms are carnivorous and others are scavengers.

The Limnophila include the pulmonate mollusks that inhabit fresh water for the most part. These embrace the familiar pond snails, orb or wheel snails, tadpole snails, and fresh water limpets, which are widely distributed. There is scarcely a body of water of any size that does not contain one or more species of this group. The shells and animals are greatly diversified, much more so than in the groups included in the gill bearing snails, which are older geologically and have become more stable. Evolution appears to be actively operating in these fresh water mollusks, which accounts in a measure for the similarity of many of the species, and also for the difficulty in fixing more definite specific limits for their characterization. Their lateness in the geological time scale also indicates that they have probably not yet reached a state of equilibrium as regards species forming.

The presence of a distinct pseudobranch or accessory gill in the Planorbidae and Ancylidae, in addition to a modified lung cavity, is of great interest. While most species are believed to come to the surface for air at more or less frequent intervals, it is known that many species can remain for long periods submerged, and in deep lakes the Limnophila seldom or never seek the air for respiratory purposes. It is possible that the pseudobranch is helpful for this purpose, although in the case of the Lymnaeas, respiration takes place through the skin. The habit of floating in a reversed position on the under side of the surface film is quite characteristic of nearly all members of this group. The diversified genitalia, radula, jaws, breathing organs, and shell, combine to make the Limnophila one of the most interesting groups of the molluscan phylum, and it is to be regretted that zoologists have not given them the study they deserve.

The genital organs of the fresh water Pulmonata are similar in form to these of the land pulmonates, and in general the same terminology can be used for both. However, in some minor features a special terminology seems desirable. The male system is made up of a large, sac-like praeputium, behind which there is a smaller penis sheath, into which the vas deferens enters. In the writer's Monograph of the Lymnaeidae (1911), these were called respectively the penis sac and the penis. Simroth (1912) uses the terminology for the penial organs referred to above, and this appears to be well suited

for the groups in question. Pilsbry (1911), in a review of the Lymnaeidae Monograph, has suggested that the penis (now penis sheath) should be called the epiphallus as in the land shells, but this organ is scarcely homologous with the epiphallus, which is described as an enlargement of the vas deferens as it enters the penis. In the fresh water pulmonates the organ here designated as the sheath (also known as hyperphallus or capsule of the verge) contains the true penis, which is extended through the praeputium during copulation. In some groups, there is a swelling of the vas deferens near the penis sheath which may be comparable to the epiphallus of land mollusks.

Within the praeputium there are usually several muscular pillars which guide the penis during protrusion, and at the upper or inner end of the praeputium there is usually a fleshy ring of tissue which is an excitory organ called the sarcobelum. The shape of the penis within the penis sheath and the comparative size of the penis sheath and praeputium are good characters for either specific or group separation. The presence or absence of certain glands or appendages (as well as a flagellum) also aid in the general classification of this group of mollusks. The female organs are less variable on the whole than the male organs. These differ somewhat from the same organs in the land pulmonates and some special terminology is employed. The details of this variation are noted under each family.

KEY TO FAMILIES OF LIMNOPHILA

1. a. Shell patelliform ---------- *Ancylidae*
   b. Shell spiral ---------- 2
2. a. Shell discoidal, orb-like ---------- *Planorbidae*
   b. Shell with elongated spire ---------- 3
3. a. Shell dextral ---------- *Lymnaeidae*
   b. Shell sinistral ---------- *Physidae*

Family LYMNAIDAE Broderip, 1839, emend

SHELL (Fig. 86): Normally dextral, rarely sinistral, ovately-oblong or elongate; spire more or less attenuated; columellar axis thickened by a shelly deposit and typically gyrate or twisted; peristome thin, sharp; shell covered with a corneous periostracum or epidermis.

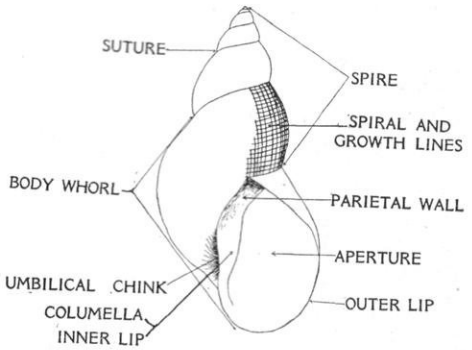

Fig. 86. Parts of Shell of Stagnicola.

ANIMAL (Fig. 87): With a short, wide, rounded foot; head supporting a velum which is retained from the larval state; tentacles flattened, triangular, the eyes sessile upon their inner base; a large superior and two smaller, narrow, lateral jaws present; central tooth unicuspid, lateral teeth bi-or tri-cuspid, marginals serrated; kidney very large, wide pear-shaped; ureter proceeding directly forward without flexure; buccal retractors two in number, very long, inserted distally in the columellar muscle, the right retractor near the penis retractors and the

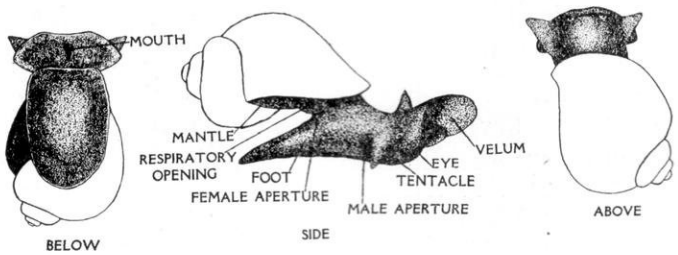

Fig. 87. Animal of Lymnaeid, *Stagnicola emarginata mighelsi.* Maine.

left retractor some distance from this point; stomach with bilobed crop, the pyloric portion and intestine strongly flexed; without pseudobranch; genitalia with the genital apertures separated; the male organs consist of penis within the penis sheath, praeputium, vas deferentia, and prostate; the female organs consist of vagina, oviduct, receptaculum seminis, albumen gland, and egg gland; an ovotestis and ovisperm duct are common to both male and female systems. The penis sheath and

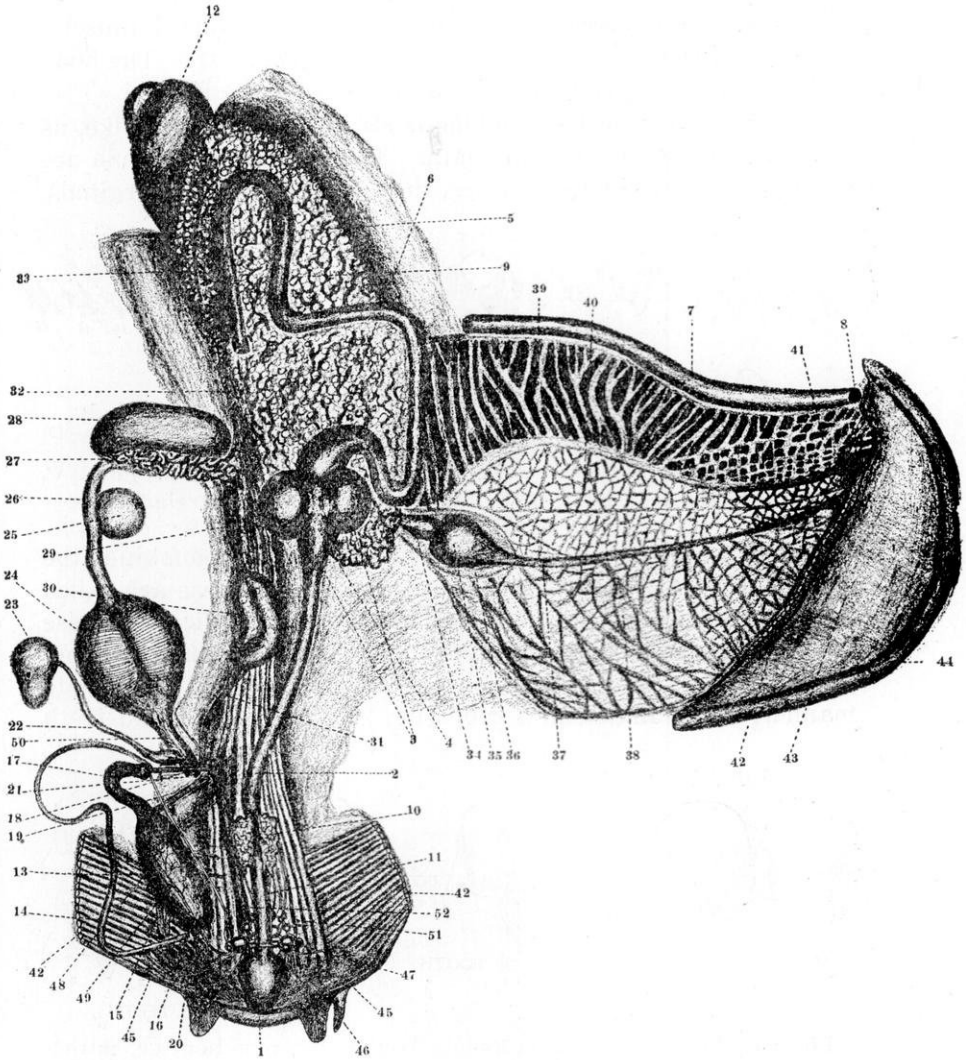

Fig. 88. Anatomy of *Stagnicola reflexa*. Animal removed from shell, dissected, and the organs separated. 1, buccal sac; 2, oesophagus; 3, gizzard; 4, crop; 5, intestine 6, pyloric portion of stomach; 7, rectum; 8, anus; 9, liver or digestive gland; 10, salivary gland; 11, ducts of salivary gland; 12, spire portion of body, containing one lobe of the digestive gland; 13, praeputium; 14, vas deferens; 15, anterior protractor muscles of praeputium; 16, posterior protractor muscles of praeputium; 17, penis sheath; 18, retractor muscle of penis sheath; 19, retractor of praeputium; 20, penal opening; 21, vaginal opening; 22, duct of receptaculum seminis; 23, receptaculum seminis; 24, oviducal bulb or uterus; 25, nidamental gland; 26, oviduct; 27, spermoviduct or carrefour; 28, albumin gland; 29, posterior portion of prostate; 30, anterior enlarged portion of prostate; 31, prostatic portion of vas deferens; 32, ovisperm duct; 33, ovotestis; 34, ventricle; 35, auricle; 36, pericardiac cavity; 37, pulmonary vein; 38, plexus of blood vessels on left lobe of kidney; 39, pulmonary sac or rete; 40, glandular portion of kidney, or renal organ; 41, ureter; 42, cut edge of muscles connecting head with velum; 43, velum; 44, muscular collar of velum; 45, cut edge of head; 46, tentacle; 47, supra-esophageal ganglia; 48, nerve to penis sheath; 49, nerve to praeputium; 50, nerve of female genital organs; 51, columella muscles and foot retractor muscles; 52, right retractor muscle of buccal sac.

praeputium are retracted by one or more powerful muscles which are inserted in the columella muscle (fig. 88). The body of the animal is striated, not granulose as in the helices.

The radula of the Lymnaeidae is strap-like or ribbon-like, as in the other groups of Pulmonata. The teeth of the radula are divisible into two distinct series, the laterals and the marginals.

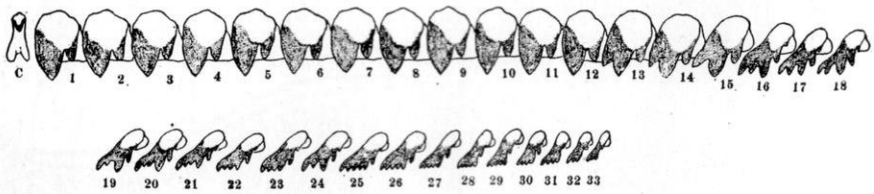

Fig. 89. Radula of *Stagnicola reflexa*, showing One Half of Row. C, central tooth; 1–12, lateral; 13–15 intermediate; 16–33 marginal teeth.

Between these two series there is a third, which combines the characteristics of both laterals and marginals; these are called intermediate teeth. A single half row of teeth, indicating these diverse groups, is shown in figure 89. There are usually from 80 to 100 rows of teeth, which overlap in the usual pulmonate manner, like shingles on a roof (fig. 90). The marginal teeth

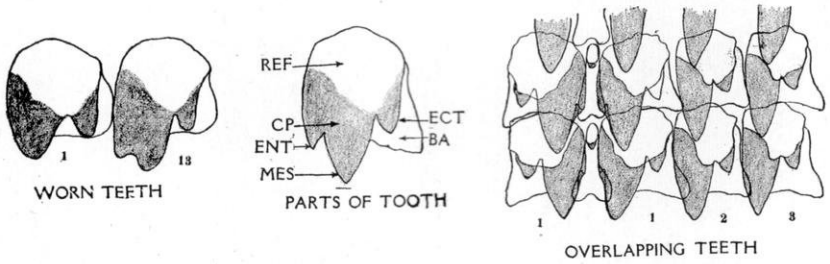

Fig. 90. Parts of Lymnaeid Radula Teeth. REF, reflection; CP, cutting part of tooth; ENT, entocone; MES, mesocone; ECT, ectocone, BA, base of attachment.

are always multicuspid or serrated, indicating descent from the Tectibranchiate stock of marine mollusks. In studying the radulae of this family it is important to consider only the newer perfect teeth, as the older teeth near the mouth are usually much worn by use, and hence give a false idea of the true form of the cusps (fig. 90). The nomenclature of the individual teeth is indicated in figure 90.

The eggs of Lymnaea are laid in irregularly elongate-ovate, gelatinous masses on stones, sticks, stems and leaves of water plants, on other shells, both dead and those occupied by the animal, and, in fact, on any kind of debris. The size of the egg masses varies considerably in the same species as do also the number of eggs in each mass (pl. XXII, figs. 22, 23).

In *Lymnaea palustris elodes* the number varies from 26 to 64 and in *Lymnaea reflexa* from 100 to 130. Eggs may be found from July to late September.

The embryology of the Lymnaeas does not differ radically from that of other Pulmonata, excepting in some minor features, notably the retention of the velum in post embryonic life. In the trochosphere a ring is formed about the developing embryo, which becomes ciliated and is used as an organ of locomotion. This is termed the velum, and when fully developed the mollusk is said to be in the veliger stage. The mollusk retains this velum in post embryonic life, though it loses its fringe of cilia and its locomotor function (see figure 91).

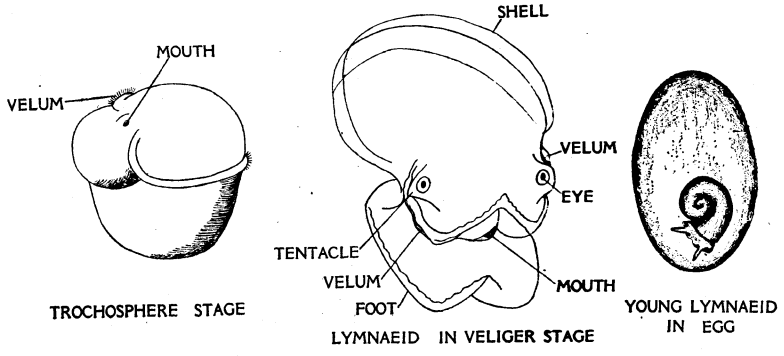

Fig. 91. Development of Lymnaeid.

The young Lymnaea, just before it leaves the shell, is an interesting object, especially when viewed with a lower power by the aid of which its spiral journeyings inside the egg may be observed (figure 91). The shells at this time consist of a trifle less than two whorls, which are flat and helix-like, quite unlike the long-spired shell of the mature animal. The eggs of Lymnaea are easily obtained and the development of the embryo may be plainly seen and studied with ordinary powers of a compound microscope. Much good work may be done by any-

one who will compare the development of some of the common species.

DISTRIBUTION: World-wide, but more numerous in the north temperate zone.

GEOLOGICAL RANGE: Upper Jura (Purbeck) to recent fauna. Maximum development in late Tertiary time. In America the family ranges as far back as the Comanchean Period.

As restricted above, the Lymnaeidae form a markedly uniform and well-characterized group of fresh-water Pulmonata. The general morphology of the family type is indicated in figure 88. For an extended account of the morphology, ecology, and other matters relating to the family, see Baker, Monograph of the Lymnaeidae.

American Lymnaeas may be divided into three groups, based on the characteristics of the radula. These are, first, those with bicuspid laterals, second, those with tricuspid laterals, and third those in which the laterals have an entoconic swelling, representing the entocone of the tricuspid group. In Lymnaea, the first lateral may occasionally be tricuspid, and in Radix the first lateral is normally tricuspid, the balance being bicuspid. A classification based primarily on the dentition, with the other characteristics more or less secondary, would be as follows:

Genus LYMNAEA LAM. First lateral bi-or tricuspid, balance of laterals bicuspid; prostate with bulbous termination; penis sheath less than half the length of the praeputium.

Genus STAGNICOLA LEACH. Laterals bicuspid, intermediate teeth tricuspid; prostate long-ovate; penis sheath ¾ of, to as long as the praeputium; sarcobelum a small muscular ridge.

Subgenus STAGNICOLA ss.* Shell large, with gyrate or plaited columella, with heavy impressed spiral lines, not hirsute; penis narrow, acutely elongated, with muscular ridge near distal end.

Subgenus HINKLEYIA nov. subg. Shell small, without plait on the columella which is more or less hour-glass-shaped, spiral lines heavily impressed, the periostracum standing erect in the lines giving a somewhat hirsute appearance to fresh shells; penis very thick with constriction in center.

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* First lateral sometimes tricuspid (i. e. European *palustris*).

Subgenus NASONIA nov. subg. Shell small, without columellar plait, surface without distinct spiral lines; penis rather thick.

Genus ACELLA HALDEMAN. Lateral teeth with a large entoconic swelling, intermediate teeth tricuspid; shell very long and narrow, the apical whorls very long and flat-sided; penis sheath as long as praeputium, the latter with large sarcobelum; penis long, tapering, with slight swelling at end; prostate elongated, flatly cylindrical.

Genus PSEUDOSUCCINEA BAKER. Lateral teeth tricuspid; shell succineiform; penis sheath half the length of the praeputium; prostate long and narrowly, roundly cylindrical, with the proximal end somewhat enlarged; oviduct globular.

Genus RADIX MONTFORT. Lateral teeth tricuspid; prostate with ovate or pyriform termination; spermatheca pyriform, not round; penis sheath much longer than praeputium, very narrow and tube-like; shell large and more or less bulbous, with patulous aperture.*

Genus BULIMNEA HALDEMAN. Lateral teeth tricuspid; shell bulimiform, apical whorls wide, rounded; penis sheath much longer than praeputium, enlarging toward distal end; praeputium with large sarcobelum; penis long, narrow, gradually tapering to end; prostate long, irregularly spindle-shaped.

Genus FOSSARIA WESTERLUND. Lateral teeth tricuspid; penis sheath shorter than praeputium, the latter without sarcobelum; penis long, narrow, tapering; prostate ovate, rounded at either end; shell small, without distinct spiral lines, normally.

This classification appears to be more natural than that proposed in the Lymnaeidae monograph and is herein used. As to whether the groups should be classed as genera or subgenera will probably be a matter of personal opinion. They are herein considered as of generic importance.

KEY TO WISCONSIN GENERA OF LYMNAEIDAE

Animal Features

1. a. Radula with bicuspid laterals ---------- 2
   b. Radula with tricuspid laterals ---------- 4

* Some specimens introduced into America had bicuspid laterals 2–8, with an endoconic swelling. The first lateral was distinctly tricuspid. All European authors cite the species as with tricuspid laterals and they are so figured.

2. a. Prostate bulbous ---------- *Lymnaea*
   b. Prostate long, ovate or cylindrical ---------- 3
3. a. Lower part of oviduct narrowly pyriform, penis slender, with muscular ridge near proximal end ---------- *Stagnicola*
   b. Lower part of oviduct globular, wide, penis wide and thick, with a constriction near the center ---------- *Hinkleyia*
4. a. Radula with endocone represented only by swelling which does not become a true cusp ---------- *Acella*
   b. Radula with distinct tricuspid laterals ---------- 5
5. a. Praeputium without sarcobellum of notable size; penis sheath ⅔ length of praeputium ---------- *Fossaria*
   b. Praeputium with distinct, large sarcobelum ---------- 6
6. a. Penis sheath 1¼ times length of praeputium, gradually enlarging toward end; prostate irregularly cylindrical *Bulimnea*
   b. Penis sheath ½ length of praeputium; prostate cylindrical, narrow, with enlarged, globular distal end ---- *Pseudosuccinea*

Shell Features (Plate XI)

1. a. Spire elongated, as long as or longer than aperture ---------- 2
   b. Spire acute, much shorter than the elongated aperture (Fig. 3) ---------- *Pseudosuccinea*
2. a. Shell very large, body whorl wide, much inflated ---------- 3
   b. Shell small or of medium size, body whorl slightly inflated or flatly rounded ---------- 4
3. a. Shell horn color, spire acute (Fig. 6) ---------- *Lymnaea*
   b. Shell greenish or reddish, aperture purplish, spire wide (Fig. 5) ---------- *Bulimnea*
4. a. Shell very slender, thin, fragile, spire much longer than aperture, lip continuous (Fig. 8) ---------- *Acella*
   b. Shell more or less inflated, usually rather solid, spire as long as or a trifle longer than aperture, lip not normally continuous ---------- 5
5. a. Surface with distinct spiral sculpture ---------- 6
   b. Surface without distinct spiral sculpture, columella smooth (Fig. 2) ---------- *Fossaria*
6. a. Shell of medium size, spire usually acute, body whorl compressed or slightly inflated, columella twisted or plicate (Fig. 4) ---------- *Stagnicola*
   b. Shell small, spire and aperture about equal, surface somewhat hirsute, columella smooth, not plicate ---------- *Hinkleyia*

Genus LYMNAEA Lamarck, 1799

Prodr. Nouv. Clas. Coq., p. 75, 1799; Syst. des An. s. Vert., p. 91, 1801. Type: *Helix stagnalis* LINNAEUS (see Baker, Mon. Lymnaeidae, p. 134, 1911, for full synonymy).

SHELL: Ovately-oblong or elongated, generally thin and brittle; spire more or less attenuated; last whorl expanded;

peristome thin, somewhat flaring, without internal varical thickening; aperture ovate or oblong-ovate, sometimes rounded; axis gyrate, forming a sharp, ascending columellar plait; no true umbilicus, but there is occasionally a very small chink; columellar callus closely appressed to the body of the last whorl, forming a wide deposit; surface marked by numerous fine impressed spiral lines and close-set longitudinal growth lines, forming a finely decussated pattern; a horny periostracum or epidermis is present (pl. XI, fig. 6).

ANIMAL: With a short, wide, rounded foot; head with the usual bilobed vela area; surface of body finely striated, presenting a smooth appearance; tentacles, eyes and other characters as in the family.

JAW: Superior jaw much wider than high; dorsal margin rounded, ventral margin with a central more or less acutely rounded projection; lateral jaws triangular, the lower angle produced into a long tongue-like projection.

RADULA: With unicuspid central tooth and normally bicuspid lateral teeth (occasionally first lateral is tricuspid); marginals serrated.

GENITALIA: Praeputium very large, penis sheath very short (about one-fourth length of praeputium); retractors of praeputium normally two in number, very large, the retractor of the penis sheath attached to this muscle; protractors of praeputium very large, massive; prostate forming a bulb-like enlargement at the proximal end; penis short, tapering, with a muscular ridge near the distal end; praeputium with a small, distinct sarcobelum; spermatheca rounded, on a long, thin duct; oviduct large, cylindrically inflated; egg gland small, globular.

DISTRIBUTION: Holarctic region of America, Europe, and Asia.

The genus *Lymnaea* as here restricted includes those species having a bulb-shaped prostate and distinct bicuspid lateral teeth without typical tricuspid intermediate teeth. The first lateral may be tricuspid in certain individuals of the typical Lymnaeas. In these characteristics these species differ from all other species of the family. The shells are usually more or less thin and brittle, and the aperture varies from long and narrow to roundly ovate or even patulous.

KEY TO VARIETIES OF LYMNAEA

1. a. Spire as long as or longer than aperture ---------- 2
   b. Spire shorter than aperture ---------- 3
2. a. Body whorl regularly rounded, aperture acutely angled above ---------- *jugularis*
   b. Body whorl with distinct shoulder, aperture rounded above ---------- *perampla*
3. a. Body whorl cylindrical, flattened, aperture elongate-ovate ---------- *lillianae*
   b. Body whorl inflated, aperture expanded, roundly ovate ---------- *sanctaemariae*

LYMNAEA STAGNALIS JUGULARIS Say

Plate XI, figures 9–13; plate XII, figures 1–4, 11–12

Lymnea jugularis SAY, Art. Conchology, Nich. Encyc., I, no pagination, 1817. Ed. III, p. 6, 1819; HALDEMAN, Mon., p. 16, pl. iv, 1841; BINNEY, L. & F. W. Sh. N. A., p. 26, fig. 29, 1865.

Lymneus appressus SAY, Journ. Phil. Acad., II, p. 168, 1818; HALDEMAN, Mon., p. 18, pl. v, 1842; BINNEY, Op. Cit., p. 25, fig. 28, 1865.

Limnaea stagnalis appressa BAKER, Moll. Chi. Area, p. 283, figs. 92, 93, pl. 34, fig. 1, 1902.

Lymnaea stagnalis appressa BAKER, Mon. Lymn., p. 137, pl. xix, figs. 4–10; pl. xx, figs. 1–6; pl. xxii, figs. 1–3, 1911.

Limnaeus speciosus ZIEGLER, Icon., I, pt. 2, p. 96, pl. 2, fig. 50, 1835.

TYPE LOCALITY: *Appressa,* Lake Superior; *jugularis,* not stated by Say; *speciosus,* fresh waters of America.

WISCONSIN RECORDS:

1860. *Limnaea jugularis* LAPHAM, p. 155. Milwaukee.
1865. *Limnaea stagnalis* BINNEY, p. 29. Milwaukee.
1897. *Limnaea stagnalis* WISWALL, p. 48. Southern Wisconsin.
1906. *Limnaea stagnalis appressa* CHADWICK, pp. 22, 80. Milwaukee and vicinity; Okauchee Lake and Delafield, Waukesha Co.; East Twin River, Two Rivers, Manitowoc Co.; Lake Winnebago, west of High Cliff, Calumet Co.; Kenosha.
1911a. *Lymnaea stagnalis appressa* BAKER, p. 238. Tomahawk Lake.
1918. *Limnaea stagnalis* MUTTKOWSKI, p. 474. Lake Mendota.
1924. *Lymnaea stagnalis appressa* BAKER, p. 136. Fox River; lakes Winnebago and Butte des Morts.

SHELL: Large, elongated, somewhat fusiform, thin; color yellowish or brownish horn, sometimes blackish; surface shining; lines of growth rather coarse, crossed by distinct impressed spiral lines; nuclear whorls 1¼, smooth but texture resembling satin finish, shining; whorls 7, the early ones not rapidly increasing in diameter, the body whorl more rapidly

expanding; all spire whorls very flat-sided, longer than wide, the body whorl more rounded: spire long, acutely pointed, usually more than half as long as the entire shell: sutures distinct, sometimes impressed; aperture ovate, sometimes somewhat dilated above, rounded below; the outer border usually well rounded; outer lip thin, acute; parietal wall with a thin callus which is appressed to the umbilical region, either completely closing the umbilicus or leaving a small chink; pillar of the columella gyrate, forming a heavy, oblique, ascending plait.

L. 50.0; D. 22.0; Ap. L. 25.5; D. 13.0 mm.	Oconto (U. of W., 4672).
L. 53.0; D. 21.0; Ap. L. 25.5; D. 13.0 mm.	" " "
L. 48.0; D. 22.0; Ap. L. 25.5; D. 13.5 mm.	" " "
L. 45.5; D. 21.0; Ap. L. 22.0; D. 12.5 mm.	" " "
L. 31.5; D. 13.4; Ap. L. 16.0; D. 8.5 mm.	" " "

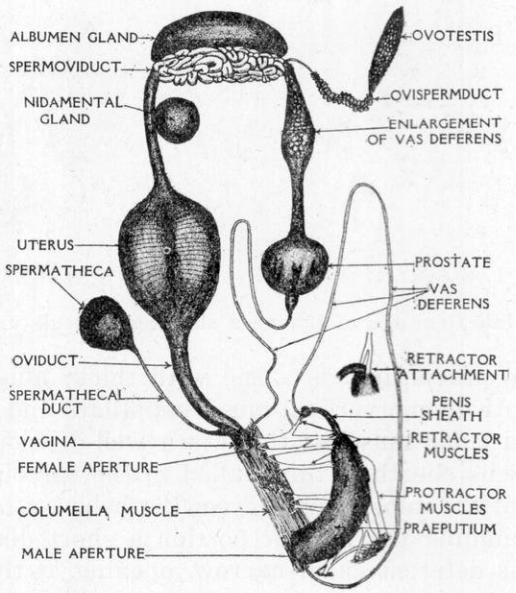


Fig. 92. Genitalia of *Lymnaea stagnalis jugularis.*

ANIMAL: Light or dark horn colored, tinged with bluish on the foot; tentacles triangular, flat, rather long and tapering; foot short and wide, truncated before and roundly pointed behind.

GENITALIA (Fig. 92): Praeputium very large, cylindrical, wide at penial opening and tapering toward the distal end;

penis sheath short, about one-quarter the length of the praeputium; vas deferens five times the length of the praeputium; before it enters the muscular tissue of the body; vas deferens from vaginal opening to prostate half as long as the penial portion; prostate large, bulbous, flattening behind to form a wide, more or less ribbon-like body of the vas deferens, which gradually enlarges and then decreases in diameter before it enters the spermoviduct; protractor muscles 5–8 in number, 2–5 posterior and 3 anterior; these muscles are split at their extremities into many small branches where they enter the body wall, columella muscle, and penis sac and praeputium; retractor muscles 1–3 in number inserted in the columella muscle; the retractor of the penis sheath is inserted in the posterior retractor of praeputium and the penial nerve enters this muscle (fig. 93). Rarely but one retractor is present. In-

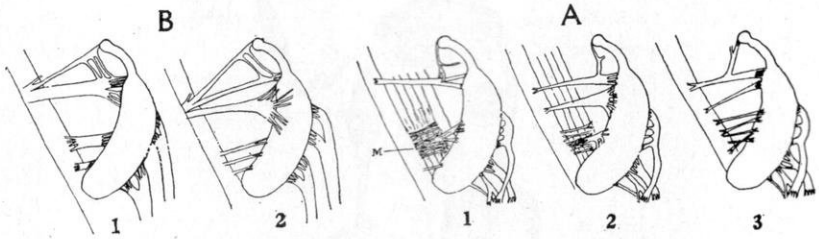


Fig. 93. Male Genitalia of Lymnaea showing Musculature of Organ.

ternally the praeputium is a sac with thick, muscular walls, there being two long, vertical muscular pillars and many large, ridge-like circular muscles; there is a well-developed sarcobelum; the penis sheath is thin-walled to the sarcobelum; penis long, wide at the upper part, narrowing below, a large ring or ridge surrounding the narrow portion a short distance above the end; vas deferens canal narrow, opening at the tip of the penis (fig. 94).

The female organs consist of a very short and wide vagina, which enters a long and narrow oviduct, which is greatly enlarged (oviducal bulb or uterus) about midway, finally entering the long, much convoluted spermoviduct which lies just below the very large, albumen gland; between the enlargement of the oviduct and spermoviduct there is a small, rounded nidamental gland; the spermatheca is roundly pyriform with a

long, narrow duct which enters the vagina just above the female opening:

The ovotestis is embedded in the liver or digestive gland and a rather short, more or less convoluted ovisperm duct connects it with the oviduct. The organs are brightly colored in freshly

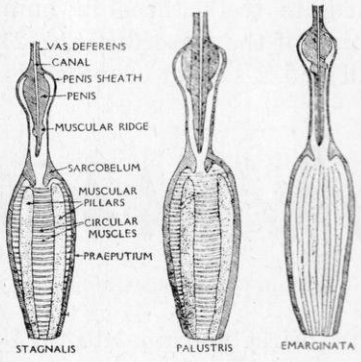


Fig. 94. Sections of Male Organ of Lymnaeids.

killed animals, the enlarged portion of the oviduct and the spermatheca are bright orange, the prostate is orange shading into black, the vagina is whitish and the penis sheath flesh colored, the praeputium being blackish. The other organs are white. For descriptions of variation in muscles, etc., see Baker, 1911c, p. 142.

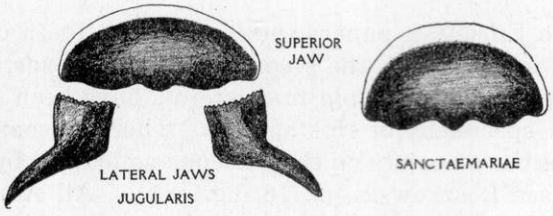


Fig. 95. Jaws of Lymnaea.

JAWS (Fig 95): The superior jaw arched, very wide and low, its cutting edge with a narrow, somewhat acute swelling in the middle, with a larger, convex swelling on each side; lateral jaws somewhat triangular, the lower point of the triangle produced, long and tongue-like, directed downward and outward when the jaws are pressed out flat. The cutting edge of the jaws is very dark chestnut colored, almost black in some specimens.

RADULA (Fig. 96): Formula $\frac{24}{3-4+1}+\frac{3}{3}+\frac{19}{2}+\frac{1}{1}+\frac{19}{2}+\frac{3}{3}+\frac{24}{3-1+}$ (46–1–46). Central tooth with a single spade-shaped cusp; first to nineteenth lateral teeth bicuspid; the mesocone very large, rather narrow and acute, the ectocone short, spade-shaped and placed rather high on the reflection; the sixteenth to nineteenth teeth develop a very small cusp just above the ectocone; intermediate teeth three in number, the endocone arising by a splitting of the mesocone (20, 21), the ectocone becoming very small and a second cusp developing on the reflec-

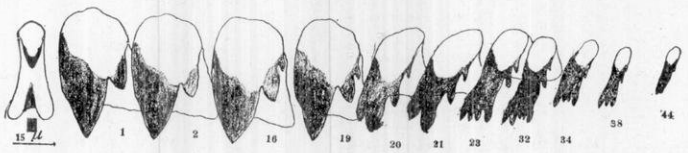


Fig. 96. Radula of *Lymnaea stagnalis jugularis.*

tion just above it. First marginal teeth 4–5 serrate distally, with a small ectocone. The typical marginal teeth are narrow and elongated with very small cusps (32, 34). The extreme outer marginals are small, narrow and indistinctly serrated distally (38, 44). The number of teeth seems to vary in different individuals. The writer has counted from 46–1–46 to 54–1–54; Binney (L. and F. W. Sh., p. 28) gives 40–1–40 and (p. 155) 47–1–47 teeth. It is probable that the membrane having 54–1–54 teeth was abnormal. 46–1–46 is the number usually counted.

In some European papers the first lateral tooth of *stagnalis* is figured as tricuspid, the second lateral, however, always being bicuspid. No tricuspid first laterals have been seen in any American specimens of this species. There is some variation in the number of points on the ectocone as figured by European writers (see Roszkowski, pl. 16, fig. 181). All American specimens have been very uniform in this respect, however, and no splitting of the ectocone has been observed.

ECOLOGY: The American form of *stagnalis* is usually found in more or less stagnant parts of ponds or lakes and rivers about vegetation. It may frequently be seen floating among pond weeds and algae, the foot applied to the surface film of the water, the shell hanging downward. It has been seen to eat rotting vegetables and fruit, and it is known to attack living animals, as small fish (see Baker, 1911c, p. 147). Some spe-

cific habitats in Wisconsin are noted below: Bayfield, in pool behind beach of Lake Superior, mud bottom, water .9–1.3 m. deep, on floating logs and among vegetation. Near Oshkosh in small bay of Lake Winnebago, water .9 m. deep, vegetation thick, snails on under side of *Castalia* leaves. Asylum Bay, Lake Winnebago, in marsh behind point, water .6–.9 m. deep, soft mud bottom, snails among thick vegetation of *Myriophyllum, Ceratophyllum, Elodea, Potamogeton,* and blanket algae. Omro, Fox River, near bank, among vegetation, water .6–.9 m. deep, mud bottom.

DISTRIBUTION: North America from about the 37th (Colorado) and 41st (Illinois) parallels of north latitude to the Arctic Ocean. A circumboreal species, of which the variety *jugularis* occupies the greater part of the American range.

DISTRIBUTION IN WISCONSIN: *Jugularis* is widely distributed throughout the State and is probably universally to be found.

REMARKS: *Lymnaea stagnalis jugularis* is the largest American member of the family and is easily known by its large, yellowish or horn-colored shell, long spire and large aperture. Apparently typical *stagnalis* is found only in parts of Alaska, the variety *jugularis*, and others, taking its place in the American continent. The aperture is more oval and not so angular as the typical form, and the columellar callus is more closely appressed to the parietal wall, giving the axis a conspicuous twist which is absent in most specimens of typical *stagnalis*.

In the writer's Monograph of the Family Lymnaeidae the *appressa* of Say is used for this American form of *stagnalis*. If the *jugularis* be considered a synonym of *appressa,* as seems highly probable, that name given a year earlier must be used for the variety. Say's type of *jugularis* has been lost and we must depend upon the description for its identification. As Say especially calls attention to the resemblance of his *jugularis* to the *stagnalis* of Europe, there seems little doubt of the identity of this form with the later described *appressa,* although Say does not mention *jugularis* in comparing his *appressa* with *stagnalis*. The size, one inch, suggests that Say's specimen was immature.

It has been suggested that the *fragilis* of Linn. is the same as *jugularis,* but as there is some uncertainty concerning just

what the *Helix fragilis* really is, it seems much better to use the name given by Say for the American variety (see Baker, 1911c, p. 149 for a discussion of the relation of European names to the American species). The anatomy of European and American forms is almost identical.

There is some variation in the height and acuteness of the spire, in the angulation of the outer lip, and in the length and width of the aperture. Say's specimen of *appressa* came from Lake Superior and a specimen from Bayfield, similar to Binney's figure of Say's type is figured.

The river form of the American *stagnalis* is slightly narrower and the spire is narrower and more elongated than the typical lake form, which more nearly resembles Haldeman's and Binney's figures of *jugularis*. So great is the variation, however, that this distinction would not hold good in a large series. The natural habitat of *jugularis* is more or less stagnant parts of both lakes and rivers, making an almost identical habitat in both ecological regions.

LYMNAEA STAGNALIS PERAMPLA Walker

Plate XII, figures 5–7

Limnaea stagnalis WALKER, Nautilus, VI, p. 31, pl. 1, fig. 6, 1892.
Lymnaea stagnalis var. perampla WALKER, Nautilus, XXII, p. 8, pl. ii, figs. 5, 6, 1908.
Lymnaea stagnalis perampla BAKER, Monog. Lymn., p. 151, pl. xx, fig. 7–9, pl. xxii, fig. 5, 1911.

TYPE LOCALITY: Houghton Lake, Roscommon Co., Mich.

WISCONSIN RECORDS: None.

SHELL: Differing from variety *jugularis* by its shorter, rapidly accuminating spire and larger, strongly shouldered body whorl; the first three whorls of the spire are slender and increase regularly in size; the penultimate whorl is disproportionately enlarged, swollen and subangulated by the flattening of the upper part of the whorl, which in the body whorl develops into a prominent shoulder.

L. 45.5; D. 26.0; Ap. L. 28.0; D. 18.0 mm.	Type.
L. 39.5; D. 20.5; Ap. L. 24.0; D. 12.0 mm.	Green Lake (U. of W., 4673).
L. 36.0; D. 17.5; Ap. L. 20.4; D. 10.0 mm.	" " "

ANIMAL, JAW, AND GENITALIA: Not examined. The specimens in Green Lake were all without the animal.

ECOLOGY: No exact data are available concerning the ecological characteristics of the Wisconsin specimens. In Douglas Lake, *perampla* lives in protected situations on mucky shores among vegetation.

DISTRIBUTION: At present known only from Michigan and Wisconsin.

DISTRIBUTION IN WISCONSIN: Known only from Green Lake, Green Lake Co. (Baker).

REMARKS: *Perampla* is rare in Green Lake and has been seen only as empty, bleached shells. No living specimens were found and it may be an extinct form so far as this locality is concerned. Specimens were dredged from a depth of 39.5 m. and from about 3 m. It is a distinct variety and may be a form of glacial time which is dying out.

LYMNAEA STAGNALIS LILLIANAE F. C. Baker

Plate XII, figures 8–10

Lymnaea stagnalis lillianae BAKER, Nautilus, XXIII, p. 112, 1910; Mon. Lymn., p. 154, pl. xxi, figs. 8–12, pl. xxii, fig. 6, 1911.

TYPE LOCALITY: Tomahawk Lake, Oneida Co., Wisconsin.

WISCONSIN RECORDS:

1911a. *Lymnaea stagnalis lillianae* BAKER, p. 238. Tomahawk Lake.
1911c. *Lymnaea appressa lillianae* BAKER, p. 153. Tomahawk Lake.
1916. *Lymnaea stagnalis lillianae* BAKER, p. 282. Tomahawk Lake.

SHELL: Elongate-ovate, with short spire and elongated, narrow aperture, which is typically longer than the spire; whorls flattened, elongated, very flat-sided and sloping, especially the body whorl which is cylindrical; spire sharply acuminated; whorls 5½ to 6; body whorl elongated, flattened, roundly shouldered; aperture long and narrow, slightly expanded; axis strongly gyrate; umbilical region with a very minute, narrow chink; sculpture and nuclear whorls as in *stagnalis jugularis*.

L. 42.0; D. 22.0; Ap. L. 26.0; D. 13.0 mm. Type.
L. 41.5; D. 20.0; Ap. L. 24.0; D. 12.0 mm. Tomahawk Lake (Baker coll., 384, cotypes).
L. 37.5; D. 19.5; Ap. L. 23.0; D. 12.0 mm. Tomahawk Lake (Baker coll., 384, cotypes).
L. 38.0; D. 19.5; Ap. L. 22.2; D. 12.3 mm. Tomahawk Lake (Baker coll., 384, cotypes).

ANIMAL: Similar to that of *stagnalis jugularis* in form; in color varying from yellow to jet black.

JAW: Similar to that of *stagnalis jugularis.*

RADULA: Formula $\frac{16}{4-5}+\frac{8}{3-4}+\frac{15}{2}+\frac{1}{1}+\frac{15}{2}+\frac{8}{3-4}+\frac{18}{4-4}$ (39–1–39); the teeth are similar in form to those of *stagnalis jugularis;* there are but fifteen laterals, in this respect differing from both *jugularis* and *sanctaemariae* which have respectively nineteen and eighteen laterals; the intermediate teeth are double those of *stagnalis* and *sanctaemariae,* and the total number of teeth is less.

GENITALIA: Similar to those of *stagnalis jugularis;* the praeputium retractors are two in number, the penis sheath retractor inserted in the posterior retractor, as shown in figure 93 A 2; this arrangement of the retractor muscles allies this race with *jugularis* rather than with *sanctaemariae,* in which there is a distinct penis retractor (see figure B). Breeds in August; eggs in September.

ECOLOGY: *Lillianae* is typically an inhabitant of sandy shores, in shallow water, where it is subjected to heavy wave action; only once was a specimen found in a still-water habitat, and this instance was undoubtedly caused by drifting from its normal habitat. When any number of specimens were found, the habitat was invariably an exposed beach. Associated with *lillianae* were *Stagnicola emarginata wisconsinensis* and *Helisoma pilsbryi.* Individuals were observed crawling over the sandy beach or attached to water-soaked logs or other shore debris. The animal of this race exhibits two color modifications, one bright yellow and the other black or grayish-black. No cause for this color dimorphism was apparent. It is not protective, as both forms occupy the same area of white sandy beach.

DISTRIBUTION: Western New York west to Minnesota; probably southern Canada also.

DISTRIBUTION IN WISCONSIN: At present known only from Tomahawk Lake, Oneida Co. (Baker).

REMARKS: *Lillianae* may be known by its short spire, long and narrow aperture, and compressed body-whorl. It was at first thought to be a form of *sanctaemariae* but a comparison with that species shows it to be uniformly narrower with compressed body-whorl, and more acute spire. In *sanctaemariae* the body-whorl is usually very rotund; the aperture is also

roundly ovate, while in *lillianae* it is elongate-ovate. The musculature of the male organ is also quite different from *sanctaemariae,* and similar to that of *jugularis. Lillianae* differs from *jugularis* in its short spire, flattened and compressed body-whorl and elongated aperture. It appears to be a distinguishable race of *stagnalis.* No true *jugularis* were found associated with this race in Tomahawk Lake. There were a few specimens with spires and aperture of equal length, showing clearly that the race is a modification of the *jugularis* type, caused, doubtless, by a change of environment.

LYMNAEA STAGNALIS SANCTAEMARIAE Walker

Plate XII, figure 13; plate XVII, figures 32–34

Limnaea jugularis SOWB., Conch. Icon., XVIII, Lim., pl. 4, fig. 24, 1872.
Lymnaea stagnalis sanctaemariae WALKER, Nautilus, VI, p. 31, pl. 1, figs. 4, 5, 1892; BAKER, Mon. Lymn., p. 156, pl. xxi, figs. 1–7; xxii, figs. 7, 8; xxiii, figs. 1–3, 1911.
Limnaea stagnalis higleyi BAKER, Nautilus, XVIII, p. 142, 1905.

TYPE LOCALITY: *Sanctaemariae,* Neebish Rapids, St. Mary's River, Michigan: *higleyi,* Michipicoten Island, north shore Lake Superior.

WISCONSIN RECORDS:

1926. *Lymnaea stagnalis sanctae-mariae* WINSLOW, p. 6. Little Arbor Vitae Lake.

SHELL: Broadly ovate, with short spire and widely expanded aperture, which is usually twice the length of the spire; spire whorls flattened, producing a mammilliform appearance; spire rapidly accuminating; whorls, 5½; body whorl very large, rounded or even globular, slightly shouldered in some specimens; aperture large, somewhat flaring, expanded; axis typically strongly gyrate; the umbilical region is generally tightly closed, but in some specimens there is a small chink; sculpture usually strong. Nuclear whorls as in *stagnalis jugularis.*

L. 33.00; W. 18.50; Ap. L. 20.00; W. 11.00 mm.	Michipicoten Island.
L. 50.00; W. 30.00; Ap. L. 32.00; W. 22.00 mm.	higleyi.
L. 38.00; W. 22.00; Ap. L. 25.00; W. 17.00 mm.	higleyi (type).
L. 49.50; W. 29.50; Ap. L. 32.00; W. 17.50 mm.	Siskowit Lake.
L. 45.50; W. 27.00; Ap. L. 31.50; W. 17.00 mm.	" "
L. 32.50; W. 17.00; Ap. L. 19.50; W. 10.50 mm.	Sault St. Marie.

ANIMAL: Similar to *Stagnalis jugularis.*

GENITALIA (Fig. 93): Similar in general to that of *stagnalis jugularis,* but differing in details of the penial retractors (fig. B.). The penis sheath retractor, instead of being inserted in the praeputium retractor, as in *jugularis* (fig. A), is inserted in the columella muscle close to the insertion of the praeputium retractor. In addition, there are two or three short muscles connecting the penis sheath retractor with the praeputium retractor. In one specimen the praeputium retractor was split to form two muscles, the lower muscle being very heavy, with many insertions at its juncture with the praeputium (B, 2). A specimen from Sault Ste. Marie had the two retractors fused to form a broad band of tissue for about half their length to the insertion in the columella muscle. All of the muscles of the male system in *sanctaemariae* are heavier than those of *stagnalis jugularis.*

JAW (Fig. 95): Superior jaw higher than *stagnalis jugularis,* with a more acute central swelling; lateral jaws not differing from those of *stagnalis jugularis.*

RADULA: Similar to that of *stagnalis jugularis* but with eighteen laterals, the intermediate teeth beginning on the nineteenth tooth.

ECOLOGY: Attached to the larger rocks that are not readily moved by the action of the surf. From the records of Ruthven and Adams, this race would seem to be typically an inhabitant of a region under the influence of clear, shore waters in situations where there is considerable action of the waves. In this respect it differs widely from *stagnalis jugularis,* which is a lover of quiet waters subject to more or less stagnation. In the St. Mary's River it inhabits the Neebish Rapids, which provides an environment similar to that afforded by the wave action of the Lake Superior stations.

Sanctaemariae exhibits beautifully the correlation of the animal with its environment. In Isle Royale the form living on an exposed lake beach is rather small with a thick shell. The form living in Siskowit Bay, where the water is quiet, is the largest of any North American *Lymnaea,* and the shell is thin and brittle. There is usually little variation in general form; rarely a specimen occurs in which the body whorl is compressed and the spire lengthened. These forms approach some

individuals of *L. stagnalis lillianae,* but are doubtless cases of parallel development.

DISTRIBUTION: Northern Michigan and Lake Superior; not at present known outside of the area of Lake Superior drainage and the northern part of Michigan and Wisconsin.

DISTRIBUTION IN WISCONSIN: Little Arbor Vitae Lake, Vilas Co. (Juday, Winslow). In the Wisconsin River drainage.

REMARKS: This rather distinct race may be known by its very short spire, rotund body-whorl and wide, somewhat patulous aperture. It appears to be a northern race which reaches its maximum development in the cold waters of Lake Superior.

The name *sanctaemariae* was apparently founded on immature specimens; *higleyi* is the fully mature form. Specimens from Sault Ste. Marie have a coarse dark brown epidermis and many of the specimens appear to have suffered an injury to the last third of the body whorl, which is joined to the body of the shell in such a manner as to leave a deep channel at the suture. This portion of the last whorl is also disposed to be malleated.

It is somewhat of a surprise to find this variety in the drainage of the Wisconsin River, the specimens previously collected having been almost without exception from the drainage and waters of Lake Superior. The Little Arbor Vitae Lake specimens are undoubted *sanctaemariae,* differing but little from the form as found in Michigan. There is some variation toward the *lillianae* form, which is interesting for the reason that that variety is found in Tomahawk Lake about seven miles to the south and in the same drainage (see pl. XVII, figs. 32–33).

Genus STAGNICOLA (Leach) Jeffreys, 1830

Stagnicola LEACH, Proof-sheets, pp. 141, 145, 1819; Jeffreys, Linn. Trans., XVI, ii, p. 376, May 29, 1830. Type: *Buccinum palustre* Müller. Not *Stagnicola* Brehm, Dec. 1830 (Aves).

Limnophysa FITZINGER, Syst. Verz., p. 112, 1833. Type: *Buccinum palustre* Müller.

Radula with bicuspid lateral teeth and distinctly tricuspid intermediate teeth; prostate long-ovate or cylindrical; penis sheath as long as or a trifle shorter than praeputium; sarcobelum a small muscular ridge; retractor muscles of male organ two in number, insertion in columella muscle either jointly or

but slightly separated; shell variable in both size and structure.

Subgenus STAGNICOLA (Leach) Jeffreys

SHELL: Elongated with gradually increasing whorls; outer lip with (usually) a heavy varical thickening just within the aperture, representing a period of rest in the growth of the shell; pillar slightly twisted and plicated; inner lip appressed to the columellar region, forming an impervious or narrowly open axis; sculpture of strong growth lines and equally strong spirally impressed lines, forming a notably decussated pattern (pl. XI, fig. 4)

RADULA: As in the genus.

GENITALIA: Generally as in the genus; penis rather long and slender, enlarged at the proximal end and with a distinct muscular ridge near this end (see fig. 94).

Stagnicola includes the majority of the species of the larger Lymnaeas, in which the shell is distinctly sculptured by longitudinal and spiral lines, the columella has a plait or fold, a twisted axis, and the outer lip usually has a heavy internal callus. The radula is quite different from that of typical *Lymnaea,* in that the first lateral is never normally tricuspid and there are distinct tricuspid intermediate teeth. The prostate, as well as the male organ, are also different. In habitat, *Stagnicola* is usually found in larger bodies of water, lakes, ponds, streams, pools; a few species, however, prefer more or less stagnant pools and ditches which become more or less dry in summer.

KEY TO SPECIES OF STAGNICOLA

1. a. Spire longer than aperture ---------- 2
   b. Spire as long as or shorter than aperture ---------- 9
2. a. Body whorl flattened, elongated ---------- 3
   b. Body whorl rounded ---------- 6
3. a. Penultimate whorl longer than wide ---------- 4
   b. Penultimate whorl as long as wide or wider than long ---- 5
4. a. Whorls very flat sided, sutures not deeply impressed, aperture long and narrow, without distinct plait ----------*exilis*
   b. Whorls flatly rounded, sutures well marked or deeply impressed, aperture ovate, no distinct columella plait----*reflexa*
5. a. Whorls oblique, flatly rounded, sutures not deeply impressed, aperture ovate, acute above ----------*umbrosa*
   b. Whorls not very oblique, sutures deeply impressed, aperture ovate, wide at the upper part where outer lip is arched ----------*lanceata*

6. a. Spire whorls long and acutely pointed, all whorls regularly increasing in diameter, sutures deeply impressed, aperture roundly ovate ---------- 7
   b. Spire whorls short and blunt, wide, sutures not much indented, aperture elongate ovate ---------- 8
7. a. Body whorl well rounded, apical whorls wider than high, aperture roundly ovate ---------- *elodes*
   b. Body whorl flatly rounded, spire whorls as wide as high or higher than wide, aperture long ovate ---------- *jolietensis*
b. a. Aperture regularly elongate ovate not effuse at lower part, outer lip regularly rounded, widest at center ---------- *winnebagoensis*
   b. Aperture effuse at lower part where it is widest, outer lip flattened ---------- *nashotahensis*
9. a. Spire as long as aperture, forming a narrowly acute pyramid ---------- 10
   b. Spire somewhat shorter than aperture, forming a wide, short pyramid ---------- 13
10. a. Inner lip triangular, tightly appressed to columella, closing umbilicus or leaving only small chink, axis twisted and plaited ---------- 11
    b. Inner lip forming flat, smooth, shelf-like projection over columella, without plait ---------- 12
11. a. Spire whorls acute, regularly increasing in size, shell narrowly elongated, body whorl long and narrow ---- *palustris*
    b. Spire whorls short, rather blunt, shell wide, ovate, body whorl slightly inflated ---------- *catascopium*
12. a. Apical whorls acute, long, aperture long ovate, inner lip folded over columella completely closing umbilicus, aperture continuous ---------- *canadensis*
    b. Apical whorls short, blunt, aperture roundly ovate, inner lip folded over columella, leaving conspicuous umbilical chink ---------- *emarginata*
13. a. Body whorl globular, spire very wide, turban-shaped, sutures deeply impressed, aperture round, inner lip forming flat expansion over open umbilicus ---- { *vilasensis* / *wisconsinensis* }
    b. Body whorl ovate, whorls flattened, spire narrow, sutures not deeply impressed, aperture ovate, inner lip wide, appressed to columella region, leaving small chink ---------- 14
14. a. Penultimate whorl disproportionately enlarged, and shoulderd, apical whorls very small, aperture often effuse, inner lip thick, appressed to columella completely closing umbilical region ---------- *angulata*
    b. Penultimate whorl large but with the apical whorls forming a regularly increasing spire, aperture regularly ovate, inner lip thin, reflexed over umbilical region leaving small chink ---------- 15

15. a. Spire more or less acute, one-third length of shell, aperture roundly ovate, inner lip appressed to columellar region forming flat expansion with a slight fold ----*walkeriana*
    b. Spire depressed, broad, two-fifths length of shell, aperture elongate-ovate, inner lip forming wide expansion over columellar region without plait, shell about half size of *walkeriana* ----------*woodruffi*

GROUP OF STAGNICOLA PALUSTRIS

In this group the shell is much elongated, usually narrow, the spire is usually longer than the aperture, the latter being usually elongate ovate. The habitat is normally rivers, ponds, small streams or swampy pools where the water is normally quiet. They are seldom found in lakes.

STAGNICOLA PALUSTRIS ELODES (Say). Pond Snail

Plate XIII, figures 3–7, 9–13

Limneus elodes SAY, Journ. Phil. Acad. Sci., II, p. 169, 1821; Amer. Conch., IV, pl. xxxi, fig. 3, 1832.
Limnaea palustris BINNEY, L. & F–W. Sh. N. A., II, p. 44, fig. 60, 1865; BAKER, Mon. Lymn., p. 298, pl. 26, 33, 1911 (part).
Limnea fragilis HALDEMAN, Mon., p. 20, pl. 6, 1842 (part).

TYPE LOCALITY: Canandaigua Lake, N. Y. (probably in swampy shore pool).

WISCONSIN RECORDS:

1860. *Limnaea fragilis* LAPHAM, p. 155. Milwaukee.
1865. *Limnaea palustris* BINNEY, p. 47. Milwaukee.
1897. *Limnaea palustris* WISWALL, p. 48. Southern Wisconsin.
1906. *Limnaea palustris* CHADWICK, pp. 22, 81. Milwaukee and vicinity.
1915. *Lymnaea palustris* ANDREWS, p. 200. Lake Butte des Morts.
1920d. *Galba palustris* BAKER, p. 120. Milwaukee.
1924. *Lymnaea palustris* BAKER, p. 136. Lake Butte des Morts and near Oshkosh.

SHELL: Varying from elongate to elongate-ovate, usually rather thin; color varying from pale brown to almost jet black; surface dull to shining, covered with numerous crowded growth lines crossed by several elevated spiral lines and by numerous very fine impressed spiral lines; in many specimens the last whorl, and frequently the whole shell, is heavily malleated; the whorls are sometimes encircled by coarse wrinkles, and frequently the epidermis is so arranged as to show longitudinal

stripes of white and horn color, alternating; whorls seven, rounded, the last varying in its rotundly but usually obese; spire sharp and pointed, varying from over half to three-fifths the length of the entire shell; sutures well impressed; aperture varying from roundly-ovate to long-ovate, more or less expanded; peristome thin, acute, sometimes expanded, in old specimens or at resting stages thickened by a heavy deposit or varix within; the peristome is white and there is a band of very dark brown which edges the varix; inner lip closely appressed to the parietal wall, forming a heavy callus, which in some specimens is so extensive as to make an almost continuous aperture; axis twisted, forming a rather heavy, ascending columellar plait; umbilical chink generally very narrowly open, but sometimes closed.

L. 32.0; D. 12.0; Ap. L. 14.0; D. 6.5 mm.	Say's type *elodes*.
L. 34.0; D. 12.5; Ap. L. 14.0; D. 6.6 mm.	L. Winnebago (U. of W., 4679).
L. 32.0; D. 12.6; Ap. L. 13.0; D. 7.0 mm.	" "
L. 30.0; D. 11.7; Ap. L. 13.5; D. 7.0 mm.	" "
L. 27.5; D. 13.0; Ap. L. 14.6; D. 7.5 mm.	" "
L. 25.0; D. 11.2; Ap. L. 12.4; D. 5.8 mm.	" "
L. 20.5; D. 10.0; Ap. L. 10.5; D. 5.0 mm.	Chilton (U. of W., 4678).
L. 20.2; D. 9.5; Ap. L. 10.0; D. 4.6 mm.	" " "
L. 22.5; D. 10.0; Ap. L. 11.0; D. 5.0 mm.	" " "
L. 21.0; D. 10.0; Ap. L. 10.7; D. 5.0 mm.	DePere (U. of W., 4677).
L. 20.0; D. 9.0; Ap. L. 10.2; D. 5.0 mm.	" " "

ANIMAL: Black, lighter below, the body spotted with white which shows through the shell; foot wide and short, rounded before and behind; tentacles short and rather wide.

GENITALIA (Fig. 97): Male organs: Praeputium cylindrical, 4.50 mill. long, 1.50 mill. greatest diameter; penis sheath 3.00 mill. long, round, of equal diameter throughout; vas deferens 15.00 mill. long; penis sheath retractor very long and very narrow; praeputium retractor very long, wide, ribbon-like; praeputium protractors usually six in number, three anterior and three posterior. The anterior protractors are largest and are frequently fused; prostate duct 5.00 mill. long, slightly enlarging as it enters the prostate; prostate flattened, much elongated, rounded at either end, the larger end receiving the prostate duct; the prostate gradually tapers to the narrow portion which joins the spermoviduct.

The praeputium is a muscular body with thick walls; internally there are two well defined vertical muscular pillars and

many heavy circular muscles as in *stagnalis jugularis*. Between the praeputium and the penis sheath there is a thickened ridge, the sarcobelum. The walls of the penis sheath are thin. The penis is very wide at its summit where it receives the vas deferens and below this portion there is a ridge which passes about two-thirds the way round the penis; below this ridge the penis gradually narrows to a point. The opening is terminal, in the center (fig. 94).

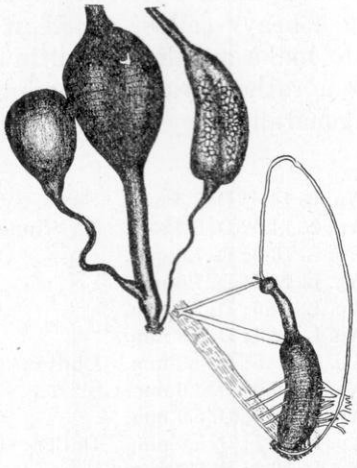


Fig. 97. Genitalia of *Stagnicola palustris elodes*.

Female organs: Receptaculum seminis large, pear-shaped, connected with the oviduct by a duct 7.00 mill. long, which enters the oviduct 1.25 mill. from the vaginal opening; the uterus is very elongate-ovate, narrowing suddenly at both ends; it is markedly creased in the center, longitudinally, where the prostate is attached; nidamental gland very small, rounded; albumen gland not differing from those already described; the lower portion of the oviduct is long and very narrow.

The organs are colored as follows: Praeputium, blackish; penis sheath yellowish flesh; prostate, flesh; receptaculum seminis, yellowish; albumen gland yellowish. The musculature of the praeputium varies considerably. The posterior protractors may be one or four in number, while the anterior protractors vary in number and in position.

JAW (Fig. 98): Superior jaw wide and rather high, with a rounded median swelling on the ventral margin about one-

third the diameter of the jaw in width. Lateral jaws as in *stagnalis*.

RADULA (Fig. 99): Formula $\frac{21}{4-6}+\frac{4}{3}+\frac{9}{2}+\frac{1}{1}+\frac{9}{2}+\frac{4}{3}+\frac{21}{4-6}$ (34–1–34). Central tooth with a rather long, sharp cusp; lateral teeth (9) narrow, bicuspid, the mesocone long and narrow, the ectocone short, rather wide and placed high up on the reflection; transition teeth (10–13) narrow, tricuspid, the me-

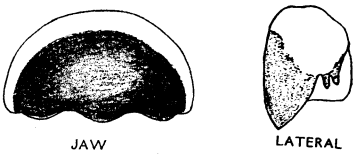


Fig. 98. Jaw and Tooth of *Stagnicola palustris elodes*.

socone very long and narrow, the entocone very small and placed a little below the middle of the mesocone; the entocone first appears on the tenth tooth and gradually becomes larger until in the 14th tooth it is as large as the mesocone; marginal teeth long and very narrow, tri–, quadri–, or penta-cuspid, the cusps at the distal end of unequal size; there are two outer cusps, one placed about midway of the reflection and one, smaller, placed some distance above this; the marginals gradually become smaller toward the edge of the membrane, and the distal end of the reflections become separated by three or four cusps of equal size. In one membrane examined, the first lateral to the right of the central tooth had a bifid ectocone. This was observed on all the first laterals in this membrane (fig. 98).

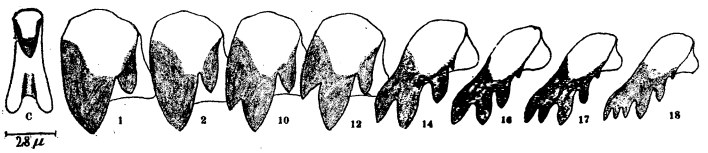


Fig. 99. Radula of *Stagnicola palustris elodes*.

ECOLOGY: Found plentifully in bodies of water of greater or less size, on floating sticks and submerged vegetation, on stones and on the muddy bottom. Inhabits both clear and stagnant water, but prefers a habitat in which the water is not in motion. Seldom found out of the water, as is the case with the

smaller species of the genus *Fossaria.* The more distinctly malleated forms inhabit stagnant pools where the bottom is muddy, with more or less decaying vegetation present. The food of *elodes* is made up of both animal and vegetable matter, the species being literally vegetiferous, scavengiferous and carnivorous. The animal of *elodes* is very rapid in movement. When crawling, the shell is frequently moved rapidly from side to side, and is carried at all conceivable angles. It is a very rapid feeder and will soon clear up the sides of an aquarium.

Typical *elodes* is not usually found in swales but in lakes and rivers where the water is quiet and where vegetation is more or less abundant. The margins of rivers and protected bays of lakes and ponds appear to be the natural habitats of this polymorphic species. Near Lake Winnebago very large and fine specimens were collected in a small pond behind the beach on Doemel Point. Mud bottom, water .3–1 m. deep. Vegetation mostly *Typha,* with *Pontederia* and *Sagittaria.* Animals most abundant in .3 m. of water at edge of pool on mud bottom. Young animals 10 mm. long have 5 whorls and are like the adult shell.

GENERAL DISTRIRUTION: *Elodes* has been seen or recorded (under the name of *palustris*) from New England west to the Rocky Mountains, and from Canada south to New Mexico. The western forms should probably be included under *nuttalliana* and other race-names.

DISTRIBUTION IN WISCONSIN: Apparently most abundant in the eastern part of the State. Known from drainages of the Fox and Rock rivers and of Lake Michigan.

REMARKS: *Lymnaea palustris elodes* is one of the commonest and most variable of the family. The large, more or less corpulent shell, with its coarse sculpture and heavy columella plait will usually easily separate it from related species and varieties. The whorls in typical *elodes* are well rounded, especially the body whorl. The spire is usually longer than the aperture and is generally acutely pointed in Wisconsin specimens. The whorls are, usually, wider than high, a characteristic which will help to distinguish the narrower forms from *umbrosa* and *reflexa.* The principal variation is in the form of the spire, which in some specimens is long and narrow and in others short and wide. This range of variation is well-shown on the plate.

A restudy of the American and European shells usually referred to *palustris,* in addition to considerable field collecting in Wisconsin, Illinois, and New York, has led the author to change some of the opinions published in the Lymnaeidae of North and Middle America (1911). European authors appear to differ as to just what is considered typical *palustris.* Forbes and Hanley (Brit. Moll., IV, pl. cxxiv, fig. 2) figure a large shell with deep sutures and rounded whorls. Stelfox (1911, pl. vii, figs. 21–24) figures shells with rather long spires and more or less rounded with deep sutures. Roszkowski (1914, pl. 15, figs. 166–170) figures a small shell with short spire, flat sided whorls, and shallow sutures. Specimens of *palustris* received from Germany and France conform to this form which are here taken as typical.

Elodes is not the same as *umbrosa,* as stated in the Lymnaea Monograph, their two type localities being separated by over a thousand miles of intervening territory. The type locality of *elodes* is Canandaigua Lake, and recently shells answering to the diagnosis of Say were collected in a beach pool four miles south of the City of Canandaigua. The shells herein figured on plate XIII appear like the variety *corvus* Gmelin, and perhaps they should bear that name. Specimens from England and Ireland appear referable to this variety. English specimens are figured on plate XIII (1, 2) and a German specimen also (8) for comparison. It is probable that parallel cases of variation can be found for all forms found in America and Europe, but in the present intensive separation of minor variations it appears best to distinguish our American *palustris* by Say's name, thereby definitely fixing the type of shell. It is probable that the forms in and west of the Rocky Mountains should bear the name of *nuttalliana* Lea; there are also other recognizable variations, several of which have been differentiated.

The radulae of the American and European forms appear to differ somewhat. American specimens show 34–1–34 teeth, the transition teeth beginning at the tenth tooth. Roszkowski (1914, pl. 16, figs. 191, 192) figures the transition tooth at the thirteenth, and shows the first lateral as tricuspid and in one membrane the first three laterals are figured as tricuspid. This variation has not been observed in any American specimen examined. Crosse and Fischer (Mis. Scient. Mex., II, p. 41,

1870) refer to the lateral teeth of *palustris* as being tricuspid. Additional specimens of the American form should be systematically examined to ascertain whether or not this variation is geographic or individual.

STAGNICOLA UMBROSA (Say)

Plate XIII, figures 14–22; plate XVII, figures 12–14

Limneus elongatus SAY, Journ. Phil. Acad., II, p. 167, 1821; BINNEY, Op. Cit., p. 32, fig. 49, 1865 (preoccupied name).

Limneus umbrosus SAY, Amer. Conch., IV, pl. xxxi, fig. 2, 1832; BINNEY, Op. Cit., p. 40, 1865.

Limnea umbrosa HALDEMAN, Mon., p. 24, pl. vii (part), 1842.

Limnaea palustris michiganensis WALKER, Nautilus, VI, p. 33, pl. 1, figs. 9, 10, 1892.

Galba elodes BAKER, Mon. Lymn., p. 322, 1911.

TYPE LOCALITY: Waters of Missouri near Council Bluff, Nebraska, for *umbrosa;* Ecorse and Greenfield, Wayne Co., Mich., for *michiganensis.*

WISCONSIN RECORDS:

1865. *Limnaea reflexa* BINNEY, p. 41. Near Madison.

1911c. *Lymnaea elodes* BAKER, p. 326. Milwaukee; Lake Mendota; Madison.

1915. *Lymnaea elodes* ANDREWS, p. 200. Lake Butte des Morts.

1924. *Lymnaea elodes* BAKER, p. 136. Omro, Fox River; Lake Butte des Morts.

SHELL: Elongated, narrow, attenuated, rather thin; periostracum light yellowish horn, frequently jet black; occasionally longitudinally striped; surface dull to shining; sculpture as in *palustris;* whorls 6 to 7, rather evenly increasing in size, typically flatly rounded, especially the body whorl; spire long and very much attenuated; sutures usually less impressed than in *palustris;* aperture elongate-ovate, generally much shorter than the spire; peristome with heavy varical thickening; inner lip narrow, reflected and appressed to the columellar region, forming a distinct plait and usually completely closing the umbilicus; parietal callus rather wide, heavy.

L. 30.0; D. 12.0; Ap. L. 13.0; D. 5.0 mm.	Say's type *umbrosa.*	
L. 34.5; D. 14.0; Ap. L. 15.0; D. 8.0 mm.	Lake Mendota	(U. of W., 4680).
L. 32.0; D. 12.5; Ap. L. 14.0; D. 7.0 mm.	"	"
L. 31.0; D. 13.0; Ap. L. 15.0; D. 7.5 mm.	"	"
L. 31.0; D. 12.0; Ap. L. 14.0; D. 7.2 mm.	"	"
L. 27.5; D. 10.5; Ap. L. 12.0; D. 6.0 mm.	"	"
L. 25.0; D. 8.5; Ap. L. 11.0; D. 5.0 mm.	"	"

L. 30.0; D. 12.0; Ap. L. 14.2; D. 7.0 mm. Fox River (U. of W., 4681).
L. 28.0; D. 10.0; Ap. L. 12.0; D. 6.0 mm. " "
L. 25.0; D. 10.5; Ap. L. 12.5; D. 6.5 mm. " "

ANIMAL, GENITALIA, JAW, RADULA: Essentially as in *palustris.*

ECOLOGY: "Inhabits the ponds and tranquil waters of the upper Missouri" (Say). In Fox River it is abundant in pond-like areas where vegetation is thick. Also found in ponds and sloughs which become more or less dry in summer.

DISTRIBUTION: Western New York west to South Dakota: Rainy Lake, Ontario, south to northern Kansas and Ohio.

DISTRIBUTION IN WISCONSIN: *Umbrosa* is common only in isolated localities, judging by the records at hand.

Lake Michigan Drainage: Kenosha, Kenosha Co. (Wiswall); pool in Johnston woods, near Milwaukee, Milwaukee Co. (C. E. Brown).

Fox Drainage: Fox River at Omro; Lake Butte des Morts, Winnebago Co. (Baker); Lake Butte des Morts (Andrews).

Chippewa Drainage: Prentice, Price Co. (Bullock).

Rock Drainage: Near Madison, Dane Co. (Wiswall); Lake Mendota, Dane Co. (Bullock, Juday); Windsor, Dane Co. (Bullock); Monticello, Green Co. (Bullock); Mud, Ashippun and Dutchmans lakes, Oconomowoc River, Waukesha Co. (Cahn).

Fox River (Illinois): Beulah Lake, Walworth Co. (Woodruff).

REMARKS: *Umbrosa* differs from *elodes* in having more loosely coiled whorls and in being narrower and more attenuated, with more flat-sided whorls. In narrow specimens of both species *umbrosa* is seen to have a longer, more compressed body whorl and a narrower and longer aperture. The whorls of *umbrosa* are also comparatively longer than those of *elodes,* though not as long as in *reflexa. Umbrosa* is on the whole less variable than *elodes.*

A restudy of the shells formerly referred to *elodes* and *umbrosa* has led the author, as in the case of *elodes-palustris,* to change his opinion of the relationships of the two forms. The narrow form called *umbrosa (elongata)* by Say is a common species in the Middle West and Mississippi Valley and is not the same as the eastern form named *elodes,* the two type localities being separated by over a thousand miles. In the writer's monograph the remarks hold true for everything excepting the reference of the form to *elodes. Umbrosa* appears to be more widely distributed in Wisconsin than *elodes.*

STAGNICOLA UMBROSA JOLIETENSIS (F. C. Baker)

Plate XIII, figures 23–26

Limnaea reflexa jolietensis BAKER, Nautilus, XV, p. 17, 1901; Moll. Chi. Area, p. 280, pl. 32, fig. 4, 1902.

Limnaea reflexa attenuata BAKER (non Say), Trans. Acad. St. Louis, XI, p. 20, pl. 1, fig. 4, 1901.

Galba elodes jolietensis BAKER, Mon. Lymnaeidae, p. 327, pl. xxxiv, figs. 25–30; pl. xxxv, figs. 1–2, 1911.

TYPE LOCALITY: Rock Run, Joliet, Ill.

WISCONSIN RECORDS:

1911c. *Galba elodes jolietensis* BAKER, p. 329. Milwaukee.

SHELL: Attenuated, more or less scalar, perisotracum light yellowish horn; sculpture as in *palustris;* whorls 6 to 7, loosely coiled, generally quite convex; spire long, attenuated, pointed, somewhat scalar; sutures typically very deeply impressed; aperture elongate-ovate or lunate, about one-third the length of the shell; peristome thin, bordered by a heavy varix which is edged with dark red or chestnut; inner lip thin, narrow, reflected over and nearly closing the umbilicus, leaving a very small chink; columella with a distinct, ascending plait; axis strongly twisted. The surface is sometimes more or less malleated.

L. 24.0; D. 8.0; Ap. L. 9.5; D. 3.2 mm.	Type.	
L. 27.0; D. 11.0; Ap. L. 12.0; D. 6.0 mm.	Lake Mendota	(U. of W., 4683).
L. 25.2; D. 10.0; Ap. L. 11.2; D. 5.2 mm.	"	"
L. 25.0; D. 10.1; Ap. L. 11.0; D. 5.0 mm.	"	"
L. 23.0; D. 8.7; Ap. L. 10.0; D. 5.0 mm.	"	"

ANIMAL AND JAW: As in *palustris.*

GENITALIA (Fig. 100): As in *palustris.* The retractors of the male organ vary lightly in size, but otherwise the organs are very uniform.

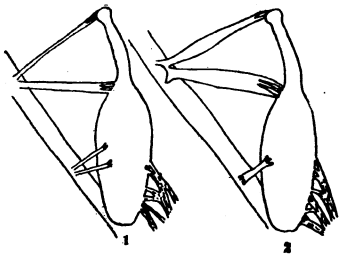


Fig. 100. Male organ of *Stagnicola umbrosa jolietensis.*

RADULA (Fig. 101): **Formula** $\frac{2\,2}{4-6}+\frac{2}{3}+\frac{8}{2}+\frac{1}{1}+\frac{8}{2}+\frac{2}{3}+\frac{2\,2}{4-6}$ (32–1–32). The teeth do not differ materially from those of *palustris;* the transition teeth begin at the ninth tooth and the marginal teeth begin at the eleventh tooth. There are over 80 rows of teeth. In some membranes the intermediate teeth begin at the tenth tooth.

Fig. 101. Radula of *Stagnicola umbrosa jolietensis.*

ECOLOGY: In small creeks, ditches and along the shores of rivers; habits similar to those of *elodes.*

DISTRIBUTION: Wisconsin to eastern New York; central Michigan south to northern Illinois and northern Ohio.

DISTRIBUTION IN WISCONSIN: Only known in the State from scattered records.

Lake Michigan Drainage: Milwaukee, Milwaukee Co. (Baker, Lea).
Rock Drainage: Lake Mendota, Dane Co. (Wagner).

REMARKS: This variety may be known by its sharp, attenuated spire, very convex whorls and elongated aperture. It varies somewhat in the flatness of the whorls and the impression of the sutures. It was at first described as a variety of *reflexa,* but more abundant material shows it to be rather related to *umbrosa.* Some specimens strongly resemble Say's figure of *elodes* in the Amer. Conch., but these do not agree with the type in the Philadelphia Academy collection. The Lake Mendota specimens are not as typical as those from Illinois but they are clearly this variety and not *umbrosa.*

STAGNICOLA REFLEXA (Say)

Plate XIV, figures 1–6; plate XVII, figure 15

Lymneus reflexus SAY, Journ. Phil. Acad., II, p. 167, 1821; Amer. Conch., IV, pl. 31, fig. 2, 1832; Binney, L. & F–W. Sh. N. A., II, p. 39, fig. 48, 1865.
Limnea reflexa HALD., Mon. p. 26, pl. 8, 1842.
Limnaea reflexa iowaensis BAKER, Nautilus, p. 10, 1904; Mon. Lymn., p. 334, 1911.
Limnaea reflexa crystallensis BAKER, Nautilus, XVIII, p. 11, 1904.

Limnaeus palustris var. *distortus* ROSSMASSLER, Icon., I, p. 97, pl. 2, fig. 52, 1835; BINNEY, Op. Cit., p. 41, fig. 52, 1865.
Galba reflexa BAKER, Mon. Lymn., p. 332, figures and full synonymy.

TYPE LOCALITY: *reflexa,* Lake Superior; *iowaensis,* Muscatine, Iowa; *crystallensis,* Crystal Lake, McHenry Co., Ill.; *distortus,* not stated.

WISCONSIN RECORDS:

1865. *Limnaea reflexa* BINNEY, p. 41. Milwaukee; Aztalan; Farwell's Mills, Madison.
1897. *Limnaea reflexa* WISWALL, p. 48. Southern Wisconsin.
1906. *Limnaea reflexa* CHADWICK, pp. 22, 81. Milwaukee and vicinity; Sand Ridge Creek, Kenosha Co.; Delafield, Waukesha Co.
1920d. *Galba reflexa* BAKER, p. 120. Milwaukee (fossil).
1924. *Lymnaea reflexa* BAKER, p. 136. Swale north of Oshkosh and in woods on Plummer's Point, Lake Butte des Morts; Terrel's gravel pit, Lake Butte des Morts.
1911c. *Galba reflexa* BAKER, p. 338. Milwaukee (marl deposits).

SHELL: Very much elongated, narrow, thin, sometimes scalar; color honey-yellow to black, sometimes obscurely longitudinally banded; surface shining, covered with numerous closely crowded growth lines, with fine impressed spiral lines which reticulate the surface; the growth lines are also wavy and elevated, in some specimens forming ridges of considerable size; nuclear whorls smooth, brownish or blackish, in form like those of *palustris;* whorls seven, flatly rounded, last whorl much compressed; the sixth and seventh whorls are much longer in comparison with their width than are any of the preceding whorls; spire very long and pointed, occupying nearly two-thirds of the entire length of the shell; sutures impressed; aperture lunate or elongate-ovate, narrowed at the upper part, very oblique and effuse in some specimens; peristome thin, sharp, thickened by a heavy callus or varix on the inside, the varix chocolate or purplish in color; lower part of peristome dilated; inner lip narrow, reflected over the umbilical region, leaving a very small chink or entirely closing the umbilicus; columella oblique, with a heavy plait across its center, running up into the whorl; the callus on the parietal wall varies from a very thin wash to an erect, thick inner lip which causes the aperture to be continuous; axis twisted.

L. 34.0; D. 11.0; Ap. L. 14.5; D. 5.5 mm. Say's type *reflexa.*
L. 35.0; D. 12.0; Ap. L. 13.6; D. 7.5 mm. Calumet Lake, Ill. (Baker coll. 333).

L. 39.5; D. 14.0; Ap. L. 15.5; D. 7.5 mm. Oshkosh swale (U. of W., 4686).
L. 29.5; D. 12.0; Ap. L. 12.7; D. 6.1 mm. " "
L. 25.0; D. 10.0; Ap. L. 11.5; D. 5.6 mm. " "
L. 19.0; D. 8.1; Ap. L. 10.0; D. 5.0 mm. " "
L. 16.0; D. 6.2; Ap. L. 8.0; D. 3.0 mm. " (U. of W., 4684).

ANIMAL: Similar to *palustris*.

GENITALIA (Fig. 102): As a whole the genitalia of *reflexa* are like those of *palustris*. The spermatheca differs from that of *palustris* in being quadrate instead of pyriform. The in-

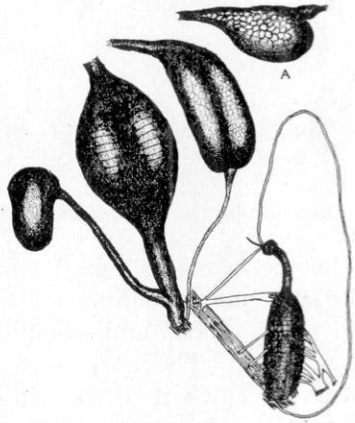


Fig. 102. Genitalia of *Stagnicola reflexa*.

ternal structure of the penis and praeputium is like that of *palustris* (see fig. 94). The muscles of the male organ vary considerably in form and position. In specimens from Calumet Lake (fig. 103), the retractor muscles of the praeputium (2) and penis sheath (3) have each an additional band of muscle; the posterior protractor muscles vary from two to four in number; the anterior protractors are quite uniform, however. The color of the organs is as follows: Praeputium blackish,

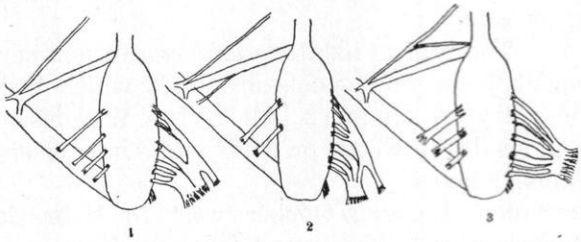


Fig. 103. Male Organ of *Stagnicola reflexa* showing Muscaluture.

prostate yellowish, apermatheca purplish-flesh; the rest of the organs are white or flesh-colored. The egg capsules are large, measuring 34.5 by 1.6 mm. and may contain as many as 130 eggs.

JAW: Similar to that of *palustris.*

RADULA (Fig. 104): Formula: $\frac{2\,3}{4-6}+\frac{4}{3-4}+\frac{2}{2}+\frac{1\,1}{2}+\frac{1}{1}+\frac{1\,1}{2}+\frac{2}{2}+\frac{4}{3-4}+\frac{2\,3}{4-6}$ (40–1–40); lateral teeth bicuspid, the mesocone long and rather wide, the ectocone small and wide; the first lateral tooth is wider than those which follow; intermediate teeth four in number, tricuspid, the entocone small, placed toward the

Fig. 104. Radula of *Stagnicola reflexa.*

lower margin of the mesocone; a small cusp appears on the outer margin of the ectocone; marginal teeth long, narrow, oblique, 4 to 6 cuspid at the distal end, causing this part of the tooth to resemble a comb. The cusps are very irregular in size. There are over 100 rows of teeth. In one membrane examined, the first lateral to the right of the center tooth had a bifid ectocone. In another specimen there were 15 laterals on the right side of the central tooth and 14 laterals on the left side; in all membranes examined the last two (generally 12 and 13) laterals have the lower inner part of the mesocone slightly excavated, apparently a first indication of splitting to form an entocone. The radula of *reflexa* is similar to that of *palustris,* the teeth being, perhaps, a trifle wider. The radula figured in Mollusca of the Chicago Area (p. 279) for *reflexa* is probably *palustris* (or *umbrosa*), as it corresponds with these species, but not with *reflexa,* which has a larger number of laterals than *palustris.*

ECOLOGY: The typical habitat of *reflexa* in northern Illinois and Wisconsin is in small pools or ponds which may become more or less dry in summer. All of the Wisconsin habitats have been in swales in woods or fields, none have been found in large streams or lakes.

DISTRIBUTION: Eastern Quebec west to Nebraska, Manitoba south to southern Illinois and southern Kansas.

DISTRIBUTION IN WISCONSIN: *Reflexa* is apparently rare in Wisconsin, the known records being confined to the southeastern part of the State. Say's original specimens came from Lake Superior but none were found in Bayfield County.

Lake Michigan Drainage: Milwaukee and vicinity, Milwaukee Co. (Chadwick, Lapham); Sand Ridge Creek, Kenosha, Kenosha Co. (Chadwick).

Fox Drainage: Swales north of Oshkosh and in woods on Plummer's Point, Terrel's gravel pit, Lake Butte des Morts, Winnebago Co. (Baker); swale near west end Green Lake, Green Lake Co. (Baker).

Rock Drainage: Delafield, Waukesha Co. (Chadwick); Aztalan, Jefferson Co.; Farwell's mills, near Madison, Dane Co. (Baird, Binney); Genesee and Pewaukee lakes, Waukesha Co., Lake Koshkonong, Jefferson Co. (Cahn).

REMARKS: *Reflexa* is one of the commonest of the Lymnaeas in certain localities; it is very variable and is frequently confounded with long-spired specimens of *umbrosa.* The spire of *reflexa* is always longer than the aperture, and may be twice as long. As a general rule, *reflexa* has higher whorls in comparison with their width than in *umbrosa;* the last two whorls are disproportionately larger and the penultimate whorl is usually large and has a "puffy" appearance; the whorls are also rounder, with deeper sutures. Moreover *reflexa* is very rarely malleated, while *umbrosa* usually shows traces of malleation due to its wallowing habit. The aperture in *reflexa* is also more halfmoon-shaped and has a peculiar "twist." A close study of the shape of the whorls will usually separate *reflexa* from *umbrosa.* Even half-grown specimens of *umbrosa* can be distinguished from *reflexa* by the shape of the body whorl, which in this species is more compressed and flattened than in *umbrosa.* The majority of specimens of *reflexa* examined have been usually constant in form. The inner lip is sometimes raised so as to make the aperture continuous, and the epidermis is sometimes heavily zebra-marked, both spirally and longitudinally. The spire varies somewhat in height. Very old individuals which have survived until the third season are exceptionally large and the aperture is peculiarly oblique and reflexed.

Wisconsin *reflexa* are rather wider than specimens from Illinois, in this respect resembling some forms of *umbrosa.* The typical form as found in northern Illinois is figured for comparison.

STAGNICOLA EXILIS (Lea)

Plate XIV, figures 7–11; plate XVII, figure 16

Lymnaea exilis LEA, Trans. Amer. Phil. Soc., V, p. 114, pl. 19, fig. 82, 1837; Obs., I, p. 226, pl. 19, fig. 82, 1837; BINNEY, L. & F–W. Sh. N. A., II, p. 40, fig. 50, 1865; BAKER, Mon. Lymnaeidae, p. 343, pl. xxxvi, figs. 21, 22; pl. xxxvii, figs. 1–11, 1911.

Limnaea zebra TRYON, Amer. Journ. Conch., I, p. 228, pl. 23, fig. 4, 1865.

TYPE LOCALITY: *Exilis,* near Cincinnati, Ohio; *zebra,* Minnesota.

WISCONSIN RECORDS:

1911c. *Lymnaea exilis* BAKER, 1911. Milwaukee; Green Bay and De Pere; East River; Fox River.

SHELL: Elongate, attenuated, thin; periostracum light corneous or honey-yellow, sometimes streaked zebra-like; surface dull to shining, growth lines distinct, crowded, crossed by numerous very fine incremental striae; nuclear whorls 1¼, small, similar to those of *palustris* in outline, light corneous to very dark brown in color; whorls six to seven, very flat-sided, the last a little over one-third the length of the entire shell; spire long and very acutely attenuated, forming an almost unbroken, acute triangle in typical specimens; sutures impressed, frequently margined below by a white band edged with chestnut; aperture elongate-ovate, narrow, oblique, slightly contracted at the upper part; rounded at the lower part; peristome sharp, a rather heavy callus within which is dark chestnut colored, the remainder of the aperture being brownish or horn color; this color shows on the outside as a light band in many specimens; inner lip very narrow, erect, reflected over the umbilicus, completely closing it; the callus on the parietal wall is well marked and is so heavy in some specimens, especially when slightly raised, as to render the aperture continuous; the axis is slightly twisted, frequently somewhat gyrate.

L. 37.0; D. 11.5; Ap. L. 14.0; D. 6.2 mm.	Lea's type *exilis.*
L. 38.5; D. 12.0; Ap. L. 16.0; D. 7.5 mm.	Green Bay (U. of W., 4688).
L. 31.5; D. 10.0; Ap. L. 13.3; D. 6.0 mm.	" "
L. 34.5; D. 10.5; Ap. L. 14.5; D. 6.1 mm.	Grantsburg (U. of W., 4687).
L. 29.0; D. 9.5; Ap. L. 13.0; D. 5.5 mm.	" "
L. 23.5; D. 8.0; Ap. L. 10.6; D. 5.0 mm.	" "
L. 16.5; D. 6.5; Ap. L. 8.0; D. 3.5 mm.	" (U. of W., 4685).

ANIMAL: As in *reflexa.*

JAW AND RADULA: Not differing materially from *reflexa.*

GENITALIA: As in *reflexa.*

ECOLOGY: *Exilis* is an inhabitant of sloughs, ponds, and streams which dry up more or less during a portion of the year. Stagnant pool behind beach, south end Prairie Lake.

DISTRIBUTION: Ohio to Kansas, northward to northern Minnesota and northern Michigan.

DISTRIBUTION IN WISCONSIN: Well distributed over the State in scattered localities. It is more widely distributed than *reflexa.*

St. Croix Drainage: Grantsburg, Burnett Co.; New Richmond, St. Croix Co. (Bullock).

Chippewa Drainage: Pool near Prairie Lake, near Chetek, Barron Co. (Baker).

Wisconsin Drainage: Wisconsin River above Big Dells, Juneau Co. (Baker).

Rock Drainage: Bark River, highway 67, Waukesha Co. (Cahn).

Fox Drainage: East River, Green Bay and DePere, Brown Co. (Marston); Fox River and Green Bay, Brown Co. (Walker).

Lake Michigan Drainage: Milwaukee, Milwaukee Co. (Lapham).

REMARKS: This very charactistic and usually very distinct species is a common Lymnaea in the Upper Mississippi Valley streams and ponds. Its most pronounced distinguishing features are the long, flat-sided whorls, the attenuated, steeple-shaped spire, the shallow sutures and the long, narrow aperture. Many specimens have zebra-like markings (the form named *zebra* by Tyron) and in not a few individuals the inner lip is erect and causes the whole aperture to stand out from the body-whorl. The axis has a distinct twist and some individuals have an almost gyrate axis. This fact has led some conchologists to place it in the genus *Acella.* The axis is not typically gyrate, a fact which may be verified by breaking open the whorls; the species is a typical *Stagnicola.* There is considerable variation in the shape of the aperture; in many specimens the twist, so characteristic in *reflexa,* is entirely absent, while in others, notably in old specimens, the twist is markedly developed. The whorls also vary somewhat in rotundity.

STAGNICOLA LANCEATA (Gould)

Plate XIV, figures 12–15; plate XVII, figure 17

Limnaea lanceata GOULD, Proc. Bost. Soc. N. H., III, p. 64, 1848; AGASSIZ, Lake Superior, p. 244, pl. 7, figs. 8, 9, 1850; BINNEY, L. & F–W. Sh. N. A., II, p. 68, fig. 112, 1865; TRYON, Con. Hald. Mon., p. 113, pl. 18, fig. 11, 1872.

Galba lanceata BAKER, Mon. Lymnaeidae, p. 350, pl. xxxvii, figs. 17–22, 1911.

TYPE LOCALITY: 'Pic Lake', north shore Lake Superior.

WISCONSIN RECORDS:

1911c. *Galba lanceata* BAKER, p. 250. Tomahawk Lake.
1911a. *Galba lanceata* BAKER, p. 240. Tomahawk Lake.

SHELL: Elongate-cylindrical, rather thin, compressed; periostracum light to very dark horn colored; surface dull to shining; growth lines and spiral lines very heavy producing a conspicuously marked reticulated appearance; whorls 6 to 6½, flatly rounded, slightly oblique, not rapidly increasing in diameter, the body whorl very long and much compressed; sutures well marked; spire acutely pyramidal, generally a trifle longer than the aperture; nuclear whorls like *palustris* in outline and number, very dark chestnut colored; aperture elongated, slightly oblique, rounded below and somewhat acutely angled above, where the outer lip is slightly arched, as it joins the body whorl; outer lip with a conspicuous varix, bordered by a dark chestnut band; inner lip very narrow, forming a sharp keel on the columella and a thick deposit of callus on the parietal wall; there is no evidence of an umbilical chink; the columella is marked by a distinct plait.

L. 31.0; D. 10.4; Ap. L. 12.0; D. 6.0 mm. Tomahawk Lake (Baker coll., 749).
L. 27.5; D. 10.0; Ap. L. 12.5; D. 6.0 mm. Tomahawk Lake (Baker coll., 749).
L. 19.5; D. 7.01; Ap. L. 9.5; D. 4.3 mm. Tomahawk Lake (Baker coll., 749).
L. 28.0; D. 9.5; Ap. L. 12.5; D. 6.0 mm. Tomahawk Lake (Baker coll., 750).
L. 24.0; D. 8.0; Ap. L. 11.0; D. 4.5 mm. Tomahawk Lake (Baker coll., 750).

ANIMAL: Not differing from *elodes*. Two colors were observed, one yellow and the other black.

GENITALIA AND JAW: As in *reflexa*.

RADULA: Formula: $\frac{1\,8}{5-7}+\frac{3}{3-4}+\frac{9}{2}+\frac{1}{1}+\frac{9}{2}+\frac{3}{3-4}+\frac{1\,8}{5-7}$ (30–1–30); The teeth are similar in form to those of *reflexa.*

ECOLOGY: In Tomahawk Lake this species lives in swampy or quiet bays or pond-like bodies of water connecting with the lake. In quiet bays it may be found rarely on the sandy shore in shallow water. Its more usual habitat is in swampy areas where there is a quantity of vegetation such as *Typha* and the pond scums, in which situation it may be found on floating logs or in the vegetation. In this region it is typically an inhabitant of swampy, Typha-bordered bogs, in which there is an accumulation of old logs.

In Pike Creek near Salmo, Bayfield Co., it occurs in swampy areas where there is much vegetation and much floating timber and other debris. This similar to the Tomahawk Lake habitat.

DISTRIBUTION: North shore of Lake Superior and eastern Ontario south to northern Ohio, west to Wisconsin.

DISTRIBUTION IN WISCONSIN: Well distributed over the northern part of the State, in scattered localities.

Lake Superior Drainage: Pike Creek near Salmo and near Bayfield, Bayfield Co. (Baker).

Wisconsin Drainage: Tomahawk Lake, Oneida Co. (Baker); Plum Lake, Vilas Co. (Cahn).

Chippewa Drainage: Prentice, Price Co. (Bullock).

Green Bay Drainage: Marinette, Marinette Co. (Bullock); Sturgeon Bay, Door Co. (Baker).

REMARKS: *Lanceata* is one of the Lymnaeas which has been much misunderstood for many years. By several authors it has been considered a synonym of *kirtlandiana* and *exilis.* An examination of a cotype in the Smithsonian collection, and a study of Gould's figures and descriptions, aided by a collection of several hundred specimens from the northern states shows that it is a good species. It is true that Binney's figure is very poor, but the two figures in Agassiz's Lake Superior (pl. 7, figs. 8 and 9) are excellent and answer exactly to Gould's description. These are almost identical with the figures on the plate of this volume. Binney's figure of *kirtlandiana* bears some resemblance to *lanceata* but quite correctly typifies *kirtlandiana* in which the whorls are more oblique, a feature absent in *lanceata.* Tryon's figure in his continuation of Haldeman's Monograph, is very poor and looks more like a form of *exilis* than *lanceata.*

Lanceata is liable to be confused with three forms of Lymnaea; *exilis,* which has a longer spire with more flat-sided oblique whorls, a narrower, more oblique aperture and a twist like that of *reflexa;* immature *reflexa,* which differs in the form of the penultimate whorl (which is disproportionately enlarged) and in the shape of the aperture, which is slightly oblique and reflexed; and *umbrosa,* which has a wider shell, wider spire whorls and a rounder aperture. With reasonable care there ought to be no difficulty in distinguishing *lanceata* from all related species. The spire whorls are only slightly oblique, notwithstanding the fact that Gould says in his description "quite oblique." The rectangular shape of the aperture and the flatly cylindrical form of the body whorl, will aid much in dstinguishing *lanceata.*

STAGNICOLA WINNEBAGOENSIS (F. C. Baker)

Plate XIV, figures 16–20

Lymnaea winnebagoensis BAKER, Nautilus, XXXVI, p. 22, 1922.

TYPE LOCALITY: Oshkosh, Lake Winnebago, Wisconsin.

WISCONSIN RECORDS:

1922a. As above.

1924. *Lymnaea winnebagoensis* BAKER, p. 136. Lakes Winnebago and Butte des Morts.

SHELL: Elongated, rather thick and solid; periostracum very light horn color; surface dull, lines of growth crowded, coarse, crossed by more or less deeply incised spiral lines; nuclear whorls 1½, small, well rounded, dark wine or light horn colored; whorls 7, flatly rounded, the body whorl more convex; spire long, forming a very regular sharp-pointed cone, longer than the aperture; sutures impressed; aperture ovate; outer lip slightly thickened within by an inconspicuous varix edged with purple; inner lip rather wide, reflected and appressed tightly to the columellar region; leaving a very narrow umbilical chink, and forming a wide callous deposit on the parietal wall; columella with a heavy, oblique plait, twisting the axis.

L. 26.0; D. 12.2; Ap. L. 12.0; D. 6.0 mm.	Type (U. of I., Z11826).
L. 22.5; D. 10.4; Ap. L. 10.0; D. 5.0 mm.	Paratype (U. of I., Z11826).
L. 19.0; D. 10.0; Ap. L. 10.0; D. 5.0 mm.	" "
L. 18.0; D. 9.1; Ap. L. 9.1; D. 4.2 mm.	" "
L. 15.5; D. 7.1; Ap. L. 7.2; D. 3.5 mm.	" "
L. 6.9; D. 3.2; Ap. L. 4.0; D. 1.6 mm.	" "

ANIMAL: Resembling that of *palustris.*

GENITALIA: Resembling *reflexa.* The praeputium is more than twice as long as the penis sheath. There are two retractor muscles, one from the penis sheath and one from the praeputium, both very heavy and wide. The protractor muscles are as in *reflexa.* Internally, the male organ is the same as *palustris* and *reflexa.*

JAW (Fig. 105): Superior jaw wide, arched; ends rounded; cutting edge with two small lobes in the center and a wide lobe on either side.

Fig. 105. Superior Jaw of *Stagnicola winnebagoensis.*

RADULA: Formula $\frac{10}{4-6}+\frac{4}{3}+\frac{3}{2}+\frac{1}{1}+\frac{3}{2}+\frac{4}{3}+\frac{10}{4-6}$ (22–1–22). Central tooth as in *reflexa* but only 18 μ wide at the lower part; lateral teeth bicuspid as in *reflexa;* transition teeth four in number, tricuspid, the entocone rather small and placed near the lower end of the tooth; marginals long and narrow, 4 to 6 cuspid, in shape like those of *reflexa.* The radula of *winnebagoensis* is peculiar in having but 22 teeth on each side of the central tooth. This is the narrowest membrane of any of the *palustris* group, the smaller number of teeth being approached only by the smaller Lymnaeas.

ECOLOGY: Young and immature individuals live among vegetation in protected places, like coves and bays; adults in deeper water on gravel and sand bottom.

DISTRIBUTION: Known only from Wisconsin at present.

DISTRIBUTION IN WISCONSIN: Winnebago and Butte des Morts lakes, Winnebago Co. (Baker); Fox River, De Pere, Brown Co. (Marston).

REMARKS: This characteristic species has a *palustris*-like form, the sculpture of *catascopium,* and a radula formula different from most species of the typical Stagnicolas. The shell resembles several other species: *Lymnaea nashotahensis,* from which it may be known by its different sculpture and its less rounded whorls and shallower sutures; and *Lymnaea danielsi* and *minnetonkensis,* neither of which are found in Wisconsin. Though the texture of the shell is similar to that of

catascopium, the form is quite different, the spire being acute while that of *catascopium* is very wide and blunt. *Winnebagoensis* is the most abundant gastropod in Winnebago Lake, the shore debris often being made up largely of this species. For the ecology of this and other species of Mollusca found in this lake see Baker, 1924, pp. 109–146.

STAGNICOLA NASHOTAHENSIS (F. C. Baker)

Plate XIV, figures 21–26, plate XVII, figure 18

Lymnaea nashotahensis BAKER, Nautilus, XXIII, p. 19, 1909.
Galba nashotahensis BAKER, Mon. Lymnaeidae, p. 108, pl. xlvi, figs. 18–24, 1911.

TYPE LOCALITY: Lower Nashotah Lake, Waukesha Co., Wis.

WISCONSIN RECORDS:

1909, 1911. As above.
1913b. *Galba nashotahensis* BAKER, p. 68. Waukesha Co.
1920d. *Galba nashotahensis* BAKER, p. 121. Waukesha Co.

SHELL: Elongated, somewhat pyramidal; surface dull, growth lines conspicuous, crossed by fine impressed spiral lines; whorls 6–6½, rather rapidly increasing in diameter, flatly rounded, the body whorl very large and quite convex, or even gibbous; spire broadly pyramidal or conic, longer than the aperture; sutures well marked; aperture elongate ovate, much narrowed above, generally wide and flaring below; outer lip with varical thickening; inner lip rather broad, reflected over the umbilical region, forming a conspicuous expansion and leaving a well marked umbilical chink; parietal callus wide and rather thick, in some specimens rendering the aperture continuous; axis twisted; the columella is plicate in the immature shell but in adult or old specimens the inner lip is raised over the umbilicus, somewhat as in *emarginata.*

L. 33.5; D. 13.0; Ap. L. 14.0; D. 7.0 mm.	Largest type.
L. 26.7; D. 11.0; Ap. L. 12.3; D. 6.0 mm.	Cotypes (Baker coll., 223).
L. 23.0; D. 10.5; Ap. L. 11.5; D. 6.0 mm.	" "
L. 20.0; D. 9.2; Ap. L. 10.0; D. 5.0 mm.	" "
L. 25.0; D. 12.1; Ap. L. 12.0; D. 7.0 mm.	Green Lake (U. of W., 4690).
L. 23.0; D. 11.5; Ap. L. 11.1; D. 6.0 mm.	" "
L. 22.–; D. 10.2; Ap. L. 11.5; D. 6.1 mm.	" "
L. 21.0; D. 10.4; Ap. L. 11.5; D. 6.0 mm.	" "

ANIMAL: Unknown.

ECOLOGY: Unknown. Specimens from Green Lake were dredged from a depth of 7 meters in a marl bed. Spring Lake

specimens occurred in a marl deposit at the edge of the lake. Nashotah specimens are all beach shells, but evidently recently living.

DISTRIBUTION: Specimens have been seen from Michigan (Kegobic) and Wisconsin.

DISTRIBUTION IN WISCONSIN: All known localities are in the southeastern part of the State.

Fox Drainage: Green Lake and Spring Lake, Green Lake Co. (Baker).
Rock Drainage: Nashotah, Waukesha Co. (Woodruff); Lower Nashotah Lake, Waukesha Co. (Cahn).

REMARKS: *Nashotahensis* was at first thought to be a form of *danielsi;* it differs markedly from that species, however, in several particulars—the spire is broader and not so acute, the body whorl is larger and inclined to be gibbous, and there is a conspicuous umbilical chink (*danielsi* is usually imperforate). In *nashotahensis* the aperture is elongate ovate, narrowed above and broadened below where it is often patulous. The upper whorls are strongly suggestive of *reflexa,* the penultimate whorl, in some specimens, having the swollen appearance so characteristic of *reflexa.*

Young specimens somewhat resemble *catascopium,* differing in being narrower, with a more elongate aperture, longer and less rounded whorls and a less distinctly plicate columella. There is also an umbilical chink which is usually absent in *catascopium. Nashotahensis* was probably contemporaneous with one of the glacial stages of the Great Lakes. The material from Green Lake is quite variable, specimens varying from typical *nashotahensis* to a *palustris*-like form. They are all referable to this species, however, the variation being due probably to more or less unfavorable glacial conditions.

This species was at first thought to be extinct, but in recent collecting Dr. Cahn found about a dozen specimens in beach debris of Lower Nashotah Lake which showed conclusively that they had been recently inhabited by the living animal. *Nashotahensis* and *winnebagoensis* are closely related, as are also *danielsi* and *minnetonkensis,* but until the radulae of all four species have been examined their exact relationship cannot be certainly determined. *Danielsi* has 28–1–28 teeth with nine laterals; *winnebagoensis* has 22–1–22 teeth with eight laterals, indicating that these two species are specifically distinct.

It is hoped that living material may be found in Lower Nashotah Lake to determine the relationship of this form. Until the animals of these species have been examined it seems best to consider them distinct species.

GROUP OF STAGNICOLA EMARGINATA

In this group the shell is shortened, ovate or roundly ovate, the spire is as long as or shorter than the aperture, the latter being round or roundly ovate. The habitat is normally in lakes or large rivers, often in situations where there is violent wave action. They are seldom or never found in swampy pools or in unusually quiet waters.

STAGNICOLA EMARGINATA (Say)

Plate XV, figures 1–3; plate XVI, figures 15–20

Lymneus emarginatus SAY, Journ. Phil. Acad., II, p. 170, 1821; Amer. Conch., part VI, pl. 55, fig. 1, 1834.

Limnea emarginata HALDEMAN, Mon., p. 10, pl. 2, figs. 1–5, 1842.

Limnaea emarginata BINNEY, L. & F–W. Sh. N. A., II, p. 51, figs. 75–79, 1865.

Galba emarginata BAKER, Mon. Lymnaeidae, p. 408, pl. xxx, figs. 27, 28; xli, figs. 18–24; xliii, figs. 1–12, 1911.

TYPE LOCALITY: Lakes of Maine. Nylander (Nautilus, XXXIV, p. 77) suggests that Mud Lake or Second Lake, Aroostook County be made the type, since typical *emarginata* occurs in this lake. See also Baker, op. cit.

WISCONSIN RECORDS: None.

SHELL: Large, ranging from ovate to somewhat globose, inflated, usually rather thin, more or less translucent; periostracum corneous, varying from almost pure white to rather dark brown; the periostracum is sometimes ornamented by longitudinal lighter bands, much narrower than the ground color of the shell; frequently there will be a broad band of white on the last whorl, and the sutures are sometimes bordered by a white line; nuclear whorls 1½ large, wide and low, flattened, chestnut colored; surface dull to shining, lines of growth coarse, crowded, frequently wrinkled and sometimes crossed by several spiral ridges, in addition to the fine spiral impressed lines, giving the surface a malleated aspect; whorls 5 to 5½, convex to subglobose, shouldered, more or less inflated, the last

whorl large and usually quite convex, showing a tendency to expand and flare, and also to become shouldered; spire varying from broadly, acutely pyramidal to depressed globose or flattened, frequently eroded; sutures generally deeply impressed, in some individuals markedly so; aperture ovate or somewhat rectangular, very large, somewhat expanded or flaring in some specimens, a trifle effuse anteriorly; the aperture occupying one-half to two-thirds of the length of the shell; aperture whitish to brownish or deep chocolate in color; peristome thin, with a thin whitish or brownish internal varix in fully adult specimens; inner lip white, wide, rather broadly reflected and forming a wide expansion which strongly emargins the umbilical chink; in the majority of specimens the parietal callus is very thick and is a trifle raised so as to make the aperture continuous; the columella varies from smooth to heavily plicated; the umbilicus varies from a small chink to a rather wide perforation, emargined by the inner lip; axis slightly twisted. There is generally a marked rest varix midway of the body whorl, and in some specimens as many as five of these varices may be counted; in many individuals the lower part of the aperture becomes twisted to such an extent that it spreads far beyond the umbilical opening; axis twisted and slightly plicate. The juvenile shells are very globose, the strongly shouldered whorls appearing only in nearly adult or old individuals.

L. 19.5; D. 11.5; Ap. L. 11.0; D. 5.7 mm. Autotype (Phil. Acad.).
L. 28.0; D. 18.0; Ap. L. 18.5; D. 10.5 mm. Mud Lake, Maine (Chi. Acad. Sci.).
L. 21.0; D. 12.9; Ap. L. 12.2; D. 7.0 mm. Mud Lake, Maine (Baker coll. 234).
L. 20.5; D. 13.6; Ap. L. 14.8; D. 9.0 mm. Mud Lake, Maine (Baker coll. 234).
L. 18.5; D. 11.5; Ap. L. 11.4; D. 7.5 mm. Mud Lake, Maine (Baker coll. 234).
L. 19.0; D. 12.0; Ap. L. 11.0; D. 7.0 mm. Little Arbor Vitae Lake (U. of I., Z22516).
L. 20.0; D. 11.0; Ap. L. 11.5; D. 6.5 mm. Little Arbor Vitae Lake (U. of I., Z22516).

ANIMAL (Fig. 87): Color generally blackish or bluish black, head, tentacles and the greater part of the body flecked with white or yellowish white, giving the surface the appearance of being covered with a superficial bloom when the animal is in motion. Foot broadly rounded before, more acutely be-

hind, very broad and much flattened on the margins; head and velum rather short, ranging from semi-circular to very wide in form, with the lateral ends obtusely pointed, according as the animal is motionless or rapidly progressing; the vela area is very large in this species, and frequently assumes a bilobate form anteriorly. Mantle large and conspicuous, fitting closely to the aperture of the shell, bluish-black flecked with whitish or yellowish. Tentacles broad, flat, thin, triangular and very large and conspicuous, obtusely pointed at their extremity, blackish flecked with yellowish-white. Eyes black, surrounded by a yellowish-white zone, placed on rather large swellings at the inner base of the tentacles. Respiratory orifice placed near the posterior angle of the shell; the so-called 'siphon' is capable of great expansion, and when taking in air at the surface of the water is sometimes extended to a length of nearly a third of an inch. The pulmonary cavity fills about half of the body whorl, and is colorless and transparent as seen through the shell, where the heart may also be seen pulsating. Some animals are lighter than others, the extremes of light and dark being very great.

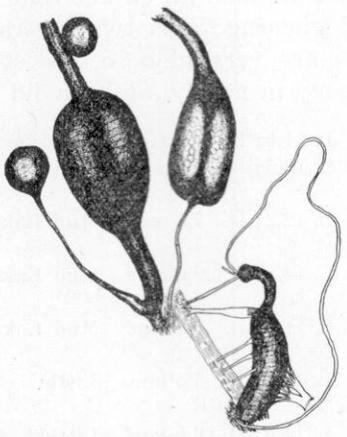
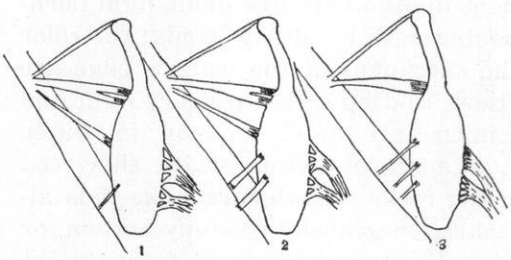


Fig. 106. Genitalia of *Stagnicola emarginata.*

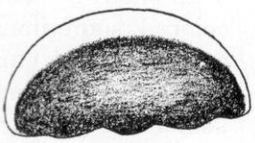
GENITALIA (Fig. 106): Praeputium rather large, cylindrical, penis sheath less than half as long as praeputium, very slender; retractor muscle of praeputium very wide, strong, widening and band-like near the praeputium where it is attached by many small muscles; retractor of penis sheath long

and slender; the two retractors meet in the columella muscle where they usually form one muscle, though two branches were observed in one specimen protractor muscles of praeputium normally five in number, two anterior, forming a wide band of muscle with many small points of attachment; and three posterior, long, narrow, entering the columella muscle. Prostate very large, flattened, elongated, squarely rounded anteriorly, gradually tapering posteriorly where it forms a large duct which joins the spermoviduct; vas deferens long and of small diameter. Of the female organs, the spermatheca is large, rounded, with a long, narrow duct. The other organs are as usual in the genus.

There is some variation in the number of the retractors of the praeputium; in two specimens examined the posterior protractor had shifted its position so as to form a second inferior praeputium retractor (fig. 107, 1, 2). The specimens were from Isle Royale, Lake Superior. The penis and the general interior form of the penis sheath and praeputium is similar to that of *palustris*. The longitudinal muscles of the praeputium are very heavy, but the spiral muscles are scarcely noticeable (fig. 94).



GENITALIA



JAW

Fig. 107. Male genitalia and Jaw of *Stagnicola emarginata*.

JAW (Fig. 107): Superior jaw wide and low; dorsal margin broadly arched, smooth; ventral margin with a narrow central projection; anterior face of jaw striated. The lower lateral margins are frequently produced into rounded prolongations. Color very dark brown.

RADULA (Fig. 108): Formula $\frac{2\,3}{4-6}+\frac{2}{3}+\frac{1\,0}{2}+\frac{1}{1}+\frac{1\,0}{2}+\frac{2}{3}+\frac{2\,3}{4-6}$ (35–1–35); central tooth unicuspid, the cusp long and narrow, the cutting point small and acute; lateral teeth bicuspid, wide,

the mesocone wide, spade-shaped, the ectocone rather narrow; toward the intermediate teeth the laterals become narrower; intermediate teeth tricuspid, entocone small and placed near the distal end of the mesocone; the ectocone is small and is placed about half way up the margin of the reflection; there is a small denticle above the ectocone; marginal teeth serrated, the distal

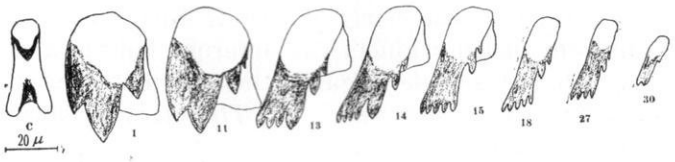


Fig. 108. Radula of *Stagnicola emarginata.*

extremity four to six cuspid, the inner margin frequently with two small denticles. There are over 100 rows of teeth. In a membrane from an Isle Royale specimen the second intermediate tooth and the first two lateral teeth had the entocone broken up into from three to five long, sharp serrations (108, B.). In another specimen there were fourteen lateral teeth instead of the normal number, ten.

ECOLOGY: "The specimens in Mud Lake are small, light horn-colored, sometimes ornamented with revolving bands; the color of the animal varies. The specimens at the water's edge are bluish-black or gray, and those in deep water are very light and sometimes orange. Specimens are most common in water about three feet in depth, on a gravel bottom, where they feed on confervae, growing on the rocks. In Square Lake it is always found at low water mark, on gravelly or stony bottom, or on a gravelly bar where there is a strong current from the inlet or thoroughfare (Nylander, Maine specimens). In Plum Lake dead specimens were found on a sand shore by Dr. Cahn.

DISTRIBUTION: Maine to western Ontario, south to the northern part of the south peninsular of Michigan, northern Wisconsin, and northern New York.

DISTRIBUTION IN WISCONSIN: At present known only from Vilas County, in Plum Lake (Cahn).

REMARKS: Students generally have mixed the true *emarginata* with forms of *catascopium* and *palustris,* besides confounding several varieties under this name. The original specimens came from Maine and it is to this state that we must

look for typical *emarginata.* Such material has been abundantly collected by Olof O. Nylander in the lakes of Aroostook Co. It is unfortunate that Say's type specimens from Maine have not been preserved. The two autotypes in the Philadelphia Academy are from Saratoga Lake, New York, and do not accurately represent the Maine form, being of a transition nature between typical *emarginata* and the race called *canadensis.*

The small, narrow shell with sharp pointed spire has been taken as typical *emarginata,* but Say did not have this form in mind, although he may have included it in his species. Typical *emarginata* has a rather short, broadly pyramidal spire, the whorls being well rounded, the body whorl quite convex, the aperture ovate or almost round in some specimens, and the inner lip wide and broadly reflected, overhanging the large, conspicuous umbilical chink. The distinguishable features of the shell are the rounded, sub-globose shape of the last whorl, and the broad spire with the upper spire whorls broadly depressed and flattened. *Catascopium* may be at once distinguished from *emarginata* by its narrower shell, and especially by its inner lip which is narrow and closely appressed to the umbilical region leaving at most only a very small chink. There is also a distinct plait in *catascopium.*

The Vilas County specimens vary from forms like the Maine specimens to those with a sharply pointed spire, like Say's Saratoga Lake specimens. It is apparently rare in Wisconsin.

STAGNICOLA EMARGINATA CANADENSIS (Sowerby)

Plate XV, figures 4–11; plate XVII, figure 19

Limnaea canadensis SOWB., Conch. Icon., XVIII, Limn., sp. 45, pl. 7, figs. 45, a, a (not a, b as stated on plate), 1872.

Limnaea emarginata, ampla, of authors; see BAKER, Mon. Limnaeidae, p. 428, 1911.

Galba emarginata canadensis BAKER, Mon. Lymnaeidae, p. 427, pl. xliv, figs. 19–23; pl. xlv, figs. 1–20, 1911.

Limnaea barbadensis SOWB., Conch. Icon., XVIII, Limn., sp. 100, pl. 14, fig. 100, 1872.

TYPE LOCALITY: Unknown, probably in Canada; *barbadensis,* erroneously given as Barbadoes, probably Canadian.

WISCONSIN RECORDS:

1911c. *Galba emarginata canadensis* BAKER, p. 429. Green Bay; Kenosha.

SHELL: Elongated to ovate, varying from thin to rather thick; periostracum very light horn, sometimes darker, pellucid; nuclear whorls small, smooth, rounded, consisting of 1½ white or horn colored whorls in outline similar to those of *catascopium;* surface and sculpture as in *emarginata;* whorls 5½ to 6, rounded, convex, the body whorl quite convex; spire typically long, attenuated, but shorter and depressed in some individuals; sutures well impressed; aperture long-ovate, occupying from half to three-fourths, the length of the shell, much expanded and flaring in some forms; interior of the aperture varying from white to brownish; peristome thickened by a white varix; inner lip wide, raised, reflected over the umbilical region either entirely closing the perforation or leaving a small chink; the parietal callus is usually rather thick and sometimes becomes heavy and raised so as to render the aperture continuous; the umbilical chink is emargined as in the typical form; in some specimens the columella has a heavy, ascending plait; axis twisted.

L. 19.5; D. 10.5; Ap. L. 11.5; D. 5.7 mm.	Detroit Harbor (U. of W., 4691).
L. 18.5; D. 10.5; Ap. L. 10.2; D. 5.6 mm.	Detroit Harbor (U. of W., 4691).
L. 17.6; D. 10.0; Ap. L. 10.2; D. 5.1 mm.	Detroit Harbor (U. of W., 4691).
L. 24.2; D. 12.5; Ap. L. 14.0; D. 8.0 mm.	Sturgeon Bay (U. of W., 4692).
L. 23.5; D. 12.0; Ap. L. 13.0; D. 7.0 mm.	" "
L. 20.0; D. 11.0; Ap. L. 12.1; D. 6.1 mm.	" "
L. 19.5; D. 11.1; Ap. L. 10.0; D. 6.0 mm.	" "
L. 18.5; D. 9.5; Ap. L. 10.0; D. 5.0 mm.	" "
L. 20.0; D. 10.5; Ap. L. 11.0; D. 6.0 mm.	" "

ANIMAL, JAW, AND GENITALIA: As in *emarginata.* Animal yellowish in color.

ECOLOGY: At Sturgeon Bay this variety lived on a stony shore in shallow water, exposed to the waves of the open bay. The animal is very sluggish in its movements.

DISTRIBUTION: Anticosti Island west to eastern Wisconsin, south to southern Michigan, northern Pennsylvania, and southern New York.

DISTRIBUTION IN WISCONSIN: At present known only from the eastern part of the State, in the Lake Michigan drainage.

Detroit Harbor, Door Co. (Bullock); Sturgeon Bay, Door Co., west of town (Baker); Green Bay (Marston); Kenosha, Kenosha Co. (Wiswall).

REMARKS: *Canadensis* differs from typical *emarginata* by having a narrower and more flatly rounded body whorl, a longer, more acuminate spire, narrower and more elongated spire whorls, an elongated instead of an ovate or rounded aperture and a more or less plicate instead of a simple columella. The shape of the penultimate whorl is very different in the two races, that of *emarginata* being very wide and low and notably convex, while that of *canadensis* is high and narrow, comparatively, and usually rather flatly rounded. The umbilical chink is usually either absent or is reduced to a very narrow slit. In individual specimens it may be widely open. Typically it is a very distinct race, but there are intermediate forms which show its relation to *emarginata.*

This is the race which has usually been called typical *emarginata;* an examination of Maine and Wisconsin material, in connection with Say's original description, figures and autotypes, shows that the typical form is not the one with the acuminate spire, but with the broad and depressed spire. Say's figure emphasizes the globoseness of the whorls. Certain specimens of this race may be confused with *catascopium,* and may be known from that species by their large size, and heavier inner lip, longer spire and (usually) absence of a plait.

The distribution in Wisconsin is peculiar, all records being on or near the shore of Lake Michigan. It seems to be largely a lake shell, river localities being rare and confined to immediate connections with bays or lakes.

STAGNICOLA EMARGINATA ANGULATA (Sowerby)

Plate XV, figures 12–18

Limnaea angulata SOWB., Conch. Icon., XVIII, Lim., No. 47, pl. 7, fig. 47, 1872.

Limnaea emarginata BAKER, Bull. Chi. Acad. Sci., II, p. 212, pl. 1, fig. D, 1900.

Galba emarginata angulata BAKER, Mon. Lymnaeidae, p. 421, pl. xliv, figs. 1–9, 1911.

Limnaea ampla, binneyi, decollata, mighelsi, of authors (see Baker, Op. Cit., p. 421, 1911).

TYPE LOCALITY: North America (probably founded on Michigan specimens).

WISCONSIN RECORDS:

1853. *Limnea emarginata* LAPHAM, p. 368. Madison.

1860. *Limnaea emarginata* LAPHAM, p. 155. Madison.

1865. *Limnaea emarginata* BINNEY, p. 53. Madison.
1897. *Limnaea emarginata* WISWALL, p. 48. Southern Wisconsin.
1897. *Limnaea ampla* WISWALL, p. 48. Southern Wisconsin.
1900b. *Limnaea emarginata* BAKER, pp. 195, 212. Madison.
1906. *Limnaea decollata* CHADWICK, p. 80. Madison.
1906. *Limnaea emarginata* CHADWICK, p. 82. Madison; Kenosha.
1911c. *Galba emarginata angulata* BAKER, p. 424. Madison; Kenosha.

SHELL: Solid, rotund, tumid; periostracum, light horn, varying to brownish or purplish; sculpture as in *emarginata,* but growth lines coarse, the surface of the shell frequently raised into ridges, sometimes giving a malleated aspect; spiral lines rather conspicuous; nuclear whorls rather large, rounded, whitish, the outline resembling those of *catascopium;* whorls 5 to 5½, rounded, tumid, the body whorl usually very convex; the whorls increase very rapidly in size and are generally strongly angulated on the shoulders of the penultimate and body whorl; spire short, tumid, wide; sutures impressed; aperture ovate, longer than the spire, rounded and effuse anteriorly, angulated posteriorly; outer lip with a slight varial thickening within; inner lip broad, reflected, closely appressed to the shell, generally completely closing the umbilicus; the parietal callus is very thick and in old shells is raised so as to make the aperture continuous; the columella is much thickened and frequently develops a strong plait; axis slightly twisted.

L. 22.5; D. 14.1; Ap. L. 14.0; D. 8.5 mm.	Lake Houghton, Mich.
L. 23.2; D. 13.2; Ap. L. 14.0; D. 8.0 mm.	L. Noquebay (U. of W., 4694).
L. 20.2; D. 12.0; Ap. L. 13.0; D. 7.0 mm.	" "
L. 19.5; D. 12.0; Ap. L. 12.5; D. 7.0 mm.	" "
L. 18.8; D. 11.5; Ap. L. 12.0; D. 7.5 mm.	" "
L. 18.0; D. 10.5; Ap. L. 12.5; D. 6.3 mm.	" "
L. 20.5; D. 13.0; Ap. L. 13.0; D. 7.4 mm.	Madison (U. of W., 4693).
L. 19.0; D. 11.2; Ap. L. 11.2; D. 6.0 mm.	" "
L. 17.2; D. 10.5; Ap. L. 11.0; D. 5.5 mm.	" "
L. 17.0; D. 11.0; Ap. L. 11.0; D. 6.0 mm.	" "

ANIMAL: Not seen alive.

GENITALIA: Practically the same as in *emarginata* (see Baker, Mon., p. 422, pl. xii, fig. H).

JAW: As in *emarginata.*

RADULA: Formula $\frac{19}{5-7}+\frac{3}{3-4}+\frac{9}{2}+\frac{1}{1}+\frac{9}{2}+\frac{3}{3-4}+\frac{19}{5-7}$ (31–1–31); the teeth are in all respects like those of *emarginata.* In one specimen there were ten instead of nine full laterals, and the transition teeth began very abruptly.

ECOLOGY: Not recorded for Wisconsin specimens. In Michigan found at a depth of 12 feet in July and near shore in water from .3 to 1 m. deep, on sand bottom, in which they were partly buried. In Minnesota they have been found on both sand and pebble bottom.

DISTRIBUTION: Michigan to Minnesota, south to central Wisconsin.

DISTRIBUTION IN WISCONSIN: *Angulata* appears to be rare and to be found in but a few localities, rather widely separated.

Lake Michigan Drainage: Kenosha, Kenosha Co. (Wiswall); Lake Noquebay, near Crivitz and Marquette, Marquette Co. (Bullock).

Rock Drainage: Lake Mendota (first of four lakes), Dane Co. (Bullock, Lapham, Wiswall).

REMARKS: *Angulata* is very closely related to *emarginata,* the chief points of difference being the more solid shell, tightly closed umbilicus, angulated whorls and depressed spire. Specimens from Houghton Lake, Mich., were compared with Sowerby's types in the British Museum and found to be identical, hence the assumption that the original shells probably came from some lake in this state. The Wisconsin shells show a strong variation toward typical *emarginata,* some forms being easily referred to that species in the absence of a large set showing variation. The majority of individuals are readily referred to *angulata.* The Madison *angulata* have been referred to *ampla (mighelsi)* by early writers on Wisconsin shells, but they differ markedly from that variety, which does not occur in the State (see Baker, Mon., p. 425). Wherever found, *angulata* occurs in large numbers. It is typically a lake form and authentic specimens have not been found in any other environment.

STAGNICOLA EMARGINATA VILASENSIS F. C. Baker

Plate XVI, figures 21–26

Stagnicola emarginata vilasensis BAKER, Nautilus, XL, p. 82, 1927.

TYPE LOCALITY: Big Muskallonge Lake, Vilas Co., Wis.

SHELL: Large, elongate-ovate to almost globular in form, inflated, thin to rather thick; periostracum brownish to whitish horn color; surface dull, sculpture of coarse growth lines and well-developed spiral lines; heavy spiral ridges are present on the body whorl of some specimens; whorls 5½, convex, more

or less tumid, the body whorl usually more or less flattened, almost straight in some individuals, with a pronounced shoulder; spire elongated or very much flattened, varying from as long as the aperture to one-fifth its length; sutures deeply impressed; aperture large, expanded, often patulous, long-ovate to roundly-ovate, from one-half to four-fifths the length of the shell, rounded below, somewhat angular above, yellowish-brown or purplish within; peristome sharp, thin; inner lip very wide, broadly reflexed over the umbilical region, leaving a rather widely open umbilical chink; there is a wide columellar callus spreading well over this region which is frequently raised from the body whorl, causing the aperture to become entire; not infrequently the inner lip is strongly curved to the left, producing a pseudo-canal; there is a marked columellar plait.

L. 35.0; D. 28.0; Ap. L. 27.0; D. 16.5 mm.	Type. (U. of I., Z21678).
L. 33.0; D. 27.0; Ap. L. 25.0; D. 15.3 mm.	Paratype. (U. of I., Z21679).
L. 38.0; D. 25.5; Ap. L. 25.0; D. 15.2 mm.	" "
L. 32.5; D. 20.0; Ap. L. 20.0; D. 12.0 mm.	" "
L. 29.0; D. 22.0; Ap. L. 19.5; D. 12.0 mm.	" "

ANIMAL: Not examined.

RADULA: Unknown.

ECOLOGY: Not collected living.

GENERAL DISTRIBUTION: Known from Vilas Co., Wis., and Crow Wing Co., Minn.

DISTRIBUTION IN WISCONSIN: Known only from Big Muskallonge Lake, Vilas Co. (Cahn)

REMARKS: This fine shell, though at first sight apparently quite a distinct species, is doubtless an extreme variation of *Stagnicola emarginata.* Its nearest relative appears to be *mighelsi* Binney, from which it differs in its more angular body whorl which forms a distinct shoulder, its broader, flatter spire and usually deeper sutures, and its wider and rounder aperture, which is more patulous. The flattening of the body whorl in the majority of specimens examined is peculiar. There are long-spired examples which recall typical *emarginata,* small specimens recalling *angulata,* and some rounded specimens recalling *wisconsinensis.* It may be a variation produced by isolation, as Big Muskallonge Lake is without an outlet at the present time. Typical *emarginata* occurs in Plum Lake, about five miles east of Muskallonge Lake, but these are normal, resembling the Maine specimens (pl. XVI, figs. 15–20). The

new variety also occurs in Pelican Lake, Crow Wing Co., Minnesota, indicating a wide range. These were collected many years ago by Dr. W. A. Nason and are now in his collection in the University museum (No. Z21681). The new variety appears to be the maximum variation in the *emarginata* group, rivaled only by some extreme examples of *mighelsi.* The very wide and patulous aperture and outer lip will at once distinguish this variety from any other Wisconsin shell.

STAGNICOLA EMARGINATA WISCONSINENSIS (F. C. Baker)

Plate XV, figures 19–25; plate XVII, figure 20

Galba emarginata BAKER, Nautilus, XXIII, p. 113, 1910.
Lymnaea emarginata wisconsinensis BAKER, Nautilus, XXIV, p. 58, 1910.
Galba emarginata wisconsinensis BAKER, Mon. Lymnaeidae, p. 425, pl. xliv, figs. 10–18, 1911.

TYPE LOCALITY: East shore Tomahawk Lake, Oneida Co., Wisconsin.

WISCONSIN RECORDS:

1910a. *Galba emarginata* BAKER, p. 113. Tomahawk Lake.
1910b. *Lymnaea emarginata wisconsinensis* BAKER, p. 58. Tomahawk Lake.
1911c. *Galba emarginata wisconsinensis* BAKER, p. 425. Tomahawk Lake.
1911a. *Galba emarginata wisconsinensis* BAKER, p. 240. Tomahawk Lake.
1926. *Lymnaea emarginata wisconsinensis* WINSLOW, p. 6. Little Arbor Vitae Lake.

SHELL: Very large, varying from elongated to globose, inflated, usually rather thin; periostracum varying from light yellowish horn to chestnut; nuclear whorls as in *emarginata;* sculpture as in *emarginata;* many specimens have, in addition to the spiral impressed lines, a number of heavy, more or less equidistant spiral ridges encircling the body whorl; the last whorl may also be somewhat malleated; whorls 5 to 5½, globose, roundly shouldered, inflated, the body whorl very globose and disproportionately swollen; spire varying from broadly acute to depressed, usually about half the length of the entire shell; suture well marked, often deeply impressed; aperture roundly-ovate, rarely quadrate, seldom flaring; peristome with internal, varical thickening; inner lip wide, whitish, broadly reflected over the umbilical region producing a wide, flat expan-

sion, which emarginates the umbilical chink, as in the typical form; umbilical chink usually very large and conspicuous; imperforate individuals are rare; the parietal callus is thick and wide producing a continuous aperture in some specimens; the lower part of the aperture is somewhat effuse in a few individuals.

L. 23.0; D. 15.0; Ap. L. 12.0; D. 7.0 mm.	Cotypes	(Baker Coll., 814).
L. 23.0; D. 17.5; Ap. L. 13.0; D. 9.0 mm.	"	"
L. 21.2; D. 15.5; Ap. L. 13.0; D. 9.0 mm.	"	"
L. 23.0; D. 16.0; Ap. L. 12.5; D. 8.5 mm.	"	"
L. 23.0; D. 16.0; Ap. L. 12.0; D. 9.5 mm.	"	"
L. 20.5; D. 16.0; Ap. L. 12.0; D. 8.0 mm.	"	"
L. 29.0; D. 21.5; Ap. L. 16.0; D. 10.5 mm.	"	"

ANIMAL: Similar to typical *emarginata.* The animals of the Tomahawk Lake race are of two very pronounced colors, black with white dots and bright yellow with white dots. This difference in the animal is quite conspicuous rendering the light colored specimens less noticeable than the dark colored individuals against the white sand of the shore.

JAW, RADULA AND GENITALIA: In all respects similar to those of *emarginata.*

ECOLOGY: In Tomahawk Lake, this species is very abundant, the shore after storms being literally paved with dead shells. It lives on the sandy or pebbly shores, in water from a few inches to several feet in depth. By wading along the beach thousands may be collected. The localities in this lake are all on exposed points or in curved bays where the shore receives the full force of the waves. No specimens were found in sheltered places, where the water was at all stagnant. They were observed irregularly scattered over the surface, crawling over the sand, where a distinct track was left, or else lying half buried in the sand. The two different colors mentioned by Nylander as being characteristic of the Maine *emarginata* were also observed in the Tomahawk Lake specimens.

DISTRIBUTION: At present known only from Wisconsin.

DISTRIBUTION IN WISCONSIN: Tomahawk Lake, Oneida Co. (Baker); Little Arbor Vitae Lake, Vilas Co. (Winslow); drainage of the Wisconsin River.

REMARKS: This race differs from all the other races of *emarginata* in its very globose body and rounded aperture. The race is very variable, the variant being the spire which is

elongated or depressed. Some individuals approach *mighelsi* but this is rare, the shell being usually much more globose than that race. *Angulata* differs in having a heavier shell, a much less globose body whorl, and an elongated and angulated, instead of rounded, aperture. The umbilicus is closed in *angulata* while it is usually open in *wisconsinensis*. The globose form will, however, separate this race from all others. The umbilical chink is usually conspicuous but may be so wide as to form a deep umbilicus or it may be entirely closed, the last condition being rare. The shells from Arbor Vitae Lake vary somewhat from the Tomahawk Lake type of shell, having a longer spire, and aperture, the whorls on the whole not being as rotund as in typical *wisconsinensis*. They are all of the same general type, however, and found in the same drainage. A specimen is figured on plate XV, (fig. 25).

STAGNICOLA WALKERIANA F. C. Baker

Plate XVII, figures 1–11

Stagnicola walkeriana BAKER, Nautilus, XXXIX, p. 119, 1926.

TYPE LOCALITY: Madeline Island, near Bayfield, Wis.

WISCONSIN RECORDS:

1926a. *Stagnicola walkeriana* BAKER, p. 119. Madeline Island, Bayfield.

SHELL: Ovately globose, inflated, rather thin periostracum pale horn, darker in many specimens, sometimes tinged with purple; surface dull to shining, lines of growth coarse and close-set, spiral striation well marked; apex wine-colored; whorls 5, rapidly increasing in diameter, inflated, tumid, body whorl rather bulbous; spire short, broadly conic, rather wide; nuclear whorls 1½ in number, flattened, especially the first whorl which is very flat, sunken in the volution of the second whorl in the adult shell, and separated by a deep sutural channel; sutures impressed; aperture ovate or elliptical, sometimes rounded, occupying more than half the length of the shell, with brownish interior; outer lip convex, thin or thickened by a slight brown-edged varix; inner lip flattened, reflected over the parietal wall to form a rather thin callus and raised above the umbilicus, forming a broad, flat projection partly hiding the otherwise distinct umbilical chink; axis not much twisted, but the columella is slightly thickened and in many specimens the

inner lip is appressed so as to form a rather well-marked plait; the umbilical chink varies greatly in size; the surface of the shell is often malleated.

L. 17.0; D. 11.0; Ap. L. 10.5; D. 6.2 mm. Madeline Island (U. of W., 4695). Type.
L. 16.5; D. 11.0; Ap. L. 11.1; D. 6.0 mm. Madeline Island (U. of W., 4695). Paratype.
L. 16.2; D. 10.0; Ap. L. 10.0; D. 6.7 mm. Madeline Island (U. of W., 4695). Paratype.
L. 14.0; D. 9.1; Ap. L. 9.1; D. 6.0 mm. Madeline Island (U. of W., 4695). Paratype.
L. 14.6; D. 9.0; Ap. L. 9.0; D. 6.0 mm. Madeline Island (U. of W., 4695). Paratype.
L. 15.1; D. 9.5; Ap. L. 9.0; D. 5.2 mm. Madeline Island (U. of I., Z19437).
L. 11.0; D. 7.0; Ap. L. 7.0; D. 4.0 mm. Madeline Island (U. of I., Z19437).
L. 17.5; D. 11.1; Ap. L. 10.8; D. 6.9 mm. Sturgeon Bay (U. of W., 4696.)
L. 14.0; D. 9.0; Ap. L. 9.0; D. 5.3 mm. " "
L. 16.0; D. 9.0; Ap. L. 9.3; D. 5.0 mm. " "

ANIMAL: Similar to *catascopium.*

GENITALIA: Generally like *catascopium.* The prostate is very large, exceeding that organ in *catascopium.* Male organ retracted by two large, powerful muscles, that of the praeputium being especially wide. Anterior protractor muscles contained in one wide band; posterior protractors 2–4 in number, slender. Internal structure of male organ as in *catascopium.*

JAW (Fig. 109): Superior jaw wide and low, ends rounded; ventral margin straight with a small swelling at each end, the center forming either a straight line or a slight curve.

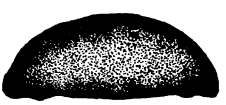


Fig. 109. Superior Jaw of *Stagnicola walkeriana.*

RADULA: Formula $\frac{20}{5-7}+\frac{4}{3-4}+\frac{11}{2}+\frac{1}{1}+\frac{11}{2}+\frac{4}{3-4}+\frac{20}{5-7}$ (35–1–35). The teeth are like those of *catascopium.* The above formula was very constant in the specimens examined. Only one membrane deviated from this, and in this radula the laterals were 15 in number, the formula being $\frac{16}{5-7}+\frac{4}{3-4}+\frac{15}{2}+\frac{1}{1}+\frac{15}{2}+\frac{4}{3-4}+\frac{16}{5-7}$ (35–1–35). The radula of *walkeriana* differs from both *catascopium* and *emarginata,* the former having 9 laterals and the

latter 10 laterals normally. All have the same number of teeth in a row (35–1–35).

ECOLOGY: The habitat of *walkeriana* in Lake Superior is on rocks or rocky ledges bordering the shore, usually not more than a meter below the surface. The habitats are usually on the protected side of islands and along the shore, the species not being generally found on shores facing the heavy surf of Lake Superior. Near Sturgeon Bay, however, the species lives on the rocky ledges of the open shore, fully exposed to the waves of Lake Michigan. These specimens, on the average, have a longer spire than the Lake Superior shells from Bayfield County.

DISTRIBUTION: Lakes Superior and Michigan.

DISTRIBUTION IN WISCONSIN: Known at present only from the northern and northeastern parts of the State.

Lake Superior: Apostle Islands and shore of Bayfield peninsula, Bayfield Co. (Baker).

Lake Michigan: Lake Michigan shore of Door Co., near Sturgeon Bay (Baker).

REMARKS: *Walkeriana* resembles both *catascopium* and *emarginata angulata.* It is comparatively wider than *catascopium,* is (usually) umbilicated, has a shorter, broader spire and more tumid whorls. The columella is quite different, being broader, erect, and lacking the plait and twist of that species. It may be known from *angulata* by its more regularly ovate shell, more pointed spire, more ovate and less rounded aperture, and less rotund body whorl. *Angulata* is also larger and heavier than *walkeriana.* It more closely resembles *emarginata ontariensis,* which, however, has a thicker shell of a different color and texture, a longer, more pointed spire with flat-sided whorls, a more compressed body whorl, and a differently shaped inner lip (see Baker, Mon. Lymn., p. 432).

A restudy of *binneyi, apacina,* and *solida* leads the writer to change completely the opinion given in the Monograph of the Lymnaeidae concerning these species. *Binneyi* is a river species, its type locality being the Hell Gate River, Montana, which is a tributary of the Columbia, the Pacific coast drainage. All authors have confused several species with the true *binneyi,* which should be restricted to river forms conforming to the diagnosis and figure of Tryon in the Journ. Conch., p. 229, pl. 23, fig. 3. This is different from the lake shells under consid-

eration, which all have a short spire and a differently shaped aperture. The two type specimens of *binneyi* in the Philadelphia Academy (58506) are like Tryon's description and are different from the shell of the Great Lakes. A good series of *binneyi* from the original locality is a desideratum.

The reference of certain Michigan lake shells to *apicina* by the writer in the Lymnaea monograph is also erroneous. They have only a superficial resemblance to the types of the western form (see Lymn. Mon. pl. xlviii, figs. 1, 2) and it is now believed that *apicina,* with *solida* as a synonym, should be restricted to the region west of the Rocky Mountains, the Pacific drainage. This is a river species and obviously would be different from a typical Great Lake species. A good series of *solida* from the original locality, the Willamette River, Oregon, should be studied, both as to shell and animal.

These lake forms previously referred to *binneyi* and *apicina* should apparently be separated from all other species of the lake region and they are accordingly recognized under the name of one of America's distinguished students of the Mollusca, Dr. Bryant Walker. *Walkeriana* was at first thought to be a variation of *Lymnaea nasoni,* described from Thunder Bay, Alpena, Mich., but the examination of a good series of this species from Alpena and Alcona counties conclusively shows that it is not this form, which is smaller, more solid, of a different color and texture, with a differently formed columella and spire. *Nasoni* is apparently related to *catascopium* while *walkeriana* recalls some forms of *emarginata.*

The reference of these lake shells to another species removes an apparent anomaly in the distribution of the west coast forms to which they have been referred and brings them more in accord with our present knowledge concerning the ecological distribution of species in lakes and rivers.

STAGNICOLA CATASCOPIUM (Say)

Plate X, figures 13–19; plate XVII, figures 21–30

Lymnea catascopium SAY, Nich. Encyc., Am. Ed., II, pl. 2, fig. 3, 1817 (no pagination); Amer. Conch., VI, pl. 55, fig. 2, 1834.

Limnaea cornea Val., in HUMBOLDT and BONPLAND, Rec. d'obs. de Zool., II, p. 251, 1832.

Limnaea sericata ZIEGLER, Rossmassler Icon., I, p. 98, 1837.

Lymnea pinguis SAY, Journ. Phil. Acad., V, p. 123, 1825.

Lymnaea linsleyi DE KAY, Moll. N. Y., p. 72, pl. 4, fig. 74, a, b, 1843.

Limnaea brownii TRYON, Amer. Journ. Conch., I, p. 229, pl. 23, fig. 15, 1865.

Limnaea intertexta CURRIER, Kent. Sci. Inst., Mis. Pub., No. 1, 1868.

Galba catascopium BAKER, Mon. Lymnaeidae, p. 380, pl. xxx, figs. 25–26; pl. xl, figs. 6–35; pl. lxi, figs. 1–4; pl. xlvii, fig. 10, 1911 (see this volume for extended bibliography of the species).

TYPE LOCALITY: *Catascopium* and *pinguis,* Delaware River, Philadelphia, Pa.; *brownii,* Elyria, Ohio; *linsleyi,* Stratford, Conn.; *cornea,* environs of Philadelphia; *intertexta,* outlet of Black Lake, Holland, Mich.

WISCONSIN RECORDS:

1860. *Limnaea catascopium* LAPHAM, p. 155. N. W. Territory.

SHELL: Varying from short-ovate to elongate-fusiform, thin to very thick and solid; periostracum light-horn to dark chestnut; surface dull to shining, in some specimens almost polished; lines of growth crowded, fine to coarse; spiral sculpture varying from faint to deeply incised, producing a wavy appearance, surface seldom malleated; nuclear whorls 1¼, small, well rounded, white or wine colored; whorls 5 to 6, well rounded, the body whorl typically very large and moderately convex; spire varying from short, depressed, dome-shaped to turreted, acutely conical or pyramidal; sutures impressed, in some specimens almost channeled; aperture ovate or long ovate, somewhat produced and effuse anteriorly, as long as, or longer than, the spire; peristome thickened within by a longitudinal varix edged with chestnut; inner lip narrow, reflected and appressed tightly to the columellar region, either completely closing the umbilicus or leaving a very small, narrow chink; columella with a heavy oblique plait causing the axis to be twisted; in specimens from some localities the shell is very solid and the inner lip and axis is covered by a heavy coating of white, shelly material. The parietal wall is covered by a more or less thickened callus.

L. 20.1; D. 11.0; Ap. L. 12.0; D. 6.0 mm. Say's type.

L. 21.3; D. 12.0; Ap. L. 12.1; D. 9.0 mm. Red Cedar River (U. of W., 4697).

L. 17.0; D. 10.5; Ap. L. 10.0; D. 6.0 mm. Red Cedar River (U. of W., 4697).

L. 16.0; D. 10.0; Ap. L. 10.0; D. 5.6 mm. Red Cedar River (U. of W., 4697).

L. 16.5; D. 10.0; Ap. L. 9.5; D. 5.1 mm. Red Cedar River (U. of W., 4697).

L. 14.5; D. 9.6; Ap. L. 9.5; D. 5.1 mm.	Red Cedar River (U. of W., 4697).
L. 19.2; D. 12.0; Ap. L. 12.0; D. 8.0 mm.	Prairie Lake (U. of W., 4699).
L. 18.0; D. 10.2; Ap. L. 10.0; D. 6.2 mm.	" "
L. 15.9; D. 9.0; Ap. L. 9.2; D. 5.5 mm.	" "
L. 16.0; D. 10.9; Ap. L. 10.1; D. 6.1 mm.	" "
L. 14.0; D. 9.0; Ap. L. 8.2; D. 5.0 mm.	" "

ANIMAL: Yellowish or blackish, covered with small whitish flecks; foot about as long as the aperture, wide, rounded behind; tentacles lighter colored at their tips.

GENITALIA (Fig. 110): Penis sheath almost as long as the praeputium, the latter being of much greater diameter; a long and thick retractor muscle attached to both penis sheath and praeputium, with a common insertion in the columellar muscle;

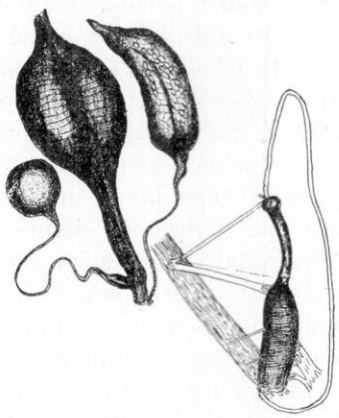


Fig. 110. Genitalia of *Stagnicola catascopium.*

protractor muscles of praeputium variable in number; prostate very large, flatly cylindrical, narrowing at the posterior end; the duct to the prostate is about half as long as the vas deferens, and enlarges slightly as it enters the prostate. Spermatheca large, globular, its ducts slender, a trifle longer than the prostate duct. The internal structure of the praeputium and penis sheath is the same as that of *emarginata;* the circular muscles in the praeputium were developed in one group of specimens and the longitudinal in another group. The genitalia are quite similar to those of *Lymnaea palustris elodes.*

The protractor muscles (fig. 111) vary considerable in number and position. The penis sheath retractor was uniform in

all specimens examined. The protractor muscles exhibited the greatest variation. The anterior protractor is made up of one very wide muscle, composed of from two to four branches which again subdivide as they enter the penis-sac. The posterior protractor muscles vary from one to four in number, and likewise vary in their relative positions, in some individuals being rather widely separated, and in others crowded together. In two examples there was but one anterior protractor.

JAW (Fig. 111): Superior jaw arched, very wide, low; ends acutely rounded; central lobe narrow, acute. In the worn jaw the ends are rounded and the central projection is wide and blunt.

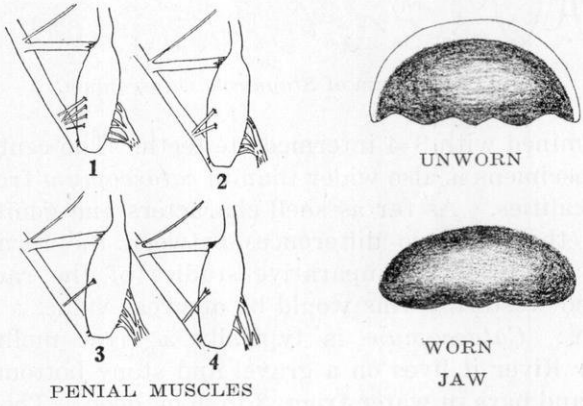


Fig. 111. Male Genitalia and Jaw of *Stagnicola catascopium.*

RADULA (Fig. 112): Formula $\frac{2\,2}{5-7}+\frac{4}{3-4}+\frac{9}{2}+\frac{1}{1}+\frac{9}{2}+\frac{4}{3-4}+\frac{2\,2}{5-7}$ (35–1–35). Central tooth with a rather long, acute cusp; lateral teeth rather narrow, bicuspid, the mesocone very large, spade-shaped, the ectocone small and rather wide; tenth to thirteenth teeth transitional, wide and tricuspid, the entocone splitting off from the mesocone, and gradually becoming larger; the thirteenth tooth is very wide, the entocone and mesocone are subequal and very acute; the true marginals begin at the fourteenth tooth which develops two to three small cusps on the entocone; outer marginals irregularly 4 to 5 cuspid, the cusps being confined to the distal end of the tooth on the extreme outer teeth; the marginal teeth have one or two small cusps

high up on the outer margin. The teeth are crowded on the membrane, fitting more closely than in *Stagnicola palustris elodes*. There are about 105 rows of teeth.

The radula of *catascopium* shows some variation in the number of lateral teeth. In specimens from New York and Michigan the normal number is 9. New York state specimens vary from 9 to 11. In one example there were 15 laterals on one side of the central tooth and 12 laterals on the other side. The Red Cedar River *catascopium* have the general formula 18–4–7–1–7–4–18 (29–1–29). There are but 7 laterals in all the spec-

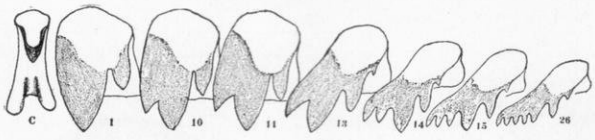


Fig. 112. Radula of *Stagnicola catascopium*.

imens examined with 3–4 intermediate teeth. The center tooth of these specimens is also wider than in *catascopium* from more eastern localities. As far as shell characters and genitalia are concerned there are no differences between the forms from these two localities. Comparative studies of the radulae of eastern and western forms would be of great value.

ECOLOGY: *Catascopium* is typically a river mollusk. In Red Cedar River it lives on a gravel and stony bottom and on gravelly sand bars in water from .3 to .6 m. deep. The current is rather rapid and the shells have developed apertures of good size to permit the foot to obtain a firm hold on the rocks. A rock a meter in diameter was often peppered with these snails. In Prairie and Chetek lakes the snails were found on either stony shores or on floating logs. The lake shells are developing a form with rather wider apertures, similar to the form in the Great Lakes herein described as *walkeriana*. This appears to be a direct response to a change from a river to a lake habitat, for Prairie Lake, and the associated bodies of water, were artificially made by damming the Chetek river, hence the original habitat for all of the lake forms was a river. Dead shells were dredged in Green Lake from a depth of 33.5 m. The animal is slow in motion. Observed breeding in July.

The original habitat in the Delaware River, near Philadelphia, is of special interest as it is in tide water, though not

saline. The Lymnaeas are subject to the ebb and flow of the tide in the same manner as the Littorinas, Purpuras and similar littoral forms. This ecological condition is interesting because of the fact that during regularly recurring periods the Lymnaeids are out of the water and are subject to the rays of the sun. It may be that the heavy shell (which is much thicker than in specimens living in quiet, uniform waters, as in the Genessee River at Rochester) serves as a protection against too much drying during these periods of ebb tide. The animals inhabit a wide strip of beach between low water mark and half tide, in company with *Physella ancillaria, Helisoma bicarinata* and *Goniobasis virginica.*

DISTRIBUTION: Eastern Canada and Nova Scotia west to North Dakota, Great Slave Lake south to northern Iowa, northern Ohio, and Maryland.

DISTRIBUTION IN WISCONSIN: For some reason the records of *catascopium* in Wisconsin are notably scarce, though widely distributed.

Chippewa Drainage: Red Cedar River and Prairie and Chetek lakes, Barron Co. (Baker); Chippewa Falls, Chippewa River, Chippewa Co. (Bullock).
St. Croix Drainage: Osceola, Polk Co. (E. E. Hand).
Fox Drainage: Green Lake, Green Lake Co. (Baker).
Rock Drainage: Lake Koshkonong, Jefferson Co. (Cahn).

REMARKS: *Catascopium* is frequently confounded with *palustris elodes* and *emarginata.* It differs from the latter in the manner in which the inner lip is appressed to the axis, and in having generally a narrower more fusiform shell and a more elongated aperture. *Emarginata* is typically umbilicated and the inner lip is widened out to form a broad expansion, quite different from the narrow inner lip of typical *catascopium.* It differs from *palustris elodes* in its shorter, wider and less acute spire, in having one whorl less and in having generally a wider, more fusiform shell and finer sculpture. The columellar plait is not generally as pronounced in *catascopium* as it is in *elodes. Catascopium* is, also, seldom malleated while *palustris* is frequently so marked. The more fusiform shape, wider shell, one less whorl and the less acute spire will serve to distinguish the majority of specimens of *catascopium* from *palustris.*

The *catascopium* of the Red Cedar River are quite similar in

form to those of the type locality in the Delaware River, though the shell is much thinner. Prairie and Chetek lake specimens have a larger aperture and spire, though there are many individuals which are quite typical. The shell on the whole is a little heavier than in the Red Cedar River form. The *catascopium* of the Chippewa River are rather heavy and the aperture is quite patulous and the spire is very short, in a way resembling the form called *pinguis* by Say (see pl. XVII, figs. 28–30). The specimens from the latter locality are quite uniform and are apparently very abundant. The variation of this species in other places is described in the Monograph of the Lymnaeidae, page 390.

STAGNICOLA WOODRUFFI (F. C. Baker)

Plate X, figures 1–5

Limnaea catascopium pinguis BAKER (non Say), Trans. Acad. Sci. St. Louis, XI, p. 5, pl. 1, fig. 12, 1901.

Limnaea woodruffi BAKER, Bull. Chi. Acad. Sci., II, p. 229, fig., 1901; Moll. Chi. Area, p. 264, pl. 31, fig. 8, 1902.

Galba woodruffi BAKER, Mon. Lymnaeidae, p. 398, pl. xlii, figs. 18–22, 1911.

TYPE LOCALITY: Lake Michigan, Oak Street, Chicago, Ill.

WISCONSIN RECORDS:

1906. *Limnaea catascopium* CHADWICK, pp. 22, 82. Milwaukee.
1906. *Limnaea catascopium var.* CHADWICK, pp. 22, 82. Milwaukee.

SHELL: Small, ventricose, inflated, rather solid; periostracum greenish-horn or olivaceous; surface shining, growth lines crowded, very distinct, crossed by fine impressed spiral lines; nuclear whorls roundly inflated, light or dark horn colored; whorls 4–4½, convex, tumid, the body whorl very large, occupying more than two-thirds the length of the shell; spire generally much depressed, globose; sutures well impressed; aperture very large, long-ovate to roundly ovate, broadly rounded below, angulated above, occupying about two-thirds the total length of the shell; it is sometimes shouldered; outer lip thickened within by a heavy longitudinal varix; inner lip rather wide, with parallel margins, spreading over the umbilicus which it slightly emargins and forming a wide, flattened expansion; an umbilical chink is usually present; the callus on the parietal wall is thick and heavy and is the same width as the inner lip; in some specimens the columellar is thickened in

the middle forming a distinct tubercle; a columella plait is not developed, but the axis, especially in the upper whorls, is distinctly twisted.

L. 11.8; D. 8.5; Ap. L. 8.5; D. 5.5 mm.	Type.
L. 12.0; D. 8.0; Ap. L. 8.5; D. 5.0 mm.	Kenosha (Baker coll., 794).
L. 12.5; D. 8.0; Ap. L. 8.0; D. 5.0 mm.	" "
L. 11.5; D. 7.5; Ap. L. 8.0; D. 5.0 mm.	" "
L. 9.5; D. 6.0; Ap. L. 6.6; D. 4.0 mm.	Millers, Ind. (Baker coll., 1720).
L. 8.5; D. 5.5; Ap. L. 6.0; D. 3.0 mm.	" "

ANIMAL: Similar to *catascopium,* color generally yellowish-white.

GENITALIA: Organs similar to those of *catascopium.* The spermatheca is perhaps a trifle more pear-shaped and the prostate wider below than in *catascopium.* The retractor muscle of the praeputium is very wide and strong; the penis sheath retractor is narrower and about as in *catascopium.* Protractor muscles vary as in *catascopium.* The internal structure of the praeputium and penis sheath is the same as in *catascopium.* The general color of all organs is whitish or yellowish white.

JAW: Superior jaw wide and low, in general resembling that of *catascopium* when worn, the center projection being very wide and broadly, flatly rounded (see fig. 111). In several examples examined all jaws were like this. Lateral jaws as in *palustris.*

RADULA: Formula $\frac{1\ 7}{5-7}+\frac{2}{3}+\frac{7}{2}+\frac{1}{1}+\frac{7}{2}+\frac{2}{3}+\frac{1\ 7}{5-7}$ (26–1–26). General tooth shorter and wider than in *catascopium,* the lower part very wide. Laterals seven in number; 8th–9th teeth intermediate, tricuspid; marginals as in *catascopium. Woodruffi* resembles *catascopium* in general, differing in the wider form of the central tooth, and usually in the smaller number of laterals as well as of intermediate teeth and in the lesser number of marginal teeth. *Catascopium* from Red Cedar River has the same number of laterals—7.

ECOLOGY: *Woodruffi* is known only from the shore of Lake Michigan. What its exact habitat may be is not yet definitely known. Until 1916 no living specimens had been collected. During July of that year the late Mr. L. E. Daniels found many specimens on the shore at Millers, Ind., containing the living animal. They have not yet been seen actually living on the shore. It is probable that they live on the numerous sand bars which border the shore of Lake Michigan, possibly at some dis-

tance from the shore and the dead shells are washed in by storms and high seas.

DISTRIBUTION: At present known only from the states bordering Lake Michigan—Michigan, Indiana, Illinois, and Wisconsin.

DISTRIBUTION IN WISCONSIN: Known from Milwaukee south to Illinois on the Lake Michigan shore.*

Milwaukee, Milwaukee Co. (Chadwick); Kenosha, Kenosha Co. (Wiswall).

REMARKS: *Woodruffi* may be known by its very short, broad spire, rapidly increasing and tumid whorls, its large, ovate or roundly ovate aperture and its broad, flat inner lip without a plait. It resembles *emarginata* in the form of its emarginate inner lip and *catascopium* in the general depressed form of the shell. The small size, large aperture and peculiar inner lip will distinguish *woodruffi* from both of these species. It somewhat resembles *walkeriana* but differs in the depressed spire and broad, flat inner lip, without a plait. The shells vary somewhat in rotundity, some specimens being a trifle flattened on the body whorl and having the spire somewhat elevated. There is some variation in the degree of umbilication which may be marked or absent. The aperture may also be roundly ovate, oblong-ovate or elliptical. With all this variation, however, the species seems quite distinct and is very uniform in its specific features. Young shells are quite thin, but adult specimens are very thick and solid and show a tendency to become imperforate as well as to acquire a tubercle or swelling on the middle of the columella.

Since its discovery in 1901, the species has been collected in large numbers all along the southern shores of Lake Michigan from Milwaukee, Wis., to Michigan City, Indiana. This abundance of material is ample evidence that the species is living in goodly numbers somewhere in the deep water of the southern part of Lake Michigan. After a northerly storm the beaches along the lake are strewn with the dead shells of *woodruffi*. This is especially true at Millers, Indiana, where the

* The record from Lake Geneva cited in the Mon. Lymn., p. 399 is no doubt erroneous, as no species like *woodruffi* have been seen from any of the small lakes in southeastern Wisconsin. As suggested in the work cited, the record is probably a case of mixed labels.

beach is very wide and evenly sloping, and in the line of beach debris, this Lymnaea may be found by thousands.

Woodruffi is separable from *catascopium* by its distinct shell characters. The radula differs from the eastern specimens of *catascopium* examined but is almost the same as specimens from Red Cedar River, each having seven laterals, while eastern *catascopium* has not less than nine laterals, and may have as many as eleven. *Woodruffi* is a lake form, possibly an offshoot of *catascopium* which has become adapted to a lake environment. That it has developed to the species point is shown by the absence of any intermediate forms between typical *woodruffi* and *catascopium.* It appears to be confined to the southern part of Lake Michigan, for the Lymnaea of the lake shore found in the Green Bay region and farther north is of another species.

Subgenus HINKLEYIA Nov. Subgen.

Shell small, outer lip with small internal callus, inner lip appressed to the columellar region, forming a smooth triangular expansion over the umbilicus, which is normally wide and deep; axis not twisted and without a plait; sculpture of spiral lines in which the periostracum is impressed giving the shell a somewhat hirsute appearance.

RADULA: With bicuspid laterals.

GENITALIA: Penis sheath two-thirds length of praeputium; penis short and thick with a constriction in the middle; prostate more ovate and not as much elongated as in *Stagnicola;* oviduct much more globose than in *Stagnicola;* spermatheca globular.

TYPE: *Lymnaeus caperatus* Say.

DISTRIBUTION: Holarctic portions of America.

This widely distributed American Lymnaeid differs sufficiently from all of the other species to be included in a group especially made for it. The periostracum is peculiar in being impressed within the spiral lines, giving a somewhat hirsute appearance to fresh specimens. The smooth columella without plait allies the group with *Nasonia,* in which it was previously placed, but in that group the surface sculpture is without distinct spiral lines, in most cases, smooth. The habitat of *caperata* is almost always in small pools which become dry in

summer, in this respect resembling certain species of *Stagnicola* and also many forms of *Nasonia.*

The group is dedicated to the late Mr. Anson A. Hinkley of Du Bois, Illinois, who spent many years in a study of the Mollusca of Illinois and other parts of North, Central, and South America. His collection is now in the museum of the University of Illinois.

STAGNICOLA CAPERATA (Say)

Plate XVIII, figures 43–47

Lymneus caperatus SAY, New Harmony Dis., p. 230, 1829.
Galba caperata BAKER, Mon. Lymnaidae, p. 225, pl. xxviii, figs. 20–33; pl. xxix, figs. 1–3, 1911 (see this work for full synonymy).
Lymnaea smithsoniana LEA, Proc. Phil. Acad., p. 113, 1864; Journ. Phil. Acad., VI, p. 161, pl. 24, fig. 76, 1866.
Limnaea ferrissi BAKER, Moll. Chi. Area, p. 277, pl. 31, fig. 26, 1902.
Lymnaea umbilicata Authors, non Adams.

TYPE LOCALITY: *Caperata,* Indiana; *smithsoniana,* Loup Fork of the Platte River; *ferrissi,* Joliet, Ill.

WISCONSIN RECORDS:

1860. *Limnaea caperata* LAPHAM, p. 155. Milwaukee.
1865a. *Limnaea caperata* BINNEY, p. 56. Milwaukee.
1897. *Limnaea caperata* WISWALL, p. 48. Southern Wisconsin.
1906. *Limnaea caperata* CHADWICK, pp. 22, 82. Vicinity of Milwaukee; Lake Winnebago.
1906. *Limnaea caperata umbilicata* CHADWICK, pp. 22, 82. Milwaukee and southward; Sand Ridge Creek, Kenosha.
1924. *Lymnaea caperata* BAKER, p. 136. Pools near Oshkosh on shores of Lakes Winnebago and Butte des Morts.

SHELL: Ovately-elongated, turreted, rather solid; color yellowish horn to brown, sometimes black; surface dull to shining; lines of growth very fine, crowded, irregular; shell encircled by numerous equidistant, heavily impressed spiral lines which give the shell a rather latticed or wavy appearance; these spiral lines appear at first to be elevated, this effect being caused by the epidermis standing erect in the otherwise impressed spiral lines; this epidermis may be scraped or brushed off, after which the surface resembles the other Lymnaeas with spiral lines; whorls 6–6½, very convex; spire acutely conic, generally longer than the aperture; nucleus consisting of one and a third whorls, in outline resembling the nucleus of *Stagnicola bulimoides techella* (see Lymn. Mon.), sculpture of satin finish and color generally deep wine or

brown; sutures very heavily impressed; aperture ovate, its terminations more or less rounded, frequently reddish or purplish within; peristome thin, sharp, thickened by an internal rib, which is edged with dark purple; inner lip reflected over the umbilicus to form a wide, smooth, triangular expansion, without a columellar plait; parietal callus very thin; axis thickened but not twisted; umbilical chink open, generally rather wide and deep. The surface of the shell is frequently marked by two, three or more rest periods, showing as heavy yellowish longitudinal bands; the spiral lines are so heavy that they may be plainly seen on the inner whorls of the shell when broken open.

L. 12.0; D. 5.0; Ap. L. 5.0; D. 3.0 mm.	Say's specimen.
L. 11.5; D. 6.2; Ap. L. 5.5; D. 3.0 mm.	Type smithsoniana.
L. 13.0; D. 6.2; Ap. L. 6.2; D. 3.2 mm.	Near Oshkosh (U. of W., 4701).
L. 12.0; D. 6.1; Ap. L. 5.2; D. 3.0 mm.	" "
L. 11.2; D. 5.2; Ap. L. 5.0; D. 2.5 mm.	" "
L. 9.0; D. 5.0; Ap. L. 4.5; D. 2.3 mm.	" "
L. 9.7; D. 5.0; Ap. L. 4.2; D. 2.2 mm.	" "

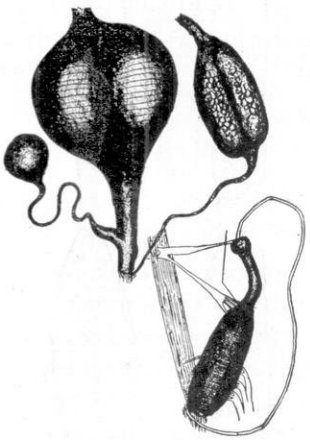


Fig. 113. Genitalia of *Stagnicola caperata.*

ANIMAL: Black or bluish black, lighter below and minutely flecked with small, whitish dots, which are scarcely visible except on the top of the head; head distinct; tentacles short, flat, triangular; foot short and wide, 8 mill. long and 3 mill. wide. The animal is very rapid and decisive in its movements.

GENITALIA (Fig. 113): Penis sheath about two-thirds as long as praeptium, the latter large and cylindrical; prostate

large, ovately cylindrical, rounded at both ends; retractors large and strong, that of the penis sheath enlarged at its attachment to the columella muscle, that of the praeputium enlarged at its attachment to the praeputium; anterior protractor muscles of praeputium wide, thick, with three insertions in the praeputium; posterior protractors one or two, very narrow and fine. The spermatheca is small, rounded, with a long duct; oviduct (oviducal bulb or uterus) very large, somewhat bulbous, the lower narrow portion very short. There is very little variation in the genitalia of *caperata.*

Internally the praeputium and penis sheath are similar to the larger Lymnaeas. The walls of the praeputium are thick and there are both vertical and spiral muscles. The walls are much thickened at the junction of penis sheath and praeputium. The penis is short and thick, symmetrical, rather bulbous at the upper, proximal part, tapering to a blunt point at the distal end. The penial aperture is at the center of the distal end. There is no thickened ring at the upper part of the penis of *caperata* as in the larger Lymnaeas (fig. 114).

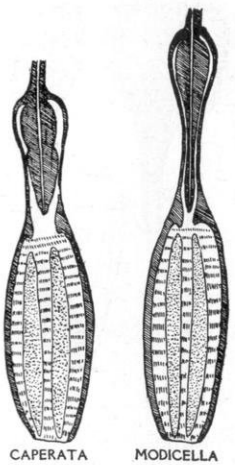


Fig. 114. Sections of Male Organ of Lymnaeidae.

JAW (Fig. 115): Wide and rather high, the median swelling occupying about one-third of the width; ends rather bluntly rounded.

RADULA (Fig. 116): Formula: $\frac{20}{5-7}+\frac{4}{3-4}+\frac{8}{2}+\frac{1}{1}+\frac{8}{2}+\frac{4}{3-4}+\frac{20}{5-7}$ (32–1–32); central tooth with a rather broad, spade-shaped

cusp; lateral teeth bicuspid, the mesocone very broad, the ectocone very small and placed rather high; intermediate teeth tricuspid, the entocone of the ninth, tenth and eleventh teeth very small and acute, placed high on the mesocone, which is smaller than in the lateral teeth; the twelfth tooth is very much modified, with the three cusps about equal in size; marginal teeth claw-like, the entocone split to form from three to four small cusps, the mesocone and ectocone reduced in size and a small cusp appearing prominently above the ectocone. There are over eighty-five rows of teeth.

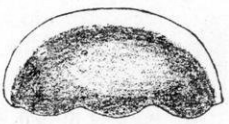


Fig. 115. Jaw of *Stagnicola caperata.*

ECOLOGY: In the Mississippi Valley this species seems to almost invariably occupy intermittent streams or small pools, ponds and ditches which dry up in the summer. In Illinois it is usually found in association with *Aplexa hypnorum* and *Sphaerium occidentale,* either in small streams, pools or sloughs, or in spring pools in the woods which become completely dry in late spring and summer. The species hibernates to a greater degree than any of the other Lymnaeas, a fact attested by the many rest varices observed on the shell of large individuals. In these dry ponds living specimens may frequently be found by digging into the mud, leaves and other debris. In Wisconsin, *caperata* has been found almost invariably in small woodland pools which become dry in summer and fall, or in small streams which become wholly or partially dry.

DISTRIBUTION: From Quebec and Massachusetts west to California; Yukon Territory and James Bay south to Maryland, Indiana, Colorado and California.

DISTRIBUTION IN WISCONSIN: The records show that *caperata* is confined to the eastern part of the State; but this is doubtless due entirely to lack of records, for the species should be universally distributed throughout the State. It is at present known from the drainages of the Fox, Wisconsin, Rock rivers, and Lake Michigan.

REMARKS: Although the statement has been made that *caperata* may prove a heterogenous assemblage of different

forms, it is nevertheless true that it is one of the most distinct and uniform of American Lymnaeas. The striking manner in which the epidermis stands erect in the impressed spiral lines is peculiar to this species and will always distinguish it when the specimens are fresh. Some small specimens resemble individuals of *humilis,* and have been thus reported by various collectors. *Caperata* is one of the commonest of American Lymnaeas and is found over a very wide stretch of country. It varies somewhat in the length of the spire and in the rotundity of the whorls, but this variation is not marked or uni-

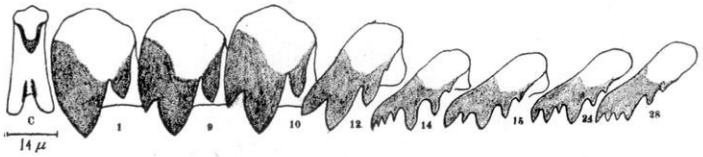


Fig. 116. Radula of *Stagnicola caperata.*

form. Specimens from Iowa, Illinois and Indiana are very large and robust. Many specimens are quite scalar and the color variation is wide. The shell is sometimes quite thin, though generally very solid.

Half-grown specimens with short spire have been identified as *umbilicata* by many students and have been so reported from various parts of the country. A study of Adams' specimen of *umbilicata* has shown, however, that these authors were in error, Adams' specimens being quite a different species.

Subgenus NASONIA Nov. Subgen.

Galba BAKER (non Schrank), Mon. Lymn., p. 200, 1911. Type: *Limnaea cubensis* PFR.

SHELL: Small, turreted, surface without distinct spiral lines, axis not twisted, forming a series of smooth, almost round pillars from apex to umbilicus; inner lip usually forming a wide, smooth, spreading callus which is turned back against the parietal wall; umbilicus a small chink or round opening; outer lip thin, sharp, rarely forming, when adult, an internal callus within the edge (pl. XI, fig. 1).

RADULA: As in the genus.

GENITALIA: Penis sheath shorter than praeputium; prostate relatively short, ovate, rounded at both ends; spermatheca ovate; oviduct ovate or pyriform.

DISTRIBUTION: West Indies and Central America north to the United States (Georgia, Kansas, Colorado, Washington) and British Columbia (Vancouver Island).

This subgenus includes the small Lymnaeas which have a shell without spiral sculpture and a peculiarly flattened inner lip. They exhibit terrestrial habits to a much larger degree than any other group of Lymnaeas, being found usually on wet banks or bars of mud, quite out of the water. The smooth shell, simple axis, wide inner lip, and absence of lip callus distinguish this southern group from all other members of the genus *Stagnicola.* It was placed in the genus *Galba (Fossaria)* in the Lymnaeidae monograph, but that group has tricuspid lateral teeth, while the present group has bicuspid lateral teeth. None of the species has as yet been found in Wisconsin, which is probably not included in their distribution.

The name of the group is in honor of Dr. William A. Nason (deceased), a pioneer naturalist and conchological student of Illinois, a contemporary of William Stimpson and Robert Kennicott. Dr. Nason's collection is in the museum of the University of Illinois.

Genus ACELLA Haldeman, 1841

Acella HALDEMAN, Mon. Limn., pt. 3, p. 6, July, 1841. Type: *Lymnaea gracilis* JAY (=*haldemani* 'Desh.' Binney).

Shell thin, acute, with slender spire; outer lip slightly expanded at the margin, simple, axis gyrate; columella not plicate; sculpture of growth lines only (pl. XI, fig. 8).

JAW: Very high, with a strong, prominent median swelling.

RADULA: With bicuspid lateral teeth, the mesocones of which are strongly modified by a large swelling on the inner side, corresponding in position to an entocone. Intermediate teeth strongly tricuspid.

GENITALIA: Penis sheath almost as long as praeputium, the latter with a large, dependent sarcobelum; prostate large, flatly cylindrical, rounded at both ends; penis short, rather thick, with an ovate swelling near the distal end; retractor muscle split into several branches as it enters the praeputium.

DISTRIBUTION: Nearctic; recent fauna only.

Acella differs generically from all other Lymnaeidae in its shell, all the whorls of which are very long in proportion to their

width, even the nuclear whorls, a condition not shared by any other American Lymnaeas (see fig. 117). The prostate differs in being long and regularly cylindrical. The radula is the most peculiar of any Lymnaeid yet examined, the mesocone of the lateral teeth having a very decided swelling on the inner side, which is probably a modified entocone. The ninth tooth (transition) is distinctly tricuspid, while the tenth tooth is a typical marginal, the transition being very abrupt.

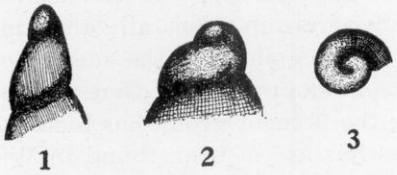


Fig. 117. Nuclear Whorls of Lymnaeids. 1, *Acella;* 2, *Stagnicola palustris;* 3, *Lymnaea stagnalis jugularis.*

The only radula of Lymnaea known which is at all comparable with this species is *Lymnaea hawaiensis* Pilsbry, described from Hawaii, in which the laterals are modified in much the same manner. This species is very small and of a wholly different character and should probably be made the type of a distinct group of Lymnaeas. The combination of the characters of the shell, radula and genitalia gives to this species a higher rank than a subgenus or section and entitles it to full generic consideration.

Annandale and Rao (1925, p. 144) suggest that certain fossil Indian species are referable to this genus. This is extremely doubtful; no living species have the peculiar radula excepting as mentioned above. Narrow shells occur in *Stagnicola,* to which the Indian fossils possibly belong.

ACELLA HALDEMANI ("Deshayes" Binney)

Plate X, figures 6–8

Lymnaea gracilis JAY, Cat., Ed. 3, p. 112, pl. i, figs. 10, 11, 1839 (non Ziethen, 1830); BINNEY, Op. Cit., p. 69, fig. 114, 1865.

Limnea gracilis, HALD., Mon., p. 50, pl. 13, fig. 21, 1842; Binney, L. & F–W. Sh. N. A., II, p. 69, fig. 113, 1865.

Limnaea haldemani DESHAYES, BINNEY, Journ. de Conch., VII, No. 4, Oct., 1867.

Acella haldemani BAKER, Mon. Lymnaeidae, p. 192, pl. xviii, fig. 1; pl. xxvi, figs. 1–4, 1911.

TYPE LOCALITY: Lake Champlain.

WISCONSIN RECORDS:

1860. *Limnaea gracilis* LAPHAM. Milwaukee.
1911c. *Acella haldemani* BAKER, p. 196. Milwaukee.

SHELL: Very slender, thin and fragile; color of periostracum yellowish-white; surface generally dull, growth lines closely set, fine; no spiral sculpture; nucleus consisting of about one whorl which is long oval in outline and resembles the end of a bullet; when turned to one side the outline of the nuclear and post nuclear whorls resembles a liberty cap (see fig. 117); whorls 5½, very oblique and flat-sided; spire very slender and acute, much longer than the aperture; sutures heavily impressed, bordered by a narrow band indicating the position of

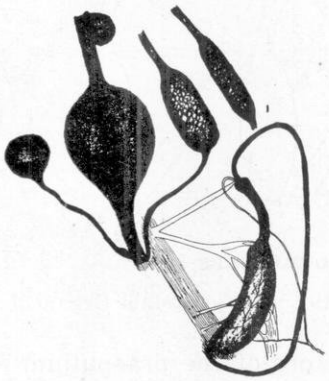


Fig. 118. Genitalia of *Acella haldemani.*

the previous connected lips; aperture long-ovate, elongated and narrowed, made continuous by the raised inner lip; peristome thin, acute, inner lip elevated in some specimens and causing the aperture to be continuous; in other individuals it is attached but not appressed to the parietal wall; the aperture is also twisted to the left and narrowed at its junction with the body whorl; axis gyrate; there is a small umbilical chink; there is no plait on the columella, which is almost straight.

L. 25.1; D. 5.0; Ap. L. 10.5; D. 3.0 mm. Oneida Lake (Baker coll., 431).
L. 24.0; D. 4.5; Ap. L. 9.5; D. 2.6 mm. " "
L. 24.6; D. 4.2; Ap. L. 9.5; D. 2.2 mm. " "

ANIMAL: In color yellowish, flecked with fine white dots, which become larger on sides of body and edge of mantle; un-

der side of foot bordered by a dark margin; tentacles small; foot broadly long-ovate and shorter than aperture; the relation of foot to shell and aperture is as follows: shell, 22.5 mm.; aperture 11 mm.; foot 7 mm.; the shell and animal are in life almost transparent, the organs showing plainly through the shell, especially those of the digestive system.

GENITALIA (Fig. 118): Praeputium large, cylindrical, penis sheath slender, about two-thirds as long as the praeputium, enlarged at the distal end; prostate flatly cylindrical the ends broadly rounded; protractor muscle of penis sheath long, rather thick and wide, entering the columellar muscle at the tions (fig. 119, 1, 3); the retractors of penis sheath and prae-

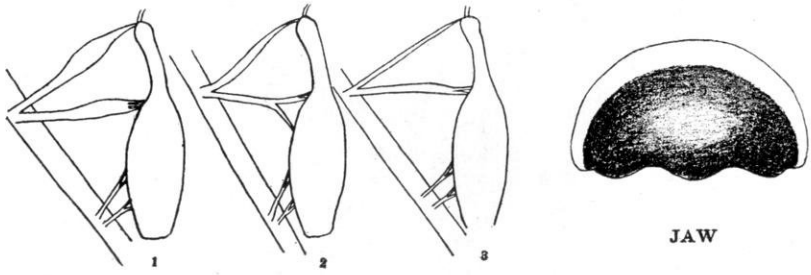


Fig. 119. Jaw and Male Organ of *Acella.*

putium; the retractors of the praeputium exhibit some variation in their method of insertion in this organ; in two specimens the muscle was split to form four rather widely separated insertions (fig. 119, 2) while in all other specimens examined there was a single band of muscle with two small insertions (fig. 119, 1, 3); the retractors of penis sheath and praeputium may be joined as they enter the columellar muscle and form a single band at this point; protractor muscles usually four in number, two anterior and two posterior; the anterior muscle may be single and very wide with several attachments. The oviduct (uterus) is regularly pear-shaped and the spermatheca globular and of small size.

Internally the male organ has a conspicuous sarcobelum which hangs below in the cavity of the praeputium; the walls of the praeputium are thick, those of the penis sheath are thin; the longitudinal muscles of the wall of the praeputium

are heavy and conspicuous; the penis is much elongated and swollen near the termination (fig. 120).

JAW: Superior jaw about twice as wide as high with squarish ends and a heavy convex median swelling (fig. 119).

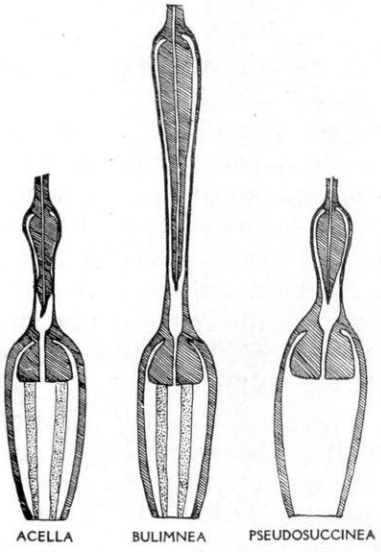


Fig. 120. Sections of Male Organs of Lymnaeids.

RADULA (Fig. 121): Formula: $\frac{1\,2}{6-8}+\frac{1}{3}+\frac{8}{2}+\frac{1}{1}+\frac{8}{2}+\frac{1}{3}+\frac{1\,2}{6-8}$ (21–1–21). Central tooth with a sharp, spade-shaped cusp, the opaque portion of the reflection strongly trilobate; lateral teeth eight in number, bicuspid, the mesocone very broad and modified on the inner side by a strong swelling which probably corresponds in position to an entocone; ectocone small, broad,

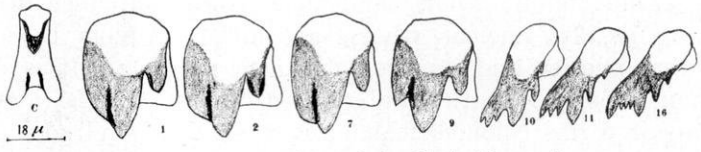


Fig. 121. Radula of *Acella haldemani.*

placed rather high up on the reflection; the seventh and eighth teeth are narrower than those preceding; the ninth tooth is intermediate and is strongly tricuspid, the entocone being very sharp, wide, and placed rather high upon the inner side of the

tooth; marginal teeth beginning abruptly with the tenth tooth and six to eight cuspid, acquired by splitting of the ectocone placed high on the outer margin of the tooth; the mesocone persists throughout the marginal teeth as a rather large cusp, while the entocone splits up into several small denticles. The first lateral on one side in one membrane had a double cuspid ectocone. There are about 80 rows of teeth.

ECOLOGY: *Haldemani,* is an inhabitant of the larger lakes, in more or less sheltered bays, always a protected habitat, in water from .3 to over 1 m. deep. Adult specimens only have been found in the fall; apparently it comes toward shore in the colder part of fall, in October and November. Young specimens have been found in July on the narrow leaves of the pondweed, *Potamogeton interruptus,* the flat leaves forming admirable habitats for the long shells of the *Acella* (Baker, 1918b, p. 178). Adults are usually found on the stem of the bulrush, *Scirpus.* For a resume of the known facts of the ecology of this species see Baker, 1911c, p. 197.

DISTRIBUTION: Vermont and eastern Ontario west to Northern Minnesota, south to Northern Illinois and Ohio.

DISTRIBUTION IN WISCONSIN: *Acella haldemani* is apparently rare in Wisconsin. Only one record is known, that of Lapham, who quotes if from Milwaukee. No later records are available, the writer not finding it at any of the places visited. It is known from eastern Minnesota and there is one record from northern Illinois (Cedar Lake, Lake Co.) which is authentic. While it is doubtless rare it is very possible that it will be rediscovered in some of the Wisconsin Lakes.

REMARKS: *Acella haldemani* is the slenderest of the Lymnaeas, its height being five times its breadth. It is also very thin and fragile. It cannot be mistaken for any other species, its graceful, oblique whorls and slender form at once distinguishing it. Its nuclear whorls are different from those of any other species and its radula is also peculiar. It is very common in some localities and rare in others. In its favorite habitats it forms colonies which cover several hundred yards, but the species is rarely found at any great distance from this colony location.

Genus PSEUDOSUCCINEA F. C. Baker, 1908

BAKER, Science, n. s., XXVII, p. 943, June, 1908; Mon. Lymnaeidae, p. 162, 1911. Type: *Lymnaea columella* SAY.

SHELL: Of medium size, succiniform; spire generally short and somewhat dome-shaped; last whorl very large, expanded; axis gyrate and imperforate; columellar plait not well marked; outer lip sharp (plate XI, figure 3).

JAW: Wide and low, with a bluntly rounded median projection.

RADULA: With tricuspid lateral teeth; marginals serrated.

GENITALIA: Penis sheath thick, less than half the length of the praeputium, penis simple, praeputium with large sarcobelum (fig. 120); protractor muscle of penis sheath normally inserted in posterior retractor of praeputium, the latter with two retractors; prostate long, narrowly cylindrical, with a slight rounded enlargement at the proximal end; spermatheca globular; oviduct large, almost round.

DISTRIBUTION: North, Middle and South America. Principally south of Canada and east of the great plains.

The Succinea-like shells of *Lymnaea columella* have been usually placed in *Radix* on account of the large, somewhat flaring aperture. Dr. Dall, in his Alaska Mollusca, has expressed the opinion that it belongs to *Stagnicola*. A study of the anatomy shows that it differs markedly from *Stagnicola* in its genitalia and in its radula. The peculiar shape and small size of the prostate, the number and position of the retractor muscles of the male organ and the Succinea-like form of the shell are characters sufficient to separate this group from the other subdivisions of the family. Several of the species have been described under the genus *Succinea*. The reference by Annandola and Rao (1925, p. 171) of certain Indian species to this genus is doubtful, although the figures of *acuminata* on p. 156 have a Succinea-like form and the lateral teeth are tricuspid. The genitalia, however, are different. *Pseudosuccinea* is believed to be exclusively an American genus. The Indian species may represent another group.

PSEUDOSUCCINEA COLUMELLA (Say)

Plate X, figures 9–12, 20

Lymnaea columella SAY, Journ. Phil. Acad., I, p. 14, 1817; Binney, L. & F–W., Sh. N. A., II, p. 33, fig. 38, 1865.

Pseudosuccinea columella BAKER, Mon. Lymnaeidae, p. 163, pl. xxiii, figs. 8–20; pl. xxiv, figs. 1–4, 1911.

Lymnea columellaris C. B. ADAMS, Amer. Journ. Sci., XXXVI, p. 392, 1839 (absq. descr.)

Limnaea navicula VAL., Rec. Obs., II, p. 251, 1833.

Limnea succiniformis ADAMS, teste Haldeman, Mon., p. 40, 1842.

Succinea pellucida LEA, Proc. Phil. Acad., p. 109, 1864; Journ. Phil. Acad., VI, p. 178, pl. 24, fig. 106, 1866; Binney, Op. Cit., I, p. 271, fig. 488, 1869.

Succinea wilsoni LEA, Proc. Phil. Acad., p. 109, 1864; Journ. of same, VI, pp. 177, 179, pl. 24, fig. 105, 1866; Binney, Op. Cit., I, p. 260, fig. 464, 1869.

Lymnaeus macrostomus SAY, Journ. Phil. Acad., II, p. 170, 1821; Binney, Op. Cit., II, p. 34, fig. 39, 1865.

Limnaea acuminata C. B. ADAMS, Amer. Journ. Sci., XXXIX, p. 374, 1870.

TYPE LOCALITY: *Columella,* type locality not mentioned by Say, probably near Philadelphia; *macrostomus,* Cayuga Lake, N. Y.; *acuminata,* New Bedford, Mass.; *navicula,* Philadelphia, Pa.; *Succinea wilsoni,* Darien, Ga.; *Succinea pellucida,* type locality not given.

WISCONSIN RECORDS:

1860. *Limnea columella* LAPHAM, p. 155. Milwaukee.

1906. *Limnaea columella* CHADWICK, pp. 22, 81. Mill pond at Delafield, Waukesha Co.

1911c. *Pseudosuccinea columella* BAKER, p. 239. Tomahawk Lake.

SHELL: Ovate, somewhat pointed, thin, fragile, transparent; color light greenish or yellowish horn; surface shining, covered with rather coarse growth lines, and encircled by heavily impressed spiral lines; whorls four, well rounded, rapidly enlarging, the last one three times the size of the rest of the shell; spire sharply conic, rather short; apex small, very dark brown; sutures tightly appressed; a ridge is frequently formed at the suture where the lines of growth meet the whorl above; aperture ovate, dilated, expanded at the lower part; peristome thin, acute; inner lip closely appressed to the body whorl and reflected over the umbilicus, either completely closing the latter or leaving a small, narrow chink; axis slightly twisted; the columellar region is so narrow and so peculiarly

arched that a view may be taken from the base nearly to the apex, as in *Succinea retusa;* this is especially noticeable in the wide shells called *macrostoma.* The nuclear whorls do not differ in outline from those of *Lymnaea stagnalis.* The nucleus consists of about 1¼ smooth whorls. The growth lines are very heavy at the beginning of the post nuclear shell.

L. 21.5; D. 12.0; Ap. L. 14.0; D. 7.0 mm.	Type *columella.*
L. 19.0; D. 10.2; Ap. L. 13.0; D. 8.0 mm.	Clinton, Ohio (Baker coll., 407).
L. 17.2; D. 8.0; Ap. L. 12.1; D. 6.1 mm.	" "
L. 17.5; D. 9.0; Ap. L. 12.6; D. 7.0 mm.	" "
L. 14.5; D. 7.0; Ap. L. 9.0; D. 5.1 mm.	" "
L. 12.0; D. 5.5; Ap. L. 7.9; D. 4.0 mm.	" "

ANIMAL: Almost transparent, with a short, wide foot, bluntly rounded behind; head separated from foot by a constriction; tentacles short, thick, triangular, quite transparent; color of body dirty white, darker on the body, which is covered

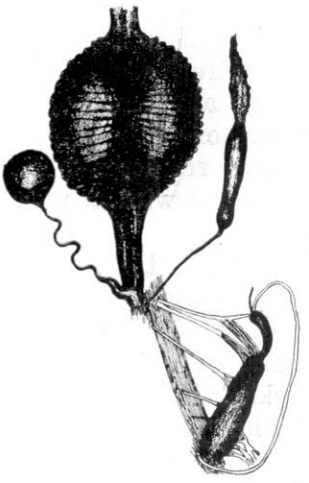


Fig. 122. Genitalia of *Pseudosuccinea columella.*

with white spots, seen through the transparent shell; edge of mantle transparent; head above lilac-tinted, the head is not much in advance of the edge of the shell when the animal is in motion. Like *Succinea,* the animal appears to be too large for the shell.

GENITALIA (Fig. 122): Praeputium large, cylindrical; penis sheath short, less than half the length of the praeputium;

prostate long, narrow, cylindrical, proximal portion globular, with a slight constriction behind, where it again enlarges to form the cylindrical portion; this becomes narrower and forms a ribbon-like body which connects with the spermoviduct; protractor muscles of the praeputium always five in number, two posterior and three anterior; retractor muscles three in number (generally uniform), inserted in the columellar muscle; the retractor of the penis sheath is inserted in the posterior retractor of the praeputium, generally near its insertion in the columellar muscle; in several examples short muscles connected the penis sheath with the praeputium.

The retractor muscles of the penial system exhibit some variation (see fig. 123), especially in the location of the insertion of the penis sheath retractor in the posterior praeputium retractor, which location may be near the penis sheath (4) or near the columellar muscle (1). In one case (2) the termination of the anterior retractor was inserted in the posterior retractor near its junction with the praeputium. In another individual (3) the posterior retractor was entirely separated from the anterior, the retractor of the penis sheath being inserted at both ends; in another specimen the retractor of the penis sheath was entirely separated from the posterior retractor of the praeputium, with many fine muscles connecting with the praeputium (see fig. 122).

The vagina is very short and the lower portion of the oviduct very wide; spermatheca small, rather globular, its duct very long and narrow, inserted near the external opening of the vagina; the oviducal bulb (uterus) is very large, almost globular, and much wrinkled; in life the organs are usually yellowish or whitish, with the spermatheca bright orange color.

The characteristic features of the genitalia of *columella* are the cylindrical form of the prostate, the large, globular uterus, the comparatively small size of the spermatheca, the large size of the praeputium and the size, number, and peculiar insertions of the retractor muscles.

The internal structure of the male organ is like that of *Acella* in the presence of a large, dependent sarcobelum in the praeputium; the latter has thick walls while the penis sheath has thin walls. The penis is short, wide, elongate pyriform, without constriction of any kind, and with the canal centrally located (fig. 120).

JAW (Fig. 123): Superior jaw wide and low, arched, about three times as wide as high; lower margin with a wide, bluntly rounded median projection.

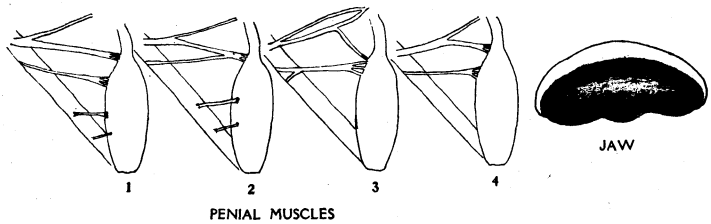


Fig. 123. Jaw and Male Organ of *Pseudosuccinea columella.*

RADULA (Fig. 124): Formula: $\frac{2\,3}{5+}+\frac{2}{4}+\frac{1\,0}{3}+\frac{1}{1}+\frac{1\,0}{3}+\frac{2}{4}+\frac{2\,3}{5+}$ (35–1–35); central tooth with a wide reflection, the cutting point broadly spade-shaped; lateral teeth with a quadrate base of attachment; reflection rather wide, reaching below the base of attachment, tricuspid, the mesocone the largest; all cusps wide and spade-shaped; the second lateral has the entocone nearer the distal extremity, the ectocone becoming higher on the reflected portion; the eleventh and twelfth teeth are modified and connect the lateral with the marginal teeth, a second

Fig. 124. Radula of *Pseudosuccinea columella.*

small cusp appearing on the outer edge of the reflection above the ectocone in the eleventh tooth; marginal teeth beginning abruptly, much longer than wide, multicuspid, the distal extremity becoming serrated.

The marginals show great variation in the number, shape and position of the distal cusps. In the Mollusca of the Chicago area the lateral teeth are described as bicuspid, but this is an error, as all subsequent examinations have shown the radula to be tricuspid. In one membrane the first lateral was abnormal in having two small cusps above the entocone. Nearly all of the first laterals in this membrane were of this abnormal form.

ECOLOGY: *Columella* is an inhabitant of ponds and streams where the water is more or less stagnant; a locality with an abundance of lily pads is particularly favorable; it is found also along the shore in shallow water in the vicinity of cat-tails *(Typha)* and other reeds, upon which it is often found, mimicking the situs of the pulmonate genus *Succinea.* Rarely found in running water. *Columella* is a lover of shallow bays and small ponds or creeks, where it may browse in the pond scum and on bits of rotting stems of water plants. It has been collected by the writer associated with *Lymnaea stagnalis jugularis, Fossaria obrussa* and *Stagnicola palustris elodes.*

DISTRIBUTION: Nova Scotia west to Minnesota, eastern Kansas and central Texas; Manitoba and Quebec south to Texas and Florida.

DISTRIBUTION IN WISCONSIN: Judging by the records, *columella* is very rare in Wisconsin, excepting in a very few localities. Much of this scarcity may be due to insufficient field work.

Wisconsin Drainage: Tomahawk Lake, Oneida Co. (Baker).
Rock Drainage: Mill pond at Delafield, Waukesha Co. (Chadwick); Mud Lake, Waukesha Co. (Cahn).
Lake Michigan Drainage: Near Milwaukee, Milwaukee Co. (Lapham).

REMARKS: *Columella* may easily be known by its Succinea-like shell, resembling very closely specimens of *Succinea ovalis* Say. It is subject to considerable variation, especially in the height of the spire and in the size of the aperture; the whorls also vary in convexity. There is also some variation in consistency, some shells being heavy and thick, with a rather rough surface, while others are very thin, delicate and shining. The species is so unlike the other Lymnaeas, however, that it need never be confounded with any species.

For additional data concerning the variation and range of this species, see Baker, Monograph Lymnaeidae, p. 270.

Genus BULIMNEA Haldeman, 1841

Haldeman, Mon. Limn., part 3, p. 6, July, 1841. Type: *Lymnaeus megasomus* Say; Baker, Mon. Lymnaeidae, p. 183, 1911.

SHELL: Bulimiform, solid, generally richly colored; spire and aperture about equal in length; outer lip simple; axis twisted, inclining to gyrate, the fold quite sharp; inner lip ex-

panded and folded back, completely closing the umbilicus. (Pl. XI, fig. 5)

JAW: With a wide, slightly convex median swelling.

RADULA: With tricuspid lateral teeth.

GENITALIA: Penis sheath 1¼ times longer than praeputium, enlarging toward end which is squarely truncated, not rounded; penis very long, tapering; praeputium with large dependent sarcobelum; retractors of praeputium one or two; protractors very large and with numerous branches; prostate large, long, irregularly flattened; oviduct pyriform, long, narrow at the lower part; spermatheca globular. Egg capsules very large, highly gelatinous, each capsule containing many eggs (125–150). See pl. XXII, fig. 22.

DISTRIBUTION: Northern United States and Canada, nearctic.

Bulimnea differs from the rest of the family in its peculiar bulimiform, darkly colored shell, its long, club-shaped penis sheath and large and irregular prostate. The penis sheath is very peculiar, being very long, and gradually increasing in diameter to the end, which is cut off almost squarely and not rounded as in other Lymnaeas; the end is more than double the diameter of the organ as it leaves the praeputium; the protractor muscles are also more numerous than in any groups excepting *Lymnaea.*

BULIMNEA MEGASOMA (Say)

Plate VIII, figures 19–23; plate XVII, figures 31, 35

Lymnaeus megasomus SAY, Rep. Long's Exp., II, p. 263, pl. 15, fig. 10, 1824; Binney, L. & F–W. Sh. N. A., II, p. 37, figs. 46, 47, 1865.
Limnea megasoma HALDEMAN, Mon., p. 13, pl. 3, figs. 1–3, 1841.
Bulimnea megasoma BAKER, Mon. Lymnaeidae, p. 184, pl. xxv, figs. 1–6, 1911.

TYPE LOCALITY: Bois Blanc Lake, Manitoba.

WISCONSIN RECORDS:

1860. *Limnaea megasoma* LAPHAM, p. 155. N. W. Territory.
1906. *Limnaea megasoma* CHADWICK, pp. 22, 81. Molas Creek, Manitowoc Co.; Lake Koshkonong, Jefferson Co.; Oconto.
1891. *Limnaea megasoma* MARSTON, p. 81. Oconto.
1911a. *Bulimnea megasoma* BAKER, p. 239. Tomahawk Lake & Wisconsin River.
1911c. *Bulimnea megasoma* BAKER, p. 189. Tomahawk Lake and Wisconsin River; Molas Creek; Lake Koshkonong; West Superior; Green Bay; St. Croix River, Douglas Co.; Oconto.

SHELL: Large, ovate, inflated, bulimniform; periostracum brownish, greenish or olive, with, in many specimens, longitudinal streaks of green, orange, purple or ochraceous; surface strongly marked with growth lines, which are raised to form wide, flat ridges in some specimens; the spiral, wavy lines of the Lymnaeas are present, but are rather faint; some specimens are strongly malleated; nuclear whorls 1¼ in number, dark chestnut colored in some specimens, light yellowish horn in others; outline of second whorl shouldered near the suture of the first whorl; texture that of satin finish; whorls 5–5½, rounded, somewhat flattened at the previous sutures; spire varying from rather elongated to depressed dome-shaped; sutures well impressed; aperture large, subovate, inflated, chestnut brown or dark purple within, occupying from half to two-thirds of the length of the entire shell; peristome thin; parietal wall with a thin wash of callus which is tightly appressed to the body whorl, completely closing the axis and umbilical region; pillar twisted, forming a raised, prominent ascending plait.

L. 43.2; D. 22.5; Ap. L. 25.2; D. 12.1 mm. Type.
L. 52.0; D. 29.0; Ap. L. 31.5; D. 17.0 mm. Moose Ear Creek pool (U. of W., 4702).
L. 38.0; D. 24.0; Ap. L. 24.0; D. 14.0 mm. Moose Ear Creek pool (U. of W., 4702).
L. 34.5; D. 21.2; Ap. L. 21.5; D. 12.0 mm. Moose Ear Creek pool (U. of W., 4702).
L. 46.5; D. 25.0; Ap. L. 26.0; D. 14.5 mm. Tomahawk Lake (Baker coll., 428).
L. 39.5; D. 22.0; Ap. L. 24.0; D. 11.3 mm. Tomahawk Lake (Baker coll., 428).
L. 27.5; D. 15.8; Ap. L. 18.2; D. 8.5 mm. Tomahawk Lake (Baker coll., 428).

ANIMAL: "Blackish, the head and tentacles marked with small yellow spots which give a brownish color on close inspection, and when the animal is in motion the surface has the appearance of being covered with a superficial bloom of a russet color; foot of blackish gray, lighter beneath; mantle bluish gray, slightly tinged with yellow toward the posterior angle of the shell aperture. Head broadly semi-circular, spreading below, obtusely angular at the posterior lateral margins and slightly emarginate in front. Foot disc broadly rounded in front and tapering behind to an obtusely rounded point; about

five-eighths of an inch wide near the anterior end, and together with the head measures about one inch and five-eighths in length when the animal is in motion. Tentacles broad and thin, more than half an inch long, slightly curved inward and irregularly tapering to an obtuse point. Eye spots small, situated at the inner base of the tentacles; yellow in color, with a black center. Respiratory orifice of the pulmonary sac situated a little less than half an inch from the posterior angle of the shell aperture, and when dilated, as in the act of receiving air, is about one-fourth of an inch in its greatest diameter, and regularly oval in outline." (Whitfield, see pl. XVII, figs. 31, 35)

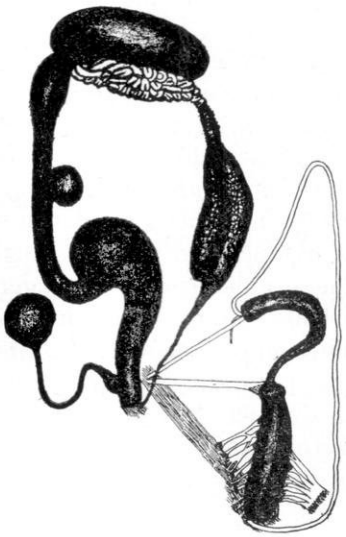


Fig. 125. Genitalia of *Bulimnea megasoma.*

GENITALIA (Fig. 125): Praeputium large, cylindrical, slightly enlarged at the distal end; penis sheath longer than praeputium, club-shaped, enlarged toward the distal end which is more than twice the diameter of the proximal end; prostate irregularly cylindrical, somewhat folded, contracted posteriorly to form a narrow, irregularly convoluted tube, which enters the much convoluted spermoviduct; retractor muscles two or three in number, one penis sheath retractor and one or two praeputium retractors; the latter are attached to the praeputium by a number of small muscles spread out in fan shape;

protractor muscles numerous, six or more posterior, and one large muscle on the anterior side which is split into six or more smaller muscles. These muscles vary in number and position, the posterior protractors being widely separated (2) or close together (1) and joined by small branches (see fig. 126). Internally, the praeputium has a large sarcobelum which hangs down into the cavity, the walls are thick, and there are heavy longitudinal as well as spiral muscles. The walls of the penis sheath are thin; the penis is very long, symmetrical, without constriction, and gradually tapers from the distal end to the praeputium (see fig. 120).

The oviduct is rather long and comparatively narrow, the lower portion somewhat pyriform, narrowing into a somewhat tube-like body which enters the large convoluted spermoviduct beneath the albumen gland. Egg gland rather small, globular; spermatheca globular, not very large, connected with the vagina by a tube of medium length.

The organs are colored as follows: penis sheath, flesh; praeputium, blackish; prostate, bright orange; spermatheca, mottled flesh and yellowish; albumen gland, purplish and flesh; egg gland, light flesh; oviduct, light flesh; spermoviduct yellowish and whitish. The peculiarities of the genitalia of *megasoma* are the great length and small diameter of the penis sheath and its peculiar enlargement at the distal end, the cylindrical form of the prostate, the pyriform shape of the lower portion of the oviduct (uterus), and the number and position of the retractor and protractor muscles of the male organ. These features differ from those of any American Lymnaeid examined.

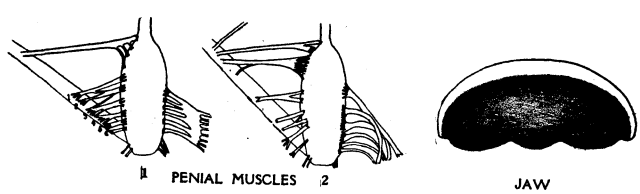


Fig. 126. Jaw and Male Organ of *Bulimnea.*

JAW (Fig. 126): Median jaw about three times as wide as high, with a broad convex median projection on the cutting edge; lateral jaws very long, triangular, the cutting edges somewhat irregular.

RADULA (Fig. 127): Formula: $\frac{3\,1}{5+}+\frac{3}{4}+\frac{1\,4}{3}+\frac{1}{1}+\frac{1\,4}{3}+\frac{3}{4}+\frac{3\,1}{5+}$ (48–1–48). Central tooth with a broad, short cutting point; lateral teeth rather short, quadrate, broad, tricuspid, the second to tenth teeth narrow, the entocone placed nearer the distal end of the reflection; several of the lateral teeth show a tendency to a splitting of the mesocone, a small accessory cusp resulting, as figured by Whitfield; eleventh to fourteenth laterals becoming narrower toward the marginal teeth, which begin at about the eighteenth tooth, the reflection being narrow, with three or more cusps at or near the distal end and one or more higher up on the outer margin; outer marginals very narrow, irregularly tri-, quardi or penta-cuspid. The fifteenth to seventeenth teeth are intermediate, the entocone moving upward and becoming larger; the eighteenth tooth is a typical marginal.

Fig. 127. Radula of *Bulimnea megasoma.*

ECOLOGY: *Megasoma* is usually an inhabitant of small, quiet bodies of water or swamps. Near Bayfield it was found in a small beach pool which had assumed a swampy character, the water was from .3 to 1 m. deep and the bottom of soft, sticky mud. Near Moose Ear Creek this species was found in a small pond but a few yards in diameter, ranging from a few inches to a meter in depth, mud bottom, and filled with old branches and other debris. A few specimens had gotten into the creek, which is a cold, rapid stream, and were trying to live in the deeper, quiet stretches of the stream. In another locality nearby (ten mile creek) these animals were found in a swampy area separated from the creek by an old beach barrier.

At Tomahawk Lake, Wisconsin, *megasoma* lives in swampy portions of sheltered bays where the water is quiet. The bottom of such a habitat is boggy and the water is so shallow that frequently little boggy islands are formed, and on these *megasoma* may be found, one or two specimens on each island. In other parts of this habitat they may be found near the shore,

clinging to logs and other debris. A small, swampy slough, lying between the Wisconsin River and Gilmore Creek, Oneida County, afforded the best habitat for *megasoma,* where they lived in considerable number. This slough is about a quarter of a mile long and two or three hundred feet wide; the water is (in summer) but a few inches in depth, but the mud, which is about the consistency of mush, is from six to ten feet in depth. *Megasoma* lives on the surface of the mud and on old logs which the lumbermen have left in the swamp.

That *megasoma* is not always a quiet water species is evidenced by their presence in deep water which is rather rough. Dr. R. C. Rush thus comments on specimens taken in Georgian Bay, east of Grand Manitoulin Island, on Toad Island: "At first I thought this was a stagnant water species but had to change my mind. It is common in the giant bur-reed marshes at the southwest end of the island. While fishing for bass off the northern point of the island one day I noticed a huge two-inch *megasoma* coming up the rock from deep water. He was down six feet when I first saw him and I waited forty minutes for him to come within reach. Later, I saw and collected them in water from six to ten feet deep on rocks in the channels where the surf pounds all day long. They start breeding about the last week of September and deposit eggs in October."

DISTRIBUTION: Northern New England (Vermont) west to Minnesota, Iowa, and Manitoba; northern Ohio (latitude 41°) northward to about latitude 57° in British America.

DISTRIBUTION IN WISCONSIN: *Megasoma* is widely distributed in northern and central Wisconsin, fairly abundant in its favorite localities, which, however, are rather widely scattered.

Lake Superior Drainage: Beach pool near Bayfield, Bayfield Co. (Baker).

Green Bay Drainage: Oconto, Oconto Co., (Marston, Wiswall); west side Green Bay (Crawford, Wetherby).

Lake Michigan Drainage: Molas Creek, between Two Rivers and Two Creeks, Manitowoc Co. (Brown, Chadwick).

Wisconsin Drainage: Tomahawk Lake and Wisconsin River, Oneida Co. (Baker); Plum Lake, Vilas Co. (Cahn).

Rock Drainage: Lake Koshkonong, Jefferson Co. (Chadwick).

St. Croix Drainage: Grantsburg, Burnett Co. (Bullock); St. Croix River, Douglas Co. (Graenicher); West Superior, Douglas Co. (Conrad).

Chippewa Drainage: Pool near Moose Ear Creek and swamp near Ten Mile Creek, near Chetek, Barron Co. (Baker).

REMARKS: *Megasoma* is the largest and finest Lymnaeid in Wisconsin as well as in the United States. The peculiar color as well as the bulimoid shape easily distinguish it from all other species of the family. The spire varies somewhat in height but on the whole the species is notably stable in form, exhibiting little variation of a striking character. It seems common or even abundant in the State, in the favorable localities in which it occurs.

Genus FOSSARIA Westerlund, 1885

Fossaria WESTERLUND, Fauna Paläarct., Binnenconch., V, p. 49, 1885. Type: *Buccinum truncatulum* O. F. MÜLLER.

Simpsonia F. C. BAKER, Mon. Lymn., p. 236, 1911. Type: *Lymneus humilis* SAY. (Not *Simpsonia* ROCHEBRUNE, 1905).

Pseudogalba F. C. BAKER, Nautilus, XXVI, p. 120, 1913 (new name for *Simpsonia*, preoccupied).

SHELL: Small, turreted, spire usually pointed and as long as or longer than the aperture; without distinct spiral striation; axis not twisted, smooth, without a plait; inner lip reflected forming a narrow, somewhat triangular expansion either rolled in toward the umbilical chink or standing erect and emargining the umbilical chink, which may be narrowly open or quite deep and round (pl. XI, fig. 2).

JAW: Superior jaw arched, about three times as wide as high, with a large rounded central projection.

GENITALIA: Penis sheath usually shorter than praeputium, the latter without distinct sarcobelum, which is represented by an inconspicuous ridge; penis long, wide at the upper part, narrow and elongated toward the end, simple; usually a single retractor muscle each for penis sheath and praeputium, inserted jointly or but slightly separated in the columellar muscle; sometimes the penis sheath retractor is inserted in the retractor of the praeputium; prostate ovate, rounded at both ends; spermatheca rounded or pear-shaped.

Pilsbry (Aquatic Moll. Belg. Congo, 1927, p. 106) has stated that the type of *Galba* Schrank is not the *Buccinum truncatulum* of Müller but the *Galba pusilla* of Schrank, which is described as "smaller than a grain of wheat." This was undoubtedly a young shell and in the absence of a type it is impossible to ascertain just what species it might have been. For this reason the genus should be rejected, and the next available

name used in its place. This appears to be *Fossaria* of Westerlund, as stated by Pilsbry. As it has tricuspid lateral teeth it cannot well be considered a section under *Stagnicola* which has bicuspid laterals. *Simpsonia* F. C. Baker is an absolute synonym of *Fossaria* founded on the mistaken assumption that *truncatulum* had bicuspid laterals like the small Lymnaeids of the south, now included in subgenus *Nasonia* (see ante, p. 264). An examination of the radula of *truncatulum* shows it has tricuspid laterals like the small forms typified by *obrussa* and *humilis* (see Anandale and Rao, 1925, p. 170, fig. X, E). This group is quite separable from the other divisions of the family by its shell and radula.

DISTRIBUTION: Holarctic and Palearctic.

This genus contains the smaller Lymnaeas represented by *humilis, modicella, parva, obrussa* in America and *truncatula* in Europe and Asia. The lateral teeth are distinctly tricuspid, the shell is usually pointed, the axis round and the inner lip triangular.

KEY TO SPECIES OF FOSSARIA

1. a. Whorls rounded ---------- 2
   b. Whorls shouldered ---------- 5
2. a. Spire acute, usually longer than aperture, turreted, sutures very deeply impressed ---------- 3
   b. Spire broadly conic, spire usually as long as aperture, sutures not deeply impressed ----------*modicella*
3. a. Body whorl well rounded, aperture roundly ovate, umbilicus round, deep, spire whorls well rounded and sutures deeply impressed ----------*parva*
   b. Body whorl flatly rounded, aperture ovate or elongate ovate, umbilicus a small chink, spire whorls flatly rounded, sutures well marked but not as deeply impressed as in *parva* ---------- 4
4. a. Shell 13 mm. or more in length, aperture elongate ovate, sutures well impressed ----------*peninsulae*
   b. Shell 10 mm. or less in length, aperture ovate, sutures not much impressed ----------*rustica*
5. a. Shell large (15 mm.), spire acute, aperture large, ovate, sutures well marked but not deeply impressed ----------*obrussa*
   b. Shell small (11 mm.), spire usually depressed, broad, aperture small, sutures deeply impressed ---------- 6
6. a. Spire longer than aperture, rather acute, shell narrow, whorls as high as wide or higher than wide ----------*exigua*
   b. Spire short, wide, about as long as aperture, shell wide, spire whorls wider than high ---------- 7

7. a. Whorls strongly, squarely shouldered, especially the body whorl, aperture long ovate, rounded at both ends, narrow; spire whorls flat-sided ----------*decampi*
   b. Whorls roundly shouldered, aperture regularly roundly ovate; spire whorls rounded ----------*galbana*

FOSSARIA PARVA (Lea)

Plate XVI, figure 7; plate XVIII, figures 1–5

Lymnaea parva LEA, Proc. Amer. Phil. Soc., II, p. 33, 1841; Trans. Amer. Phil. Soc., IX, p. 11, 1844; BINNEY, L. & F–W. Sh. N. A., II, p. 64, fig. 102, 1865.

Galba parva BAKER, Mon. Lymnaeidae, p. 243, pl. xxix, figs. 5–14; pl. xxx, figs. 9–12, 1911.

Lymnaea curta LEA, Proc. Amer. Phil. Soc., II, p. 33, 1841; Trans. Amer. Phil. Soc., IX, p. 11, 1844; BINNEY, Op. Cit., p. 64, fig. 101, 1865.

TYPE LOCALITY: *Parva* and *curta,* Cincinnati, Ohio.

WISCONSIN RECORDS:

1906. *Limnaea parva* CHADWICK, p. 83. Milwaukee.
1924. *Lymnaea parva* BAKER, p. 136. Lake Butte des Morts, north of Oshkosh.

SHELL: Small, rather solid, turreted, translucent; periostracum light horn or yellowish white, pellucid; surface shining, growth lines close set and well marked, sometimes elevated so as to roughen the surface of the last whorl; spiral lines very fine or absent; whorls 5–5½, very convex, regularly increasing in size; nucleus of 1¼ whorls, smooth, with satin-finish sculpture; in outline the nucleus is rounded, the first whorl being very large; the sculpture of the shell begins very abruptly; spire elevated, forming an acute pyramid, generally longer than the aperture; sutures deeply impressed; aperture roundly and regularly elliptical, continuous in many specimens, a trifle effusive at the lower end; outer lip thin, sometimes developing a white deposit or varix a short distance from the edge; inner lip markedly and broadly reflected over the umbilicus, forming a broad, even expansion; parietal callus well marked, thick; umbilical chink well marked, open, axis straight, not twisted, thickened by shelly deposit.

L. 4.50; D. 2.50; Ap. L. 1.50; D. .50 mm. Type parva.
L. 7.75; D. 4.10; Ap. L. 3.50; D. 1.50 mm. Type curta.
L. 5.00; D. 2.75; Ap. L. 2.25; D. 1.50 mm. Dyer, Indiana.

L. 9.00;	D. 4.50;	Ap. L. 3.80;	D. 2.00 mm.	Des Moines,	Iowa.
L. 8.00;	D. 4.00;	Ap. L. 3.80;	D. 1.90 mm.	"	"
L. 7.50;	D. 4.00;	Ap. L. 3.50;	D. 1.75 mm.	"	"
L. 7.25;	D. 3.75;	Ap. L. 3.00;	D. 1.50 mm.	"	"
L. 6.25;	D. 3.10;	Ap. L. 2.90;	D. 1.50 mm.	"	"

ANIMAL: Color blackish, very thickly dotted with fine white dots. The upper whorls are pinkish in the living animal, and the spotted mantle shows through the almost transparent shell.

GENITALIA (Fig. 128): Penis sheath about two-thirds as long as praeputium, very slender, with enlarged distal end. Large retractor muscles enter both penis sheath and praeputium and are united in the columellar muscle; two large, wide, heavy

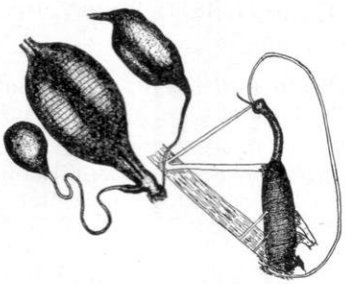


Fig. 128. Genitalia of *Fossaria parva.*

anterior protractor muscles and two small, thin, long posterior protractors; spermatheca large, somewhat pyriform, on a long duct; prostate elongate-ovate, flattened, rounded at both ends. The interior of the male organs is like that of *obrussa.*

JAW: Superior jaw a trifle more than three times as wide as high, not notably arched, with a small median swelling on the ventral margin.

Fig. 129. Radula of *Fossaria parva.*

RADULA (Fig. 129): Formula: $\frac{1\,8}{4+}+\frac{2}{4}+\frac{4}{3}+\frac{1}{1}+\frac{4}{3}+\frac{2}{4}+\frac{1\,8}{4+}$ (24–1–24); central tooth with a rather long cusp; lateral teeth tricuspid, very wide, the small entocone forming by a splitting of the large mesocone; ectocone rather large; the marginal teeth

commence at the seventh tooth, in which the entocone and mesocone are about equal in size and appear at the distal end of the reflection; the typical marginal teeth begin with the tenth tooth, the distal end of the reflection becoming serrated, while the outer edge develops several small serrations. The marginal teeth are long and narrow, and there is considerable variation in the number and position of the individual cusps. Eighty-two to ninety-five rows of teeth were counted.

ECOLOGY: *Parva* inhabits wet, marshy places, generally out of the water, on sticks, stones, or muddy flats. The animal is more prone to leave the water than any other species of the family.

DISTRIBUTION: Connecticut west to Idaho, James Bay and Montana south to Maryland, Kentucky, Oklahoma, southern New Mexico and Arizona.

DISTRIBUTION IN WISCONSIN: Though widely distributed both east and west of the State, records of this species within the confines of Wisconsin are very rare. This is doubtless due to lack of collections rather than absence of material.

Lake Michigan: Milwaukee, Milwaukee Co. (Lapham); Menomonee River, Waukesha Co. (Cahn).

Fox Drainage: Pool near marshy border of Lake Butte des Morts, north of Oshkosh, Winnebago Co.; pool in Green Lake village, Green Lake Co. (Baker).

REMARKS: *Parva* may be known by its peculiar bulimoid appearance. It is more slender than *modicella,* has a longer, more turreted spire, a more regularly elliptical aperture and a differently shaped inner lip, which is roundly and broadly reflected over the umbilicus. Some specimens resemble in outline a miniature *Campeloma* as recorded by Lea in his description of *curta.* Occasionally specimens will be found in which the whorls are more or less shouldered, the umbilicus is more widely open and the sutures are more deeply impressed. The sculpture of the surface varies, in some examples the shell being smooth while in others there are very fine revolving lines. *Parva* is a common species and will probably prove to be widely distributed. When adult and perfectly formed it is one of the most graceful and handsome of Lymnaeas, with its rounded whorls, deep sutures and elliptical aperture. It varies somewhat in corpulency, some specimens being narrow while others

are quite robust. The aperture varies from almost round to long-ovate.

FOSSARIA DALLI (F. C. Baker)

Plate XVI, figure 11

Lymnaea parva BAKER, Nautilus, XIX, p. 52, 1905 (not of Lea).
Lymnaea dalli BAKER, Bull. Ill. State Lab. Nat. Hist., VII, p. 104, 1906; Nautilus, XX, p. 125, 1907.
Galba dalli BAKER, Mon. Lymn. N. Am., p. 251, pl. xxx, figs. 13–18, 1911.

TYPE LOCALITY: Marsh, west side Lake James, Steuben Co., Ind.

WISCONSIN RECORDS: None.

SHELL: Very small, thin, ovate-conic, turreted; color greenish or whitish horn; surface dull to shining, marked by heavy, crowded growth lines which are elevated into indistinct ridges in some specimens; nucleus very small, flatly rounded, light horn-colored, similar in form to that of *Galba parva.* Whorls 4½–5, rounded and distinctly shouldered; spire generally obtusely conic, turreted, a trifle longer than the aperture; sutures very deeply impressed; aperture elongate ovate or elliptical, continuous in many specimens; outer lip acute; inner lip forming a rather flat erect extension over the umbilical region, leaving a pronounced chink; the lower part of the aperture is somewhat effusive; the columellar extension of the inner lip is sometimes so appressed at its junction with the parietal wall as to form a pseudo-plait; the inner edge of the outer lip frequently forms a rib-like varix in very old specimens.

L. 3.25; W. 2.00; Ap. L. 1.50; W. 1.00 mm.	(Lake James)	Type.
L. 4.00; W. 2.00; Ap. L. 2.00; W. 1.00 mm.	" "	"
L. 3.00; W. 2.00; Ap. L. 1.25; W. .90 mm.	" "	"
L. 4.25; W. 2.00; Ap. L. 1.75; W. 1.00 mm.	" "	"
L. 4.50; W. 2.50; Ap. L. 2.00; W. 1.10 mm.	(Scalariform).	
L. 3.75; W. 2.75; Ap. L. 2.00; W. 1.25 mm.	Rockford, Ill.	
L. 4.00; W. 2.10; Ap. L. 2.00; W. 1.10 mm.	" "	

ANIMAL, JAW, RADULA AND GENITALIA: Not examined.

GENERAL DISTRIBUTION: Ohio to Northern Michigan and Montana, south to Kansas and Arizona.

DISTRIBUTION IN WISCONSIN: No actual records are at present known from Wisconsin, but as the species is found

both east and west of the State it will doubtless be found in Wisconsin sooner or later.

ECOLOGY: Similar to *Galba parva.*

REMARKS: This little species, the smallest of our American Lymnaeas, is related in *Galba parva,* appearing at first sight to be a small example of that species. It differs from *parva* in its smaller size, rounder and more turreted whorls, slenderer outline, longer and narrower aperture and smaller and less conspicuous umbilicus. The whorls are inclined to be shouldered, also, a feature not emphasized in *parva.* There is some variation in the length of the spire, many specimens having a rather long spire, while in others the spire is much depressed and the whorls are humped, this last being in slightly abnormal forms. The inner lip of *dalli* is different from that of *parva,* being generally more erect; in *dalli* there is a denting in or constriction at the point of juncture of the inner lip and the parietal wall which is not notably apparent in *parva.*

Young specimens of *parva* are similar to *dalli,* but may be distinguished by the less number of whorls in shells of the same size and in the different shape of the whorls. The two species, *parva* and *dalli,* are related, but are easily separated when attention is given to the details of size and form.

FOSSARIA MODICELLA (Say)

Plate XVI, figure 8; plate XVIII, figures 6–10

Lymneus modicellus SAY, Journ. Phil. Acad., V, p. 122, 1825; BINNEY, L. & F–W. Sh. N. A., II, p. 64, fig. 100, 1865.

Galba humilis modicella BAKER, Mon. Lymnaeidae, p. 259, pl. xxix, figs. 31–37; pl. xxxi, figs. 1–9, 1911.

Lymnaea jamesii LEA, Proc. Phil. Acad., p. 113, 1864; Journ. Phil. Acad., VI, p. 161, pl. 24, fig. 77, 1866.

TYPE LOCALITY: *Modicella,* Owego, Tioga County, N. Y., on the Susquehanna River; *jamesii,* ponds near Cincinnati, Ohio.

WISCONSIN RECORDS:

1865. *Limnaea humilis* BINNEY, p. 67. Milwaukee.
1897. *Limnaea humilis* WISWALL, p. 48. Southern Wisconsin.
1904c. *Limnaea humilis* BAKER, p. 103. Near Kilbourn.
1906. *Limnaea humilis* CHADWICK, pp. 22, 82. Vicinity of Milwaukee; Lake Winnebago, west of High Cliff.
1911a. *Galba humilis modicella* BAKER, p. 240. Wisconsin River, Oneida Co.

1911c. *Galba humilis modicella* BAKER, p. 265. Prairie du Chien; Bridgeport (fossil).

1924. *Lymnaea humilis modicella* BAKER, p. 136. Near Oshkosh, in Lake Winnebago.

SHELL: Of medium size, elongate-ovate or fusiform; periostracum light yellowish horn; surface shining, with distinct, rather coarse lines of growth and frequently very fine spiral lines; whorls 4½ to 5, convex, the body whorl very large, flatly rounded; spire generally short, broadly or acutely conic, sometimes dome-shaped; sutures well impressed; nuclear whorls 1¼, the first whorl very small, the second very large, the sculpture of the post-nuclear whorls beginning gradually; aperture ovate or elongate ovate, somewhat narrowed above; peristome thin; inner lip narrow, reflexed over the umbilical region, rolled over and appressed at the point of contact with the parietal wall, but standing more erect at the lower part; umbilical chink small, narrow but distinct; axis smooth, forming an hour-glass-shaped column.

L. 8.5; D. 4.2; Ap. L. 4.7; D. 2.7 mm. Type *modicella*.
L. 8.0; D. 5.0; Ap. L. 5.0; D. 3.0 mm. Mc. Henry Co., Ill. (Baker coll. 255).
L. 9.5; D. 5.0; Ap. L. 5.0; D. 3.0 mm. Mc. Henry Co., Ill. (Baker coll. 255).
L. 10.5; D. 5.5; Ap. L. 5.5; D. 4.0 mm. Mc. Henry Co., Ill. (Baker coll. 255).
L. 10.5; D. 5.5; Ap. L. 6.0; D. 3.0 mm. Mc. Henry Co., Ill. (Baker coll. 255).
L. 7.1; D. 4.0; Ap. L. 4.0; D. 2.5 mm. Chippewa Falls (U. of W., 4712).

ANIMAL: As in *obrussa*.

GENETALIA AND JAW: Similar to *obrussa*.

RADULA: Formula: $\frac{18}{5-6}+\frac{1}{4}+\frac{6}{3}+\frac{1}{1}+\frac{6}{3}+\frac{1}{4}+\frac{18}{5-6}$ (25–1–25); lateral teeth tricuspid; the seventh tooth transitional; marginals beginning abruptly on the eighth tooth. The shape of the teeth do not differ from those of *obrussa*.

ECOLOGY: *Modicella* usually selects as a habitat a mud flat or a strip of muddy beach which is kept rather moist. It is also found in small pools, especially those that have a border of moss or much debris. It does not normally live in large bodies of water.

GENERAL DISTRIBUTION: Eastern Quebec, Nova Scotia, and New Jersey west to Vancouver Island; Manitoba south to southern California, Arizona, Texas, and Alabama.

DISTRIBUTION IN WISCONSIN: *Modicella* is widely distributed over the State. It is known from the drainages of the St. Croix, Chippewa, Fox, Wisconsin, and Rock rivers, and the streams draining into Lake Michigan.

REMARKS: *Modicella* is closely related to the *humilis* of the southeastern part of the United States, differing in its narrower shell and longer aperture, and more or less impressed inner lip where it joins the parietal wall. From *parva* it may be known by the impressed inner lip, which is flat and erect in that species. *Obrussa* is larger and more elongated and the inner lip is notably compressed and bent inward at its junction with the parietal wall. *Galbana* is similar in some of its forms, but is typically shorter, more corpulent and has a more depressed spire, more shouldered whorls and a rounder aperture. *Modicella* is a common mollusk in many parts of the United States and is usually readily distinguished. Wisconsin specimens are smaller on the average than specimens from states east and south, but this disparity in size may be due to lack of sufficient material from this State. Large specimens are illustrated for comparison with Wisconsin specimens.

Continued study of this species leads the author to consider it specifically distinct from *humilis,* as far as shell characteristics are concerned. The animal of *humilis* has not been examined.

FOSSARIA MODICELLA RUSTICA (Lea)

Plate XVI, figure 10; plate XVIII, figures 11–13

Lymnea rustica LEA, Proc. Amer. Phil. Soc., II, p. 33, 1841; Trans. Amer. Phil. Soc., IX, p. 10, 1844; BINNEY, L. & F–W., Sh. N. A., II, p. 65, fig. 106, 1865.

Galba humilis rustica BAKER, Mon. Lymnaeidae, p. 268, pl. xxxi, figs. 10–14, 1911.

TYPE LOCALITY: Poland, Ohio.

WISCONSIN RECORDS: None.

SHELL: Small, elongated, subfusiform; periostracum light yellowish horn, darker in some specimens; surface shining, growth lines coarse, spiral lines absent or very faint; whorls 5 to 5½, convex, rather slowly increasing in diameter, the body whorl suddenly enlarging; spire long, very acute, generally a trifle longer than the aperture; nuclear whorls resembling those of *modicella;* sutures impressed; aperture usually nar-

rowly elliptical; outer lip thin, sometimes with a varix; inner lip narrow, reflected, the lower part turned up, the upper part at its junction with the parietal wall impressed and flattened, forming a slight plait; umbilical chink usually very narrow, in some specimens nearly closed; axis as in *modicella.*

L. 7.5; D. 4.0; Ap. L. 3.7; D. 1.5 mm. Autotype.
L. 10.0; D. 4.6; Ap. L. 4.7; D. 2.5 mm. Phillips (U. of W., 4713).
L. 8.0; D. 3.5; Ap. L. 3.6; D. 1.5 mm. Ashland Junction (U. of W., 4714).
L. 9.5; D. 4.5; Ap. L. 4.5; D. 2.0 mm. Joliet, Ill. (Baker coll., 557).

ANIMAL, GENITALIA, JAW: As in *modicella.*

RADULA: Formula: $\frac{1\,2}{4-5}+\frac{2}{3-4}+\frac{6}{3}+\frac{1}{1}+\frac{6}{3}+\frac{2}{3-4}+\frac{1\,2}{4-6}$ (20–1–20); the teeth are similar in all respects to those of *modicella.*

ECOLOGY: Similar to that of *modicella.* Usually on mud flats and the margins of rivers and streams.

DISTRIBUTION: New York west to Utah, Nebraska south to New Mexico.

DISTRIBUTION IN WISCONSIN: Widely, though sparsely distributed in the State.

Lake Superior Drainage: Ashland Junction, Bayfield Co. (Bullock); pool near Cliff House, Bayfield, Bayfield Co. (Baker).
Green Bay Drainage: Marinette, Marinette Co. (Bullock).
Lake Michigan Drainage: Milwaukee, Milwaukee Co. (Slocum, fossil).
Fox Drainage: Spring Lake, Green Lake Co. (marl beds, Baker).
Chippewa Drainage: Phillips, Price Co. (Bullock).
Wisconsin Drainage: Glen six miles east of Devils Lake, Sauk Co. (Baker).

REMARKS: *Rustica* appears to be a modification of the *modicella* type of shell, characterized principally by its long, very acute spire and ovate aperture. Its long, pointed spire will distinguish it from any form of *modicella.* It is liable to be confounded with forms of *exigua,* but in that species the aperture is longer and narrower and inclined to be squarish, while in *rustica* it is more acutely rounded at the extremities. The spire in *rustica* is longer and more acute than in *exigua,* the spire whorls being less inflated. Half-grown specimens of *obrussa* are similar in general form, but differ in the form of the aperture, which is longer and narrower and forms a distinct shoulder at the junction of the outer lip with the body whorl, while in *rustica* this part of the lip is gracefully curved.

The aperture is sometimes almost round and the spire varies much in height. *Rustica* is evidently more nearly related to *modicella* than to *obrussa* and may be considered a variety of the former.

The type of *rustica* is not in the Smithsonian collection and is probably lost. Lea's description and the figure in Binney's work, however, leave no doubt as to the kind of shell Lea had in mind. A single specimen in the Lea collection in the Smithsonian Institution is marked *rustica* and agrees fairly well with Lea's description.

This small variety is probably poorly represented because of mixture with *modicella* and *obrussa*. When systematically sought, it will probably be found to be abundant over the State.

FOSSARIA OBRUSSA (Say)

Plate XVI, figure 14; plate XVIII, figures 14–24

Lymneus obrussus SAY, Journ. Phil. Acad., V, p. 123, 1825; BINNEY, L. & F–W. Sh. N. A., II, p. 49, fig. 69, 1865.

Galba obrussa BAKER, Mon. Lymnaeidae, p. 270, pl. xxvi, figs. 8–13; pl. xxxi, figs. 20–37, 1911.

Lymnea philadelphica LEA, Proc. Amer. Phil. Soc., II, p. 23, 1841; Binney, Op. Cit., p. 50, fig. 71, 1865.

Lymnaea desidiosa Authors, non Say (See Baker, Mon. Lymnaeidae, p. 275).

TYPE LOCALITY: *Obrussa*, Harrowgate, Philadelphia County, Penn.; *philadelphica*, River Schuylkill, near Philadelphia.

WISCONSIN RECORDS:

1904c. *Limnaea desidiosa* BAKER, p. 103. Dells of the Wisconsin River.

1906. *Limnaea desidiosa* CHADWICK, pp. 22, 83. Milwaukee and vicinity; Two Rivers, Manitowoc Co.; north shore of Lake Winnebago, west of High Cliff.

1911a. *Galba obrussa* BAKER, p. 240. Shore of Tomahawk Lake.

1920d. *Limnaea desidiosa* BAKER, p. 120. Milwaukee (fossil).

SHELL: Subconic, pointed, oblong, rather thin, frequently somewhat inflated; periostracum generally light yellowish horn color; surface shining, covered with numerous coarse lines of growth; under a strong lens very fine spiral lines may be seen; whorls 5½, rounded, somewhat shouldered, the shoulder being near the suture; the last whorl is very large, half the length of the entire shell, generally compressed but quite obese in some specimens; spire acute, sharply conical; nuclear whorls 1¼, resembling those of *Galba parva* in outline and sculpture;

sutures deeply indented; aperture very elongate-ovate, somewhat produced anteriorly; peristome thin, acute; inner lip reflected over the umbilical chink to form a thin, narrow expansion, which is usually appressed to the umbilical region, giving the axis a slight twist; parietal callus very thin; umbilical chink varying from distinctly open to scarcely observable; the surface of the shell is frequently malleated.

L. 9.5; D. 4.5; Ap. L. 5.0; D. 2.5 mm.	Type *obrussa.*
L. 13.0; D. 6.1; Ap. L. 7.2; D. 4.0 mm.	Lemont, Ill. (Baker coll., 635).
L. 11.5; D. 5.5; Ap. L. 6.1; D. 3.0 mm.	" "
L. 11.0; D. 5.3; Ap. L. 6.1; D. 3.0 mm.	" "
L. 10.5; D. 5.5; Ap. L. 6.0; D. 3.0 mm.	" "
L. 11.9; D. 5.5; Ap. L. 6.0; D. 3.0 mm.	DePere (U. of W., 4715).
L. 11.1; D. 5.1; Ap. L. 5.9; D. 2.9 mm.	" "
L. 10.3; D. 5.0; Ap. L. 5.1; D. 2.5 mm.	" "
L. 9.1; D. 4.5; Ap. L. 5.0; D. 2.1 mm.	" "

ANIMAL (Fig. 130): With a very small, more or less oblong foot, when viewed from the base, the anterior and posterior borders rounded; color dark gray or blackish, lighter below, sometimes yellowish, the whole surface is dotted with whitish or yellowish, which is especially noticeable about the eyes; tentacles triangular, flat, short, more or less transparent; the black eyes are placed on prominences at the inner base of the tentacles.

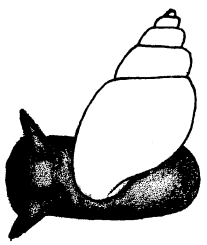


Fig. 130. Animal of *Fossaria obrussa.*

GENITALIA (Fig. 131): Not differing essentially from *parva.* The prostate is more regularly cylindrical and the spermatheca is rounder. The penis sheath is almost as long as the praeputium; the circular muscles of the praeputium are very strong and obscure the large longitudinal muscles. The penis is very long and narrow, projecting somewhat below the enlarged division between the penis sheath and the praeputium

(sarcobelum). The retractor of the penis sheath may be inserted in the columellar muscle or it may be inserted midway of the retractor of the praeputium (fig. 132, 1, 2). The general form of the male organ is the same as in *modicella* (see fig. 114).

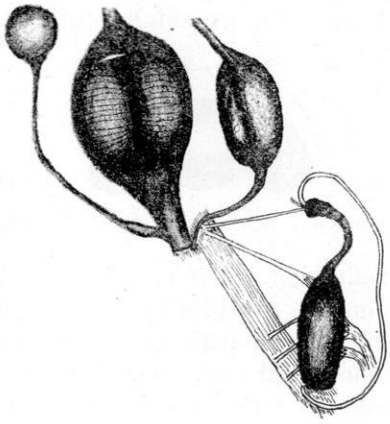


Fig. 131. Genitalia of *Fossaria obrussa.*

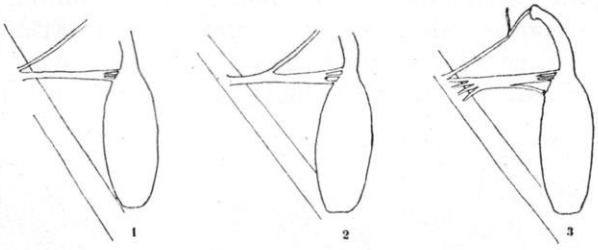


Fig. 132. Male Musculature of *Fossaria.* 1, 2, *obrussa,* N. Y.; 3, *peninsulae,* Maine.

JAW (Fig. 133): Superior jaw about three times as wide as high, much arched, with rounded ends and a wide, flatly convex median swelling.

RADULA (Fig. 134): Formula: $\frac{16}{4-7}+\frac{2}{3-4}+\frac{8}{3}+\frac{1}{1}+\frac{8}{3}+\frac{2}{3-4}+\frac{16}{4-7}$ (26–1–26); central tooth with a rather pointed cusp; lateral teeth tricuspid, with a subquadrate base of attachment, the reflection very broad, the entocone short and rather small, the mesocone long and wide, reaching below the lower margin of the base of attachment, the ectocone large and placed rather

high up on the reflection; the ninth and tenth teeth are modified laterals and are intermediate between laterals and marginals; they are rather narrow with two unequal cusps at the distal end and a third cusp placed higher up on the reflection; a small cusp is frequently developed very high up on the outer side of the reflection; marginals at first long and narrow, four to seven cuspid with one or more small denticles high up on the

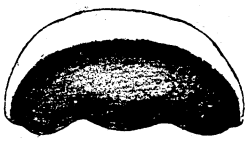


Fig. 133. Jaw of *Fossaria obrussa.*

outer side of the reflection. The cusps vary widely in number, size and position on the marginal teeth, but are usually four in number; extreme outer marginals narrow with four or more denticulations at the distal end. The examination of a small, narrow form of *obrussa* from Des Moines, Iowa, gave 25–1–25 teeth, the intermediate teeth beginning with the seventh tooth, the ninth tooth being a true marginal. A specimen from Maine had seven laterals, the marginals beginning abruptly with the eighth tooth. *Obrussa* seems more variable in the number and position of the lingual tooth than any of the other small Lymnaeas. There are more than seventy rows of teeth.

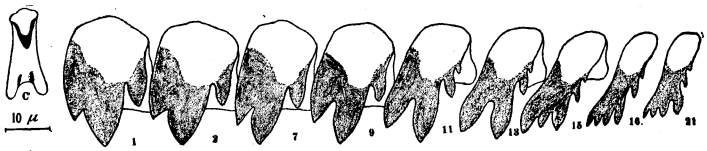


Fig. 134. Radula of *Fossaria obrussa.*

ECOLOGY: The normal habitat of this species is in small bodies of water, as creeks, ponds, sloughs, bays, and marshy spots along river banks. It is at home on sticks, stones, and any other debris that may be in the water or along its edge.

DISTRIBUTION: From the Atlantic to the Pacific oceans, and from Mackenzie Territory, Canada south to Arizona and northern Mexico.

DISTRIBUTION IN WISCONSIN: At present known only from the northern and eastern part of the State.

Fox Drainage: De Pere, Brown Co. (Marston); west of High Cliff, Lake Winnebago, Calumet Co. (Chadwick).

Wisconsin Drainage: Shore of Tomahawk Lake, Oneida Co.; Dells of the Wisconsin River, Columbia Co. (Baker); Found Lake, Vilas Co. (Cahn).

Lake Michigan Drainage: Milwaukee and vicinity, Milwaukee Co.; Two Rivers, Manitowoc Co. (Chadwick).

Rock Drainage: Lakes Oconomowoc, La Belle, and Ashippun, Waukesha Co.; Lake Koshkonong, Jefferson Co. (Cahn).

REMARKS: *Obrussa* is one of the most widely distributed, as it is one of the most variable, of the American Lymnaeas. The spire may be long or short, pointed or wide, and strongly shouldered. The whorls may be slender, scalar or wide and corpulent, while the aperture varies from almost round to long and narrow. The umbilicus may be rather widely open or it may be reduced to a minute chink, depending upon whether the inner lip is closely appressed to the axis or is raised over the umbilical region. Imperforate specimens are, however, very rare. The fine spiral sculpture can only be seen when the shell is examined with the aid of a powerful lens; in some specimens these lines are very distinct, while in others they are scarcely discernable. Typically, *obrussa* may be known by its pointed spire, compressed body whorl and elongated and shouldered aperture, which is also strongly effuse at the anterior end; the inner lip is appressed to the body whorl about the middle of the aperture. The shape of the shell, of the aperture and of the inner lip is quite different from *modicella,* the shell being larger and more elongated, the last whorl not so convex; the aperture is longer and narrower and much more effuse, besides forming a distinct shoulder at its junction with the body whorl; the inner lip is more compressed in the middle where it joins the parietal wall. In shells of the same size, *modicella* has five whorls, while *obrussa* has four whorls; in form the young of *obrussa* somewhat approach *modicella.* The shell is, typically, much larger than *modicella, parva* and the other members of the *humilis* group. Within certain limits, *obrussa* is very easily recognized and need not be confounded with any other species.

The Wisconsin specimens are not as variable as are those from some other states and the shell here is more easily recognized than elsewhere. For further remarks on the variability

of the species and on its synonymy, see the Lymnaea Monograph mentioned.

Lea's *acuta* (Trans. Amer. Phil. Soc., V, p. 114, pl. 19, fig. 81, 1837) appears to be a recognizable variety, characterized by large size, long, acute, scalariform spire, and long, narrow aperture. Specimens of this form measuring 18 mm. in length, from Toledo, Ohio, have been collected by Mr. Calvin Goodrich. The type locality is in a pond 4 miles north of Philadelphia, Penn.

FOSSARIA OBRUSSA PENINSULAE (Walker)

Plate XVI, figure 6; plate XVIII, figures 25–29

Lymnaea desidiosa var. *peninsulae* WALKER, Nautilus, XXII, pp. 9, 163, pl. ii, fig. 7, 1908.

Galba obrussa peninsulae BAKER, Mon. Lymnaeidae, p. 283, pl. xxxii, figs. 1–6, 1911.

TYPE LOCALITY: Headwaters of the Union River, Ontonagan Co., Mich.

WISCONSIN RECORDS: None.

SHELL: Of good size, slender, elongated; periostracum yellowish or brownish horn; surface dull to shining, growth lines rather coarse and heavy, spiral lines faintly impressed on some specimens, very heavily impressed in others; whorls 6, very convex, body whorl subcylindrical, somewhat compressed; spire long and acute, subturreted to turreted; sutures deeply impressed; aperture oval, not notably expanded; outer lip thin; inner lip narrowly reflected forming a triangular expansion, narrow and erect at the lower part of the aperture, wide and flatly appressed to the parietal wall at the upper part; umbilical chink very narrow.

L. 13.5; D. 6.2; Ap. L. 7.0; D. 3.1 mm.	Type.	
L. 12.0; D. 5.0; Ap. L. 6.0; D. 3.0 mm.	Salmo	(U. of W., 4717).
L. 13.5; D. 5.9; Ap. L. 6.5; D. 3.9 mm.	"	"
L. 13.1; D. 5.5; Ap. L. 6.0; D. 3.5 mm.	"	"
L. 8.9; D. 4.1; Ap. L. 4.8; D. 2.0 mm.	"	"

ANIMAL: As in *obrussa.*

GENITALIA: Similar to *obrussa.* The retractor muscle of the praeputium differs in being much larger, fan-shaped, with numerous branches at either end.

JAW and RADULA: As in *obrussa.*

ECOLOGY: Occurs quite numerously in the rock pools of the middle beach (Walker and Ruthven, Lake Superior). In Bayfield County, near Lake Superior, this variety is found in a small creek, on rocks in a rapid current and in small falls. It was also found in a small, rapid stream which was the outlet from the hatchery ponds at Salmo. The variety appears to be typically an inhabitant of rapid water or of shores where the waves cause more or less movement of the water.

DISTRIBUTION: Northern Maine west to Wisconsin; in Wisconsin and Michigan found in streams flowing into Lake Superior.

DISTRIBUTION IN WISCONSIN: Known only from the Bayfield peninsula in streams flowing into Lake Superior.

Outlet of hatchery ponds, Salmo, south of Bayfield; Chicago Creek, north of Bayfield; pond behind beach near Bayfield; all Bayfield Co. (Baker).

REMARKS: This variety differs from typical *obrussa* in being more slender, with a longer, more turreted spire, deeper sutures and a more oval aperture. The body whorl is more cylindrical than in the typical form. Mr. Walker says: "It is apparently characteristic of the small rivers tributary to Lake Superior. With the exception of a few specimens from Sault Ste. Marie, the typical form has not been as yet found in the upper peninsula at all. As a characteristic local form of a large region, it seems worthy of a name."

The Chicago Creek specimens are rather more typical, Salmo specimens having a more effuse aperture than is usual in typical *peninsulae*. All belong to the same form of shell, however, the variation, as would be expected, being in the direction of the *obrussa* form of shell. *Peninsulae* probably inhabits most of the northern part of Wisconsin bordering Lake Superior. No typical *obrussa* have been seen from this part of the state.

FOSSARIA OBRUSSA DECAMPI (Streng)

Plate XVIII, figures 30–33; plate XVI, figure 12

Limnaea desidiosa var. *decampi* STRENG, Nautilus, IX, p. 123, text fig., 1906.

Galba obrussa decampi BAKER, Mon. Lymnaeidae, p. 289, pl. xxxii, figs. 15–22, 1911.

TYPE LOCALITY: Brook's Lake, Newaygo Co., Mich.

WISCONSIN RECORDS:

1911c. *Galba obrussa decampi* BAKER, p. 291. Milwaukee (fossil).
1920d. *Galba obrussa decampi* BAKER, p. 120. Milwaukee (fossil).

SHELL: Small, oblong or subfusiform, somewhat inflated, subconic, rather solid; periostracum pale horn; surface rather dull, growth lines distinct but not coarse, spiral striation generally absent; whorls 5, rather rapidly enlarging, the spire whorls convex, and distinctly shouldered near the suture, the body whorl very much flattened in the middle; spire short, broadly conic, turreted, about as long as the aperture; nuclear whorls as in *obrussa;* sutures deeply impressed, forming a distinct shoulder; aperture very long and narrow, somewhat elliptical, rounded below and forming a prominent shoulder at the upper part; inner lip narrowly reflected, forming an expansion which is not much compressed at its junction with the parietal wall; the lower part of the inner lip stands quite erect; umbilical chink large and conspicuous, emargined by the inner lip.

L. 12.0; D. 6.0; Ap. L. 7.0; D. 3.5 mm.	Silver Lake (U. of I., Z22515).
L. 11.5; D. 5.5; Ap. L. 6.0; D. 3.0 mm.	" " " "
L. 9.5; D. 5.0; Ap. L. 5.0; D. 2.5 mm.	Spring Lake (U. of W., 4718).
L. 8.1; D. 4.2; Ap. L. 4.0; D. 2.0 mm.	" "
L. 9.0; D. 4.8; Ap. L. 4.5; D. 2.1 mm.	" "
L. 7.5; D. 4.0; Ap. L. 4.0; D. 2.1 mm.	" "

ANIMAL, JAW, RADULA, GENITALIA: Unknown.

ECOLOGY: The habitat of *decampi* is probably the same as that of *obrussa.*

DISTRIBUTION: Maine west to Wisconsin, northern Michigan south to northern Illinois.

DISTRIBUTION IN WISCONSIN: Known only as a fossil in Wisconsin and confined to the eastern part of the State.

Rock Drainage: Lake Wingra, near Madison, Dane Co. (Bullock); Oconomowoc, Silver, Dutchmans, Golden, La Belle lakes, Waukesha Co. (Cahn).

Wisconsin Drainage: Upper Goshen Lake, Vilas Co. (Juday).

Fox Drainage: Green Lake, Green Lake Co., 39.5 and 47.5 meters, in marl deposit; Spring Lake, near Green Lake, in shallow marl deposit (Baker, Juday).

Lake Michigan Drainage: Milwaukee, Milwaukee Co., marl deposit near Bay View (Baker, Slocum); Canal between Sturgeon Bay and Lake Michigan, Door Co. (Baker).

REMARKS: *Decampi* is a very distinct and characteristic variety of *obrussa,* known at once by its strongly shouldered whorls and the peculiar manner in which the outer lip is arched at its junction with the body whorl. It appears to be one of the most common of the Pleistocene species and no doubt lived, with *galbana,* in the more or less icy waters of Post-glacial time. Small specimens may be confused with *galbana,* but that species does not have the elongate aperture nor the distinctly shouldered whorls of *decampi,* the aperture being rounder and the shell much heavier and more robust in *galbana. Decampi* varies greatly in the comparative height of the spire; examples from the same locality will embrace individuals with a long, slender spire and with a short, dome-shaped spire. Though common as a Pleistocene fossil, no living specimens of this variety have been recorded from the State.

FOSSARIA EXIGUA (Lea)

Plate XVI, figure 9; plate XVIII, figures 34–37

Lymnea exigua LEA, Proc. Amer. Phil. Soc., II, p. 33, 1841; BINNEY, L. & F–W. Sh. N. A., II, p. 65, fig. 105, 1865.

Galba obrussa exigua BAKER, Mon. Lymnaeidae, p. 285, pl. xxxii, figs. 7–14, 1911.

Lymnea plica LEA, Op. Cit., p. 33, 1841; BINNEY, Op. Cit., p. 65, fig. 103, 1865.

Limnaea plicatula D'URBAN, Geol. Surv. Can., Rep. Prog., p. 242, 1859.

Lymnea planulata LEA, Op. Cit., p. 33, 1841; BINNEY, Op. Cit., p. 65, fig. 104, 1865.

TYPE LOCALITY: *Plica,* Tennessee; *planulata,* White Sulphur Springs, West Virginia; *exigua,* Tennessee.

WISCONSIN RECORDS:

1911c. *Galba obrussa exigua* BAKER, p. 288. Milwaukee (fossil).

1924. *Galba obrussa* BAKER, p. 136. Small stream near Lake Butte des Morts.

1924. *Galba obrussa exigua* BAKER, p. 136. Pond in Tyrrell's gravel pit.

SHELL: Small, turreted, subfusiform, generally narrow; surface dull to shining, growth lines coarse, elevated, crowded; spiral lines sometimes present; whorls 5, generally well rounded, slowly increasing in diameter; spire wide, elevated, turreted, generally longer than the aperture; nuclear whorls as in *obrussa;* sutures deeply impressed; body whorl generally

compressed, subcylindrical; aperture ovate to elliptical, slightly effuse; outer lip thin; inner lip narrow, tightly appressed at its junction with the parietal wall, the lower part erect or turned upward; umbilical chink very small, frequently entirely closed.

L. 9.1; D. 4.2; Ap. L. 4.1; D. 1.7 mm.	Type *plica.*
L. 10.7; D. 5.0; Ap. L. 5.7; D. 2.3 mm.	Sturgeon Bay (U. of W., 4720).
L. 10.7; D. 5.0; Ap. L. 5.2; D. 2.3 mm.	" " " "
L. 9.0; D. 4.0; Ap. L. 4.7; D. 2.0 mm.	Tyrrell's pond (U. of W., 4719).
L. 8.2; D. 4.0; Ap. L. 3.9; D. 2.0 mm.	" " " "

ANIMAL: Similar to *obrussa.*

GENITALIA: In all respects like *obrussa.* There are two posterior and two anterior protractor muscles of the praeputium.

JAW: As in *obrussa.*

RADULA (Fig. 135): Formula: $\frac{18}{4-7}+\frac{1}{4}+\frac{6}{3}+\frac{1}{1}+\frac{6}{3}+\frac{1}{4}+\frac{18}{4-7}$ (25–1–25); central tooth like that of *obrussa;* lateral teeth tricuspid, the reflection quite broad, the entocone small, the mesocone very large and the ectocone small; the laterals become narrower at the third tooth, the entocone approaching the

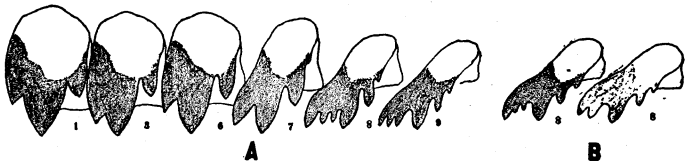


Fig. 135. Radula of *Fossaria exigua.* A, Normal; B, Variation in First Marginal.

distal end; the seventh tooth is intermediate, the entocone becoming larger, so that it and the mesocone are subequal in size; the true marginals begin at the eighth tooth and are claw-like. The eighth tooth varies somewhat in the form of the denticulations. (See fig. 135.) There are over sixty rows of teeth.

The radula of *exigua* differs from that of *obrussa* in having the marginals begin on the seventh instead of the eleventh tooth.

ECOLOGY: In bayous, small ponds, lakes and streams, and the protected shores of rivers, on mud flats and in situations similar to those in which *Fossaria modicella* lives. In Illinois the species is generally found in ditches and on the

margins of small lakes. In New York it is found in swampy places and on the protected shores of lakes and bays.

Very heavy specimens were found in Sturgeon Bay, near the city, in water 2 m. deep, on a sand bottom. In an artificial pond in Tyrrell's gravel pit the species was found near shore on a stony bottom in shallow water.

DISTRIBUTION: Maine west to Iowa and Minnesota, northern Michigan south to Tennessee.

DISTRIBUTION IN WISCONSIN: At present known only from the eastern part of the State.

Green Lake Drainage: Sturgeon Bay, Door Co. (Baker).

Fox Drainage: Pond and stream near Lake Butte des Morts, Winnebago Co. (Baker); pond near west end Green Lake, Green Lake Co. (Baker).

Lake Michigan Drainage: Milwaukee, Milwaukee Co. (Baker, Slocum, fossil).

Rock Drainage: Tributary stream to Ashippun River, Waukesha Co. (Cahn).

REMARKS: This small species appears quite separable from *obrussa.* The spire is usually long and the whorls flatly rounded, the body whorl more or less compressed; the most noteworthy feature appears to be the very deep suture, which is almost channelled in some specimens, causing the whorls to be turban-shaped. This feature is present in the majority of the specimens examined. The aperture is also more regularly ovate than in *obrussa,* and the inner lip is peculiarly flattened near the umbilical region, giving rise to a pseudo-plait. Some specimens resemble *modicella rustica,* but in that race the spire is acutely conical, the whorls regularly increase in size, the body whorl is not compressed in the middle, and the aperture is roundly ovate, while in *exigua* the spire is broadly turreted, the whorls are more or less disproportionate in size and the body whorl is very cylindrical. Sturgeon Bay specimens are very thick.

In the Lymnaeidae Monograph, this form is considered a race of *obrussa.* Further consideration has led to the belief that it should rank as a distinct species. The form of the shell is quite different and the radula differs notably in the smaller number of lateral teeth (6), *obrussa* having ten laterals. *Exigua* is not common in Wisconsin, judging by the small number of references in the collections examined.

FOSSARIA GALBANA (Say)

Plate XVI, figure 13; plate XVIII, figures 40–42

Lymnaeus galbanus SAY, Journ. Phil. Acad., V, p. 123, 1825; BINNEY, L. & F–W. Sh. N. A., II, p. 72, fig. 117, 1865.

Galba galbana BAKER, Mon. Lymnaeidae, p. 291, pl. xxxii, figs. 25, 27, 1911.

TYPE LOCALITY: Marl pit near Franklin, N. J.

WISCONSIN RECORDS: None.

SHELL: Small, subovate, rather inflated, thick; surface shining, growth lines coarse, prominent, without spiral lines; whorls 5, convex, roundly shouldered, rapidly increasing in diameter, the body whorl very large and somewhat flattened on the periphery; nucleus small, flatly rounded, similar in form to that of *obrussa;* spire usually short, broadly acutely conical, generally occupying about half the length of the shell; sutures deeply impressed; aperture ovate, generally rounded above and below; outer lip simple, acute; inner lip erect, forming a rather broad, flat reflection over the umbilical region which emargins the umbilial chink and which is without plait-like thickening; there is a rather thick callus on the parietal wall; umbilical chink narrowly open.

L. 8.0; D. 4.5; Ap. L. 4.2; D. 2.0 mm.	Say's type.	
L. 6.5; D. 4.0; Ap. L. 4.0; D. 2.1 mm.	Milwaukee (Baker coll., 199).	
L. 6.0; D. 3.5; Ap. L. 3.1; D. 2.0 mm.	"	"
L. 5.0; D. 3.0; Ap. L. 2.8; D. 1.5 mm.	"	"

ANIMAL, JAW, RADULA, GENITALIA: Unknown.

ECOLOGY: Possibly a lake or pond species.

DISTRIBUTION: New Jersey west to Wisconsin. The distribution of the fossil form is insufficiently known.

DISTRIBUTION IN WISCONSIN: At present known only as a fossil from marl beds near Milwaukee at Bay View (Baker, Slocum).

REMARKS: *Galbana* is very little understood among conchologists, probably on account of its being described as a fossil. It is very common in many localities, has a wide range and is remarkably uniform. It has been mistaken for both *Galba humilis* and *Galba modicella,* but it is a shell of a quite different shape. *Obrussa decampi* has a superficial resemblance, but is a much narrower shell with elongated aperture and squarely

shouldered whorls, besides being much larger than *galbana.* The inner lip is also differently appressed than in either *humilis, modicella,* or *decampi. Galbana* may be known by its swollen and somewhat shouldered last whorl, its short, generally dome-shaped spire, its deep sutures and its broadly reflected inner lip which emargins the umbilical chink. The spire varies somewhat in height, as does also the aperture.

Like its congener, *Fossaria obrussa decampi, galbana* lived in the cold waters of Pleistocene times. There is good reason to believe that the species is now extinct, recent forms referred to it being characteristic of another species.

FOSSARIA SAYI Sp. Nov.

Plate XVIII, figures 38, 39

Galba galbana BAKER, Mon. Lymn., p. 291 (part), pl. xxxii, figs. 23, 24, 28–36, 1911.

Lymnaea galbana, part, of authors.

TYPE LOCALITY: Squaw Island, near Buffalo, N. Y.

WISCONSIN RECORDS: None.

SHELL: Elongate-ovate, very thick; periostracum whitish or yellowish, sometimes spermaceti-like; surface shining, often malleated, lines of growth very coarse, without spiral lines; whorls about 5, flatly convex, body whorl very large, somewhat shouldered at the upper part, much flattened at the periphery; nucleus dark colored, like *obrussa* in form; spire as long as or shorter than aperture, rather acute; sutures impressed; aperture elongate-ovate, broadly rounded and effuse below, narrowly rounded above; outer lip simple on the edge but thickened within, especially at the upper part; inner lip rather thick, broadly reflected over the umbilical region, either closing the umbilicus or leaving a very small chink; a more or less heavy callus on the parietal wall produces an entire aperture in some specimens; the columella is nearly straight and is appressed in the middle to form a pseudo-plait in many specimens.

L. 8.0; D. 4.9; Ap. L. 4.1; D. 2.2 mm. Squaw Island (Baker coll., 270). Type.

L. 7.8; D. 4.0; Ap. L. 5.0; D. 2.0 mm. Squaw Island (Baker coll., 270). Paratype.

L. 7.9; D. 4.1; Ap. L. 4.1; D. 2.0 mm. Squaw Island (Baker coll., 270). Paratype.
L. 7.1; D. 4.0; Ap. L. 4.0; D. 1.6 mm. Squaw Island (Baker coll., 270). Paratype.
L. 7.0; D. 4.0; Ap. L. 4.2; D. 1.6 mm. Squaw Island (Baker coll., 270). Paratype.
L. 10.0; D. 5.0; Ap. L. 5.5; D. 2.7 mm. Squaw Island (Chi. Acad. Sci., 23313).

ANIMAL: Not examined.

DISTRIBUTION: Great Lake region; New York to Michigan; Ontario.

DISTRIBUTION IN WISCONSIN: Not yet reported from this State but it should be found somewhere on the Lake Michigan side.

REMARKS: *Fossaria sayi* differs from *galbana* in its more solid shell, less deeply impressed sutures, hence less rounded whorls, which are higher in proportion to width than in *galbana,* the narrower and more compressed body whorl, the longer aperture which is more effuse at the lower part, and the more tightly appressed inner lip which forms a pseudo-plait near the parietal wall. The umbilical chink is also narrower and often closed. The spire is more acute than in *galbana.*

A restudy of additional material from White Pond, N. J., as well as from other Pleistocene deposits, has convinced the writer that the shells of the recent fauna referred to *galbana* are another species. As far as material has been examined, *galbana* appears to be an extinct species. The form herein called *sayi* may well be the descendant of the Pleistocene shell but the two have diverged so far at the present time as to constitute two recognizable forms. *Sayi* appears to be a species of the Great Lakes and their bays and connecting waters. The Squaw Island specimens were collected by Miss Mary Walker of Buffalo, N. Y.

Family PLANORBIDAE H. and A. Adams, 1855

See Baker, Trans. Wis. Acad. Arts, Sci., Lett., XXII, p. 200, 1926.

Shell discoidal, ultra-dextral or ultra-sinistral, or physoid. Animal (fig. 136) sinistral, having the pulmonary, genital, and excretory orifices on the left side. Tentacles long and slender, cylindrical, the eyes placed at their inner base. Head

with large vela area. Genitalia variable, but always consisting of a praeputium and a penis sheath in the male system; there is no epiphallus. Jaw in three segments, the superior large, the lateral narrow, very long. Radula with a comparatively small number of teeth in a straight, horizontal row; center tooth bicuspid, lateral teeth large, bi- or tricuspid, marginals long and narrow, multicuspid. There is a large secondary branchia (pseudobranch) on the left side which is highly vascular. The digestive system includes a rather short

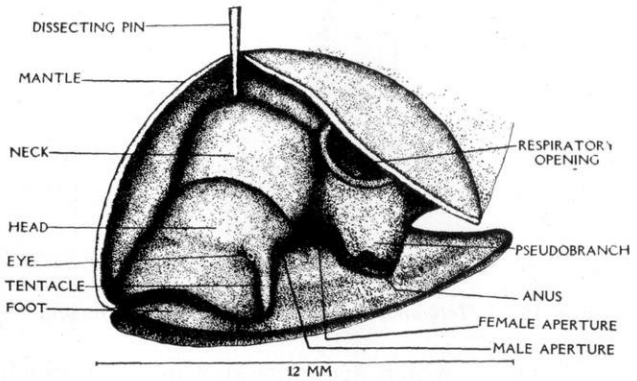


Fig. 136. Animal of *Helisoma trivolvis*. Lake Chetek.

oesophagus, and an elongated, pyriform, combined crop, gizzard, and stomach, which differ from both Physidae and Lymnaeidae in form. (Fig. 137.) The blood or haemolymph is red.

The Planorbis-like snails have suffered some vicissitudes at the hands of nomenclaturists. The group was originally included with *Lymnaea, Physa,* and other fresh water pulmonates. Some of these have been separated from time to time, as the differences in the structure of the animal have been ascertained. As the group now stands it includes the Planorbinae (the discoidal species), the Pompholaginae (large dextral shells with large aperture), and the Bulininae (shells with Physoid aspect).

The Pompholaginae appear somewhat different from the other groups assigned to the Planorbidae and it might be separated as a family Pompholagidae, differing in shell, genitalia, and somewhat in radula and jaw. The genitalia are not sufficiently well described for comparison with the other groups.

The division of the family into groups is met with some difficulties, the shell characters being relatively uniform. The male organ of the genitalia afford good characters of generic importance, two of which appear to divide the family into two sections. Simroth (1912, p. 502) has recognized four principal

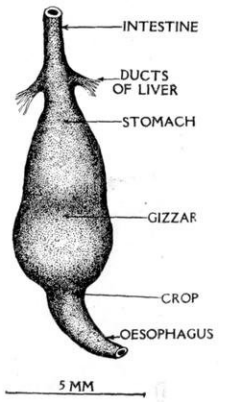


Fig. 137. *Helisoma trivolvis.* Region of Stomach.

types of male organ which are quite distinct and which would seem to indicate as many genera. Annandale has added a fifth and the writer would add still another. The five types as outlined by Annandale are as follows: The examples are the authors (see fig. 138).

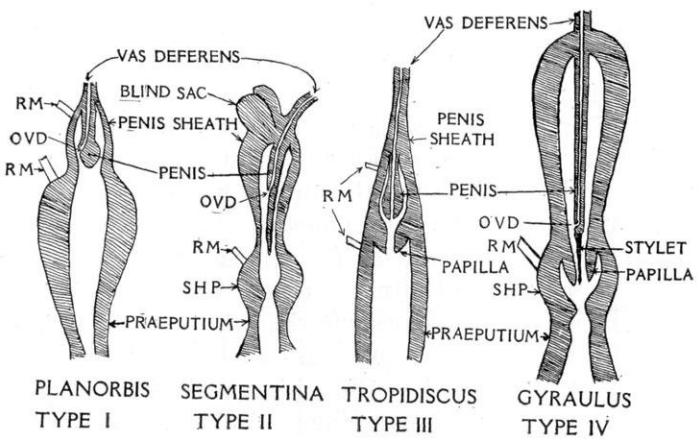


Fig. 138. Types of Male Organ of Planorbidae. After Simroth. SHP, swollen head of praeputium; OVD, opening of vas deferens; RM, retractor muscle.

Type I. Penis short, bulbous, asymmetrical, without a penis stylet, with an elongate, thick-walled praeputium. Sheath with two retractor muscles (*Iantha, Planorbis,* not found in America).

Type II. Penis slender, elongate, asymmetrical at the tip, with a comparatively short, thick-walled praeputium, without a penial stylet. Sheath with a pair of ear-like processes above, with a single retractor muscle (*Segmentina, Planorbula,* found in America).

Type III. Penis cylindrical, symmetrical, without a penial stylet, with a short, thin-walled but well differentiated praeputium and two retractor muscles (*Tropidiscus,* not in America).

Type IV. Penis cylindrical, but asymmetrical at the tip, with a horny stilet and a praeputium of complex structure. Sheath with a single retractor muscle (*Spiralina, Gyraulus,* found in America).

Type V. As in type III, but without differentiated praeputium and with a penis very long and sometimes coiled in the sheath (*Hippeutis, Indoplanorbis,* not found in America).

Type VI. Penis cylindrical, elongated, asymmetrical, without horny penial stylet, with a large, elongated praeputium, thick-walled, and with a penial gland at the upper part of the praeputium which is connected with the penis sheath by a long, tube-like duct. There are two retractors (*Helisoma,* found only in America).

The family may be divisible into subfamily groups based on the characteristics of the male organ, but not enough data is at hand for this purpose. Should the differences indicated under Helisoma prove constant after an examination of other species and genera, this group of American planorbes might be separated as a subfamily Helisominae, the distinguishing character being the peculiar gland and its duct.

Key to Genera of Wisconsin Planorbidae

1. Shell small, ultra-dextral; much depressed, with carinate or subcarinate periphery; penis sheath longer than praeputium, which is regularly cylindrical; penis with horny stylet; jaw made up of many small plates; radula with long base of attachment, reaching below margin of cusps, laterals bi- or tricuspid ---------- *Gyraulus*

2. Shell small, ultra-dextral, depressed, acutely carinate on the periphery; penis sheath longer than praeputium which is short and widely pyriform; radula and jaw as in *Gyraulus* ----------*Menetus*
3. Shell small, ultra-dextral, with rounded periphery; interior of aperture armed with several lamellae; penis-sheath shorter than praeputium, the latter with a gland, but no duct; no stylet on penis; jaw in three pieces, a large superior, and two long and narrow lateral; radula with tricuspid teeth, the base of attachment about as long as the cusps in the laterals, shorter in the marginals ----------*Planorbula*
4. Shell large, ultra-sinistral, with a deep umbilicus and sunken spire; penis sheath usually shorter than praeputium, the latter with a large gland and a long duct; penis without stylet; jaw with large superior and small lateral pieces; radula with tricuspid laterals, the base of attachment shorter than the cusps ----------*Helisoma*

Typical *Planorbis* is not found in America. Haldeman's *Planorbina* is not known anatomically, and hence its status is uncertain. The shells bear some resemblance to the large *Planorbis corneus* of Europe. The type of the genus *Planorbis* is in some dispute, Dall (1905, p. 84) assigns the *Helix cornea* of Linn. as type, citing Montfort, 1810, as the first author to designate a type of Müller's genus *Planorbis*. Some English authors (see Kennard and Woodward, 1924, p. 9), however, give the name to Geoffroy, a non-binomial author, who cites *Helix planorbis* Linn. as the type. It is also contended that this species is also the type, by tautonomy, of *Planorbis* Müller, that species being listed by Müller among the names assigned to the genus. It would appear, after reviewing all the evidence (and if Geoffroy be considered non-binomial) that the rules of the International Code are best subserved by following Dall's contention that Montfort properly selected the type of *Planorbis* Müller, the *Helix cornea*, in 1810. This is also the conclusion of Pilsbry, 1927, p. 115.

Typical *Planorbis* differs from any American species in the shape of the male generative organs (see fig. 138) and particularly in the radula which has bicuspid laterals with the formula 33–1–33, a much larger number of teeth than in any American species yet examined. Its distribution includes Europe, Africa, including Madagascar, and Asia.

Genus HELISOMA, Swainson, 1840

Helisoma SWAINSON, Malac., p. 337, 1840. Type: *Planorbis bicarinatus* SOWERBY. Probably = *bicarinatus* Say (*antrosus* Conrad). Dall (1905, p. 84) has no doubt but that the *bicarinatus* of Sowerby and Say are identical. Binney (1865, p. 124) says that it "appears to be identical with *Planorbis campanulatus*. The figures look like *bicarinatus*.

Shell ultra-sinistral, few whorled, the whorls carinate above and often below, and rapidly enlarging; base funicular; aperture suddenly expanding and thickened; shell carried perpendicularly, not at a sharp angle (fig. 139). Genitalia (fig. 140): female system, ovotestis long and narrow, lobulated; hermaphrodite duct very long, much lobulated in front of the ovotestis,

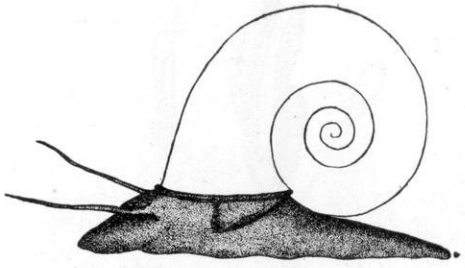


Fig. 139. Animal of *Helisoma trivolvis*. Beach Pond, Bayfield.

the lower, simpler portion of duct very long, much longer than in *Physella* or *Lymnaea;* albumen gland large, broadly triangular in shape, its duct very short, entering the spermoviduct; the oviduct is long and narrow, enlarging about the center and enveloped by the large nidamental gland; lower part of oviduct forming the vagina, a thick-walled tube of small diameter; the spermatheca is narrowly pyriform, at the end of a narrow duct of varying length in the different species; the duct enters the lower part of the vagina near the external female orifice.

Male system: the prostate is placed about midway of a long duct, the upper part narrow and ribbon-like joining the oviduct just below the albumen gland; the prostate is elongated, somewhat cylindrical and much lobulated; the vas deferens is long, narrow and tube-like, enters the muscular tissue of the body wall near the female external opening, and emerges again near the male opening. The male organ consists of a pyriform

praeputium and a slender penis sheath* which may be placed at one side of the summit of the praeputium or about the center of one side. In the first type there are two retractor muscles but in the last type but one retractor, apparently. In the upper part of the praeputium there is a large gland-like organ, placed in a swelling of the praeputium, and connecting this gland with the base of the penis sheath (externally) there is a rather long

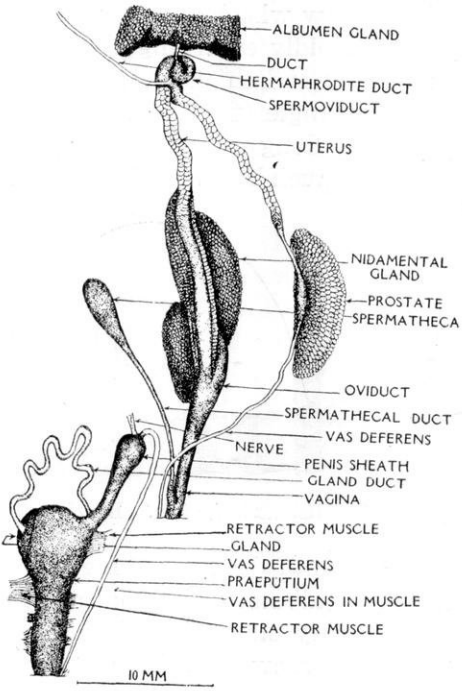


Fig. 140. Genitalia of *Helisoma trivolvis*. Beach Pond, Bayfield.

tube about the size of the vas deferens. The gland is highly muscular, more or less contractile and exhibits at its lower part, facing the inner cavity of the praeputium, a series of lobes projecting into a central cavity (see C, D, fig. 145). What may be the function of this gland is not apparent, but it may be a modified flagellum and the gland may secrete a sheath for the spermatophore, as in some land shells and in *Bulimus*. In the latter

* The terminology of the male organ is modified from that of Simroth (1912, p. 502). The schwellkorper is here designated the penis sheath, since it covers the real male organ, the penis.

genus the flagellum is semi-independent, as seems to be the case in *Helisoma.* The gland without the duct is present in *Planorbula,* and this genus may indicate a relationship with *Physa,* on the praeputium of which there is a large, ductless gland.

The penis is situated in the penis sheath and is elongate-pyriform or cylindrical in shape, symmetrical, the opening of the vas deferens being at the lower end in the center of the penis. In the normal condition the penis extends in the penis sheath about to the opening of the duct of the gland, below which the sheath is slightly contracted. The diagrams in figure 145 show these features and the relation to the gland in the praeputium. See also fig. 147, B.

The egg capsules of *Helisoma* are more leathery than those of the Lymnaeids and contain a smaller number of eggs. They are laid on vegetation of various kinds. A single capsule of *Helisoma truncata* from Winnebago Lake measured 11 by 5 mm. and was laid on a leaf of *Castalia odorata.* It was oval in form, quite firmly attached to the leaf, and contained 21 embryos almost ready to be hatched, the shells being fully formed. This was in August (see fig. 24, pl. XXII).

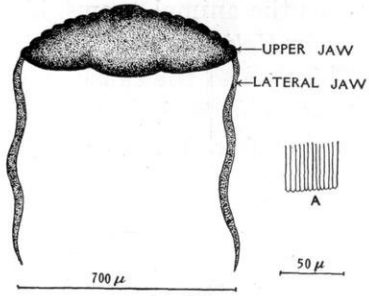


Fig. 141. Jaws of *Helisoma trivolvis.* Devils Lake. A, vertical striation and cutting edge of jaw.

The jaws consist of a large superior jaw, which may be horizontal and elongately ovate or roundly arched; it is heavily, minutely striated on the face producing a roughly serrate cutting edge (see fig. 141 showing vertical striations). There are two very narrow lateral jaws which are ribbon-like and are attached to the superior jaw at the lateral angles.

The radula is made up of horizontal rows of comparatively few teeth (18 to 23 on each side); the center tooth is rather wide (wider than in *Lymnaea*), is bicuspid, the cusps sharply

triangular, and the large base of attachment is lobed at the lower outer corners. The lateral teeth are few in number (6–8) wide, tricuspid, the mesocone usually larger and longer than the endocone or ectocone; the base of attachment is wide, but shorter than the reflected portion. The marginal teeth are at first like the laterals, the ectocone splitting into one or more cusps; later, they become more elongated, the endocone and ectocone splitting into smaller cusps, but the mesocone remaining unchanged except for a reduction in size; the base of attachment becomes correspondingly smaller toward the edge of the membrane. There are between 100 and 200 rows of teeth on a membrane (see fig. 144).

The shells of the Planorbis group have been variously described as sinistral or dextral. The animals of all species are sinistral. The large species *(Helisoma)* are all sinistral, as may be seen by examining a young snail which plainly indicates the position of the spire. The habit of carrying the shell in a perpendicular position induces a discoidal growth, and the right or left handedness of the shell is dependent upon which way the shell leans as the animal grows, if to the right, it will be ultra-sinistral, as in *Helisoma,* or if to the left ultra-dextral, as in *Gyraulus.* This is also the cause of many monstrosities. The figure of a young *Helisoma trivolvis* indicates the sinistral character of this genus (fig. 142). See Baker, 1896, Taylor, Mon., p. 111).

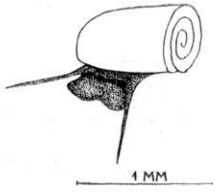


Fig. 142. *Helisoma trivolvis.* Young.

The genus *Helisoma* includes the large American planorbes, which differ from all other species yet examined by the presence of the peculiar gland on the male system. The genus is divisible into several smaller groups, based principally on differences in the genitalia.

KEY TO SPECIES OF HELISOMA

1. a. Adult shell ultra-sinistral, basal whorls regularly wound, not funicular, umbilicus small ---------- 2
   b. Adult shell ultra-dextral, base strikingly funicular, umbilicus wide and deep ---------- 11
2. a. Aperture but slightly expanded in adult shells, not campanulate ---------- 3
   b. Aperture campanulate in adult shells ---------- 7
3. a. Surface with heavy spiral lines forming latticed effect---- ----------*truncata*
   b. Surface without marked spiral lines ---------- 4
4. a. Adult shell large, exceeding 20 mm. in greatest diameter, base of whorls rounded ---------- 5
   b. Adult shell less than 20 mm. in greatest diameter, base of whorls sharply carinated ----------*winslowi*
5. a. Aperture with outer lip slightly expanded in adult shells, 2½–3 whorls showing on base ---------- 6
   b. Aperture with outer lip not expanded in adult shells, base with all whorls in same plane, 3½ whorls visible-------- ----------*pseudotrivolvis*
6. a. Three full whorls visible on base, umbilical region broad and shallow, height about 40% of diameter----------*trivolvis*
   b. Two and a half whorls visible on base, umbilical region deeply excavated, height about 50% of diameter------*pilsbryi*
7. a. Base with 2½ whorls visible, penultimate whorl rapidly decreasing in diameter in the umbilicus----------*campanulata*
   b. Base with 3½–4 whorls visible, whorls regularly and gradually decreasing in diameter in umbilicus ---------- 8
8. a. Axial height 7–8 mm., growth lines coarse, rib-like, spire whorls elevated above body whorl ----------*wisconsinensis*
   b. Axial height 5–6½ mm., growth lines fine, spire whorls coiled in same plane ---------- 9
10. a. Base with four full whorls visible, all regularly coiled, and gradually disappearing in umbilicus ----------*davisi*
    b. Base with three full whorls visible, the penultimate whorl rapidly decreasing in diameter in the umbilicus-------*ferrissi*
11. a. Width of umbilicus 50% of greatest diameter, spiral lines usually faint or absent; whorls sharply carinated ------ 12
    b. Width of umbilicus 40–45% of greatest diameter, spiral lines usually well developed; whorls rounded or carinated ---- 13
12. a. Adult shell 13 mm. or less in diameter, growth lines fine ----------*antrosa*
    b. Adult shell more than 15 mm. in diameter, growth lines coarse ----------*pericarinata*
13. a. Height of aperture about 70% of greatest diameter, notably raised above body whorl ---------- 14
    b. Height of aperture 60% of greatest diameter, not notably raised above body whorl ---------- 15

14. a. Maximum diameter of shell 14 mm., dorsal carina near center of whorl; body whorl rounded ---------- *shellensis*
    b. Maximum diameter of shell 18 mm., dorsal carina near outer edge of shell; body whorl flattened ---------- *cahni*
15. a. Whorls strongly carinated, often corded ---------- 16
    b. Whorls rounded, only slightly subcarinated ---------- *unicarinata*
16. a. Adult shell 13 mm. or more in diameter, dorsal carina near outer margin of body whorl ---------- *sayi*
    b. Adult shell 11 mm. or less in diameter, dorsal carina in middle of body whorl ---------- *striata*

KEY TO GROUPS OF HELISOMA

1. Shell ultra-dextral, carinated above and below, spire and base funicular; male system with short, thick penis sheath, placed at top or to one side of the summit of praeputium---------- *Helisoma*, ss.
2. Shell ultra-sinistral, early whorls flattened and carinate above, funicular below; male system with long, slender penis sheath, placed at top, and to one side, of preputium--- *Pierosoma*
3. Shell ultra-sinistral, whorls narrower than 1 or 2, apex not markedly depressed below the level of body whorl; base funicular; body whorl constricted behind aperture, which is campanulate; male system with slender penis sheath which is attached at top and center of praeputium-- *Planorbella*

Subgenus HELISOMA Swainson, 1840. Typical

SHELL: Ultra-dextral, of medium size, few whorled, the whorls carinated above and below and rapidly enlarging; spire and base funicular, aperture suddenly expanding with a thickened peritreme. Male system with a large, pyriform praeputium and a short, thick penis sheath; the gland and duct as described for the genus, superior jaw arched with rounded ends; lateral jaws long and narrow; radula with tricuspid laterals, each cusp sharp and spade-shaped; marginals very long and narrow, multicuspid.

This group includes the large planorbes which appear to be dextral and have a deep umbilicus which is funicular or funnel-shaped. The shell is not carried perfectly perpendicular but leans toward the left side, hence causing the shell to become coiled dextrally. The animal, also, has a less auriculated or vela-shaped head than in *Pierosoma* and *Planorbella*.

HELISOMA ANTROSA (Conrad)

Plate XIX, figures 8–15

Planorbis bicarinatus SAY, Nich. Encyc., 1st Ed., II (no pagination), No. 2, pl. i, fig. 4, 1917 (not of Lamarck, 1804); HALDEMAN, Mon. VII, p. 6, pl. i, figs. 1–6, 1844; BINNEY, L. & F–W. Sh. N. A., II, p. 123, figs. 204, 205, 1865; WALKER, Nautilus, XXIII, p. 1, pl. i, fig. 3, 1909; VANATTA, Nautilus, XXIV, p. 136, 1911.

Planorbis antrosus CONRAD, Amer. Journ. Sci., (1), XXV, p. 343, 1834; BINNEY, Op. Cit., p. 125, 1865.

Planorbis engonatus CONRAD, N. F. W. Shells, Sup. p. 8, pl. ix, fig. 8, 1834; BINNEY, Op. Cit., p. 124, fig. 207, 1865.

TYPE LOCALITY: *Bicarinatus,* Delaware River; *antrosus,* Randons Creek, near Clairborbe, Ala.; *engonatus,* near Albany, N. Y.

WISCONSIN RECORDS:

1860. *Planorbis bicarinatus* LAPHAM, p. 155. Milwaukee.
1865. *Planorbis bicarinatus* BINNEY, p. 124. Milwaukee.
1897. *Planorbis bicarinatus* WISWALL, p. 48. So. Wisconsin.
1906. *Planorbis bicarinatus* CHADWICK, pp. 23, 83. Milwaukee and vicinity; Kenosha; Golden Lake.
1913b. *Planorbis bicarinatus* BAKER, p. 68. Near Waukesha.

SHELL: Ultra-dextral, discoidal, more or less angulated; color yellowish or brownish horn, sometimes dark brown, reddish, or greenish, surface shining; sculpture of irregular, oblique, strong, sometimes elevated, lines of growth, with more or less well-developed spiral lines; nucleus small, but visible at the base of the funicular depression forming the spire, of about one turn, the first part strongly punctate, the latter part striate or puncto-striate; whorls 3½, discoidal, more or less angulated above and below, the periphery rounded or flattened; spire exhibiting all of the volutions; sutures impressed; base of shell with a deep umbilical depression which exhibits all of the volutions; aperture lunately-ovate, bluntly rounded or v-shaped above, usually v-shaped below where it extends below the body whorl; the aperture usually forms a more or less bell-shaped enlargement, higher than wide, in fully mature individuals; outer lip acute, thin, expanded, thickened within by a bluish-white callus, and with a band of reddish-brown just back of the callus; parietal wall with a thin callus; interior of aperture whitish or brownish; sometimes there are two spiral bands within the aperture, where the superior and inferior carinations make a shoulder, and extend far within the aperture.

L. 6.1; D. 11.1; Ap. L. 5.7; D. 4.2 mm. Prairie Lake (U. of W., 4620).
L. 6.0; D. 10.5; Ap. L. 5.6; D. 4.0 mm. " "
L. 4.0; D. 7.0; Ap. L. 3.5; D. 2.1 mm. " "
L. 3.1; D. 4.1; Ap. L. 2.7; D. 1.2 mm. " "
L. 8.5; D. 15.0; Ap. L. 8.0; D. 5.5 mm. Dell Creek (U. of W., 4624).
L. 8.0; D. 17.5; Ap. L. 10.5; D. 6.5 mm. Chippewa Falls (U. of W., 4628).
L. 7.0; D. 12.0; Ap. L. 6.5; D. 4.0 mm. Shelby Co., Ala. (U. of I., Z18463).

ANIMAL: With a rather wide foot rounded before and behind; tentacles rather long and filiform, as long as or longer than the foot; head rounded and not as much auriculated as in *trivolvis;* color blackish, flecked with white on the foot and tentacles; pseudobranch large, blackish, flecked with white.

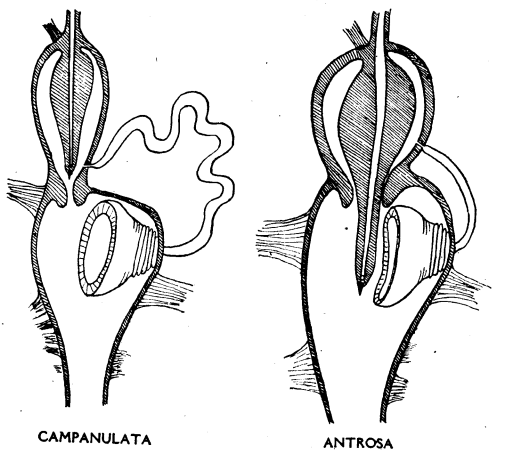


Fig. 143. Sections of Male Organ of *Helisoma.*

GENITALIA (Fig. 143): Female organs as in *trivolvis.* Male system with the penis sheath placed at the top of the praeputium; penis sheath very wide and short as compared with that of *trivolvis,* the width almost equalling the height. Praeputium pear-shaped, short and wide, the glandular portion forming a swelling near the summit. There is some variation in the form of the praeputium and penis sheath in *antrosus* from different localities. *Antrosus* is related by its genitalia to *trivolvis,* differing, however, in the great size of the penis sheath.

JAW: As in *campanulata.*

RADULA (Fig. 144): Formula 27–1–27 (18–3–6–1–6–3–18). Center tooth smaller than that of *trivolvis,* bicuspid; laterals (6) tricuspid, all cusps spade-shaped, the mesocone longer than the others; intermediate teeth (3) with the inner side of the endocone developing 1, 2, and 4 small denticles, the mesocone remaining as in the lateral teeth, but the ectocone becoming smaller; marginals very long and narrow, the mesocone as in the intermediate teeth, the endocone splitting up into 8 or 9 small denticles arranged on a plough-shaped projection, and the ectocone splitting into several small denticles. The base of attachment becomes smaller than in the laterals. The outer

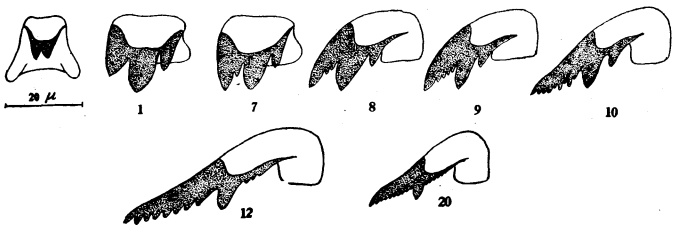


Fig. 144. Radula of *Helisoma antrosa.* Moose Ear Creek.

marginal teeth (20) are about half the length of the inner marginals, the endocone and ectocones becoming minutely serrated, the mesocone remaining as usual but is smaller.

In the Mollusca of the Chicago Area (p. 292) the formula is given as 30–1–30 with 21 marginals. The mesocone of the first lateral is shown too blunt in this figure (97). There are about 140 rows of teeth.

ECOLOGY: *Antrosa* is primarily a river and creek species, not living in the large lakes.

Conrad records it as living in a creek adhering to limestone rocks. In Illinois it is found in muddy creeks. In Chetek Lake it occurs on Castalia leaves in water 1 m. deep. In the Wisconsin River it lives along shore in shallow water on debris of various kinds.

DISTRIBUTION: *Antrosa* is found from Maine to Oregon and from Hudson Bay south to western Mexico (see Walker, Nautilus, XXIII, p. 21, for complete distribution). This includes the typical form and the varieties.

DISTRIBUTION IN WISCONSIN: Well distributed over the state, in rivers and streams, apparently in all drainages, excepting that of Lake Superior.

REMARKS: Vanatta has shown (1911, p. 138) that the name *Planorbis bicarinatus* was used by Lamarck in 1804 for a fossil from the Paris Basin which is now referred to the marine genus *Adeorbis*. This invalidates Say's name *Planorbis bicarinatus* given in 1817, according to the International Code. The next available name is Conrad's *antrosus*, published in 1834. The type specimens of *antrosus* are apparently not preserved in the Academy of Natural Sciences of Philadelphia, or elsewhere, and in their absence we must depend upon the description. This is as follows: "Shell dextral, not depressed; whorls three; spire profoundly indented or concave, with the summit of the body whorl angular; inner volutions angulated, umbilicus profound, with the margin and inner volutions angulated; body whorl abruptly dilated near the aperture; aperture longitudinally subovate, dilated". The type locality is in Alabama, in a creek, and it is to this kind of a locality that we must look for the character of shell indicated. A specimen in the Hinkley collection, from Farmer, Shelby Co., Alabama, seems to fit this diagnosis perfectly. Conrad gave no dimensions, but this specimen measures L. 7.0; D. 12.0; Ap. L. 6.5; D. 4.0 mm. The chief characteristics of the typical form are the evenly funnel-shaped spire depression, the sharply carinated dorsal border of the body whorl, the angulated basal margin of the wide umbilical depression, and the faint spiral striation. The spire depression is flat-sided and the sides converge to a common point at the bottom, without a flattening of the nuclear whorls, as in some of the varieties. The dilated aperture may occur in all of the varieties and is not of diagnostic value. *Antrosus* is a creek and river form, quite distinct from the lake forms which resemble it. It is apparently not completely synonymous with Say's *bicarinatus*, as will be shown under the next variety. This form of Planorbis is abundant in creeks and rivers in Illinois and Wisconsin, and similar forms have been seen from as far eastward as Massachusetts, westward to Minnesota and south to Alabama and Arkansas. In southeastern Wisconsin this form inhabits both rivers, creeks, and the small lakes.

HELISOMA ANTROSA UNICARINATA (Haldeman)

Plate XIX, figures 17–19

Planorbis bicarinatus var. *unicarinatus* HALDEMAN, Mon. p. 7, 1844; WALKER, Nautilus, XXIII, p. 3, pl. i, figs. 6–8, 1911.

Planorbis bicarinatus var. *angistomus* HALDEMAN, Mon. p. 7, 1844; WALKER, Nautilus, XXIII, p. 4, pl. i, figs. 4, 5, 1911.

Planorbis bicarinatus SAY, 1817, in part, at least.

TYPE LOCALITY: *Unicarinatus,* Schuylkill River, near Philadelphia, Pa.; *angistomus,* no type locality given, but probably from neighborhood of Philadelphia.

WISCONSIN RECORDS:

1911a. *Planorbis bicarinatus unicarinatus* BAKER, p. 236. Tomahawk Lake.

1918. *Planorbis bicarinatus* MUTTKOWSKI, p. 474. Lake Mendota.

SHELL: Differing from the type form in having the upper border of the body whorl either rounded or subangulated, never sharply angulated, the spire less depressed and the umbilicus narrower; spiral sculpture more or less well-developed under the periostracum.

L. 7.0; D. 12.0; Ap. L. 6.6; D. 4.0 mm. Moose Ear Creek (U. of W., 4623).

L. 7.0; D. 13.0; Ap. L. 6.7; D. 5.0 mm. Tomahawk Lake slough (Baker coll., 978).

L. 7.0; D. 12.5; Ap. L. 6.5; D. 4.8 mm. Delaware River (Baker coll., 1717).

ANIMAL: Exactly as in *antrosa.*

ECOLOGY: In Moose Ear Creek on rocks and sand bottom in rapid current, shallow water (.3 m.); Tomahawk Lake, muddy bottom of pond on sticks and other debris at mouth of creek; swampy pond near Saunder's Resort, shallow water, hard clay bottom.

DISTRIBUTION: Possibly the same as *antrosa;* seen from Connecticut and Philadelphia west to Wisconsin, south to Illinois.

DISTRIBUTION IN WISCONSIN: About as widely distributed as the typical form.

Chippewa Drainage: Moose Ear Creek, Barron Co. (Baker); Conrath, Rusk Co. Phillips, Price Co. (Bullock).

Black Drainage: Medford, Taylor Co. (Bullock).

Wisconsin Drainage: Tomahawk Lake, Oneida Co. Devils Lake, Sauk Co. (Baker).

Rock Drainage: Lake Mendota, Dane Co. (Legit, Muttkowski).

REMARKS: This variety is easily distinguished from any of the other forms of *antrosa* by the rounded or slightly carinated dorsal border of the body whorl, the flat spire whorls, only slightly depressed below the general level, and the narrow umbilicus as compared with the wide umbilicus of typical *antrosa*. It seems to be a form of creeks and rivers, as is the type form. The Philadelphia specimens seem to fit Haldeman's *unicarinata* better than Conrad's *antrosa*, all of the material from the Delaware River examined having the subcarinated dorsal surface as described by Haldeman (see pl. XIX, fig. 17). It would seem that Say's *bicarinatus* was in general the same as *unicarinatus*. Binney's figures of *bicarinatus* are like this form and these figures are like Walker's figures of Haldeman's types of *unicarinatus*. Say probably included both forms in his *bicarinatus*. The variety is characteristic enough to be recognized, in most collections being sharply marked off from the typical carinated river form and the carinated lake forms. *Angistomus* seems an absolute synonym of *unicarinatus*, the campanulate form of lip occurring with any lot of shells, in fact, of any one of the varieties. As it is believed to have been described from near Philadelphia specimens it seems better to include it under *unicarinata*.

HELISOMA ANTROSA SAYI Var. Nov.

Plate XIX, figures 20–23

Helix angulata RACKETT, Lin. Trans., XIII, p. 42, pl. v, fig. 1, 1821; BINNEY, L. & F–W. Sh. N. A., II, p. 124, fig. 206, 1865 (not of Barrow, 1815); VANATTA, Nautilus, XXIV, p. 137, 1911.

Planorbis bicarinatus striatus BAKER, Trans. St. Louis Acad. Sci., XVI, p. 9, pl. 1, fig. 11, 1906 (not the true *striatus*).

Planorbis antrosus var. WINSLOW, Oc. Papers. Mus. Zool., Univ. Mich., 180, p. 6, 1926.

Planorbis bicarinatus striatus of various authors, not Baker.

TYPE LOCALITY: Tomahawk Lake, Oneida Co., Wis. *(sayi)*; near Lake Huron *(angulata)*.

WISCONSIN RECORDS:

1906. *Planorbis bicarinatus* CHADWICK, pp. 23, 83. Little Cedar Lake, Washington Co.; Lake Winnebago, north shore, Calumet Co.

1924. *Planorbis antrosus* BAKER, p. 135. Lakes Winnebago and Butte des Morts.

1924. *Planorbis antrosus striatus* BAKER, p. 135. Winnebago and Butte des Morts.

1926. *Planorbis antrosus* var., WINSLOW, p. 6. Little Arbor Vitae Lake.

SHELL: Differing from typical *antrosa* in having a narrower and deeper umbilicus (40 per cent of greatest diameter, *antrosa* 50 per cent), the spire whorls are not as deeply immersed in the body whorl coil and the nuclear whorls form a flat surface at the bottom of the cone (in *antrosa* the spire slopes regularly to a sharp point); the spiral lines are more distinct as a rule than in *antrosa;* the body whorl is distinctly and sharply shouldered, and corded, as is also the umbilical region.

L. 8.0; D. 12.5; Ap. L. 7.5; D. 4.8 mm. Tomahawk Lake (Baker coll., 945). Paratype.
L. 8.0; D. 13.1; Ap. L. 7.5; D. 5.0 mm. Tomahawk Lake (Baker coll., 945). Type.
L. 5.8; D. 10.0; Ap. L. 5.2; D. 3.5 mm. Winnebago Lake (U. of W., 4625).
L. 7.0; D. 12.5; Ap. L. 6.5; D. 4.0 mm. Winnebago Lake (U. of W., 4625).
L. 6.0; D. 11.0; Ap. L. 5.6; D. 4.0 mm. Winnebago Lake (U. of W., 4625).
L. 4.5; D. 7.5; Ap. L. 4.0; D. 2.5 mm. Winnebago Lake (U. of W., 4625).

ANIMAL: In all respects as in *antrosa.*

ECOLOGY: *Antrosa sayi* is characteristic of lakes where there is more or less rough water. Specific habitats are as follows: Winnebago Lake, Long Point Island, gravel bottom, water 1.5 m. deep; off Long Point Island, mud bottom, 3.7 m. deep, rare; Roe Point, boulder and sand bottom, water .6 m. deep; Lake Butte des Morts, sandy-mud bottom, 1.2 m. deep, much vegetation, snails on leaves of water plants; boulder bottom on point near shore, water .5 m. deep; Tomahawk Lake, very common on logs and on sand and pebbles in a few inches of water, prefers open shores; Sturgeon Bay, marly-clay bottom, water .3 to 1.3 m. deep (Baker). In a few inches of water with coarse gravel bottom, a few feet from shore (Little Arbor Vitae Lake, Winslow).

DISTRIBUTION: The Great Lakes region in Michigan, Wisconsin, Minnesota, New York, and Canada.

DISTRIBUTION IN WISCONSIN: Apparently restricted to the northern and eastern part of the State, mostly in the deeper lakes.

Wisconsin Drainage: Tomahawk Lake, Oneida Co. (Baker); Little Arbor Vitae Lake, Vilas Co. (Winslow); Plum, Found, and Big Muskallonge lakes, Vilas Co. (Cahn).

Fox Drainage: Lakes Winnebago and Butte des Morts, Winnebago Co. (Baker); Lake Winnebago, Calumet Co. (Chadwick).

Lake Superior Drainage: Bayfield and Madeline Island, Bayfield Co. (Baker).

Lake Michigan Drainage: Little Cedar Lake, Washington Co. (Chadwick).

Chippewa Drainage: Nixon Lake, Vilas Co. (Cahn).

REMARKS: The distinguishing characteristics of variety *sayi* have been pointed out in the diagnosis. It is apparently typically a lake form closely related to Walker's *percarinata,* but smaller, with a narrower umbilicus, and with stronger spiral striation. Among the *sayi* from Winnebago Lake are forms which connect with typical *antrosa* and with *unicarinata.* Winnebago is a shallow lake, but its great area makes it one of the roughest of lakes during storms. The *antrosa* from Lake Superior, near Bayfield, are typically *sayi,* but in certain places there are forms referable to *unicarinata,* mostly in protected situations.

This variety was at first thought to be referable to variety *striata,* a Pleistocene fossil found in deposits at Milwaukee and elsewhere. Careful comparison of several hundred specimens from the type locality with lake forms shows that this reference is unwarranted and these lake shells are accordingly separated under the name here used. As Say's *bicarinata* has become untenable it seems appropriate to give his name to this widely distributed form of the species which he first differentiated. Rackett's preoccupied *Helix angulata* is apparently this variety.

HELISOMA ANTROSA PERCARINATA (Walker)

Plate XIX, figures 24–27

Planorbis bicarinatus major WALKER, Nautilus, VI, p. 136, 1893 (Preoccupied). Not *major* BECK, 1837, and other authors.

Planorbis bicarinatus percarinatus WALKER, Nautilus, XXIII, p. 6, pl. 1, fig. 12, 1909.

TYPE LOCALITY: Crystal Lake, Benzie Co., Mich.

WISCONSIN RECORDS: None.

SHELL: "Very large for the species, thick and solid, dark-horn tinged with purple; superior and basal carinae elevated into a distinct keel, which is white; lip thickened, edged with brown, behind which externally is a broad, yellowish-white

band, within banded by deep reddish-brown; lines of growth distinct, stronger and 'puckered' around the carinae; revolving lines very faint, not discernable except with a lens; aperture more or less expanded, sometimes distinctly campanulate, auriculate and distinctly modified by the extension of the carinae of the lip " (Walker).

L. 10.0; D. 18.5; Ap. L. 10.5; D. 0.0 mm. Type. Michigan.
L. 7.2; D. 14.0; Ap. L. 6.7; D. 5.0 mm. Sturgeon Bay (U. of W., 4732).
L. 6.5; D. 12.1; Ap. L. 6.0; D. 6.0 mm. " "
L. 7.8; D. 14.8; Ap. L. 7.4; D. 6.5 mm. Green Lake (U. of W., 4733).

ANIMAL: As in *antrosa.*

ECOLOGY: A form of large, deep, lakes or bays of larger lakes. On the shore of Sturgeon Bay it occurs in deep water on rocks near shore; only dead shells were found in Green Lake.

DISTRIBUTION: Michigan to Minnesota, Ontario. A form of the Great Lake region.

DISTRIBUTION IN WISCONSIN: Thus far found only in the eastern part of the State.

Fox Drainage: Green Lake, Green Lake Co. (Baker).
Rock Drainage: Lake Delavan, Walworth Co.
Lake Michigan Drainage: Sturgeon Bay and Lake Michigan Shore, Door Co. (Baker).

REMARKS: *Percarinata* is the largest of the *antrosa* group, at once known by its size, strongly corded carinae, and wide umbilicus. The form as found in Michigan is larger and somewhat more strongly carinated than the shells from Wisconsin referred to this variety, but all are undoubtedly the same type of variety. Its nearest relative, *antrosa sayi,* is also a lake form, but may be distinguished by its smaller size and particularly by the smaller size of the umbilicus, the more distinctly marked spiral lines, and the shallower spire depression, which does not form as flat-sided a cone as in *percarinata.* It does not appear to be widely distributed in Wisconsin.

HELIOSOMA ANTROSA SHELLENSIS F. C. Baker

Plate XIX, figures 32–36

Heliosoma antrosa shellensis F. C. BAKER, Nautilus, XL, p. 86, 1927.

TYPE LOCALITY: Shell Lake, Washburn Co., Wis.

WISCONSIN RECORDS: As above.

SHELL: Differing from *antrosa* in being higher axially, with a deeper and more conical basal depression and a deeper

and more flatly concave spire region; the body whorl bordering these areas is more sharply angled; aperture longer in comparison with width, with a bluntly formed v-shaped angle above and below; sculpture of distinct spiral lines; color brownish.

L. 9.0; D. 13.0; Ap. L. 8.1; D. 4.5 mm. Shell Lake (U. of W., 4627). Type.
L. 9.0; D. 12.0; Ap. L. 8.3; D. 5.0 mm. Shell Lake (U. of W., 4627). Paratype.
L. 8.0; D. 12.0; Ap. L. 7.5; D. 4.0 mm. Shell Lake (U. of I., Z19354). Paratype.
L. 6.8; D. 9.0; Ap. L. 6.0; D. 3.2 mm. Shell Lake (U. of I., Z19354). Paratype.

ANIMAL: Not examined.

ECOLOGY: Shell Lake is upwards of 40 feet in depth and this variety may be an inhabitant of the deeper parts of the lake. During an afternoon's collecting only dead shells could be found, in shore debris, although these were fresh and had evidently been washed ashore within a few days.

DISTRIBUTION: As present known only from Wisconsin.

DISTRIBUTION IN WISCONSIN: At present known only from the original locality, in the St. Croix drainage (Baker).

REMARKS: This variety of *antrosa* resembles *sayi;* somewhat, but the shell is axially higher, the body whorl is rounder, bringing the carina of the spire toward the center of the whorl and not near the periphery, as usual in *sayi.* The umbilical region is also deeper. The aperture is quite different, being more ear-shaped, the upper part forming a v-shaped projection while in *sayi* it is usually only slightly rounded at this place, the carina only giving it a sharp appearance. The angle of the body whorl in *shellensis,* while more or less sharp, does not form a distinct cord, as is usually the case in *sayi.*

The variety was at first thought to be referable to *portagensis* Baker, from Maine, but the shell is thinner, of a different color and texture, (growth lines heavier in *portagensis*), the body whorl is rounder, not flattened as in the Maine shells, the nucleus is not as deeply buried below the body whorl, and the aperture is not as distinctly ear-shaped (it is longer and narrower in *portagensis,* see pl. XIX, fig. 37). *Shellensis* is aparently a common mollusk in Shell Lake and it should be found in other lakes in this part of the State. Shell Lake is apparently

a natural body of water, and not of artificial origin, as is the case with many lakes in this part of the state.

The *antrosa* of lakes appear to be more susceptible to variation than the more typical form from rivers and creeks, more than half of the recognizable varieties being from lakes. The varieties, also, are of more northern distribution, which fact holds true for other species of Planorbidae as well as Lymnaeidae.

HELISOMA ANTROSA CAHNI F. C. Baker

Plate XXII, figures 1–6

Helisoma antrosa cahni F. C. BAKER, Nautilus, XL, p. 85, 1927.

TYPE LOCALITY: Big Muskallonge Lake, Vilas Co., Wis.

WISCONSIN RECORDS: As above.

SHELL: Higher as compared with diameter than any other variety; spire sunken below general level; umbilicus deep, rather wide, funnel-shaped; dorsal and ventral carina well marked but not corded; aperture broadly auriculate, sharply v-shaped below, usually broadly arched above where it is widest; sculpture of rather heavy growth lines which may be raised into small riblets on some specimens; spiral sculpture well marked, but fine; color whitish horn.

L. 12.5; D. 18.0; Ap. L. 12.0; D. 7.0 mm. Type (U. of Ill., Z21124).
L. 12.0; D. 18.5; Ap. L. 11.5; D. 6.5 mm. Paratype (U. of Ill., Z21124).
L. 11.0; D. 15.0; Ap. L. 10.5; D. 6.0 mm. Paratype (U. of Ill., Z21124).

ANIMAL: Not examined.

ECOLOGY: Living specimens occurred on a rocky shore. Big Muskallonge Lake has no outlet, which fact may account for its characteristic fauna.

DISTRIBUTION: Not at present known outside the state of Wisconsin.

DISTRIBUTION IN WISCONSIN: Known only from the northern part of the State, and the type locality.

REMARKS: This variety was at first thought to be a gigantic form of *portagensis* F. C. Baker, described from Maine, but its uniformly larger size, differently shaped aperture and greater relative height (8–10 per cent greater than *portagensis*) seem to mark it as another variety of the wide-spread *antrosa*. Immature shells of *cahni* have a somewhat acute dorsal angle of

the aperture, in this feature approaching *portagensis,* but this does not occur in fully adult individuals, and the carinae are never as sharply corded as in the smaller variety from Maine. *Cahni* is also much thinner in shell than *portagensis.* The new variety is named in honor of Dr. Alvin R. Cahn, of the Department of Zoology, University of Illinois, who collected the material.

HELISOMA ANTROSA STRIATA (F. C. Baker)

Plate XIX, figures 28–31

Planorbis bicarinatus striatus BAKER, Nautilus, XV, p. 120, 1902; WALKER, Nautilus, XXIII, p. 7, 1909.

TYPE LOCALITY: Coldspring Park, Milwaukee, Wis. (Pleistocene fossil).

WISCONSIN RECORDS:

1902b. *Planorbis bicarinatus striatus* BAKER, p. 120. Milwaukee.
1906. *Planorbis bicarinatus striatus* BAKER, p. 9. Milwaukee.
1906. *Planorbis bicarinatus striatus* CHADWICK, pp. 23, 84. Milwaukee (part).
1920d. *Planorbis antrosus striatus* BAKER, p. 119. Milwaukee.

SHELL: Small, of 3½ whorls, the dorsal and ventral carinae distinctly marked, cord-like, elevated; the dorsal carina is placed on the center of the upper side of the body whorl and not near the outer margin as in *sayi;* body whorl usually well rounded, not flattened; umbilicus small, deep; surface sculpture of heavy spiral lines which may become distinct ridges in many specimens; the aperture is higher than wide, more or less auriculate, expanded, often campanulate.

L. 6.0; D. 10.0; Ap. L. 5.5; D. 3.5 mm. Type (Baker coll., 1723).
L. 6.0; D. 8.5; Ap. L. 5.6; D. 3.0 mm. " " "
L. 5.7; D. 11.0; Ap. L. 5.0; D. 4.0 mm. Milwaukee (Baker coll., 178).

DISTRIBUTION: Pleistocene deposits of Wisconsin, Illinois, Michigan, and probably other northern states.

DISTRIBUTION IN WISCONSIN: Known only from Milwaukee and Devils Lake at present.

ECOLOGY: Not certainly known, but probably a lake form which lived in the cold waters immediately succeeding the retreat of the ice sheet.

REMARKS: *Striata* was at one time believed to include certain recent *antrosa* living in the smaller lakes. Its nearest rel-

ative is the form herein called *sayi,* from which it differs in its smaller size, rounder body whorl, that of *sayi* being more flat-sided, the carina is in the center of the dorsal side of the body whorl while in *sayi,* it is usually near the outer border, and the spiral lines in *striata* are in most cases very much heavier, often forming heavy spiral ridges, a feature not observed in *sayi.* These differences are reasonably constant among several hundred *striata* and *sayi* examined. It is separated from typical *antrosa* and *percarinata* by its much smaller and deeper umbilical region.

The variety *striata* is evidently a Pleistocene form which was very abundant during the early part of the formation of the Great Lakes system. Its presence in Illinois deposits suggests its migration to more northern places, Wisconsin and Michigan, by way of the Chicago Outlet. *Striata* appears, apparently, in earlier deposits than *percarinata* which is abundant in the marl deposits of Michigan, and is still living in many small, deep lakes in Michigan and Wisconsin.

The *sayi* from Lake Winnebago show a tendency to vary toward *striata,* the carina being near the center of the whorl in many specimens. The umbilicus, however, is not as narrow and the body whorl is not as rounded as in *striata. Striata* is possibly ancestral to the *sayi* of Winnebago Lake, and, also, of the more typical *sayi* from northern Wisconsin. In Devils Lake, a small form of *antrosa* was dredged at a depth of 8.5 m. which appears referable to *striata* and is probably from a fossil deposit.

Subgenus PIEROSOMA Dall, 1905

Pierosoma DALL, Alaska Moll., pp. 81, 85, 1905. Type: *Planorbis trivolvis* SAY.

SHELL: Ultra-sinistral, large, high with few transversely sculptured whorls; the early whorls carinate and flattened above, funicular below; in the adult the flattened apex is usually depressed below the upper level of the body whorl; the aperture is suddenly expanded and somewhat thickened. Male system with long, cylindrical or pyriform praeputium with a small penis sheath attached to one side of its summit; gland very large and duct long and narrow (fig. 145); spermatheca on very long duct. Jaw with superior plate rounded above, trilobate below, elongated in a horizontal plane; side jaws long and narrow.

RADULA: With the mesocone wide and blunt in the laterals, the ectocone and endocone short, sharp, spade shaped; intermediate teeth with the ectocone split into two cusps; marginals narrow, multicuspid. The marginal teeth are not as finely cuspidate nor are there as many cusps is in *Planorbella* and *Helisoma.* The figure of the radula of *trivolvis* in the Moll. Chicago Area (p. 288) is incorrect in showing the mesocone too wide and the side cusps too narrow.

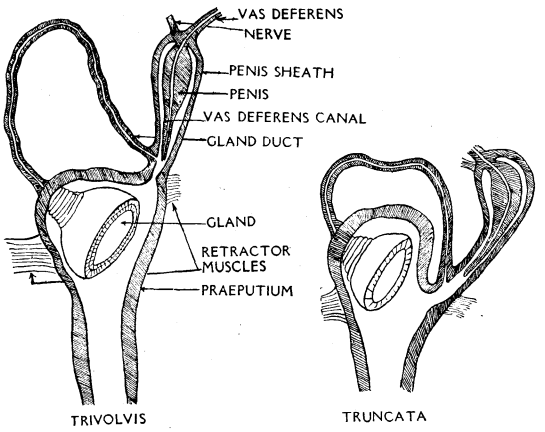


Fig. 145. Sections of Male Organ of *Helisoma.*

This group includes the largest of the American planorbes, in which the shell is typically discoidal. The animal carries the shell almost perfectly perpendicular, in the young as well as in the adult stage (see figure 139).

HELISOMA TRIVOLVIS (Say)

Plate XX, figures 1–13, 22, 23

Planorbis trivolvis SAY, Nich. Encyc., 1st Ed. II (no pagination), pl. ii, fig. 2, 1817; Amer. Conch., VI, pl. 54, fig. 2, 1834; HALDEMAN, Mon., p. 13, pl. ii, figs. 4–7, 1844; BINNEY, L. & F–W. Sh. N. A., II, p. 115, figs. 194, 195, 1865; TRYON, Con. Hald. Mon., p. 202, pl. 6, fig. 16, 1870.

Bulla fluviatilis SAY, Jour. Phil. Acad., II, p. 178, 1821; BINNEY, Op. Cit., p. 117, fig. 196, 1865 (juvenile).

Physa planorbula DEKAY, N. Y. Moll., p. 76, pl. v, fig. 83, 1843; BINNEY, Op. Cit., p. 118, fig. 197, 1865 (juvenile).

Planorbis regularis LEA, Proc. Amer. Phil. Soc., II, p. 32, 1841; BINNEY, Op. Cit., p. 117, fig. 196, 1865 (immature).

Planorbis megastoma DEKAY, Op. Cit., p. 61, pl. iv, figs. 60, 61, 1843; BINNEY, Op. Cit., p. 118, fig. 198, 1865.
Planorbis macrostomus WHITEAVES, Can. Nat., VIII, p. 113, fig., 1863; BINNEY, Op. Cit., p. 119, fig. 199, 1865.

TYPE LOCALITY: *Trivolvis,* French Creek, near Lake Erie; *fluviatilis,* Delaware River; *planorbula,* Cohoes Falls, N. Y.; *megastoma,* near Lake Ontario; *macrostomus,* ponds near Mile-end-Gate, Montreal, Canada; *regularis.* United States.

WISCONSIN RECORDS:

1860. *Planorbis trivolvis* LAPHAM, p. 155. Milwaukee.
1865a. *Planorbis trivolvis* BINNEY, p. 121. Milwaukee, Madison.
1897. *Planorbis trivolvis* WISWALL, p. 48. Southern Wisconsin.
1906. *Planorbis trivolvis* CHADWICK, pp. 22, 83. Milwaukee and vicinity; Okauchee Lake, Waukesha Co.; N. shore Lake Winnebago, Calumet Co.; East Twin River, Two Rivers, Manitowoc Co.; Kenosha; Madison.
1911a. *Planorbis trivolvis* BAKER, p. 238. Tomahawk Lake vicinity.
1924. *Planorbis trivolvis* BAKER, p. 135. Omro, Fox River; Lakes Butte des Morts and Winnebago.
1924. *Planorbis trivolvis fallax* BAKER, p. 135. Lakes Winnebago and Butte des Morts.

SHELL: Ultra-sinistral, discoidal, flat, carinate above, subcarinate below; color yellowish, brownish, or chestnut brown, surface shining; sculpture of coarse oblique, raised, more or less equidistant lines of growth; the immature shell of three whorls has distinct spiral impressed lines, but these disappear on the last whorl; whorls 4, discoidal, rounded on the periphery; spire flat, in the young perfectly flat, but in the adult sunk below the level of the last whorl, but always exhibiting all the volutions; nucleus small, of about half a turn, granular or punctate in sculpture; the lines of growth beginning abruptly; sutures deep, v-shaped; base of shell indented, showing from two to three volutions, which are rounded and have very deep sutures between them; aperture broadly lunate, somewhat expanded below and with a v-shaped angle above; the aperture is exactly the height of the last part of the body whorl; outer lip acute, thin, rounded outward, often a little thickened on the inside and bordered within by a wide chocolate or yellowish band extending from one termination to the other; parietal wall with a thin callus; interior of aperture bluish-white or horn-colored; umbilicus narrow, deep, funnel-shaped.

L. 6.2; D. 10.4; Ap. L. 6.0; D. 3.0 mm.	Wisconsin R. (U. of W., 4629).
L. 7.0; D. 13.0; Ap. L. 6.5; D. 4.0 mm.	" "
L. 9.5; D. 18.0; Ap. L. 9.2; D. 6.5 mm.	" "
L. 10.6; D. 19.5; Ap. L. 10.2; D. 6.5 mm.	" "
L. 11.5; D. 21.0; Ap. L. 10.5; D. 6.5 mm.	" "
L. 11.0; D. 25.0; Ap. L. 10.5; D. 7.0 mm.	" "
L. 14.0; D. 27.0; Ap. L. 12.0; D. 9.0 mm.	Tomahawk Lake (Baker coll., 1724).
L. 15.0; D. 30.0; Ap. L. 14.5; D. 10.5 mm.	Bayfield (U. of W., 4631).
L. 19.5; D. 32.0; Ap. L. 14.0; D. 10.2 mm.	Taber Lake (U. of W., 4632).

ANIMAL: See generic description. (Figs. 139, 142).

JAW AND RADULA: Formula 22–1–22, with 9 laterals (fig. 146). See subgeneric description.

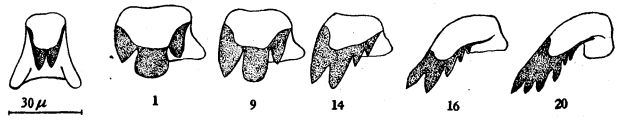


Fig. 146. Radula of *Helisoma trivolvis.* Moose Ear Creek.

DISTRIBUTION: Atlantic coast and Mississippi River drainages, northward to Arctic British America and Alaska and southward to Tennessee and Missouri. The southern distribution is not clear owing to mixing with related species.

DISTRIBUTION IN WISCONSIN: Well distributed over the State and known from the following drainages: St. Croix, Chippewa, Wisconsin, Fox, Rock, Mississippi, Fox of Illinois rivers, and streams flowing into Lake Superior and Lake Michigan.

ECOLOGY: Typical *trivolvis* is always an inhabitant of quiet, more or less stagnant water. Many of the Wisconsin habitats have been formed behind beach barriers, and the *trivolvis* in such places is usually very large and fine. Specific habitats are as follows: Asylum Bay, Lake Winnebago, in marsh behind barrier beach, mud bottom, water .9 m. deep, vegetation thick and consisting of *Myriophyllum, Ceratophyllum, Elodes, Potamogeton, Typha,* and some *Scirpus;* algae very abundant and of the blanket form; Fox River at Omro, swampy shore fine sand bottom, water .5 m. deep; Green Lake, West Creek, 2 m. deep, mud bottom, shells on floating debris or on vegetation along shore; Lake Chetek, swamp behind beach, mud bottom, very shallow water; small pool behind beach, .8 m. deep, mud bottom, on logs and debris; Tomahawk Lake, in creek and

swampy overflow, protected from rough water of lake, mud bottom, water few cm. to 1 m. deep, on logs and shore; swampy pond at mouth of dammed up creek, water stagnant, .2 to 1.3 m. deep, mud bottom; vegetation of *Chara, Spiroggra, Spirodela, Lemna, Helisoma* on bottom in water about .3m. deep.

REMARKS: *Helisoma trivolvis* may be easily recognized by its large size and expanded aperture. It can be confused with but one other Wisconsin shell, *pilsbryi,* which has higher whorls and a longer, narrower aperture. When fully mature, *trivolvis* is one of the finest Helisomas in the state. There is considerable variation in the height of the whorls and in the expansion of the aperture. Several of the synonyms listed are based on age variations; *fluviatilis, regularis,* and *planorbula* are juvenile forms, which greatly resemble a *Physella* with a truncated spire, and indicate the sinistral character of the genus. Both *megasoma* and *macrostomus* are old individuals which have survived a year longer than usual, forming the large aperture and the hump in the body whorl. This has previously been suggested by Dall (Alaska Moll.). Several specimens from Tomahawk Lake and Lake Winnebago are of this character.

Helisoma trivolvis has been a sort of dumping ground for all of the large planorbes in the United States, and some of its varieties have been referred to other species. Say's original specimens were evidently small, judging by the dimensions given, as the species attains almost twice the size stated. Certain West Coast species (*Hornii, oregonensis, subcrenatus,* etc.) have been referred to *trivolvis* as synonyms, but I do not think this approximation is correct. The radulae and genitalia should be examined before such a relationship is established.

The writer once thought a form of *trivolvis* might be separated as a lake variety, a rough water form (1924, p. 136), and this has been approximated with *fallax* Hald. The forms referred to this variety, at least in Wisconsin, appear to be individuals which have adapted themselves to a somewhat different environment, and certain typical forms do appear to differ (pl. XX, figs 1–4). But these are connected by varying forms with typical *trivolvis.* This variation is particularly notable in Lake Butte des Morts, where there is perfect gradation between the *trivolvis* of the quiet waters of the protected pond-like shore and the more exposed lake beyond this location (pl. XX,

figs. 3–6). The lake forms are smaller and more compact and in time might constitute a recognizable ecological race. The true *fallax* of Haldeman is a river form and appears different from these shells and probably constitutes a variety of *trivolvis*.

HELISOMA TRIVOLVIS PILSBRYI (F. C. Baker)

Plate XX, figures 14–21

Planorbis binneyi BAKER, Nautilus, XXIII, p. 41, 1909; Trans. Wis. Acad. Sci. Arts, XVII, p. 237, 1911; Tech. Pub., N. Y. State Coll., For., 4, p. 277, fig. 46, nos. 17, 18, 1916; Op. Cit., 9, p. 175, 1918.
Planorbis trivolvis pilsbryi BAKER, Nautilus, XXXIX, p. 117, 1926.

TYPE LOCALITY: Tomahawk Lake, Oneida Co., Wis.

WISCONSIN RECORDS:

1909b. *Planorbis binneyi* BAKER, p. 41. Tomahawk Lake.
1911a. *Planorbis binneyi* BAKER, p. 237. Tomahawk Lake.
1916. *Planorbis binneyi* BAKER, p. 277. Tomahawk Lake.
1926a. *Planorbis trivolvis pilsbryi* BAKER, p. 117. Tomahawk Lake.

SHELL: Very high as compared with its diameter; whorls 4½, rather tightly coiled, the body whorl with a rather distinct carina above; spire flat and depressed below the level of the body whorl; umbilical region deep, three full turns of the shell visible, the umbilicus small and deep; sutures varying from barely marked to deeply impressed, forming a v-shaped trough; sculpture more regular than in typical *trivolvis*, the riblets more widely spaced; aperture very high, forming a sharp triangle above, widely expanded below, somewhat flaring, but not turned over as in typical *trivolvis*.

L. 15.0; D. 27.5; Ap. L. 14.5; D. 9.0 mm.	Tomahawk Lake	(Baker coll., 846). Holotype.
L. 15.0; D. 26.0; Ap. L. 15.5; D. 9.5 mm.	Tomahawk Lake	(Baker coll., 843). Paratype.
L. 14.0; D. 26.0; Ap. L. 13.0; D. 8.0 mm.	Tomahawk Lake	(Baker coll., 843). Paratype.
L. 14.0; D. 22.0; Ap. L. 13.5; D. 9.0 mm.	Chetek Lake	(U. of W., 4637).
L. 11.5; D. 18.0; Ap. L. 11.1; D. 7.0 mm.	"	"
L. 10.5; D. 15.0; Ap. L. 10.0; D. 5.5 mm.	"	"
L. 8.3; D. 12.1; Ap. L. 8.0; D. 4.0 mm.	"	"

ANIMAL: Similar to *trivolvis*.

GENITALIA: Not different from *trivolvis*.

JAW: As in *trivolvis*.

RADULA: Formula 23–1–23, with 13 laterals. Not differing from *trivolvis* in form or denticulation.

ECOLOGY: In Tomahawk Lake this species is found in somewhat diversified habitats. In more or less sheltered bays where there is but little wave action, the mollusks living mostly on logs and floating debris, though a few occupy the sandy bottom in about .3 m. of water; another habitat is a mucky slough in a thoroughfare between lakes, the snails clinging to logs or crawling over the muddy bottom in .3 m. depth of water; the shells from this locality are a deep reddish tinge instead of the clear horn color of the shells from the other habitats; another locality is on the exposed shore of the lake where the animals receive the full force of the waves; they occur on logs or on the sandy bottom in water .3 to .5 m. deep.

In Moose Ear Creek, *pilsbryi* lives on rocks and stones in rapidly moving water, 7–15 cm. deep; in lakes Chetek and Prairie they are found near the shore in shallow water, sand or mud bottom, in water from a few cm. to 1 m. deep, on the bottom or on stranded logs. In Oneida Lake, N. Y., *pilsbryi* occurs on bouldery points and shores, fully exposed to the force of the waves. It has been observed to feed upon filamentous algae.

DISTRIBUTION: Massachusetts west to Minnesota, northern New York and central Wisconsin northward.

DISTRIBUTION IN WISCONSIN: Apparently confined to the northern part of the State.

Wisconsin Drainage: Tomahawk Lake, Oneida Co. (Baker).
Chippewa Drainage: Phillips, Price Co. (Bullock); Chetek and Prairie lakes and Moose Ear Creek, near Chetek, Barron Co. (Baker).

REMARKS: Mature *pilsbryi* differs from *trivolvis* in having higher whorls as compared with their diameter, a deeper and more funnel-shaped umbilical region, a longer and narrower aperture which is more angular above, the upper side of the body whorl (spire) is more sharply carinated, the spire whorls flatter and more regularly and deeply immersed in the coil of the body whorl, and the lines of growth are evenly spaced and heavier, often forming incipient costae. There is some variation in form, this being toward the *trivolvis* form, a variation especially noted in the Moose Ear Creek specimens. The type forms from Tomahawk Lake are very distinct and without the intermediate forms of other places would be considered a distinct species.

The writer previously considered this large corpulent Planorbis as referable to Tryon's *binneyi*. A critical comparison

of specimens from Oregon with the large shells from Wisconsin and New York shows that this approximation is incorrect and that the true *binneyi* is a different species, having a heavier shell, more heavily carinated body whorl, and especially quite different sculpture, which is coarser than that of *pilsbry*. *Binneyi* is probably related to *ammon* rather than to *trivolvis*. It seems eminently fitting that this finest Planorbis in the northeastern states should be dedicated to Dr. H. A. Pilsbry.

HELISOMA TRIVOLVIS WINSLOW (F. C. Baker)

Plate XXI, figures 39–42

Planorbis trivolvis winslowi BAKER, Nautilus, XXXIX, p. 116, 1926.

TYPE LOCALITY: Little Arbor Vitae Lake, Vilas Co., Wis.

WISCONSIN RECORDS:

1926a. *Planorbis trivolvis winslowi* BAKER, p. 116. Little Arbor Vitae Lake.

1926. *Planorbis trivolvis winslowi* WINSLOW, p. 6, Little Arbor Vitae Lake.

SHELL: Ultra-sinistral, discoidal, carinate above and below; color brownish or greenish horn; surface dull, sculpture coarse, the lines of growth forming distinct, wide-spaced riblets; whorls about 4, high, closely wound, the body whorl flatly rounded; spire with the first 2½ whorls flat, the body whorl being concave and raised above these whorls; superior angulation very distinct and often sharp; umbilicus round and deep, very small, exhibiting 2½ whorls, the base of the body whorl sharply angulated and roundly sloping into the umbilical region; the vertical striation cuts sharply across the angulated base; aperture ovate, narrowed above where it forms an acute angle raised above the body whorl; broadly rounded below and extending below the body whorl; outer lip sharp, with internal brown-edged callus, reflected and slightly flaring in some specimens (fully adult); inner lip forming a thin spreading, white callus over the parietal wall.

L. 12.5; D. 19.0; Ap. L. 13.0; D. 7.5 mm. Arbor Vitae Lake (U. of I. Z18637). Paratype.

L. 11.5; D. 18.6; Ap. L. 11.0; D. 7.0 mm. Arbor Vitae Lake (U. of I. Z18637). Paratype.

L. 13.5; D. 22.5; Ap. L. 12.2; D. 8.0 mm. Arbor Vitae Lake (U. of Mich.) Type.

L. 12.1; D. 21.2; Ap. L. 11.1; D. 7.6 mm. Arbor Vitae Lake (U. of Mich.) Paratype.

ANIMAL: Not examined.

ECOLOGY: Not described; living in a small lake.

DISTRIBUTION: Wisconsin.

DISTRIBUTION IN WISCONSIN: Known only from the northern part of the State at present.

Wisconsin Drainage: Little Arbor Vitae Lake, Big Arbor Vitae Lake, Manitowish River, all Vilas Co. (Metzelaar and Langlois, collectors).

REMARKS: *Winslowi* is apparently a very distinct variety of *trivolvis*. It resembles *pilsbryi* in some respects, but is smaller, only about half the size of adult individuals of that variety, and the body whorl is sharply angulated and more flat-sided. It was at first thought to represent a distinct species, but the presence of individuals varying toward *trivolvis* in the type lot, as well as in nearby waters, indicate a relationship to the large planorbid. Specimens from Big Arbor Vitae Lake and from the Manitowish River are of this intermediate character. The form found in Little Arbor Vitae Lake is very distinct and the radula might throw some light on its relationships. It is named in honor of Miss Mina L. Winslow, Curator of Mollusca in the Museum of the University of Michigan, who first brought the novelty to the writer's attention.

HELISOMA CORPULENTA (Say)

Plate XIX, figures 38–42

Planorbis corpulentus SAY, Long's Exped., II, p. 262, pl. xv, fig. 9, 1824; BINNEY, L. & F–W. Sh. N. A., II, p. 114, fig. 190, 1865; WALKER, Nautilus, XIII, p. 133, pl. iii, 1900; DALL, Alaska Moll., p. 87, fig. 65, 1905.

TYPE LOCALITY: Winnepeck River, Winnepeck Lake, Lake of the Woods, and Rainy Lake, Canada.

WISCONSIN RECORDS:

1860. *Planorbis corpulentus* LAPHAM, p. 155. Northwest Territory.

SHELL: Ultra-sinistral, discoidal, carinate above and below; color greenish horn, sometimes reddish; surface dull to shining; sculpture coarse, lines of growth raised into rib-like ridges, which are widely spaced on the body whorl; whorls more than 4, very high, closely wound, slightly convex, especially below the middle; spire flat in the young shell, more or less concave in mature specimens; the superior carina is very sharp in immature shells, the spire and side forming a sharp

right angle, but this feature becomes less marked in mature shells; umbilicus round, narrow, deep; in immature shells the base is flat, sharply marked off from the side by the ventral carina, but in mature shells the base becomes rounded or slightly subangulated; the very young shell is narrow and high and as the lip is attached to the basal carina of the preceding whorl there is formed a sharp, spirally entering ridge on the columella; this is only to be observed on young shells or on mature shells broken down to this stage; the aperture is at first rather long and narrow, the upper part being at first flat, then sharply triangular, and finally simply rounded; the base of the lip is always rounded; lip simple sharp, reflected in fully mature shells; there is a white callus on the parietal wall.

L. 8.0; D. 9.2; Ap. L. 7.5; D. 3.5 mm.	Minnesota (Baker coll., 1102).
L. 11.0; D. 12.0; Ap. L. 10.5; D. 6.0 mm.	" "
L. 14.0; D. 21.5; Ap. L. 12.1; D. 8.0 mm.	Rainy Lake (Baker coll., 1101).
L. 11.1; D. 14.0; Ap. L. 10.6; D. 6.6 mm.	" "
L. 15.0; D. 25.0; Ap. L. 10.8; D. 8.5 mm.	" "

ANIMAL, GENITALIA, RADULA: Unknown. The proper subgeneric grouping of this species cannot be made until the genitalia have been examined.

ECOLOGY: Not specifically recorded. Evidently largely a lake species.

DISTRIBUTION: Dall (1905, p. 87) gives the range as Northern Ontario from Lake Simcoe to Rainy Lake, Lake of the Woods, Winnepeg River and Lake to Vermilion Lake, Lat. 56°30′, in Athabaska. Knee Lake, Keewatin, Isle Lacrosse Lake, English River, Rat Portage, northern Michigan and Minnesota.

DISTRIBUTION IN WISCONSIN: No specimens of this species have as yet been reported from Wisconsin; but as it occurs in Minnesota and in the upper peninsula of Michigan it is quite likely to be found in the northeastern part of the State.

REMARKS: Say described this fine shell in 1824 and for 78 years it was misunderstood and placed in the synonymy of *trivolvis*. Walker, in 1900, brought out its true characters, provided suitable illustrations and established it as a valid species. In the early works it was confused with the species now known as *binneyi*, which it somewhat resembles when mature, though the immature shells are quite different. Say's description is very good and cannot be read to include any other species; his

figure is also sufficient when the real *corpulentus* is compared with it. Of the difference between this species and *trivolvis* Walker says "*trivolvis* is distinguished by its greater width in proportion to its height, wider and more convex whorls, finer and closer striae, wider and more oblique aperture, less prominent superior carina, which is nearly central on the penultimate whorl, the constantly rounded base of the whorls in all stages of growth, never sharply and acutely carinate as in *corpulentus;* and smaller umbilicus, not exhibiting the apical whorls". Special search should be made for this species in northern Wisconsin. Three of the specimens figured, from one of the type localities, were contributed by Hon. Justice F. R. Latchford.

HELISOMA TRUNCATA (Miles)

Plate XXI, figures 30–38

Planorbis truncatus MILES, Winchell's Geol. Surv. Mich., p. 238, 1861; BINNEY, L. & F–W. Sh. N. A., II, p. 121, fig. 202, 1865; TRYON, Con. Hald. Mon., p. 204, pl. 6, figs. 17–19, 1870; BAKER, Moll. Chi. Area, p. 290, pl. xxx, fig. 28, 1902; Trans. Acad. Sci. St. Louis, XIV, p. 107, 1904.

TYPE LOCALITY: Saginaw Bay, Mich.

WISCONSIN RECORDS:

1924. *Planorbis truncatus* BAKER, p. 135. Lakes Winnebago and Butte des Morts.

SHELL: Ultra-sinistral, orbicularly discoidal, angulated and flat above, subcarinated and rounded below; color light yellowish or brownish horn; surface shining; sculpture of numerous lines of growth, which are more or less equidistant and raised to form small costae; these are crossed by many rather widely spaced spiral ridges which give the surface a latticed appearance; these spiral lines do not appear on the flat upper or spire surface; nucleus small, of less than one whorl, oval, pearly, a trifle raised above the second whorl, sculpture punctate; whorls 4, carinated above, subcarinated below; spire flat, exhibiting all volutions in nearly the same plane; sutures bordered by a raised carina, scarcely marked excepting on the last whorl; base of shell rounded, last whorl strongly keeled; umbilical opening round, wide, rather deep; aperture ovate, somewhat oblique, a little deflected and rounded at the lower part, angulated and shouldered at the upper part; outer lip rather thick,

acute, not expanded, thickened within by a heavy, purple-bordered callus; interior of aperture whitish, showing the spiral and growth lines; parietal wall with white callus.

L. 9.0; D. 17.0; Ap. L. 8.5; D. 6.5 mm.	Sturgeon Bay	(U. of W., 4647).
L. 8.5; D. 16.5; Ap. L. 8.0; D. 6.5 mm.	"	"
L. 7.6; D. 13.8; Ap. L. 6.4; D. 4.8 mm.	"	"
L. 7.1; D. 12.1; Ap. L. 6.6; D. 4.5 mm.	"	"
L. 5.6; D. 11.1; Ap. L. 5.0; D. 3.0 mm.	"	"

ANIMAL: Brownish in color, lighter on sides of foot and tentacles; tentacles half the length of foot, rather thick and blunt; foot wide, short, rounded at both ends; head broad, auriculated; respiratory tube (pseudobranch) very large. See pl. XXII, fig. 24 for the egg capsule of this species.

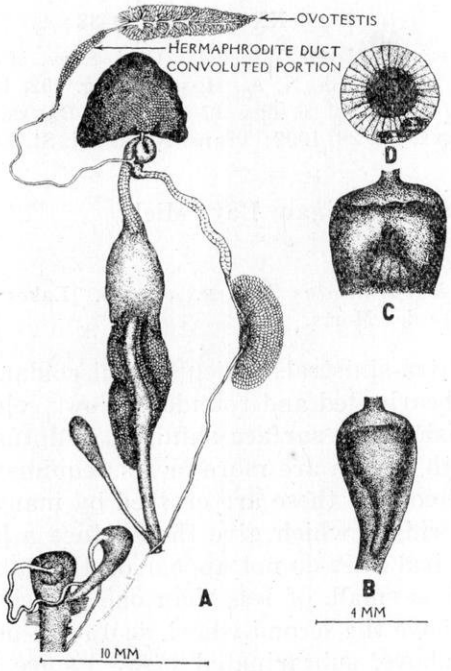


Fig. 147. Genitalia of *Helisoma truncata.* B, penis sheath. C, D, gland.

GENITALIA (Fig. 147): Female system as in *trivolvis,* but spermatheca duct much shorter. Male organs differing considerably; penis sheath placed about midway of the praeputium, instead of near its summit, the sheath much longer than in *trivolvis;* the granular portion of the praeputium rises well above

the penial insertion; penis very long, pear-shaped, the distal end narrowing to a point. The male organs are relatively smaller than in *trivolvis* and *pilsbryi.* In section the organs are like those of *trivolvis* (fig. 145).

JAW: As in *trivolvis.*

RADULA (Fig. 148): Formula 20–1–20 with 9 laterals. Chicago specimens gave 22–1–22 with about 10 laterals. The teeth are similar to those of *trivolvis,* excepting that the mesocone of the lateral teeth is more spade-shaped and not bluntly rounded. The central tooth is relatively wider than in *trivolvis.*

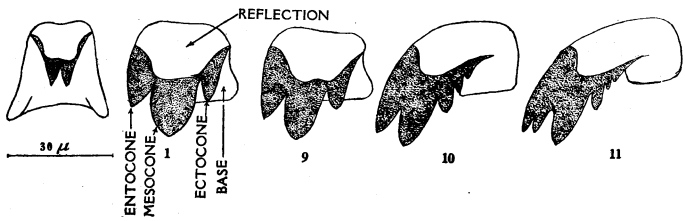


Fig. 148. Radula of *Helisoma truncata.*

ECOLOGY: A species of rough water of lakes, never found in stagnant bodies of water. Specific habitats are: Winnebago Lake, Lower Asylum Bay, sand bottom, .8 m. deep; near Miller Bay, rock bottom, .6 m. deep, sand bottom 1 m. deep, mud bottom with vegetation, off Rockaway Point, mud bottom, 4.3 m. (young); Lake Butte des Morts, boulder bottom, .5 m. deep; Neenah park, lower Fox River, on stones near shore; Sturgeon Bay, shallow water near shore on rocks, exposed to force of lake waves; inner bay, shallow water, hard bottom with thick growth of *Chara* and *Naias,* on rocks near shore, water .3–.6 m. deep; in vegetation on hard marl bottom, water 1. m. deep.

DISTRIBUTION: At present known from Michigan, Northern Illinois, and Wisconsin.

DISTRIBUTION IN WISCONSIN: Known only from the drainage of the Great Lakes.

Lake Michigan Drainage: Sturgeon Bay, Door Co. (Baker); Lakes Winnebago and Butte des Morts, Winnebago Co. (Baker); pond off Green Bay, Brown Co. (Pearse).

REMARKS: *Helisoma truncata* is distinguished from all other Wisconsin species of the genus by its flat, truncated spire,

ridge-bordered sutures, and coarse lattice-like sculpture of spiral and growth lines. There is little variation in the form of the shell as compared with other species. Young *pseudotrivolvis* somewhat resembles *truncata,* but the striae are not as coarse and the spire and umbilical region are not as sharply carinated; the whorls of *truncata* are also higher than those of *pseudotrivolvis. Truncata* and *pseudotrivolvis* are related in both shell and animal, the genitalia being identical, though the radula differs in the form of the mesocone of the lateral teeth and in the denticulation of the marginal teeth. Some specimens have a superficial resemblance to some small lake forms of *Helisoma trivolvis,* especially if that form be carinated about the suture and have some evidence of spiral striation, as is sometimes the case.

HELISOMA PSEUDOTRIVOLVIS (F. C. Baker)

Plate XX, figures 24–32

Planorbis glabratus BAKER (non Say), Bull. Ill. State Lab. N. H., VII, p. 106, 1906.

Planorbis pseudotrivolvis BAKER, Nautilus, XXXIII, p. 123, 1920.

TYPE LOCALITY: Old river bed of Salt Fork, north of Urbana, Ill.

WISCONSIN RECORDS:

1915. *Planorbis glabratus* ANDREWS, p. 200. Lake Butte des Morts.

1924. *Planorbis trivolvis pseudotrivolvis* BAKER, p. 135. Lake Winnebago and Butte des Morts, in marshy places.

SHELL: Ultra-sinistral, whorls 5, body whorl rounded above and below, the inner whorls carinated on both spire and umbilical region; spire whorls very flat, and but slightly concave; the earlier whorls are coiled so that they form a union with the carina of the preceding whorls but the last whorl gradually divides from this line, leaving a v-shaped depression between the dorsal carina and the body whorl; sutures well marked; the base exhibits three full whorls, which are not depressed and funnel-shaped as in *trivolvis;* aperture slightly oblique, somewhat lenticular, rounded above and below, sometimes a trifle expanded and bordered with red; color of shell yellowish or greenish horn, sometimes brownish; surface notably shining; spiral sculpture more regular than in *trivolvis,* the rib-striae being more clear cut with wider interstices. There are several old lip marks or rest varices on mature shells.

L. 9.0; D. 20.5; Ap. L. 8.0; D. 9.0 mm. Holotype (U. of I., Z11393).
L. 8.5; D. 19.5; Ap. L. 8.0; D. 6.0 mm. Ft. Howard (U. of W., 4648).
L. 8.0; D. 16.5; Ap. L. 7.0; D. 5.0 mm. " "
L. 10.0; D. 22.0; Ap. L. 9.6; D. 7.0 mm. Murphy Creek (U. of W., 4650).
L. 12.0; D. 28.5; Ap. L. 11.5; D. 7.5 mm. Near L. Monona (U. of W., 4649).

ANIMAL: As in *trivolvis.*

JAW: As in *trivolvis.*

GENITALIA: Essentially the same as in *truncata.* The gland duct of the male system is more than twice as long as that of *trivolvis.*

RADULA (Fig. 149): Formula variable, 21–1–21 with 11 laterals to 23–1–23 with 11 laterals. Center tooth as in *trivolvis;* lateral teeth the same; marginals with the endocone broken up into 3–6 small denticles, the ectocone into 2–4 denticles of unequal size. The denticles are all smaller than those of *trivolvis* but the teeth are of the same size. Specimens from Murphy Creek, near Madison, varied in the tooth formula as follows: 21–1–21, with 10 laterals; 22–1–22 with 11 laterals; and 23–1–23 with 10 laterals.

Fig. 149. Radula of *Helisoma pseudotrivolvis.*

ECOLOGY: *Pseudotrivolvis* is a species characteristic of very swampy conditions where the water varies much in volume or may become entirely absent. Specific habitats are as follows: pond-like portion of small creek near Ten Mile Creek, Lake Chetek, water shallow, mud bottom; Lake Winnebago, marsh on inner side of Asylum Point, soft black bottom, water .3–1 m. deep, dense vegetation; Spring Lake, mud bottom, shallow water (Baker); Ft. Howard, along railroad track (Bullock). The type locality is the old bed of a river cut off from the main stream by a canal, and now forming an ox-bow pond, with mud bottom and varying depth of water, a meter or so in spring and but a few cm. in summer. In places it becomes entirely dry and mud cracked.

DISTRIBUTION: *Pseudotrivolvis* has been seen from Illinois, Michigan, Indiana, Wisconsin, New York, and South Dakota. It may occur throughout the range of *trivolvis.*

DISTRIBUTION IN WISCONSIN: Apparently not as widely distributed as *trivolvis,* but this may be due to lack of knowledge.

Wisconsin Drainage: Wisconsin River above Kilbourn, Juneau Co. Devils Lake, Sauk Co. (Baker).

Lake Michigan Drainage: Sturgeon Bay, in small creek and in pond, Door Co. (Baker); Oconto, Oconto Co. (Marston).

Chippewa Drainage: Creek near Ten Mile Creek, Lake Chetek, Barron Co. (Baker).

St. Croix Drainage: New Richmond, St. Croix Co. (Bullock).

Fox Drainage: Winnebago and Butte des Morts lakes, Winnebago Co.; Spring Lake, pond near Green Lake, Green Lake Co. (Baker). Fort Howard, Brown Co. (Marston).

Rock Drainage: Murphy Creek, near Madison, near Lake Mendota, Dane Co. (Bullock); Lakes Oconomowoc, Genesee, Lower Nashotah, La Belle, Pewaukee, Battle Creek, Waukesha Co.; Neosho Lake, Dodge Co.; Lake Koshkonong, Jefferson Co. (Cahn).

REMARKS: This species of *Helisoma* has been identified as both *lentus* and *glabratus,* to both of which it bears some resemblance, but from which it is quite distinct. The latter species is found only in Florida (vide Pilsbry) and the former was described from Louisiana both localities far removed from Wisconsin and Illinois. Binney's figure of *glabratus* (which is not the true *glabratus* of Say) is much like *pseudotrivolvis.*

Pseudotrivolvis was at first thought to be simply a variety of *trivolvis.* The constant difference in the shell, with little tendency to vary toward the *trivolvis* form, together with the difference in the male organ and in the denticulation of the marginal teeth of the radula, point to its separation as a distinct species. The narrowly discoidal form, the height of the body whorl being much less than in *trivolvis,* the flat spire whorls and also basal whorls, the peculiar greenish color and shining surface, and the narrow, oblique, unexpanded aperture all mark it as a peculiar and characteristic form of the Helisoma group. In the Wisconsin River above the Upper Dells, both typical *trivolvis* and *pseudotrivolvis* occur in the shore drift. Whether they occupy the same habitat when living was not ascertained. No *pseudotrivolvis* were seen in company with the living *trivolvis,* though living individuals of both species were found in the vicinity. The very slow increase in height of shell is the principal distinctive character which will determine this species at once.

A single large specimen of *pseudotrivolvis* occurred with a lot of smaller specimens in the Bullock collection, from the vicinity of Lake Monona. The difference between the two species is well shown by comparing this specimen with a large trivolvis, the umbilical region exhibiting more whorls in *pseudotrivolvis* as well as on the spire, and the differences in height and form are also well shown (see pl. XX, fig. 32).

Subgenus PLANORBELLA Haldeman, 1842

Planorbella HALDEMAN, Mon. Physidae, p. 14, 1842. Type: *Planorbis campanulatus* SAY.

Shell, ultra-sinistral, depressed, whorls more numerous than in *Helisoma;* apex scarcely depressed below the level of the body whorl; base funicular; body whorl constricted behind the widely expanded, campanulate aperture. Male system with large, pyriform praeputium and short, rather slender penis sheath, situated on the center of the distal end of the praeputium; jaw as in *Helisoma,* typical; radulla with the mesocone of the lateral teeth blunt, broadly rounded, the ectocone and endocone spade-shaped as in *Helisoma.* The shell is carried almost perfectly perpendicular.

HELISOMA CAMPANULATA (Say)

Plate XXI, figures 1, 2, 4, 5, 8, 9, 13, 14

Planorbis campanulatus SAY, Jour. Phil. Acad., II, p. 166, 1821; HALDEMAN, Mon., p. 9, pl. 1, figs. 7–11, 1844; BINNEY, L. & F–W. Sh. N. A., II, p. 109, fig. 184, 1865; BAKER, Moll. Chi. Area, p. 294, pl. xxxii, fig. 11, 1902; WHITTAKER, Nautilus, xxxii, p. 127, pl. x, 1919.

Planorbis minor DUNKER, Conch. Cab., Limn., p. 52, pl. 9, fig. 10, 1850.

TYPE LOCALITY: Cayuga Lake.

WISCONSIN RECORDS:

1860. *Planorbis campanulatus* LAPHAM, p. 155. Milwaukee.
1865a. *Planorbis campanulatus* BINNEY, p. 119. Milwaukee; Aztalan.
1897. *Planorbis campanulatus* WISWALL, p. 48. Southern Wisconsin.
1906. *Planorbis campanulatus* CHADWICK, pp. 22, 84. Milwaukee and vicinity; Delafield, Okauchee and Golden lakes Waukesha Co.; Little Cedar Lake, Washington Co.; Two Rivers, Manitowoc Co.; Crystal Lake near Elkhart Lake; North shore Lake Winnebago, Calumet Co.; Kenosha.
1913b. *Planorbis campanulatus* BAKER, p. 68. Waukesha Co.
1918. *Planorbis campanulatus* MUTTKOWSKI, p. 474. Lake Mendota.

1920d. *Planorbis campanulatus* BAKER, p. 119. Milwaukee (fossil).
1924. *Planorbis campanulatus* BAKER, p. 135. Lakes Winnebago and Butte des Morts.

SHELL: Ultra-sinistral, discoidal, more or less rounded; color brownish-horn, sometimes reddish; surface shining, lines of growth oblique, raised, closely spaced, spiral striation very fine or obsolete; whorls 4½, discoidal, rounded below and subcarinated above; spire flat, exhibiting all of the volutions; sutures deeply impressed; nucleus small, of about one whorl, at first with wavy spiral striation which is followed by vertical growth lines; the fine spiral lines are sometimes broken up forming a strongly pitted surface; base of shell rounded, exhibiting 2½ volutions with a deep umbilicus in the middle; the basal whorls diminish very rapidly in diameter; aperture lunate, the termination of about the same shape, but rather more expanded below; the aperture dilates in mature shells forming a bell-shaped projection, a little wider than high; outer lip sharp, thin; just within the aperture there is a heavy ridge, where the aperture begins to expand; the sudden expansion usually about doubles the diameter of the aperture; parietal wall with a thin callus; the bell-shaped expansion is also covered with callus.

L. 6.2; D. 12.5; Ap. L. 0.0; D. 0.0 mm.	Say's measurements.
L. 6.5; D. 12.2; Ap. L. 5.0; D. 3.5 mm.	L. Delavan (Baker Coll., 1012).
L. 8.0; D. 16.0; Ap. L. 7.0; D. 5.0 mm.	" "
L. 7.1; D. 15.0; Ap. L. 6.0; D. 4.9 mm.	" "
L. 6.0; D. 14.5; Ap. L. 5.2; D. 4.1 mm.	" "
L. 5.0; D. 7.6; Ap. L. 4.9; D. 1.6 mm.	L. Pokegama (U. of W., 4639).
L. 5.5; D. 10.0; Ap. L. 4.5; D. 2.0 mm.	" "
L. 6.6; D. 12.2; Ap. L. 5.5; D. 3.2 mm.	" "

ANIMAL: Color blackish all over; tentacles rather short and blunt; head very wide and somewhat auriculated; foot broadly rounded before and rather pointed behind. Some specimens appear of a greenish color through the shell.

GENITALIA (Fig. 143): Female system; spermatheca four times as long as broad, long-ovate in shape, its duct 2½ times length of spermatheca. Male system; praeputium pear-shaped, much swollen at distal end; penis sheath narrow, slightly enlarged at vas deferens end, a trifle more than half the length of the praeputium, the gland duct rather long. The male organs differ markedly from those of *antrosa* in the small size

and narrow diameter of the penis sheath. It is also placed at the summit instead of to one side of the praeputium, as in *antrosa* and *trivolvis*.

JAW (Fig. 150): Superior jaw much arched, rounded, above, concave below, with a serrated edge and striated face. Lateral jaws as in *trivolvis*.

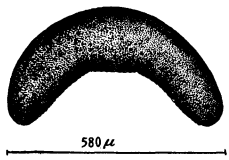


Fig. 150. Superior Jaw of *Helisoma campanulata*.

RADULA (Fig. 151): Formula 23–1–23 (14–2–7–1–7–2–14). Central tooth as in *antrosa*. Laterals with sharp, spade-shaped ectocone and bluntly rounded mesocone. Intermediate teeth two, with the ectocone split first into two and then into four smaller cusps. Marginals at first (10th) with the endocone split into a large and two small cusps, the ectocone into two cusps; marginals 11 and 12 have the endocone split up into 5–6 small cusps and the ectocone into 3–4 cusps, the mesocone with-

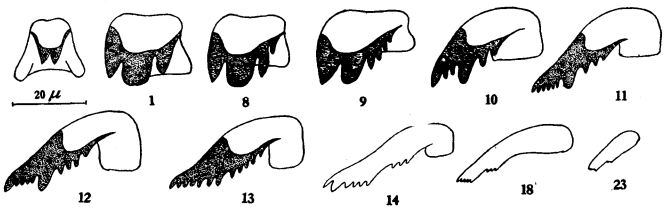


Fig. 151. Radula of *Helisoma campanulata*. Prairie Lake, Chetek.

out modification but smaller than in the lateral teeth; 13th marginal serrated, in two series, a distal of 7 cusps and an inner series of 5 small cusps; 14th to 18th marginals narrow with 4–5 small distal cusps and three outer cusps; 19th to 23rd marginals similar but gradually becoming smaller. The radula of *campanulata* differs from that of *antrosa* in the form of the mesecone of the lateral teeth and in the denticulation of the marginal teeth.

ECOLOGY: In Wisconsin, typical *campanulata* is a species of lakes. Specific habitats are as follows: Winnebago Lake.—

Asylum Bay, near shore, 1 m. deep, rock bottom; Miller Bay, near shore, 1 m. deep, sand bottom with vegetation, much algae; Lake Butte des Morts.—Near Fox River, .3 m. deep, mud bottom, vegetation; Prairie and Chetek lakes.—Near shore on submerged logs, water 1 m. deep, mud bottom, in vegetation; small creek, water .3 to 1 m. deep, mud bottom; Devils Lake.—Southwest side in marsh, mud bottom, water .5–1 m. deep.

DISTRIBUTION: Vermont west to North Dakota, south to Ohio and Illinois, northward to great Slave Lake. The southward extension may be greater, but specimens have not been seen.

DISTRIBUTION IN WISCONSIN: Widely distributed throughout the State and known from the following drainages: St. Croix, Chippewa, Wisconsin, Fox, Rock, and Fox of Illinois rivers, and streams flowing into Lake Michigan and Green Bay.

REMARKS: *Helisoma campanulata* is at once distinguished from all other species of the genus by its bell-shaped aperture, closely coiled spire whorls, and very deep sutures. *Truncata,* with which it is sometimes confused, may be distinguished by its very flat spire without deep sutures, its wider aperture, and strong spiral lines. There is considerable variation in the height of the whorls and in the extent of the campanulation of the aperture. One variation which occurs in nearly every large lot is the tendency for the last half of the body whorl to become elevated above the general plane of the spire so that the aperture projects above the body whorl. This is more common in large specimens which are fully mature, and is so conspicuous at times as to appear almost as a distortion (see Whittaker, Op. Cit.). Another variation in almost every lot is the disparity in size between individuals, some being nearly twice the diameter of others, both apparently mature, each with a bell-shaped aperture, the smaller form usually more tightly wound than the larger form. This form appears to be the *minor* of Dunker (see Winslow, 1926, p. 3). This can be considered only an individual variation as it occurs in many lots of the large typical *campanulata.* In Wisconsin it was found in lots from Lake Winnebago and Green Lake, and occurs abundantly in Crooked Lake, Emmet Co., Mich.

Some small forms of *campanulata* resemble the recently described variety *davisi* (Winslow, 1926, p. 8, pl. ii, figs. 17–19), especially a single specimen from the Lake Superior shore at

Bayfield (see pl. XXI, fig. 15). This measures L. 3.6; D. 10.5; Ap. L. 3.9; D. 2.6 mm. and has been injured, causing a repaired break at about half of the body whorl. *Wisconsinensis* occurs here and this specimen may be a variant of this form. Certain small forms associated with *campanulata* occur in the Wisconsin River, Upper Dells near Kilbourn (pl. XXI, figs. 5, 8) which also approach *davisi,* but these intergrade with the typical form and appear to be but another case of the infinite variation of this polymorphic species.

HELISOMA CAMPANULATA DAVISI (Winslow)

Plate XXII, figures 7, 8

Planorbis campanulatus davisi WINSLOW, Oc. Papers Mus. Zool. Univ. Mich., 180, p. 8, pl. II, figs. 17–19, 1926.

TYPE LOCALITY: Pinnebog River, Huron County, Mich.

WISCONSIN RECORDS: None.

SHELL: "Whorls five, increasing moderately in diameter, spire plane, the apex slightly sunken, lines of growth even, distinct, crossed by obsolescent revolving striae; umbilicus wide, exhibiting four whorls; whorls obtusely angulated above, somewhat angulated below; the last whorl scarcely elevated above the plane of the preceding whorls, the aperture moderately expanded and somewhat thickened within" (Winslow).

L. 5.0; D. 11.0; Ap. L. 4.7; D. 4.0 mm. (type, coll. Bryant Walker, 9974).
L. 5.0; D. 13.0; Ap. L. 5.0; D. 3.0 mm. Near White Lake, Oakland Co. Mich. (U. of I., Z22517).
L. 4.6; D. 11.0; Ap. L. 4.6; D. 3.2 mm. Mud Lake, Wis. (U. of I., 22518).

ANIMAL: Not examined.

DISTRIBUTION: Michigan and Wisconsin.

DISTRIBUTION IN WISCONSIN: Known only from the southeastern part of the State.

Rock Drainage: Mud Lake, Waukesha Co. (Cahn).
Lake Michigan Drainage: Menomonee River, Waukesha Co. (Cahn).

REMARKS: This recently-described variety of *campanulata* appears like a miniature form of Dall's *rudentis,* described from Knee Lake, Keewatin. It differs in its smaller size, much less axial height, and particularly in the form of the umbilicus, which in *rudentis* is distinctly cone-shaped or funnel-shaped, reamed out as expressed by Dall. The examination of a para-

type kindly loaned by Dr. Bartsch of the U. S. Nat. Mus., shows that the tightly coiled shells of Michigan and Wisconsin thought to be the same as *rudentis* are not this variety but represent two others of less axial height and differently shaped umbilical opening.

Dall's paratype examined measures as follows: L. 6.5; D. 16.0; Ap. L. 7.0; D. 4.5 mm. (U. S. N. M. 365574). Dr. Bartsch says "This specimen is a trifle smaller than the type but larger than most of the other seven specimens". *Rudentis* is probably a northern form, of the Canadian region, Hudson Bay drainage, and not found in the United States (see pl. XXII, fig. 9).

The tightly coiled forms with the regular basal coils appear to fall into three varieties:

Rudentis Dall. umbilicus funnel-shaped, axial height, 6–6.5 mm.

Michiganensis F. C. Baker, umbilicus regularly round, axial height, 5.5 mm.

Davisi Winslow, smaller than *michiganensis*, umbilicus narrow, round, axial height, 5 mm.

HELISOMA CAMPANULATA FERRISSI (F. C. Baker)

Plate XXI, figures 3, 11, 12, 16–18

Planorbis campanulatus ferrissi BAKER, Trans. Ill. Acad. Sci., XV, p. 412, 1922.

TYPE LOCALITY: Fair Grounds Quarry, Joliet, Ill. (Pleistocene fossil).

WISCONSIN RECORDS: None.

SHELL: Differing from the typical form in being much smaller, with whorls axially much shorter, the base exhibiting three full whorls which are visible, the basal whorls being usually more regularly coiled; from *michiganensis* it differs in having somewhat shorter axial whorls and in having but three full whorls visible on the base while in *michiganensis* four whorls are visible.

L. 5.0; D. 12.6; Ap. L. 4.2; D. 3.3 mm. Type (U. of I., P1068).
L. 4.0; D. 11.5; Ap. L. 4.0; D. 2.6 mm. " "

ECOLOGY: The fossil records indicate a river habitat.

DISTRIBUTION: At present known from Illinois, Wisconsin, and Michigan.

DISTRIBUTION IN WISCONSIN: Known only from the southeastern part of the state in marl deposits.

Milwaukee, Milwaukee Co. (Baker, Slocum); Spring Lake, Green Lake Co. (Baker); Oconomowoc and Lower Nemahbin lakes, Waukesha Co. (Cahn).

REMARKS: *Ferrissi* is typically distinguished from *campanulata* by its smaller size, axially shorter whorls and greater number of whorls visible on the base. It is related to *davisi,* differing in having a less number of whorls visible on the base and the whorls are not usually as regularly coiled as in the Michigan form; the shell is also usually smaller. Some specimens of *ferrissi* show a tendency to have the first whorl of the base enlarged and abruptly disappear in the umbilicus, as in the typical form, indicating a close relationship to the type. *Ferrissi* appears to be rather intermediate between *davisi* and *campanulata,* and is perhaps ancestral to the former. As far as Wisconsin is concerned it appears only as a Pleistocene fossil.

HELISOMA CAMPANULATA WISCONSINENSIS (Winslow)

Plate XXI, figures 6, 7, 19–24

Planorbis campanulatus wisconsinensis WINSLOW, Oc. Papers, Mus. Zool. Univ. Mich., 180, p. 5, pl. ii, figs. 14–16, 1926.

TYPE LOCALITY: Little Arbor Vitae Lake, Vilas Co., Wis.

WISCONSIN RECORDS:

1911. *Planorbis campanulatus* and *rudentis* BAKER, p. 236. Tomahawk Lake.

1926. *Planorbis campanulatus wisconsinensis* WINSLOW, p. 5. As above.

SHELL: "Whorls five and a half, closely coiled, increasing slowly in diameter and constricted back of the aperture; lines of growth distinct, rib-like, equidistant; the spaces between them occupied by very fine parallel striae; traces of revolving striation; spire elevated but with the apex slightly sunken; whorls carinated above sharply with the exception of the last whorl, and below obtusely; umbilicus narrow and deep, exhibiting all the whorls. The last whorl bends upward and the aperture is appressed at an angle to the upper two-thirds of the whorl. Aperture angulated above, sharp-edged, flattened somewhat at the periphery, obtusely angulated and somewhat

wider below. Sutures distinct, almost channelled where the carinae are most pronounced" (Winslow).

L. 6.5; D. 12.2; Ap. L. 5.5; D. 4.7 mm. Type (Univ. Mich., 35890).
L. 6.4; D. 14.5; Ap. L. 6.0; D. 4.0 mm. Little Arbor Vitae Lake (U. of I., Z18471).
L. 5.5; D. 10.9; Ap. L. 5.2; D. 3.1 mm. Little Arbor Vitae Lake (U. of I., Z18471).
L. 6.5; D. 13.0; Ap. L. 6.0; D. 4.0 mm. Tomahawk Lake (U. of I., Z17539).
L. 8.0; D. 16.1; Ap. L. 7.0; D. 5.4 mm. Tomahawk Lake (Baker coll., 1725).
L. 8.0; D. 16.1; Ap. L. 6.4; D. 4.6 mm. Tomahawk Lake (Baker coll., 1725).
L. 7.9; D. 17.0; Ap. L. 7.0; D. 5.5 mm. Tomahawk Lake (Baker coll., 1719).

ANIMAL: Not examined.

ECOLOGY: In a few inches of water a few feet from shore, bottom coarse gravel with thick vegetation (Little Arbor Vitae Lake, Metzelaar). Exposed shores of Tomahawk Lake, bottom sandy, water .3 to 1 m. deep; especially abundant on sand bars; rare in quiet water (Baker).

GENERAL DISTRIBUTION: Wisconsin, Michigan, and probably Quebec, Ontario, and Manitoba (Winslow).

DISTRIBUTION IN WISCONSIN: Apparently confined to the northern part of the State.

Wisconsin Drainage: Little Arbor Vitae, Big Arbor Vitae, St. Germain lakes, Vilas Co.; Tomahawk Lake and Madeline Creek, State Hatchery at Woodruff, Oneida Co. (Winslow); Found, Plum, Big Muskallonge, Little Arbor Vitae lakes (Cahn); Tomahawk Lake, Oneida Co. (Baker).

St. Croix Drainage: Yellow River, near Spooner, Washburn Co. (Baker).

Chippewa Drainage: Rice Lake, Prairie, Chetek, Pokegama lakes, Ten Mile Creek, Barron Co. (Baker); Nixon and White Sand lakes, Vilas Co. (Cahn).

Lake Superior Drainage: Bayfield, on beach, Bayfield Co. (Baker); Owen Lake, near Drummond, Bayfield Co. (Woodruff).

REMARKS: This variety of *campanulata* is easily recognized by its great axial height and carinated upper whorls, the peculiar deflection of the body whorl and the coarse, rib-like striae. It is characteristically a northern form throughout its range. It bears some resemblance to Dall's *rudentis,* but differs notably in the raised character of the spire whorls which are not carinated in *rudentis,* but rounded; the base also shows the whorls more distinctly and is peculiarly reamed out in *ru-*

dentis. The Tomahawk Lake specimens are the largest seen and differ from typical *campanulata* almost enough to require specific recognition. The radula and genitalia should be examined.

The *campanulata* group varies both in axial height and in the coiling of the whorls. The regular decrease in axial height of the different Wisconsin varieties appears to be as follows: *wisconsinensis,* 8 mm.; *campanulata,* 7 mm.; *rudentis,* 6.5 mm.; *michiganensis,* 5.5 mm.; *ferrissi,* 5 mm. *Davisi* has the same axial height.

HELISOMA SMITHII (F. C. Baker)

Plate XXI, figures 25–29

A large *Helisoma* found abundantly in Douglas Lake, Michigan, may possibly be found in northern Wisconsin (see Nautilus, XXV, p. 118, 1912). It will at once be known by its sharply angulated basal whorls, deep, funnel-shaped umbilicus, concave spire, the body whorl rising above the general level of the spire, and sharply keeled or angulated; the sculpture is of coarse riblets; the aperture in mature shells is sharply turned upward. The type measures as follows: L. 9.0; D. 17.0; aperture L. 8.5; D. 6.5 mm. (Baker coll. 1054).

The genitalia and radula differ somewhat from *campanulata* and the form would seem to rank as a species. The praeputium is very large and the penis sheath is attached at the side of the summit as in *trivolvis* and is two-thirds the length of the praeputium. The center tooth of the radula measures 25μ instead of 20μ as in the typical form. The shell characters are sufficient to separate the two forms as distinct at once.

Genus PLANORBULA Haldeman, 1842

Discus HALDEMAN, Mon. Physidae, I, p. 4 of cover, July, 1840. Type: *Planorbis armigerus* SAY. (Not *Discus* FITZINGER, 1833).

Planorbula HALDEMAN, Mon. Physidae, p. 14, 1842. Type: *Planorbis armigerus* SAY. New name for *Discus,* preoccupied by Fitzinger.

Planorbula HALDEMAN, BAKER. Trans. Wis. Acad. Sci., Arts and Letters, XXII, p. 203, 1926. Discussion of anatomy.

Haldemanina DALL, Harr. Alaska Exp., XIII, p. 97, 1905. Type: *Planorbis wheatleyi* LEA.

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* There is a *Planorbis smithi* (Preston) found in Africa and described as *Biomphalaria smithi.* As this belongs, according to Pilsbry (1927, p. 120), to typical *Planorbis* and not to *Helisoma* it does not seem necessary to change the name *smithi.* Unless placed in the same genus, the two combinations would not conflict.

SHELL: Discoidal, ultra-dextral, whorls few, slowly and regularly increasing, rounded or carinated above and below; aperture somewhat expanded, lip more or less thickened within; a single persistent set of 6 dentiform lamellae at a short distance within the aperture.

ANIMAL: Generally as in *Gyraulus,* the foot narrower in front than behind, obtusely rounded at both ends.

GENITALIA: Generally as in *Gyraulus.* Male system with wide, pyriform praeputium, and smaller, narrow, short penis sheath, with a single retractor muscle; penis very long, the termination extending well into the praeputium, symmetrical; a gland is present in the upper part of the praeputium, but there is no duct, as in *Helisoma.*

SUPERIOR JAW: Regularly elongated, trilobed below; lateral jaws long and narrow, fused with the superior jaw at the lateral angles.

RADULA: Resembling *Gyraulus* in the sharp character of the cusps, but base of attachment shorter, especially in the marginal teeth; mesocone longer than endocone, which is longer than ectocone; marginals splitting as in *Gyraulus.*

In both genitalia and radula the *Planorbula* group differs radically from the *Segmentina* of Europe and Asia. The penis sheath lacks the wing-like blind-sac shown in Simroth's figure, besides possessing the peculiar gland present in *Helisoma,* though lacking the duct (see fig. 138, type II). The radula is also different, the laterals being as in *Gyraulus* and some *Helisoma,* tricuspid, not multicuspid, as in the European *Segmentina.* The jaw is also segmented in *Segmentina,* while it is in three pieces in *Planorbula.* These differences are sufficiently well marked to remove *Planorbula* from *Segmentina* and give it a generic place in the family. The shell of *Planorbula* is carried almost flat by the animal, much as in *Gyraulus,* which the animal greatly resembles.

DISTRIBUTION: Known only from America and Africa.

KEY TO SPECIES OF PLANORBULA

1. Aperture with thin lips, scarcely thickened within ..... *armigera*
2. Aperture with a thickened crest behind the lip, notably diminishing its diameter ..... *crassilabris*

PLANORBULA ARMIGERA (Say)

Plate VIII, figures 27–30

Planorbis armigerus SAY, Journ. Phil. Acad., II, p. 164, 1818; HALDEMAN, Mon., p. 30, pl. iv, figs. 11–13, 1844.

Segmentina armigera BINNEY, L. & F.–W. Sh. N. A., II, p. 137, figs. 228–229, 1865; DALL, Alaska Moll., p. 98, fig. 76, 1905; WALKER, Nautilus, XX, p. 123, pl. vii, figs. 1–3, 1907; BAKER, Moll. Chi. Area., p. 300, pl. xxx, fig. 32, text fig. 101, 1902.

Planorbis lautus H. ADAMS, Proc. Zool. Soc. London, p. 145, 1861 (Pilsbry, vide Walker, Synopsis, p. 104, 1918). Young shell.

TYPE LOCALITY: Upper Missouri *(armigera);* New Orleans *(lautus).*

WISCONSIN RECORDS:

1860. *Planorbis armigerus* LAPHAM, p. 155. Milwaukee.
1865. *Segmentina armigera* BINNEY, p. 138. Milwaukee.
1897. *Segmentina armigera* WISWALL, p. 48. Southern Wisconsin.
1906. *Segmentina armigera* CHADWICK, pp. 23, 85. Milwaukee and vicinity; Mishicot River, at Two Rivers, Manitowoc Co.; Kenosha.
1911a. *Segmentina armigera* BAKER, p. 235. Vicinity of Tomahawk Lake and margin of Wisconsin River, Oneida Co.
1924. *Segmentina armigera* BAKER, p. 135. Near Oshkosh.

SHELL: Ultra-dextral, depressed, somewhat subcarinated above and below the periphery; color yellowish or brownish, sometimes black; surface shining; sculpture of fine, oblique lines of growth with spiral lines only rarely indicated by very faint impressions; nucleus with spiral sculpture; whorls 4½, regularly and slowly increasing in diameter, the last whorl ab-

Fig. 152. Diagrams of lamellae in apertures of *Planorbula crassilabris* and *P. armigera* (Winslow 1921). Greatly enlarged.

ruptly deflected near the aperture; spire concave, the apical whorls depressed below the general plane; sutures impressed; base of whorls rounded; umbilical region round, deep, rather wide, funnel-shaped, exhibiting all of the volutions to the spire; aperture subovate, a trifle oblique, armed within the throat by six lamellae placed as follows (152): one large lamella on the parietal wall, somewhat S-shaped, extending in an oblique direc-

tion from a point near the upper carination of the body whorl to a point near the lower carination; below this a small, acute denticle; three denticles on the outer lip (palatal) two on the periphery being prominent, short, thick and triangular, and one very small placed near the upper angle of the outer lip with the body whorl; a rather large lamella on the base of the aperture which is more or less lamelliform; outer lip acute, slightly thickened inside, the superior margin a trifle produced; interior of aperture pearly-white, with a band of reddish just within the aperture extending parallel to the edge of the aperture.

L. 3.0; D. 7.5; Ap. L. 2.0; D. 3.0 mm. Bayfield (U. of W., 4659).
L. 3.1; D. 7.0; Ap. L. 2.2; D. 3.0 mm. " " "
L. 3.0; D. 6.8; Ap. L. 2.2; D. 2.6 mm. " " "

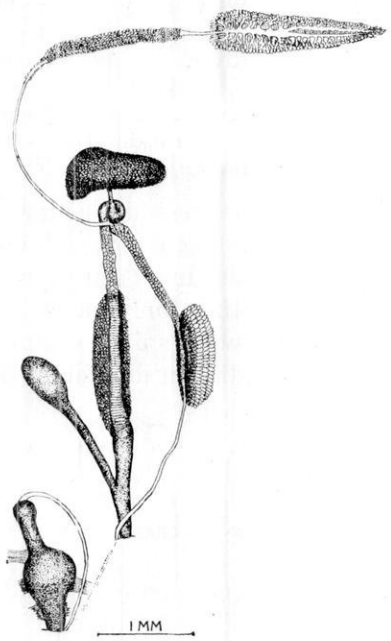


Fig. 153. Genitalia of *Planorbula armigera*. Devils Lake.

ANIMAL: With a wide, rounded foot; head distinct, somewhat auriculate; tentacles very long, filiform, 1½ times as long as foot; eyes placed as in *Helisoma;* color blackish lighter on the edge of the foot and tentacles; secondary branchia, (pseudobranch) long and pointed, thin, transparent.

GENITALIA (Fig 153) : Female system not differing notably from that of *Helisoma* or *Gyraulus*. The spermatheca is large, elongate-ovate, with a duct nearly twice as long as the gland, the duct very thick and entering the oviduct higher up than in either of the genera mentioned. Male system, with large, pear-shaped praeputium which has a large, rounded penial gland similar to that of *Helisoma* but without the duct which is always present in that genus; penis sheath a little more than half the length of the praeputium, rather wide, the distal end swollen; penis as long as penis sheath, thick, swollen at upper part, narrow, pointed at lower part, the opening centrally located; vas deferens as usual in the genus. A single large retractor muscle attached to the distal end of the praeputium; there are several protractors (fig. 154).

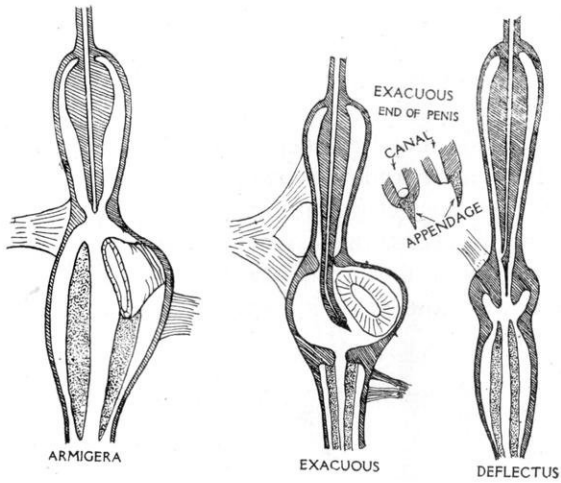


Fig. 154. Sections of Male Organ of Planorbidae.

The male genitalia of *Planorbula armigera* differs from both the *Helisoma* and *Gyraulus* type, being nearer the former in the shape of the praeputium and the presence of the penial gland though lacking the penial duct from this gland. It is quite different from that of *Gyraulus deflectus*, as will be seen by comparing the two figures. There is no penial stylet in *Segmentina*.

JAW (Fig. 155) : A large superior jaw, rounded on the dorsal margin, trilobed on the ventral margin, and minutely stri-

ated on the face; side jaws very long, narrow, ribbon-like, on a rather wide cartilage, attached to the superior jaw at its lower lateral angles.

Fig. 155. Jaws of *Planorbula armigera.* Devils Lake.

RADULA (Fig. 156): Formula 18–1–18. Central tooth as in *Gyraulus,* the reflection bicuspid, the cusps long and sharp. Lateral teeth (9 or 10) wide, tricuspid, the mesocone longest, the ectocone placed rather high up on the outer margin, the cusps all sharply spade-shaped. Marginal teeth at first (11) with a second cusp above the ectocone; later (13) the teeth become more elongated and narrower, somewhat claw-like, with two cusps above the ectocone; outer marginals (17–18) narrower and smaller with three small cusps above the ectocone. The endocone and mesocone are unmodified, but become smaller, narrower, and more sharply pointed.

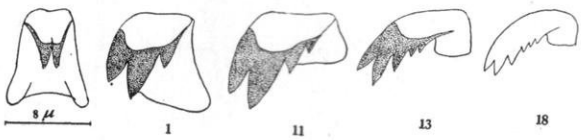


Fig. 156. Radula of *Planorbula armigera.* Devils Lake.

The radula of *Planorbula armigera* resembles *Helisoma* more than *Gyraulus,* the base of attachment being shorter than the latter, but somewhat longer, at least in the lateral teeth, than in *Helisoma.* The marginals are very much like those of *Helisoma.*

ECOLOGY: *Planorbula armigera* is largely a species of swales or of small and stagnant bodies of water. Some of the specific habitats in Wisconsin are noted below: North of Oshkosh, in small pool beneath railroad track, mud bottom, water

.3–.5 m. deep; Plummers Point, Lake Butte des Morts, woodland swale, water shallow, bottom meadow grass or mud; Devils Lake, marsh at southwest end, mud bottom, water .3–1 m. deep; small pool behind beach, Lake Chetek, shallow, with mud bottom; slough, west end Lake Chetek, soft mud bottom, water .3–1 m. deep, snails on deciduous logs, not on coniferous logs; pond behind beach, Wisconsin River, Oneida Co.

DISTRIBUTION: New England west to Nebraska, south to Georgia and Louisiana, north to Great Slave Lake.

DISTRIBUTION IN WISCONSIN: Probably distributed over the entire State and known from the drainages of the Fox, Wisconsin, Chippewa, St. Croix, Rock, and Fox of Illinois rivers, and streams draining into Lakes Superior and Michigan.

REMARKS: *Planorbula armigera* is easily recognized by its closely coiled whorls, high axial length, and especially by the presence of the lamellae within the aperture. It is so characteristic that it cannot be mistaken for any other shell. It is probably to be found in nearly all parts of the State, in small swales, pools, and swampy localities. The animal is rather active in its movements. The shell is carried tilted about 45° to the left side, the animal carrying the shell in somewhat the manner of the large *Gyraulus* species. The tentacles are usually very long and filiform but in some specimens they are much flattened.

PLANORBULA CRASSILABRIS (Walker)

Plate VIII, figures 24–26

Segmentina crassilabris WALKER, Nautilus, XX, p. 122, pl. vii, figs. 4–6, 1907.

This species has not yet been recorded from Wisconsin, but as it occurs in Michigan and Iowa it is possible that it may eventually be found in this State. That it may be recognized when found figures are given of the Michigan form. Walker differentiates the species as follows: "In external appearance, compared with *armigera,* it is smaller and more compactly coiled and higher in proportion to its width, the umbilicus is smaller and deeper, and the angulation of the base of the whorl around the umbilicus more pronounced. In *armigera* the whorls are more regularly rounded and the aperture lacks the crest behind the lip, and is not at all contracted, the thickening within the lip is very slight and does not sensibly diminish its

calibre. In *armigera,* the principal parietal lamella is much shorter, less oblique and its anterior end is less curved and truncated than that of *crassilabris,* the palatal folds are all less developed, and the spaces between them consequently greater; the upper extremity of the basal fold is less deflected and scarcely noticeable externally" (see fig. 152). L. 3.0; D. 7.5 mm. Type specimen.

The animal of this species has not been described. It is now known from Indiana, Iowa, and Michigan, and probably also occurs in other states. The characters indicated above will distinguish it should it be found in Wisconsin.

Genus MENETUS H. & A. Adams, 1855

Menetus H. and A. ADAMS, Genera Rec. Moll., II, p. 262, 1855. No type selected (not of Chenu, 1869, or Fischer, 1883). BINNEY, L. & F.-W. Sh. N. A., II, p. 125, 1865 (first species *Planorbis opercularis* GOULD).

Menetus DALL, Ann. Lyc. N. H., N. Y., IX, p. 351, 1870. Type: By designation, *Planorbis opercularis* GOULD.

Menetus BAKER, Trans. Wis. Acad. Sci., Arts and Let., XXII, p. 203, 1926 (anatomy).

SHELL: Ultra-dextral, lenticular, with a small number of rapidly increasing whorls, the last partly enveloping the preceding whorls; apical whorls not much depressed; base with a narrow umbilicus, aperture oblique, lip sharp. Genitalia generally as in *Gyraulus.* Praeputium largs, short, pyriform; penis sheath longer than praeputium, enlarged toward the distal end; penis very long, narrow, the head enlarged and projecting into the praeputium; a single retractor muscle.

JAW: As in *Gyraulus.* Radula generally as in *Gyraulus.* Shell carried almost flat as in *Gyraulus.*

If Annandale's remarks on *Hippeutis* (1922, p. 359) are correct, *Menetus* cannot be included in it, if *opercularis* is like *exacuous* in its genitalia and radula. The praeputium is not differentiated from the penis sheath in *Hippeutis,* resembling type III of Simroth's diagrams (see fig. 138). The lateral teeth, also, are arranged in pairs, a feature not observed in *exacuous.* The group seems distinctive enough to stand as a separate genus.

The pocket-like cavity in the upper part of the praeputium (see fig. 154) is peculiar as is also the manner in which the re-

tractor muscle is split to include both the penis sheath and the praeputium. The presence of the gland in the praeputium allies the group with *Helisoma,* though there is no duct.

DISTRIBUTION: America and eastern Asia.

MENETUS EXACUOUS (Say)

Plate XXIII, figures 1–5

Planorbis exacuous SAY, Journ. Phil. Acad., II, p. 168, 1821; Long's Exped., II, p. 261, 1824; DALL, Alaska Moll., p. 91, 1905; BAKER, Oneida Lake Rep., p. 281, fig. 45, Nos. 7–9, 1916.

Planorbis exacutus HALDEMAN, Mon., p. 21, pl. iv, figs. 1–3, 1844; BINNEY, L. & F–W. Sh. N. A., II, p. 126, fig. 210, 1865; TRYON, Con. Hald. Mon., p. 207, 1870; BAKER, Moll. Chi. Area., p. 296, pl. xxvi, fig. 5, 1902.

Paludina hyalina LEA, Trans. Amer. Phil. Soc., VI, p. 17, pl. xxiii, fig. 81, 1839; BINNEY, Op. Cit., p. 127, fig. 211, 1865.

TYPE LOCALITY: Lake Champlain *(exacuous);* near Poland, Ohio *(hyalina).*

WISCONSIN RECORDS:

1860. *Planorbis exacutus* LAPHAM, p. 155. Milwaukee.
1865. *Planorbis exacutus* BINNEY, p. 128. Milwaukee.
1906. *Planorbis exacutus* CHADWICK, p. 84. Milwaukee.
1913b. *Planorbis exacuous* BAKER, p. 68. Near Waukesha.
1924. *Planorbis exacuous* BAKER, p. 135 (part). Lake Winnebago.
1926. *Planorbis exacuous* WINSLOW, p. 6. Little Arbor Vitae Lake.

SHELL: Ultra-dextral, very much depressed, with an acute periphery; color light horn varying to brownish, surface shining; sculpture of fine lines of growth, often slightly elevated, crossed by very fine spiral lines under the corneous epidermis; nucleus small, rounded, sculptured with fine spiral lines; whorls 4, rapidly increasing in diameter, sloping in a flatly-rounded curve to the acutely keeled periphery; spire very flat, all of the whorls in the same plane, or the apical whorls slightly sunken below the plane; sutures well impressed; base flatly convex; umbilicus rather narrow, deep, exhibiting all the volutions to the apex; aperture obliquely, obtusely triangular or ovate; outer lip thin, acute, the superior part very much produced beyond the inferior part and expanded near the periphery; outer lip a little thickened with callus on the inside; parietal wall with thin wash of callus.

L. 1.9; D. 6.2; Ap. L. 1.5; D. 2.5 mm. Lake Chetek (U. of W., 4660).
L. 2.0; D. 5.0; Ap. L. 1.5; D. 2.4 mm. " " "
L. 1.5; D. 4.5; Ap. L. 1.2; D. 2.3 mm. " " "

ANIMAL: Color blackish; foot short, rounded.

GENITALIA (Fig. 157): Female system as in *deflectus*. Male system: praeputium large, pyriform, two-thirds as wide, as high; penis sheath a little longer than praeputium, wide, somewhat enlarged at the vas deferens end; penis very long, the spade-shaped head lodged in the upper part of the praeputium; there are four heavy protractor muscles and one large bifid retractor attached to the distal end of the praeputium and the middle of the penis sheath. When the penis is exserted, the penish sheath and praeputium assume an elongated

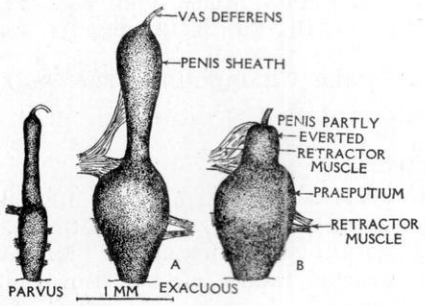


Fig. 157. Male organ of *Gyraulus* and *Menetus*.

pear-shape, as shown in B of the figure. The male organs of *exacuous* differ from those of *deflectus* in the wide pyriform praeputium and in the length of the penis. There is a large gland in a sac-like pocket of the praeputium, which is bordered above and below by a ridge like a small sarcobelum (Fig. 154).

JAW: As in *parvus*.

RADULA: Formula 17–1–17. The teeth and cuspidation are like *deflectus*. The center tooth is narrower, however, being but 4 μ wide and the laterals are also smaller than in either *deflectus* or *parvus* (width, *parvus* 4.5 μ; *deflectus* 7 μ; *exacuous* 4 μ). The marginals are also somewhat smaller.

ECOLOGY: Generally in quiet places, more or less marshy. Specific habitats: slough near west end of Lake Chetek, water .6 m. deep, bottom soft, sticky mud, from few cm. to .3 m. deep, snails on logs (not on coniferous logs). Chicago Creek, half

mile above Lake Superior, on mud flat on edge of small mountain stream of clear, cold water. The *exacuous* were always found on the mud flats in quiet water while Physa and Galba were observed in the more rapid part of the stream, especially in the little falls and rapids.

DISTRIBUTION: United States east of Rocky Mountains, north to Alaska and the Mackenzie River, south to New Mexico.

DISTRIBUTION IN WISCONSIN: Widely distributed over the State and known from the following drainages; St. Croix, Chippewa, Fox, Wisconsin, and Rock rivers, and streams flowing into Lakes Superior and Michigan.

REMARKS: *Exacuous* is easily known by its flat, lenticular shape and sharply keeled periphery. Some specimens resemble very flat, acutely keeled *deflectus,* but these may be distinguished by the deep umbilical region of *exacuous.* There is some variation in the intensity of the spiral sculpture and in the degree of acuteness of the carinated periphery. It is unlike any other species in Wisconsin and should be readily recognized. Young specimens somewhat resemble young *dilatatus* Gould, but that species does not inhabit Wisconsin.

The name *exacuous* was used in two publications by Say, and, as stated by Dall, subsequent authors had no right to change the spelling to *exacutus,* presuming that the original name was a misprint for *exacutus.* The original spelling is here used.

MENETUS EXACUOUS MEGAS (Dall)

Plate XXIII, figures 6, 7

Planorbis exacuous variety megas DALL, Alaska Moll., p. 91, 1905.

TYPE LOCALITY: Birtle, Manitoba.

WISCONSIN RECORDS:

1924. *Planorbis exacuous* BAKER, p. 135 (part). Lakes Winnebago and Butte des Morts.

SHELL: Distinguished from typical *exacuous* by its lighter color, larger size, slightly milky translucency, more distinct spiral striation, and the more or less 'pinched' appearance of the peripheral keel, which appearance is absent in typical *exacuous.*

L. 2.0; D. 7.8; Ap. L. 0.0; D. 0.0 mm. Dall's type.
L. 1.5; D. 5.5; Ap. L. 1.3; D. 2.5 mm. Bayfield (U. of W., 4661).

ANIMAL: As in *exacuous.*

GENITALIA and RADULA: In all respects like *exacuous.*

ECOLOGY: Similar to *exacuous.* Lake Butte des Morts, 1.3 m. deep, mud bottom, vegetation (leaves of *Nymphaea*); Winnebago Lake, Roec Point cove, water .3–.6m. deep, sand with gravel, in thick vegetation (*Potamogeton*); Asylum Bay Marsh behind beach barrier, water .9–1 m. deep, mud bottom, thick vegetation of *Myriophyllum, Elodea, Potamogeton,* etc., with masses of filamentous algae (Baker).

DISTRIBUTION: A northern form found principally in Wisconsin, Michigan, Minnesota, and Canada.

DISTRIBUTION IN WISCONSIN: Widely distributed in the State.

Lake Superior Drainage: Lake Superior at mouth of Pike Creek, Bayfield Co. (Baker).

Wisconsin Drainage: Big Muskallonge Lake, Vilas Co. (Cahn).

Fox Drainage: Lake Butte des Morts and Winnebago, Winnebago Co.; Green Lake, Green Lake Co. (Baker).

Rock Drainage: Lake Monona, Dane Co. (Hinkley); Ashippun and Dutchmans lakes, Waukesha Co. (Cahn).

REMARKS: Variety *megas* appears to be largely a northern form of *exacuous,* reaching its maximum development in Manitoba. It does not, however, replace typical *exacuous* in the northern part of Wisconsin for this occurs as far north as Bayfield. The chief distinction appears to be the pinched character of the periphery which causes this part of the shell to be more acutely keeled than in the typical form. It appears, also, to be largely a lake form, for in Green Lake the *megas* form was found in the lake and the typical form in the creeks flowing into the lake. The same is true at Bayfield and in Lake Winnebago. Say's types came from Lake Champlain, but whether found in the lake or in a small stream flowing into the lake is not stated. In the early days it was customary to give the locality as at the nearest geographic location. While largely a lake form, *megas* shares this distinction with the typical form which is also found in some lakes.

Genus GYRAULUS J. de Charpentier, 1837

Gyraulus AGASSIZ, in J. de Charpentier, Neue Denkschr. Allg. Schweiz. Ges. Natur., I, p. 21, 1837; first species *Planorbis hispidus* DRAP. (= *albus* MÜLLER). Type by designation of Clessin (1886); *Planorbis hispidus* DRAP. (= *albus* MÜLLER).

Planaria BROWN, Ill. Conch. Gt. Brit., Ed. I, pl. li, figs. 48, 49, 1827. Type: *Planaria alba* (=*Planorbis albus* MÜLLER).

Trochlea HALDEMAN, Amer. Journ. Sci., XLII, p. 216, 1841. New name for *Planaria* BROWN, preoccupied by Müller, 1776.

Nautilina STEIN, Leb. Schnecken u. Muscheln Umg. Berlins, p. 80, 1850. Type: as fixed by Clessin (1886), *Planorbis albus* Müller (as synonym of *Gyraulus*).

Gyraulus BAKER, Trans. Wis. Acad. Sci., XXII, p. 204, 1926. Anatomy.

SHELL: Small, ultra-dextral, with few, rapidly increasing whorls, fully exposed above and below, with a nearly median periphery, obtusely angulated, or carinated. Genitalia (fig. 158) with spermatheca on comparatively short duct; male sys-

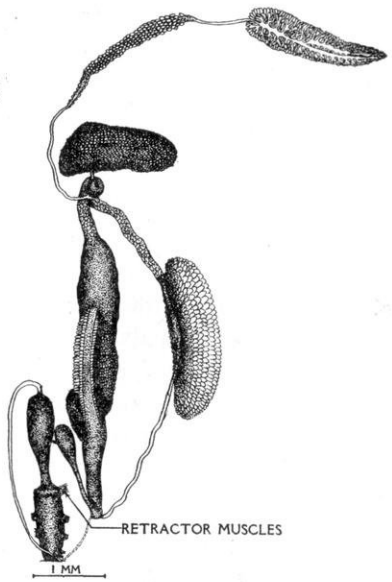


Fig. 158. Genitalia of *Gyraulus deflectus obliquus*. Lake Chetek.

tem with a regularly cylindrical praeputium, shorter than penis sheath, which is greatly enlarged at the distal end; a single retractor muscle attached to the distal end of the praeputium; without penial gland or duct; internally the praeputium is somewhat swollen and there is a large papilla surrounding the horny stylet of the penis, and below this a ring of muscular tissue contracting the diameter of the upper part of the praeputium (sarcobelum); penis very long, extending the whole length of the penis sheath, the stylet long and slender, the

opening of the vas deferens being at the side just above the stylet (see fig. 154). The genitalia of the American members of *Gyraulus* correspond to type IV of Simroth's diagram, *Gyraulus deflectus* not differing materially from that of the European *albus* (see fig. 138).

JAW: Horse-shoe-shaped cartilage on the edge of which are many horny plates, the two plates at the end of those of the shoe being larger and much longer than the others (fig. 159);

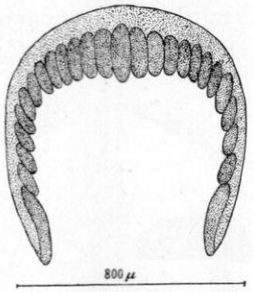


Fig. 159. Jaws of *Gyraulus parvus*. Winnebago Lake.

radula of few teeth in horizontal rows, the center tooth bicuspid and shaped as in *Helisoma;* laterals wide, with a base of attachment reaching much below the end of the reflected cusps, which are sharply triangular, the mesocone being longer than the side cusps; marginals narrower than laterals, the reflection short, the base of attachment very long, the ectocone splitting into several small cusps, the outer marginals being evenly multicuspid (fig. 160).

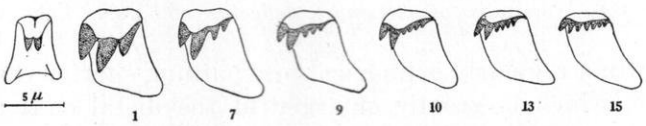


Fig. 160. Radula of *Gyraulus deflectus obliquus*. Lake Chetek.

The genus *Gyraulus* includes the small planorbes in which the shell is carried almost flat and turned to the left, hence the ultra-dextral form of the shell (fig. 161).

DISTRIBUTION: Practically world-wide.

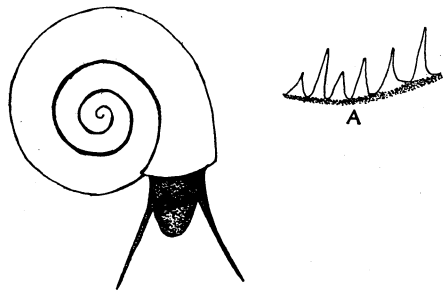


Fig. 161. Animal of *Gyraulus deflectus obliquus*. Lake Chetek. A, periostracal hairs of *Gyraulus hirsutus;* part of one row magnified.

KEY TO SUBGENERA OF GYRAULUS

1. Surface spirally striate and hispid; penis sheath swollen at distal end ---------- *Gyraulus*, s. s.
2. Surface smooth, rarely distinctly striate, not hirsute; Penis sheath regularly cylindrical, not swollen at distal end--- *Torquis*
3. Surface costate, genitalia unknown ---------- *Armiger*

KEY TO SPECIES OF GYRAULUS, S. S.

1. a. Shell with acutely keeled periphery ---------- *deflectus*
   b. Shell with rounded or subangulated periphery ---------- 2
2. a. Periphery subangulated near base of whorl, aperture ovate, oblique ---------- *obliquus*
   b. Periphery rounded, aperture roundly-ovate ---------- *hirsutus*

Subgenus GYRAULUS J. de Charpentier. Typical

As described for the genus. This group includes the typical members of the genus in which the shell is more or less hirsute. The group is well nigh world wide in distribution in the northern hemisphere, including Asia, Europe, and America.

GYRAULUS HIRSUTUS (Gould)

Plate XIII, figures 8–14

Planorbis hirsutus GOULD, Amer. Journ. Sci., (i), XXXVIII, p. 196, 1840: Invert. Mass., p. 132, fig. 135, 1841; BINNEY, L. & F–W. Sh. N. A., II, p. 132, figs. 219, 220, 1865; DALL, Alaska Moll., p. 93, fig. 75, 1905.

Planorbis albus HALDEMAN, Mon. p. 29, pl. iv, figs. 8–10, 1844; TRYON, Con. Hald. Mon., p. 210, 1870 (not of MÜLLER).

TYPE LOCALITY: Mansfield, Dedham, and Cambridge, Mass.

WISCONSIN RECORDS:

1906. *Planorbis hirsutus* CHADWICK, pp. 23, 84. East Twin River, Two Rivers.
1911. *Planorbis hirsutus* BAKER, p. 235. Tomahawk Lake.
1926. *Planorbis hirsutus* WINSLOW, p. 6. Little Arbor Vitae Lake.

SHELL: Ultra-dextral, discoidal, rounded; color light yellowish to brownish; surface dull; sculpture of fine lines of growth and widely-spaced impressed spiral lines (about 7–11 from suture to periphery) in which the epidermis or periostracum is puckered to form hair-like projections; this is lost when the shell is denuded of the epidermis and only the spiral lines are left; nucleus small, rounded, of about one whorl, partly embraced by the second whorl, sculpture at first roughly punctate, later puncto-striate; whorls 3½, discoidal, well rounded on the periphery (sometimes faintly subangulate on the body whorl), rather flattened above and below; spire flattened, exhibiting all volutions, the nuclear and second whorls only depressed below the general plane of the spire; sutures well impressed; base of shell concave, forming a wide umbilicus, showing all the volutions to the nucleus; aperture subovate, more or less oblique, rounded above and below and bluntly subangular at the periphery in some specimens; outer lip thin, acute, sometimes somewhat expanded; a thin callus on parietal wall; the body whorl near the aperture is slightly deflected and enlarged.

L. 1.8; D. 6.0; Ap. L. 1.5; D. 2.0 mm. Neponset, Mass. (Baker coll., 1123).
L. 2.1; D. 6.5; Ap. L. 1.9; D. 2.2 mm. Tomahawk Lake (Baker coll., 1130).
L. 2.0; D. 6.3; Ap. L. 1.8; D. 2.2 mm. Tomahawk Lake (Baker coll., 1130).
L. 1.9; D. 6.5; Ap. L. 1.7; D. 2.0 mm. Tomahawk Lake (Baker coll., 1130).

ANIMAL: Apparently the same as *deflectus*. Body dark, head grayish, foot brownish. Genitalia and radula not examined.

ECOLOGY: In small ditch bordering railroad track, Dedham Road, Neponset, Mass (Baker and Johnson). Gould says "found adhering to sticks in stagnant water". In Tomahawk

Lake it was found in a swamp near shore of small bay, water few cm. to .3 m. deep, bottom soft, sticky mud of clayey character, water filled with algae (Baker).

GENERAL DISTRIBUTION: Massachusetts west to Minnesota, northward to Great Slave Lake and Alaska, southward to District of Columbia and Ohio.

DISTRIBUTION IN WISCONSIN: Apparently a species of northern distribution.

Wisconsin Drainage: Tomahawk Lake, Oneida Co. (Baker); Little Arbor Vitae Lake, Vilas Co. (Winslow); Plum and Found lakes, Vilas Co. (Cahn).

Lake Michigan Drainage: East Twin River, Two Rivers, Manitowoc Co. (Chadwick).

St. Croix Drainage: Shell Lake, Washburn Co. (Baker).

Lake Superior Drainage: Big Bay, Madeline Island, Bayfield Co. (Baker).

REMARKS: *Hirsutus* may be known by its rounded periphery which is but slightly subangulated on the later part of the body whorl, and rounded basal whorls. The umbilical region is also deeply impressed, somewhat like *umbilicatellus*. *Deflectus* has a sharply angulated periphery. The variety *obliquus*, however, often quite closely resembles *hirsutus* and is liable to be confused with it. This form is usually quite distinctly subangulated on the periphery, has a broader and shallower umbilical region, and the aperture is wider and not as high. In many lots of *obliquus* there will be some specimens closely resembling *hirsutus*, but usually there are some specimens that clearly show the subangulated periphery. Wisconsin specimens of *hirsutus* have a decidedly rounded periphery.

Dall and others have been of the opinion that *hirsutus* is synonymous with *albus* Müller of Europe. In *albus*, however, the spiral lines are more numerous and closer together than in *hirsutus* and the hairs are finer, as has already been pointed out by Vanatta (Nautilus, IX, p. 55). Kennard (Proc. Mal. Soc., VIII, p. 47) is of the same opinion. *Hirsutus* appears rare in Wisconsin and seems to be confined to the northern part of the state. It is very desirable that the genitalia and radula should be examined to ascertain its relationship to *deflectus* as well as to the European *albus*.

GYRAULUS DEFLECTUS (Say)

Plate XXIII, figures 15–21

Planorbis deflectus SAY, Long's exped., II, p. 261, pl. xv, fig. 8, 1824; HALDEMAN, Mon., p. 25, pl. iv, figs. 4–7, 1844; BINNEY, L. & F–W. Sh. N. A., II, p. 129, fig. 215, 1865; BAKER, Moll. Chi. Area, p. 299, pl. xxvi, fig. 6, 1902; DALL, Alaska Moll., p. 94, fig. 74, 1905.

TYPE LOCALITY: Northwest Territory.

WISCONSIN RECORDS:

1860. *Planorbis deflectus* LAPHAM, p. 155. Milwaukee.
1865. *Planorbis deflectus* BINNEY, p. 131. Milwaukee.
1906. *Planorbis deflectus* CHADWICK, p. 23. Milwaukee; Cedar Lake, Washington Co.; Two Rivers, Manitowoc Co.
1920d. *Planorbis deflectus* BAKER, p. 119. Milwaukee (fossil).
1924. *Planorbis deflectus* BAKER, p. 135. Lakes Winnebago and Butte des Morts.

SHELL: Dextral, depressed, orbicular, with a more or less distinct keel at the periphery; color light to dark yellowish horn, rarely dark brown; surface shining; sculpture of fine lines of growth crossed by more or less distinct spiral impressed lines rather widely spaced; surface covered with a heavy epidermis which is set with rigid, hair-like projections at the spiral lines, with an especially well developed line of projecting hairs at the periphery; these hair-like projections are not as large as in *hirsutus;* nucleus as in *hirsutus;* whorls about 4½, rapidly enlarging; spire flat, all of the whorls, excepting the apical, in the same plane; sutures impressed; base slightly concave, flattened, showing all of the volutions; aperture suboval, more or less deflected, much wider than high; outer lip acute, thin, the superior portion produced much beyond the inferior portion, slightly thickened on the inside, parietal wall with thin white callus; interior of aperture often brownish.

L. 2.0; D. 7.2; Ap. L. 1.5; D. 2.5 mm.	Winnebago Lake	(U. of W., 4662).
L. 2.0; D. 6.6; Ap. L. 1.7; D. 2.5 mm.	"	"
L. 2.6; D. 6.6; Ap. L. 1.5; D. 2.4 mm.	"	"

ANIMAL: Similar to *hirsutus.*

GENITALIA, JAW, RADULA: See generic description.

ECOLOGY: A species of quiet bodies of water. Specific habitats are as follows: Winnebago Lake, near Oshkosh, shores of protected bays, .3 to 1.6 m. deep, sand and mud bottom; mile from shore in lake, bottom mud, water 3–5.4 m. deep;

Lake Butte des Morts, water .5 to 3 m. deep, near shore, mud or sandy mud bottom; dredged in Green Lake at depth of 10–47.5 m., all dead shells.

DISTRIBUTION: Massachusetts west to Nebraska, northward to Great Slave Lake, southward to Maryland.

DISTRIBUTION IN WISCONSIN: Rather widely distributed over the State.

Fox Drainage: Lakes Winnebago and Butte des Morts, Winnebago Co.; Green Lake, West Creek, Green Lake Co. (Baker); De Pere, Fox River, Brown Co. (Marston).

Wisconsin Drainage: Devils Lake, Sauk Co. (Baker, Hinkley); Wisconsin River, above Kilbourn, Juneau Co. (Baker); Tamah, Monroe Co. (Bullock).

Lake Superior Drainage: Pike Creek, near Salmo, Bayfield Co. (Baker).

Green Bay Drainage: Sturgeon Bay, Door Co. marl bed (Baker).

Lake Michigan Drainage: Kenosha, Kenosha Co. (Wiswall).

Rock Drainage: Lake Winona, Dane Co. (Hinkley); Lake Delavan, Walworth Co. (Woodruff); Lakes Oconomowoc, Genesee, La Belle, and Ashippun, Waukesha Co.; Lake Koshkonong, Jefferson Co. (Cahn).

REMARKS: Typical *deflectus* may be known by its acutely keeled periphery. There is considerable variation in the degree of carination, however, the periphery sometimes being simply subangulated and connecting with the variety *obliquus*. The aperture is typically slightly deflected, the deflection beginning at about the last fourth of the body whorl, but many specimens occur in which the aperture is not deflected at all, the body whorl being coiled in the same plane as the inner whorls. *Deflectus* is usually not as hirsute as *hirsutus*.

Say, it will be remembered, distinctly describes his *deflectus* as sharply carinated, comparing it with *exacuous*. Some modern writers have taken the *obliquus* form as typical, the periphery being rounded or subangulated. Dall (Op. Cit., p. 94) believes that *deflectus* is probably a variety of *hirsutus*, and that it is doubtfully distinct from *Gyraulus albus draparnaudi* Shepard of Europe. It differs, however, in the acute periphery, and also in the fewer number of rows of spiral lines, as is the case in *hirsutus*. A comparison of the radula and genitalia would probably show still greater differences. Typical *deflectus* is a very distinct species, not easily confused with any other in the State.

GYRAULUS DEFLECTUS OBLIQUUS (DeKay)

Plate XXIII, figures 22–26

Planorbis obliquus DEKAY, N. Y. Moll., p. 62, pl. iv, fig. 57 a, b, 1843; BINNEY, L. & F–W. Sh. N. A., II, p. 130, fig. 217, 1865.

TYPE LOCALITY: Mohawk and Newcomb's Pond, in Pittstown, N. Y.

WISCONSIN RECORDS:

1906. *Planorbis hirsutus* CHADWICK, pp. 23, 84. East Twin River, at Two Rivers.

1911a. *Planorbis hirsutus* BAKER (not Gould), p. 235. Tomahawk Lake and pools along Wisconsin River, Oneida Co.

1926. *Planorbis deflectus* WINSLOW, p. 6. Little Arbor Vitae Lake.

SHELL: Differing from typical *deflectus* in having the body whorl subangulate on the lower part, not angular at the periphery, the body whorl usually flatly sloping above the subangulated area and rounded below this area; the lower side of the body whorl is rounder than in *deflectus* and the umbilical region is deeper; the whorls are also higher than in typical *deflectus;* the sutures are also deeper.

L. 2.5; D. 7.5; Ap. L. 0.0; D. 0.0 mm. De Kay's specimen.
L. 3.0; D. 7.2; Ap. L. 2.5; D. 2.7 mm. Lake Pokegama (U. of W., 4664).
L. 2.6; D. 7.2; Ap. L. 2.3; D. 2.5 mm. " "
L. 3.1; D. 6.5; Ap. L. 2.0; D. 3.0 mm. " "

ANIMAL, RADULA, GENITALIA: As in *deflectus.*

ECOLOGY: Generally as *deflectus.* Swampy tracts on shore of Wisconsin River. Slough in Lake Chetek, water .6 m. deep, bottom boggy mud few cm. to .3 m. deep, snails on logs, none on coniferous logs; vegetation Elodea and Castalia, algae.

GENERAL DISTRIBUTION: Probably same as *deflectus.*

DISTRIBUTION IN WISCONSIN: Rather widely but sparsely distributed over the State.

Chippewa Drainage: Lakes Chetek, Pokegama, Mud, Barron Co. (Baker); Phillips, Price Co. (Bullock).

Fox Drainage: De Pere, Brown Co. (Marston); Silver Creek and Silver Lake, Green Lake Co. (Baker).

Lake Superior Drainage: Owens Lake near Drummond, Bayfield Co. (Woodruff).

Lake Michigan Drainage: Small bay off Green Bay, Door Co. (Pearse).

Wisconsin Drainage: Shore pools Wisconsin River, Oneida Co. (Baker); Little Arbor Vitae Lake, Vilas Co. (Winslow); Plum Lake, Vilas Co. (Cahn).

Rock Drainage: Near Madison, Dane Co. (Bullock); Lakes Cook, Keesus, Dutchmans, and Oconomowoc, Waukesha Co.; Crawfish River, Aztalan, Jefferson Co. (Cahn).

REMARKS: De Kay's *obliquus* has usually been considered a synonym of *deflectus,* but it seems to have good claims for varietal distinction. In many localities the two forms are quite distinct and no difficulty is encountered in separating them. In other lots, as in Green Lake, there is a decided variation from the typical *deflectus* form. In *obliquus* the angulation is rather on the base than on the periphery and in typical lots this feature will aid in separating the two forms. Some forms of *obliquus* have been identified as *hirsutus.* Comparison with undoubted *hirsutus* from Dedham, Mass., (one of the type localities, see pl. XXIII, fig. 8), shows that this approximation is not correct, the forms so identified being higher, the aperture subangulated and higher, and the body whorl subangulated below while it is rounded in *hirsutus.* The umbilical region, also, is different, in *hirsutus,* being rather deep, like *Gyraulus umbilicatellus,* while in *obliquus* it is wide showing all of the whorls of the base in almost one plane. Many of the references to *hirsutus* from the west are based on the *obliquus* form of *deflectus. Hirsutus* appears to be rare in Wisconsin and confined in the northern part of the State.

Subgenus TORQUIS Dall, 1905

Torquis DALL, Alaska Moll., pp. 83, 86, 1905. Type: By designation *Planorbis parvus* SAY.

Torquis BAKER, Trans. Wis. Acad. Sci., XXII, p. 204, 1926. Anatomy.

Shell like *Gyraulus* S. S., but with the whorls less distinctly spirally striated, not hirsute, the base more or less regularly concave, or excavated, the lip often slightly thickened within. Male system with penis sheath longer than praeputium, not enlarged at distal end but regularly cylindrical. Jaw and radula similar to *Gyraulus* S. S. This group includes the small species typified by *parvus* which differ somewhat from typical *Gyralus.* They include a compact group of planorbes found abundantly in America and Europe in Arctic, palaearctic, and nearctic regions.

KEY TO SPECIES OF TORQUIS

1. a. Base of shell with conspicuous umbilicus ---------*umbilicatellus*
   b. Base regularly concave without umbilical depression ------ 2
2. a. Whorls regularly coiled, the body whorl not notably expanded toward the aperture ---------- 3
   b. Whorls loosely coiled, the body whorl more or less rapidly enlarging toward the aperture ---------- 4
3. a. Whorls 4½, aperture not thickened within; adult shell 5 mm. in diameter ----------*circumstriatus*
   b. Whorls 4, aperture often thickened within; adult shell 4 mm. in diameter ----------*walkeri*
4. a. Base of body whorl flattened and somewhat excavated------ 5
   b. Base of body whorl rounded ----------*arcticus*
5. a. Whorls 3½, periphery rounded, at center of whorl; aperture wider than high ----------*parvus*
   b. Whorls 4, periphery below center of whorl, subangulated, much flattened above; aperture about as high as wide ----------*altissimus*

GYRAULUS PARVUS (Say)

Plate XXIII, figures 27–31, 39

Planorbis parvus SAY, Nich. Encyc., (i), II, (no pagination), Pl. I, fig. 5, 1817; HALDEMAN, Mon., p. 27, pl. iv, figs. 19–23, 1844; BINNEY, L. & F–W. Sh. N. A., II, p. 133, figs. 222, 223 (not 224), 1865; TRYON, Con. Hald. Mon., p. 211, 1870; DALL, Alaska Moll., p. 95, 1905; BAKER, Moll. Chi. Area., p. 297, pl. xxvi, fig. 7, 1902.

Planorbis concavus ANTHONY, Cat. Shells of Cincinnati (no description), 187–.

Planorbis elevatus ADAMS, Bost. Journ. Nat. Hist., III, p. 327, pl. iii, fig. 16, 1840; BINNEY, Op. Cit., p. 134, fig. 225, 1865 (young shell).

Planorbis billingsi LEA, Proc. Phil. Acad., III, p. 109, 1864; Journ. Phil. Acad., VI, p. 15, pl. 23, fig. 72, 1866; Obs. XI, p. 115, pl. 23, fig. 72, 1866; TRYON, Con. Hald. Mon., p. 211, pl. 7, fig. 10, 1870.

TYPE LOCALITY: Delaware River near Philadelphia *(parvus);* Cincinnati *(concavus);* South Boston, Mass. *(elevatus);* Ottawa River, Canada *(billingsi).*

WISCONSIN RECORDS:

1860. *Planorbis parvus* LAPHAM, p. 155. Milwaukee.
1897. *Planorbis parvus* WISWALL, p. 48. Southern Wisconsin.
1906. *Planorbis parvus* CHADWICK, pp. 23, 84. Milwaukee and vicinity.
1911a. *Planorbis parvus* BAKER, p. 235. Tomahawk Lake and vicinity.
1913b. *Planorbis parvus* BAKER, p. 68. Near Waukesha.
1918. *Planorbis parvus* MUTTKOWSKI, p. 474. Lake Mendota.
1924. *Planorbis parvus* BAKER, p. 135. Lakes Winnebago and Butte des Morts; Fox River, Omro.

SHELL (Fig. 162): Small, ultra-dextral, depressed, with a rounded periphery; color bright horn to jet black, often pearly; surface shining in the light colored specimens, dull in the dark examples; lines of growth oblique, crowded, fine, frequently crossed on the base by several fine spiral lines; nucleus small, rounded, sculpture of distinct spiral striae; whorls about 3½,

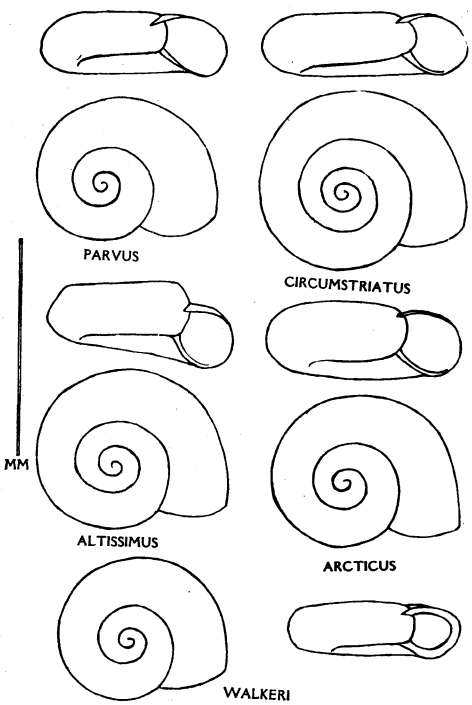


Fig. 162. Shells of Gyraulus, greatly enlarged. *Parvus*, Lake Koshkonong, U. of I., Z22522; *circumstriatus*, Genesee Lake, U. of I., Z22521; *walkeri*, Hull, Quebec, Baker coll., 2401; *arcticus*, Beaver Lake, Mackenzie District, Canada, Baker coll., 2402; *altissimus*, Milwaukee, Baker coll., 2403.

rapidly enlarging, rounded below the periphery and somewhat flattened above on the body whorl and flattened above in all the spire whorls; spire flat, the first two whorls sunken below the body whorl; sutures very deeply impressed; base slightly concave, the body whorl flattened, umbilical region wide, shallow, exhibiting all the volutions; aperture long-ovate, very nearly in the same plane as the body whorl in most specimens

but somewhat oblique in some examples; outer lip acute, thin, simple, the superior margin produced very much over the inferior margin; parietal wall with a thin wash of callus; interior of aperture yellowish-white or whitish.

L. 1.3; D. 3.5; Ap. L. 1.0; D. 1.2 mm. Delaware River form (Baker Coll., 66).
L. 1.5; D. 4.1; Ap. L. 1.2; D. 1.5 mm. Miller Bay, L. Winnebago (U. of W., 4666).
L. 1.3; D. 3.6; Ap. L. 1.1; D. 1.3 mm. Miller Bay, L. Winnebago (U. of W., 4666).
L. 1.4; D. 5.0; Ap. L. 1.5; D. 1.8 mm. Lake Koshkonong (U. of I., Z22520).

ANIMAL: Dark brown, lighter below; foot short, rounded; tentacles whitish, with a dark line on the center of the dorsal surface; secondary branchia long, narrow, whitish.

GENITALIA: Female system. Spermatheca long, narrow, the duct one and one-half times as long as the gland; Male system. Praeputium long, narrow, of about the same diameter throughout; penis sheath one and one-half times as long as praeputium, of but slightly less diameter and of the same width throughout, not enlarged at the distal end, as in exacuous and *deflectus*. There are five protractor muscles and one large retractor muscle (fig. 157).

JAW (Fig. 159): Composed of 28 plates of varying size placed on a horse-shoe-shaped cartilage, the side plates representing the lateral jaws of *Helisoma*.

RADULA (Fig. 163): Formula 10–7–1–7–10. Central tooth about the size of that of *deflectus* and larger than that of *exacuous;* lateral teeth tricuspid, somewhat smaller than those

Fig. 163. Radula of *Gyraulus parvus*. Lake Winnebago.

of *deflectus,* the center cusp a trifle longer and larger; marginal teeth about as in *deflectus*. A specimen from Chicago gave the formula 18–1–18.

ECOLOGY: Usually in quiet bodies of water, often of small size. Specific habitats recorded below: Lake Butte des Morts, 2.2 m., mud bottom, 1 m., sandy-mud bottom, pond lily zone;

1.2 m. deep, mud bottom with vegetation; .8 m. deep, sand bottom. Lake Winnebago, Miller Bay, 1 m., sand bottom; .6 m. sand and mud bottom, with vegetation; Lower Asylum Bay .8 m., sand bottom, heavy vegetation; 1.2 m. sand bottom, vegetation; Libby Point, .3 m., gravel bottom, vegetation; Roe Point, .6 m., boulder bottom, Potamogeton; Long Point Island .5 m., boulder bottom. Silver Creek, Green Lake, on logs.

The above habitat data indicates that *parvus* is partial to a habitat which has rather thick vegetation. This species is more often found in vegetation than in any other situation.

DISTRIBUTION: Eastern North America east of the Rocky Mountains from Florida northward to Alaska and northern British America. West of the Rocky Mountains it is replaced by *vermicularis,* which is not a synonym of *parvus.*

DISTRIBUTION IN WISCONSIN: Widely distributed over the state.

Lake Superior Drainage: Red Cliff Creek north of Bayfield, Pike Creek near Salmo, small brook near Bayfield, pond behind beach near Bayfield, Bayfield Co. (Baker).

St. Croix Drainage: Yellow River near Spooner, Washburn Co. (Baker).

Fox Drainage: Lakes Winnebago and Butte des Morts, Winnebago Co.; Green Lake and Silver Creek, Green Lake Co. (Baker); Bay Settlement, Brown Co. (Pearse).

Lake Michigan Drainage: Ephraiam, Door Co. (Bullock); Milwaukee and vicinity (Chadwick, Lapham); Menomonee River, Waukesha Co. (Cahn).

Wisconsin Drainage: Wisconsin River above Kilbourn, Juneau Co. (Baker). Muskallonge and Plum lakes, Vilas Co. (Cahn).

Rock Drainage: Lake Mendota, near Madison, Dane Co.; Monticello, Green Co. (Bullock); Ashippun Lake, Oconomowoc and Bark rivers, Waukesha Co.; Lake Koshkonong, Jefferson Co.; Neosho mill pond, Dodge Co. (Cahn).

REMARKS: *Gyraulus parvus* may be distinguished from the other small species of the genus by the rapidly enlarging body whorl, flattened and almost excavated lower surface of last whorl, and rounded body whorl, which is but slightly flattened above. In *circumstriatus* the whorls are more closely coiled, the last of which is not rapidly enlarged; there are also 4½ whorls in *circumstriatus* and less than four in *parvus.* From *altissimus* it may be known by its lesser axial height, rounder whorls (*altissimus* has the body whorl peculiarly flattened at

the upper part); *arcticus* has the base of the body whorl rounded, not flattened.

Parvus is a common and wide-spread species in Wisconsin, occurring in many small pools and quiet spots in lakes and rivers. There is some variation in the coiling of the whorls; normally they are coiled in the same plane and the aperture is almost in the same plane as the body whorl. But often the last part of the body whorl may be so deflected that the dorsal edge of the whorl touches the ventral border of the preceding whorl. This tendency to drop the last half of the body whorl is shared by all of the smaller species of the family. This feature is notably developed in *altissimus*. With all its variation, *parvus* always retains the enlarged characteristic of the body whorl as well as the flattened appearance of the last whorl beneath.

GYRAULUS CIRCUMSTRIATUS (Tryon)

Text figure 162

Planorbis (Gyraulus) circumstriatus TRYON, Amer. Journ. Conch., II, p. 113, pl. 10, figs. 6–8, 1866; Con. Hald. Mon., p. 212, pl. 7, figs. 14–16, 1870.

TYPE LOCALITY: Artificial pond at Weatogue, Conn.

WISCONSIN RECORDS: None.

SHELL: With rounded periphery, but body whorl slightly flattened above, obtusely subangulate below; sculpture of rather coarse growth lines with fine spiral lines frequently visible; on the base there are frequently several raised revolving lines; whorls about 4½, slowly and regularly increasing in diameter, all usually in the same plane; sutures deeply impressed, the spire whorls rounded; base flattened, with all whorls visible to spire; body whorl slightly rounded, not flattened as in *parvus;* aperture roundly ovate, not as oblique as in *parvus;* lips often joined by parietal callus.

L. 1.5; D. 6.0; Ap. L. 0.0; D. 0.0 mm.	Tryon's type.
L. 1.4; D. 5.0; Ap. L. 1.3; D. 1.4 mm.	Genesee Lake (U. of I., Z22521).
L. 1.5; D. 5.0; Ap. L. 1.3; D. 1.5 mm.	" "
L. 1.3; D. 5.0; Ap. L. 1.3; D. 1.5 mm.	" "

ANIMAL: Not examined.

ECOLOGY: Artificial pond (Tryon). Spring south of Dousman, water 20 cm. deep, on water cress; Golden Lake, pure

sand bottom, water few cm. to 1 m. deep; Silver Lake, clear sand bottom, no vegetation, shallow water (Cahn).

DISTRIBUTION: Connecticut west to Wisconsin. Exact limits, especially north and south not known. Confused with *parvus*.

DISTRIBUTION IN WISCONSIN: At present known only from the eastern part of the State.

Rock Drainage: Silver, Golden, and Genesee lakes; spring south of Dousman, Waukesha Co. (Cahn).

REMARKS: *Gyraulus circumstriatus* appears to have been ignored by the majority of American students. It has usually been placed in the synonymy of *parvus* but is, in fact, one of the most distinct of the small species of the family. Its closely coiled whorls, the last without notable enlargement (as in *parvus*), and the presence of one more whorl in mature specimens will easily distinguish it from any of the Torquis group. In the type lot there are several distinct raised spiral ridges on the base of the shell, but these are not always present (in fact they are present in but a few of the western examples) and may be seen also on some individuals of *parvus*. Pilsbry's statement that many of the small planorbes referred to *parvus* are really this species is doubtless true, though some references were probably founded on *arcticus* (see Winslow, 1926, p. 14). This species appears to be rare or local in Wisconsin.

GYRAULUS CIRCUMSTRIATUS WALKERI (Vanatta)

Text figure 162; plate XXIII, figures 32, 33

Planorbis parvus walkeri VANATTA, Nautilus, XVI, p. 58, 1902.

TYPE LOCALITY: Hartland, Vt..

SHELL: About three-fourths as large as adult *circumstriatus*, the whorls regularly and tightly coiled, about 3½ to 4 in number, regularly rounded on the periphery, rounded on base, not flattened; sutures well impressed; aperture roundly-ovate, oblique or in same plane as whorls; in many specimens there is a thickened rib or varix just within the aperture; sculpture of fine growth lines; color usually dark brown.

L. 1.0; D. 3.4; Ap. L. 1.0; D. 1.1 mm. Hull, Quebec (Baker coll., 1731).
L. 1.0; D. 4.0; Ap. L. 1.1; D. 1.1 mm. Ottawa River (Baker coll., 1732).
L. 1.0; D. 3.5; Ap. L. .8; D. 1.0 mm. Miller Bay, Lake Winnebago (U. of W., 4668).

ANIMAL: Not examined.

ECOLOGY: Not specifically known. In Winnebago Lake in protected bay among vegetation.

DISTRIBUTION: Vermont and New York west to Colorado, north to Ontario and Quebec; south to Illinois and Indiana. Probably has a wider range.

DISTRIBUTION IN WISCONSIN: At present known only from Lake Winnebago.

REMARKS: *Walkeri* may be known from *circumstriatus* by its smaller size, less number of whorls, rounder and less oblique aperture and in many specimens by the presence of a distinct rib or varix within the lip.

Pilsbry's suggestion that *walkeri* is a form of *circumstriatus* rather than *parvus* is true (see Winslow, 1926, p. 15). The formation of the thickened rib within the aperture appears to be confined to this form and has not been encountered in other species during the examination of many thousand specimens of these small planorbes. Its relationship to *circumstriatus* is not clear. Much may be learned, probably, by an examination of the radulae of the two forms, but fresh specimens are not at hand for this purpose. It appears to be very rare in Wisconsin.

GYRAULUS ARCTICUS ('Beck' Möller)

Plate XXIII, figures 34–38

Planorbis arcticus (BECK, Ms.) MÖLLER, Index Moll. Gronl., p. 5, 1842; MÖRCH, Amer. Journ. Conch., IV, p. 32, pl. 4, fig. 9, 1868; DALL, Alaska Moll., p. 96, 1905; BAKER, Trans. Ill. State Acad. Sci., XV, p. 413, 192.

Planorbis hirsutus BAKER, Journ. Geol., XXVIII, p. 449, 1920 (not of Gould).

TYPE LOCALITY: Kudsuk, Greenland.

WISCONSIN RECORDS: None.

SHELL (Text fig. 162): Of good size for the genus, ultradextral, depressed, the periphery rounded; color light corneous, surface shining; sculpture of fine, oblique lines of growth with very fine spiral lines on some specimens, rarely entirely without these lines; nucleus small, rounded, spirally striate in sculpture; whorls about 4, rapidly enlarging, the last somewhat expanded near the aperture, roundly angled at the periphery of the last whorl, the upper part of the body whorl

slightly flattened; spire flat, the whorls coiled in the same plane; the body whorl is more or less deflected about a third of the distance from the aperture; sutures deeply channelled; base concave, exhibiting all of the whorls, the umbilical region wide, but the body whorl well rounded, not flattened as in *parvus;* aperture obliquely, ovately rounded; lip thin, sharp, simple, or slightly thickened with a callus deposit; parietal wall with a white callus.

L. 0.0; D. 5.0; Ap. L. 0.0; D. 1.5 mm.	Mörch's specimen.
L. 2.2; D. 4.6; Ap. L. 1.5; D. 1.7 mm.	Horn River, B. Amer. (U. of I., Z13072a).
L. 1.5; D. 4.5; Ap. L. 1.2; D. 1.5 mm.	Horn River, B. Amer. (U. of I., Z13072a).
L. 2.4; D. 4.0; Ap. L. 1.4; D. 1.7 mm.	Chetek Lake (U. of W., 4669).
L. 1.5; D. 3.5; Ap. L. 1.1; D. 1.3 mm.	" "

ANIMAL: Grayish, tentacles long, filiform pellucid, with an internal black line from the base to the point. The head looks to me shorter and more round than that of the European species (Möller, vide Mörch).

GENITALIA AND RADULA: Not examined.

ECOLOGY: "Möller found it in a little lake on stones, covered with confervae, chiefly on the under side, and in a tank at Kuksuk, on bullrush, *Potamogeton,* and the stems of *Equisetum.* at the latter place Möller obtained, by aid of the boatswain, some dozens of specimens, but myriads of gnats prevented them from seeing, and forced them to take flight" (Mörch). Only dead shells were found in Lake Chetek and no ecological notes on the American form are available. It is found in lakes in the Mackenzie District of Canada.

DISTRIBUTION: Greenland; British America; Labrador; northern United States. Known as a fossil from Illinois.

DISTRIBUTION IN WISCONSIN: At present known only from the drainage of the Chippewa River. Prairie, Chetek, Pokegama lakes, Barron Co. (Baker); Phillips, Price Co. (Bullock).

REMARKS: A large *Gyraulus* found abundantly in British America, and rather sparsely in the United States, is apparently referable to *arcticus.* It differs from *parvus* in the rounded instead of flattened base and in the less expanded body whorl; from *circumstriatus* in its less number of whorls, in the slight enlargement of the body whorl, in its greater axial height, and its rounder aperture; from *altissimus* it differs wholly in its

rounded instead of flattened body whorl, its rounded instead of flattened body whorl above the periphery, and in its rounder aperture.

Arcticus appears to be a northern form, its distribution perhaps parallelled by *Stagnicola vahli,* and appears to have lived farther south during Pleistocene times, specimens apparently referable to *arcticus* occurring in marl deposits at Joliet, Illinois, and Logan Co., Ohio.

GYRAULUS ALTISSIMUS (F. C. Baker)

Plate XXII, figures 10–17

Planorbis altissimus BAKER, Nautilus, XXXII, p. 95, pl. vii, figs. 7–10, 1919; Journ. Geol., XXX, p. 54, 1922; Trans. Ill. State Acad. Sci., XV, p. 413, 192.

TYPE LOCALITY: Urbana, Ill., in Pleistocene deposits.

WISCONSIN RECORDS:

1920d. *Planorbis deflectus* BAKER, p. 119. Milwaukee (fossil).

SHELL (Text fig. 162): Depressed with flatly rounded periphery which is placed below the center of the whorl; lines of growth fine, crowded, but surface without spiral ornamentation; whorls 4, regularly increasing in diameter, sloping flatly to the rounded periphery; spire whorls sunken below the general level of the surface, the whorls forming a rather sharp v-shaped suture, causing the shell to resemble a miniature *Helisoma antrosa* and producing a subacute carina on the upper surface of the whorls; base of shell deeply concave, forming a wide saucer-shaped depression and umbilicus; the earlier whorls are carinate on the under side but the last whorl is flatly rounded; the last half of the body whorl is markedly deflected in typical examples, forming a contact with but half of the preceding whorl; aperture roundly ovate, shouldered or arched above, the upper margin much produced over the lower margin, the parietal callus joining the margins and causing the aperture to be continuous; the nuclear whorl is ornamented as in *deflectus* and *parvus.*

L. 2.0; D. 4.5; Ap. L. 1.5; D. 1.5 mm.	Type (U. of I., Z10775).
L. 2.4; D. 5.5; Ap. L. 1.4; D. 1.7 mm.	Milwaukee (Baker Coll., 1714).
L. 1.6; D. 5.2; Ap. L. 1.4; D. 1.6 mm.	" " "
L. 1.8; D. 4.9; Ap. L. 1.4; D. 1.6 mm.	" " "

ANIMAL: At present known only as a fossil.

ECOLOGY: Unknown.

DISTRIBUTION: Pleistocene deposits in Ohio, Indiana, Illinois, Michigan, Wisconsin, and probably other states.

DISTRIBUTION IN WISCONSIN: At present known only from marl deposits in the eastern part of the State.

Milwaukee, Milwaukee Co. (Slocum); Spring and Green lakes, Green Lake Co.; Sturgeon Bay Canal, Door Co. (Baker); near Lake Wingra, Dane Co. (Bullock).

Marl beds near Lakes La Belle, Oconomowoc, Lower Nashotah, Cooks, and Dutchmans, Waukesha Co.; Crawfish River, Aztalan, Jefferson Co. (Cahn).

REMARKS: *Altissimus* appears to be related to *arcticus*, from which it may be known by its flattened basal whorl, its strongly flattened body whorl, and deeply channelled sutures, which cause the spire whorls to appear to be subcarinated. Some specimens resemble *parvus* on the base, but the shape of the body whorl will easily distinguish these individuals. From *circumstriatus* it differs in its more loosely coiled whorls and the flattening of the body whorl.

This species is apparently an extinct form peculiar to the Pleistocene period and from which perhaps some of the recent species may have descended. In most marl deposits it takes the place of *parvus*, which is very rare as a fossil. In Illinois it is very abundant in fresh water marl deposits. In Green Lake it was dredged at a depth of 13 meters.

GYRAULUS UMBILICATELLUS (Cockerell)

Plate XXII, figures 18–21

Planorbis umbilicatus TAYLOR, Journ. Conch., IV, p. 351, 1885 (not of Müller, 1774).

Planorbis umbilicatellus CKLL., Conch. Exch., II, p. 68, Nov., 1887; DALL, Alaska Moll., p. 96, 1905.

TYPE LOCALITY: Brandon and Birtle, Manitoba.

WISCONSIN RECORDS:

1922b. *Planorbis umbilicatellus* BAKER, p. 21. Near Lake Winnebago.

1924. *Planorbis umbilicatellus* BAKER, p. 135. Near Oshkosh and north of Lake Butte des Morts.

SHELL: Large for the genus, ultra-dextral, discoidal, depressed; color light corneous or yellowish to brownish; surface shining; sculpture of distinct but fine oblique lines of growth

crossed by very fine crowded spiral lines; nucleus striated in sculpture; whorls 4¼, regularly increasing in diameter, the last part of the body whorl somewhat expanded near the aperture; whorls rounded, slightly subangulated on the periphery, which is at about the center of the whorl; spire flat, all of the volutions in the same plane or the first two whorls slightly sunken below the plane; sutures distinctly impressed but not channelled; base of body whorl flatly rounded, the umbilical region large, round, and deep, but exhibiting all of the whorls to the apex; aperture elongate-lunate or roundly triangular, narrowing toward the peripheral part of the outer lip; upper part of aperture curved, lower part deeply rounded, concave; outer lip simple, sharp, thin; parietal wall with a thin callus.

L. 2.0; D. 6.0; Ap. L. 1.8; D. 2.4 mm.	Plummer's Point	(U. of W.,	4671).
L. 2.0; D. 6.0; Ap. L. 2.0; D. 2.5 mm.	"	"	"
L. 1.9; D. 5.3; Ap. L. 1.5; D. 2.3 mm.	"	"	"
L. 1.5; D. 4.1; Ap. L. 1.1; D. 1.3 mm.	"	"	"

ANIMAL: Not examined.

GENITALIA AND RADULA: Not examined.

ECOLOGY: All specimens in Wisconsin have been found in swales.

DISTRIBUTION: From Mesilla, New Mexico northward to Manitoba, including the states of Illinois, Michigan, Iowa, Minnesota, Colorado, Montana, the Dakotas, and Wisconsin.

DISTRIBUTION IN WISCONSIN: Occurring in widely separated areas.

Fox Drainage: Near Lake Butte des Morts and Oshkosh, Lake Winnebago, Winnebago Co. (Baker).
Lake Michigan Drainage: Marinette, Marinette Co. (Bullock).
Chippewa Drainage: Prentice, Price Co. (Bullock).
Rock Drainage: Windsor, Dane Co. (Bullock).

REMARKS: *Umbilicatellus* is at once recognized by the deep, wide, round umbilicus and fine spiral lines. It is quite unlike any other species in the State, perhaps resembling *hirsutus* more than any other species, from which it is at once known by its umbilicus and the triangular shape of the aperture. *Umbilicatellus* is not common in Wisconsin, judging by the material at hand and by its rarity in half a dozen years of collecting in many parts of the State. It occurs in northern Illinois, near Chicago.

Subgenus ARMIGER Hartmann, 1840

Armiger HARTMANN, Syst. Uebersicht, p. 219, 1840; Erd- & Sussw.-Gasterop., p. 172, 1842. Type: *Armiger crista* (=*Nautilus crista* LINNAEUS).

SHELL: Ultra-dextral, very small, few rapidly increasing, costate whorls, the costae projecting at the periphery, the form like *Gyraulus* in a general way. The genitalia and radula are not known. This little species is widely distributed, being found in Europe, Algeria, and North America. The costate whorls form a distinctive group and the internal organs should also show some differences from the other members of the genus.

GYRAULUS CRISTA (Linn)

Text figure 164

Nautilus crista LINN., Syst. Nat., Ed. X, p. 709, 1758.
Turbo nautileus LINN., Syst. Nat., Ed. XII, p. 1241, 1767.
Planorbis imbricatus MÜLLER, Hist. Verm. Terr., II, p. 165, 1774.
Planorbis cristatus DRAPARNAUD, Hist., p. 44, pl. ii, figs. 1–3, 1774.
Planorbis costatus DETAR and BEECHER, leaflet of one page, Albany, Oct. 25, 1878; Baker, Nautilus, XIX, p. 120, 1906.
Planorbis nautileus WALKER, Nautilus, X, p. 117, 1897; Hanham, Nautilus, X, p. 130, 1897; TAYLOR, Nautilus, X, p. 139, 1897.
Planorbis crista DALL, Alaska Moll., p. 96, 1905; WALKER, Synopsis, p. 13, fig. 34; p. 98, 1918.

TYPE LOCALITY: Europe *(crista, nautileus, imbricatus);* Ann Arbor, Mich. *(costatus).*

WISCONSIN RECORDS: None.

SHELL: Very small, ultra-dextral, depressed, fragile; color light corneous to brownish; surface shining; sculpture of rather coarse lines of growth crossed by very fine, crowded spiral,

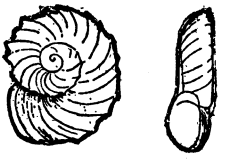


Fig. 164. *Gyraulus crista* (Linn.) Walker, 1918, fig. 34.

striae, the combination giving the surface a wavy appearance when magnified; nucleus large, roundly ovate, sculpture of impressed spiral lines; whorls 2½, rapidly increasing in diameter,

flatly rounded above, well rounded below, costate on the periphery where the costae project conspicuously, but the costae fade into the lines of growth on the upper and lower surfaces, though represented by a dark, slightly elevated ridge; in fresh specimens the epidermis is erect on each costa forming a thin projection, but on dead or fossil specimens the costae are represented only by rounded elevations or nodes on the periphery; spire flat, the last part of the body whorl descending either below the ventral part of the second whorl or about to its periphery; sutures very deeply impressed, even channelled in some specimens; base well rounded, the umbilical region broad and rather deep, exhibiting all of the whorls to the apex; aperture ovate, flattened above, rounded below, appressed to the body whorl only a short distance, slightly expanded at the parietal wall; outer lip thin, simple; the lip is appressed to the body whorl in some specimens and in others the lip is entire merely touching the previous whorl; in some specimens the costae disappear near the aperture, their place being taken by heavily marked growth lines.

L. 5; D. 1.5; Ap. L. 4; D. .5 mm. Carbondale, Ill. (Baker Coll., 1137).
L. 4; D. 1.8; Ap. L. 3; D. .8 mm. Spring Lake (U. of W., 4721).

ANIMAL: Not examined.

GENITALIA AND RADULA: Not examined.

ECOLOGY: No ecological notes available. The Wisconsin specimens are all dead shells or fossils. Nylander found it in Barren Brook, Maine, in three or four inches of water under logs and bark (Nautilus, X, p. 117).

DISTRIBUTION: Maine west to Alberta and Illinois.

DISTRIBUTION IN WISCONSIN: Silver Creek and Spring Lake, Green Lake Co. (Baker). The last locality is in a marl deposit.

REMARKS: This tiny species is at once recognized by its peculiar costate whorls. It was at one time believed to have been introduced from Europe, as it is widely distributed on the eastern continent, but its present wide-spread range in America indicates it to be indigenous or at least of very remote migration from Europe, if that be its center of dispersal. Its presence in Pleistocene deposits also indicates some degree of antiquity in America.

It would be of great interest to know the radula and geni-

talia of this species, but no specimens with the animal have been available. Hartmann has made a group *Armiger* for these costate forms but until the anatomy is more definitely known the true relationship to *Gyraulus* cannot be known.

Family ANCYLIDAE Menke, 1828

SHELL: Dextrally spiral, neritiform, planorboid, or patelliform, the embryonic apex, which is in most species deciduous, either sinistral or dextral.*

ANIMAL: Sinistral or dextral, with a large oval foot; tentacles short, rather blunt, cylindrical, the eyes sessile at their inner base; jaw in three parts or the whole segmented in plates; radula with the teeth arranged in rows nearly horizontal or slightly curved, central tooth unicuspid or bicuspid, laterals bi- or tri-cuspid, marginals comb-like or subobsolete; genitalia variable in form and position of organs; a flagellum is present in those species examined and there is a swelling of the vas deferens which appears to be comparable to the epiphallus of land shells.

DISTRIBUTION: World-wide: "with the exception of *Ferrissia* and *Gundlachia* the genera are extremely localized" (Walker).

Subfamily FERRISSINAE Walker, 1917

SHELL: Small, rather thin, broadly ovate to oblong, patelliform, the apex more or less posterior and excentric, usually more or less turned to the right, and finely radially striate, punctate, or smooth.

ANIMAL (Fig. 165): Sinistral, attached to the shell by three muscles, (columellar) two anterior, and one posterior on the left side, and by a continuous band of muscle marking the free edge of the mantle; this muscle recalls the pallial muscle of bivalves; foot very large, long and wide; head wide, short, veliform as in *Lymnaea;* the mouth is placed in the center between two lateral lobes of the velum; tentacles cylindrical, rather short, bluntly pointed, slightly tapering; eyes sessile

* The family is not an example of hyperstrophy as has been stated by some authors (see Walker, 1921, p. 123; 1923, p. 24).

on the inner base of the tentacles, which are much widened at this point; there is a large conical gill or pseudobranch, made up of several coils or folds, on the left side, which extends well beyond the foot and mantle, and in life even beyond the edge of the shell. There is also a pulmonary cavity or lung, as in other fresh water pulmonates.

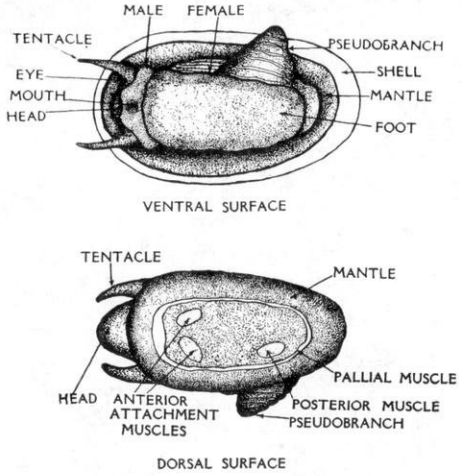


Fig. 165. Animal of *Ferrissia tarda.* Stream near Sturgeon Bay.

The male and female apertures are on the left side, the male in front of the left attachment muscle and behind the left tentacle, and the female behind this muscle and just below the short part of the pseudobranch.

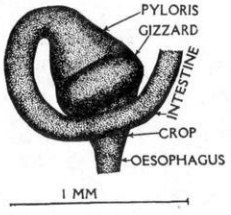


Fig. 166. Digestive organs of *Ferrissia.*

The central part of the digestive system (fig. 166) consists of a small, conical crop, followed by a ring-like gizzard, behind which the pylorus forms a diminishing cone to the intestine, which turns to the right, then forms a loop around the gizzard, forms a loop through and about the liver, running forward,

and then returns to the posterior end where it opens in the lung cavity.

GENITALIA (Fig. 167): The male organ consists of a large praeputium and a smaller subpyriform penis-sheath (hyperphallus or capsule of the verge); the vas deferens is much enlarged as it enters the penis-sheath and this enlargement may be homologous with the epiphallus of land pulmonates; there is a very large blind sac, or flagellum, with a small, short duct, entering the penis sheath at the junction of the vas deferens;

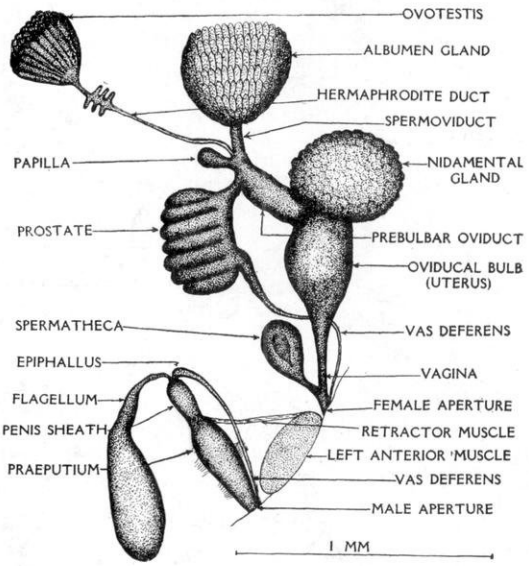


Fig. 167. Genitalia of *Ferrissia parallela*. Winnebago Lake.

distally this body swells to form a very large, club-shaped portion, as long as the penis sheath and praeputium combined, and twice as wide as the widest part of the praeputium.

In section (fig. 168) the male organs show the praeputium with thick walls; there is a large sarcobelum extending well into the body of the praeputium; the penis sheath has rather thin walls; the penis or verge is elongate-pyriform, gradually tapering to a point, the sperm canal centrally located and extending to the tip of the penis; it is somewhat plicate internally; the flagellum is seen in cross section to be a thick walled sac containing an elongated cavity; the walls become thinner as the duct becomes narrower and enters the penis sheath be-

side the epiphallus-like portion of the vas deferens; the sperm canal in the latter is of larger diameter than that of the vas deferens or penis.

There is a long and narrow retractor muscle attached to the constriction between the praeputium and the penis sheath, which is attached distally to the hinder part of the left anterior attachment muscle; other muscles, possibly protractors are attached to the praeputium (one posterior and two anterior) which are attached distally to the body wall.

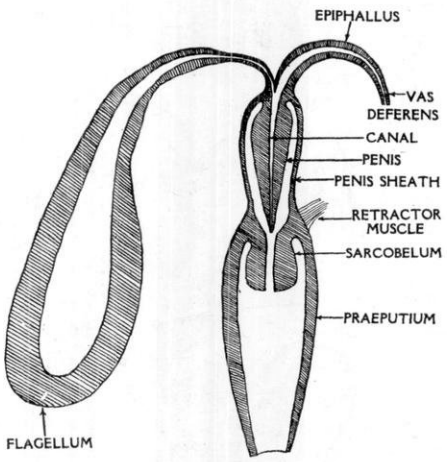


Fig. 168. Section of male organ of *Ferrissia parallela.*

The seminal duct may be divided into five regions; the lower free portion of the vas deferens which enters the body wall at the base of the penis near the penial aperture, the short concealed portion imbedded in the body tissue, the free portion extending from the vaginal opening to the prostate, forming a long and narrow tube, the lower part convoluted in front of the oviduct; near the prostate it enlarges in somewhat the same manner as the lower free portion near the head of the penis sheath (epiphallus?); the prostate is rather wide, and is made up of seven long, narrow lobes laid longitudinally; above the prostate there is a short duct which joins the sperm-oviduct; above this duct, between it and the hermaphrodite duct, there is a small, papilla-like body, a blind sac, of undetermined function.

Female system: The vaginal portion of the oviduct is very short and narrow; above it bifurcates to form the lower portion of the oviduct, which is long and narrow, and the short, rather thick duct of the spermatheca; the latter a large, somewhat pear-shaped body, containing a large, pyriform, orange-colored capsule; the narrow portion of the oviduct enlarges to form the oviducal bulb or uterus; at the summit of the uterus there is a large, rounded nidamental gland; a prebulbar portion of the oviduct lies beyond the nidamental gland, and is a short, stout sac-like body; the carrefour or spermoviduct appears to be a short, narrow duct-like body, into which open the hermaphrodite duct, the prostate duct, the prebulber oviduct, and the albumen gland; these connections seem bound together in a somewhat unusual manner, especially with the addition of the peculiar papilla-like blind sac before mentioned. The albumen gland lies above the spermoviduct and is a large rounded, somewhat irregular body, composed of many elongated, tube-like follicles.

The hermaphrodite system consists of a large ovotestis, a rounded body made up of many long, narrow, tapering follicles; the hermaphrodite duct is a rather long, narrow tube which enters the spermoviduct just above the small papilla before mentioned; near the ovotestis the ovisperm duct supports six small follicles or caeca, called by Lacaze–Duthiers, vésicules séminales. The seminal canal is enlarged within these follicles and a small branch enters each, as shown in pl. vii of the paper cited (Lacaze–Duthiers, 1899).

The genitalia of *Ferrissia* differ radically from those of *Pseudancylus fluviatilis,* as figured by Lacaze–Duthiers, the greatest difference being in the male organs (op. cit., pl. iv, fig. 7). The penis sheath and praeputium of *Ferrissia* are more like those in *Planorbis,* and totally unlike the European species. The flagellum in *fluviatilis* is long and whip-like, not short and club-like as in *Ferrissia.* The junction of this body with the vas deferens (epiphallus?) at their point of entrance into the penis sheath is strikingly different in the two groups. The prostate in *Ferrissia* has seven folds or lobes while in *fluviatilis* there are but three. In *fluviatilis* there are eleven follicles (seminal vesicles) on the ovisperm duct while in *Ferrissia* there are but six. The shape and connections of the female organs are also different.

The differences in the genitalia of these two groups indicate characteristics of subfamily grade and fully justify the separation into subfamilies as has been done by Walker. The genitalia of the Ancylidae in general appear to be quite unlike those of any other family of fresh water pulmonates.

The eggs of *Ferrissia* are rather small and are usually overlooked by collectors and students. Only one paper on this subject has been noted (Clapp, 1921, p. 5). The egg case of *Ferrissia fusca* measures 2.5 mm. in diameter and 1 mm. in height.

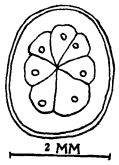


Fig. 169. Egg capsule of *Ferrissia.* Lake Winnebago.

Each egg case contains from one to nine capsules (seven being the usual number), the capsules being filled with a transparent colorless, viscous liquid. Each capsule usually contains one egg, though one was found by Clapp which contained five eggs, but these did not develop normally, and but one egg passed through the complete development. Ten days after being deposited, the embryos broke through the wall of the capsules and entered the egg case. About eight days later the young *Ferrissia* escaped from the egg case to the outer world. Complete development requires from about 18 to 21 days, 18 days being more normal. Egg cases were observed in Lake Butte des Morts on the under side of *Nymphaea* and *Castalia* leaves. The

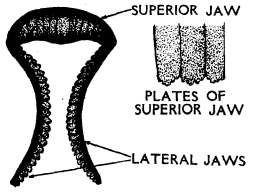


Fig. 170. Jaws of *Ferrissia.*

species was not determined (fig. 169). Clapp states that *Ferrissia fusca* in captivity laid its eggs at night.

JAWS (Fig. 170): Three in number; superior jaw wide and low, the ends attenuated, composed of about 18 segments or

plates; lateral jaws very long and narrow, curved inward, composed of more than 20 small segments or plates.

RADULA: The radula of the subfamily has a bicuspid central tooth, the cusps very large; the lower portion of the base of attachment is more or less expanded. Laterals fundamentally tricuspid, with one or more small accessory cusps. Marginals usually becoming more or less comb-like with many accessory cusps, including several interstitial cusps; the reflection is narrower than in the lateral teeth. The teeth of *Ferrissia* somewhat resemble those of *Lymnaea,* especially in the splitting of the teeth to form accessory cusps. There are from 17–1–17 to 25–1–25 teeth in a row and upwards of 80 rows have been counted.

ECOLOGY: *Ferrissia* occurs in running streams, quiet ponds, rivers, and lakes. They are found on water plants *(Scirpus, Nymphaea, Castalia, Potamogeton),* on empty naiad shells, and on rocks, and the shell appears to be more or less modified by its habitat. Some species prefer certain habitats, as *parallela* on the narrow leaf of the bulrush *(Scirpus)* and *tarda* on old naiad shells and on stones.

DISTRIBUTION: Ferrissinae is of world-wide distribution.

REMARKS: The fresh water limpets, so abundant in species and genera in the South, are reduced to a single genus with a few species in Wisconsin. All are of the limpet type. These tiny mollusks are abundant in the ponds, streams, and lakes of the State, but their small size and the difficulty of proper identification appears to have prevented most students and collectors from giving them the study they deserve. Pilsbry (1896, p. 137) first directed attention to the fact that American Ancyli might be divided into two groups based on their habitat, the "petrophilus" or rock and shell inhabiting species, and the "phytophilus" species which dwelt on the leaves of aquatic vegetation. Walker (1902b, p. 85) first called attention to the presence of peculiar sculpture on the apex of the American Ancyli and later (1903b, p. 15) divided them into two sections. Recent studies of the family by Pilsbry and Walker (Pilsbry, 1924, 1925; Walker, 1917a, 1923) have more or less radically changed the classification, placing it upon a more scientific basis through studies of the radula, jaw, animal and shell.

For the study of the Ancyli, the shells must be thoroughly cleaned from the foreign matter which usually coats them. For

this purpose the shells should be cleaned with dilute oxalic acid. They may then be studied with a compound microscope and the characteristics of the sculpture clearly seen (see Walker, 1902b, p. 85). Much additional knowledge of the habits and distribution of these tiny snails is needed and any one with care can add considerably to this knowledge. It is obvious that exact notes on the habitat relations (whether on plants, stones, or shells) are essential, from the foregoing remarks. The east American species have been rather fully described and figured by Walker (see 1917a).

Genus FERRISSIA Walker, 1903

Ferrissia WALKER, Nautilus, XVII, p. 15, 1903. Type by original designation: *Ancylus rivularis* SAY.

SHELL: Ovate to oblong, conic, more or less elevated, apex excentric and posterior, radially striate or smooth.

ANIMAL: Genitalia and Jaw as described for the subfamily.

RADULA: Central tooth long and narrow, the lower corners expanded so that the base is almost twice as wide as the reflected portion; reflection bicuspid, the cusps rather wide; there is a small swelling at the upper part of the reflection, on either side of the tooth. Lateral teeth more or less obliquely reflected, tricuspid, a large endocone and mesocone, and a smaller ectocone; above the ectocone the tooth has from 2 to 3 small denticulations or accessory ectocones*. Marginal teeth narrower than the laterals, similarly cusped, but the outer, upper part of the reflection with from 3 to 5 accessory ectocones; there may also be a large intermediate cusp between the ectocone and these small cusps. In the marginals there is a tendency to form accessory cusps on the endocone and mesocone which may be in the form of interstitial cusps between these cones, as observed in *Burnupia* and *Uncancylus*. In *Ferrissia* the teeth are in almost parallel rows.

KEY TO SUBGENERA OF FERRISSIA

1. Shell elevated, apex radially striate ----------*Ferrissia*
2. Shell depressed, apex smooth ----------*Laevapex*

* Walker describes the endocone as wanting, but the teeth of Ferrissia examined appear to possess the three cones as designated by Pilsbry for the land pulmonates, and as found in Planorbis and Lymnaea.

Subgenus FERRISSIA Walker, 1903. Typical

Includes the freshwater limpets with conic, elevated shells, often long and narrow, with the apex radially striate.

DISTRIBUTION: World-wide, but lacking in Europe and (apparently) in Siberia, Syria, and the south shore of the Mediterranean (excepting the Nile Valley and a single possibly adventitious species in Algeria), Madeira and the Canary Islands; apparently also wanting in Mexico, Central and South America (Walker, 1923, p. 14).

KEY TO SPECIES OF FERRISSIA

1. a. Apex very excentric, placed well over to the right side and near the posterior end ---------- *shimekii*
   b. Apex only slightly excentric to the right side and about a third of the distance from the posterior end ---------- 2
2. a. Shell elongated, narrow, sides of peristome almost parallel, straight ---------- *parallela*
   b. Shell oval, sides of peristome rounded ---------- 3
3. a. Shell depressed, apex acute, almost centrally placed longitudinally, sides very oblique or slanting ---------- *rivularis*
   b. Shell elevated, apex bluntly rounded, placed posteriorly of the center of the shell, sides not nearly as oblique or slanting as in *rivularis* ---------- *tarda*

FERRISSIA PARALLELA (Haldeman)

Plate XXIX, figures 1–5

Ancylus parallelus HALDEMAN, Mon., pt. 2, p. 3 of cover, 1841; p. 11, pl. i, fig. 6, 1844.

Ancylus parallelus BINNEY, L. & F–W. Sh. N. A., II, p. 142, fig. 237, 1865.

Ancylus parallelus WALKER, Nautilus, XVIII, p. 77, pl. 5, figs. 1–9, 1904.

TYPE LOCALITY: New England.

WISCONSIN RECORDS:

1906. *Ancylus parallelus* CHADWICK, p. 85. Road near St. Martins, Town Franklin, Milwaukee Co.

1911a. *Ancylus parallelus* BAKER, p. 234. Tomahawk Lake; also in small creek and in swale.

1924. *Ferrissia parallela* BAKER, p. 136. Lake Butte des Morts and Winnebago.

SHELL: Narrow, elongated, the lateral margins nearly straight, widening more or less anteriorly, ends well rounded; anterior slope rather long, slightly convex; posterior slope

shorter than anterior, straight or but slightly concave; (fig. 171) right lateral slope nearly straight, left lateral slope slightly convex; apex sub-acute, slightly turned toward the right and slightly anterior of the center of the shell; radially striate;

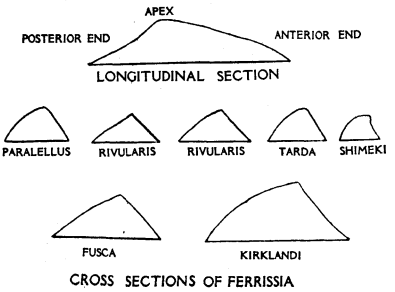


Fig. 171. Cross Sections of *Ferrissia.*

lines of growth fine, irregular, but well marked; the peritreme of the shell may be even or it may be concave at both ends, when the habitat has been upon *Scirpus.* Color of shell pale corneous.

L. 4.9; H. 1.2; D. 2.5 mm.	Red Cliff Creek (U. of W., 4724).
L. 5.0; H. 1.1; D. 2.7 mm.	" " " "
L. 5.0; H. 1.3; D. 2.4 mm.	" " " "
L. 5.1; H. 2.0; D. 2.1 mm.	Lake Butte des Morts (U. of W., 4725).
L. 5.0; H. 1.8; D. 2.5 mm.	" " " " "
L. 5.0; H. 1.5; D. 2.5 mm.	" " " " "
L. 5.0; H. 1.5; D. 3.0 mm.	DePere (U. of W., 442).
L. 6.0; H. 2.0; D. 3.0 mm.	" (" 442).

ANIMAL: See generic description.

JAW: As in the subfamily.

RADULA (Fig. 172): Formula 18–1–18. General form as described under genus *Ferrissia.* The laterals are large, typically tricuspid, without splitting into accessory cusps; accessory ectoconal cusps 4–5; the 13th tooth is transitional, and the 14th appears to be a true marginal, which is somewhat shorter than

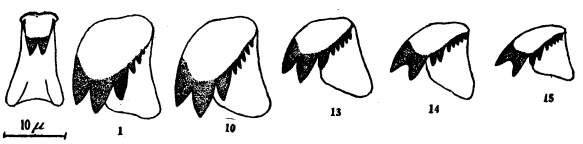


Fig. 172. Radula of *Ferrissia parallela.* Lake Winnebago.

the laterals. The endocone and mesocone become rather widely separated, the principal ectocone splits into two long, sharp cusps and there are 5 accessory ectoconals. The marginals are more oblique than the laterals. There are over 80 rows of teeth. The membranes examined indicate a high degree of uniformity in the form of the teeth and cusps in *parallela.*

ECOLOGY: *Ferrissia parallela* is usually found in quiet water, on plants, the water in such places ranging from .3 to 2 m. in depth. The animal is usually found near the surface but may occur on the lower part of such plants as Scirpus, near the bottom. *Parallela* appears to be a pond or lake species, at least in Wisconsin. The following specific habitats have been noted:

Red Cliff Creek, 100 m. from mouth at Lake Superior, on *Vallisneria* and *Potamogeton* leaves; Lake Butte des Morts on *Scirpus* and *Nymphaea;* DePere, Fox River, on wild rice; Sturgeon Bay, on *Scirpus;* Green Lake, on vegetation; Tomahawk Lake, in large protected bay, on under side of *Nymphaea;* small creek near Tomahawk Lake, on *Nymphaea* and *Castalia;* small swale or kettle lake, near Tomahawk Lake, on sticks.

GENERAL DISTRIBUTION: "Nova Scotia and New England west to Minnesota, Manitoba south to Rhode Island, Central New York, Northern Ohio and Indiana (Walker). A species of northern distribution. In Illinois it is recorded authentically from the northeastern part, in Lake and McHenry counties (Baker, 1906b, p. 101).

DISTRIBUTION IN WISCONSIN: Probably well distributed over the State, though the records would seem to give it an eastern and northern distribution.

Lake Superior Drainage: Red Cliff Creek, Bayfield Co. (Baker).

Lake Michigan Drainage: Sturgeon Bay, above city, Door Co. (Baker); pond in St. Martins, Town Franklin, Milwaukee Co. (Chadwick).

Wisconsin Drainage: Tomahawk Lake and vicinity, Oneida Co. (Baker).

Rock Drainage: Battle Creek, Cooks and Dutchman's lakes, Waukesha Co. (Cahn).

Fox Drainage: Lakes Butte des Morts and Winnebago, Winnebago Co.; Green Lake, Green Lake Co. (Baker); Fox River, De Pere, Brown Co. (Marston).

Johnson (1904, p. 120) mentions several interesting examples of one method of distribution among the Ancyli. He found a water beetle, *Dineutes,* with a specimen of *Ferrissia fusca,*

4 x 2.5 mm., attached to the elytra or wing case. A specimen of *Ferrissia parallela* was also found attached to the elytron of *Dytiscus,* another water beetle. These were full grown *Ferrissia,* and the occurrence suggests means by which these mollusks may be widely distributed.

REMARKS: *Ferrissia parallela* may usually be easily distinguished by its narrow, elongated shell with almost straight lateral margins. There is some variation in height of spire and in the width of the shell. The habitat also largely determines the form of the peritreme, for when on the narrow stem of a bullrush the ends are concave to fit the shape of the plant, and the sides are usually more convex and the shell narrower; while when on a lily leaf, the peritreme is evenly curved all round, the spire is more depressed and the shell wider. Under normal condition, *parallela* is one of the most abundant of the limpet snails in Wisconsin.

FERRISSIA RIVULARIS (Say)

Plate XXIV, figures 16–18

Ancylus rivularis SAY, Journ. Phil. Acad., I, p. 125, 1819; HALDEMAN, Mon. p. 4, pl. i, fig. 1, 1844; BINNEY, L. & F–W. Sh. N. A., II, p. 142, fig. 238, 1865.

Ancylus rivularis WALKER, Nautilus, XVIII, p. 25, pl. i, figs. 1–10, 13–15, 1904.

TYPE LOCALITY: Delaware and Susquehanna rivers, Pa.

WISCONSIN RECORDS:

1860. *Ancylus rivularis* LAPHAM, p. 155. Milwaukee.
1897. *Ancylus rivularis* WISWALL, p. 48. So. Wisconsin.
1906. *Ancylus rivularis* CHADWICK, p. 85. Root River, at Loomis Road, Town Franklin.

SHELL (Fig. 171): Ovate, the margins regularly curving, the ends rounded; anterior slope convex, posterior slope concave below the apex but more or less straight near the peritreme; right slope slightly convex or straight; left slope usually straight but sometimes slightly convex; shell rather well elevated, with a subacute apex, inclining somewhat toward the right side; the apex is situated about a third of the distance from the posterior end; apex radially striate; growth lines somewhat irregular, well marked, with more or less of radial sculpture on the anterior slope; the peritreme of the shell is usually quite flat; the greatest width of the shell is in front of

the apex, the shell narrowing somewhat posteriorly; color pale corneous.

L. 4.5; H. 1.6; D. 3.1 mm. Urbana, Ill. (Baker coll., 1731).
L. 4.5; H. 1.5; D. 3.0 mm. " " "
L. 4.7; H. 1.5; D. 3.1 mm. " " "

ANIMAL: Not examined.

JAW AND RADULA: Not examined. Walker gives the formula as 25–1–25 (1923, p. 14, fig. 3).

ECOLOGY: "Adhering to stones in rivulets" (Say). In a small stream known as the Salt Fork, near Urbana, Ill., this species is found abundantly in dead naiad shells.

GENERAL DISTRIBUTION: Massachusetts west to Nebraska, Ohio northward to Wisconsin and Michigan.

DISTRIBUTION IN WISCONSIN: *Ferrissia rivularis* is apparently very rare in Wisconsin.

Lake Michigan Drainage: Root River at Loomis Road, Town Franklin, Milwaukee, Milwaukee Co. (Chadwick). The records of Lapham and Wiswall are open to question but no authentic material is available for examination.

Rock Drainage: Ashippun River, Waukesha Co. (Cahn).

REMARKS: *Rivularis* is closely related to *tarda* and many specimens are difficult to decide upon. Both species vary in the same direction. "Taking the species as a whole, it may be said to be distinguished from *tarda* by larger size, more depressed form, more acute apex, which is more inclined toward the right side, and nearer the center (longitudinal) of the shell, the posterior slope is proportionally longer and more oblique, the anterior slope is usually not so convex, the left slope is usually longer and more convex than the right, the shell is usually decidedly wider anteriorly and the transverse section is wider in proportion to its height, and the side lines consequently more oblique. The last specification is perhaps a more reliable distinction in doubtful cases than any of the others (Walker, 1904b, p. 26).

FERRISSIA TARDA (Say)

Plate XXIV, figures 6–9

Ancylus tardus SAY, N. H. Dissem., Jan. 15, 1830; HALDEMAN, Mon. p. 7, pl. i, fig. 3, 1844; BINNEY, L. & F–W. Sh. N. A., II, p. 143, fig. 239, 1865.

Ancylus tardus WALKER, Nautilus, XVIII, p. 27, pl. i, figs. 11, 12, 16–23; pl. ii, figs. 1–22, 1904.

TYPE LOCALITY: Wabash River, Ind.

WISCONSIN RECORDS: None.

SHELL: Regularly oval or elongate oval; anterior slope quite convex; posterior slope concave; right slope (fig. 171) almost straight; left slope slightly convex; all slopes very steep; apex elevated, obtuse, almost in the median line and about a third of the length of the shell from the posterior end; apex radially striate; color rather brownish horn or even purplish, sometimes light whitish horn.

L. 3.5; H. 1.5; D. 2.3 mm.	Red Cedar River	(U. of W., 4726).
L. 3.7; H. 1.5; D. 2.5 mm.	" "	"
L. 3.1; H. 1.2; D. 2.1 mm.	" "	"
L. 3.0; H. 1.2; D. 2.0 mm.	" "	"
L. 3.5; H. 1.5; D. 2.1 mm.	Sturgeon Bay	(U. of W., 4727).
L. 3.4; H. 1.5; D. 2.1 mm.	"	"
L. 3.5; H. 1.4; D. 2.2 mm.	"	"

ANIMAL, JAW AND GENITALIA: See generic description.

RADULA (Fig. 173): Formula 21–1–21. Center tooth narrower than that of *parallela*. Laterals tricuspid, the cusps long and sharp; there are 2–4 accessory cusps above the ectocone; the 10th tooth is intermediate and is marked by a split-

Fig. 173. Radula of *Ferrissia tarda*. Stream near Sturgeon Bay.

ting of the large ectocone into two subequal cusps, with four accessory cusps above; the 14th tooth has the endocone split into two small sharp cusps, while the split ectocones are unequal, the lower one being the larger; marginals begin at about the 15th tooth; the 16th tooth shows a small accessory cusp above the endocone and one above the mesocone; the 18th tooth has a small interstitial cusp between the endocone and the mesocone; the 19th tooth has a split endocone, the mesocone and ectocone subequal and six small accessory cusps high up above the ectocone. There are more than 80 rows of teeth.

The radula of *tarda* differs from that of *parallela* principally in the splitting of the endocone and the form of the small ac-

cessory and interstitial cusps on the marginals. There was some variation on the different membranes examined, the interstitial and accessory cusps not always occurring on the same numbered tooth. Each membrane, however, was very uniform in this matter.

ECOLOGY: *Tarda* is usually found on rocks, dead naiad shells, or on debris. Wisconsin data is as follows: On dead naiad shells in Red Cedar River, current swift, water cold, bottom rocky; Lake Chetek, on dead naiad shells in shallow water; Silver Creek, Green Lake, on floating logs and other debris; Lake Butte des Morts, on dead naiad shells; small stream flowing into Sturgeon Bay, on rocks, shallow, swift current, cold water.

GENERAL DISTRIBUTION: Maine west to Mississippi Valley, south to Illinois and Ohio, north to Michigan and Wisconsin, also southern Canada.

DISTRIBUTION IN WISCONSIN: *Tarda* is rather widely distributed in Wisconsin, occupying both the Mississippi and St. Lawrence drainages.

Chippewa Drainage: Red Cedar River, near Chetek; Lake Chetek, Barron Co. (Baker).

Rock Drainage: Pipersville Rapids, Rock River, Jefferson Co. (Cahn).

Fox Drainage: Silver Creek, near Green Lake, Green Lake Co.; Lake Butte des Morts, Winnebago Co. (Baker).

Green Bay Drainage: Small creek flowing into Sturgeon Bay, Door Co. (Baker).

REMARKS: The distinction between *tarda* and *rivularis* is indicated under the latter species. *Tarda* is common while *rivularis* is rare in the State. Like the latter species, *tarda* varies much in height and width. Dr. Walker says of the Wisconsin *tarda*, "they are not typical, but seem to be a small race". As this form is found in three widely separated localities, it may indicate a small northern race. Not enough material is at hand to determine this point. Most of the Wisconsin specimens were found on dead naiad shells.

Tarda from Illinois (Monticello, Urbana, White Heath) are large and typical (5 x 3 mm.) and are found on rocks and on dead mussel shells.

FERRISSIA SHIMEKII (Pilsbry)

Plate XXIV, figures 14, 15

Ancylus obliquus SHIMEK, Bull. Lab. Nat. Hist. State Univ. Iowa, I, p. 214, iii, figs. 5a–c, 1900 (non SOWERBY, 1832, C. B. ADAMS, 1850, KRAUSS, 1853).

Ancylus shimekii PILSBRY, Nautilus, IV, p. 48, 1890; WALKER, Nautilus, XVIII, p. 81, pl. 6, figs. 17–19, 1904.

TYPE LOCALITY: Deadman's Run, Lincoln, Nebraska.

WISCONSIN RECORDS:

1906. *Ancylus* species CHADWICK, p. 85. Kraatz's brickyard, Milwaukee.

SHELL: Elevated, thin, transparent, horn-colored, with a yellowish-brown epidermis; aperture ovate, conspicuously wider anteriorly, in many (especially young) specimens slightly reniform by a barely perceptible incurving of the right margin, the anterior, left and posterior margins regularly rounded, the right slightly incurved, straight, or but slightly convex; apex somewhat acute, elevated, strongly depressed posteriorly and to the right, and curved downward, in most specimens quite overhanging the posterior right margin of the shell; the apical portion of the shell (one-half or more) is strongly laterally, or rather obliquely, compressed, a character which makes the young appear proportionally much narrower than the adults; the anterior slope of the shell is long and strongly convex, the posterior being short and concave. The surface is marked by fine lines of growth (Shimek). A cross section of the shell (fig. 171) shows the right slope to be very concave and the left slope very convex, with the apex well over on the right side. The apex is radially striate.

L. 2.7; H. 1.2; D. 1.7 mm. Average of type (Shimek).
L. 3.5; H. 1.2; D. 1.8 mm. Largest specimen (Shimek).
L. 2.5; H. 1.0; D. 1.5 mm. Winnebago Lake (U. of W., 4731).

ANIMAL: Uniform bluish-white color; the foot is ovate, wider anteriorly, and rather narrow for an *Ancylus* (Shimek).

JAW: Not examined.

RADULA: Rather narrow, the dental formula being 12–1–12 (Shimek). The small number of teeth in a row is noteworthy, being much smaller than for any other *Ferrissia* yet published. The anatomy of the animal, when examined, may show it to belong elsewhere, as suggested by Pilsbry.

ECOLOGY: Found at all seasons of the year adhering to shells of *Anodonta plana,* sticks, leaves, etc., (Shimek). The single specimen found in Lake Winnebago was obtained from .5 m. depth on a rock bottom.

GENERAL DISTRIBUTION: Nebraska; Delaware River, Pa.; Wisconsin. The records indicate a wide geographic range.

DISTRIBUTION IN WISCONSIN: Known at present only from eastern part of the State.

Fox Drainage: Long Point Island, Winnebago Lake, Winnebago Co. (Baker).

Lake Michigan Drainage: Milwaukee, Milwaukee Co. (Chadwick).

REMARKS: *Shimekii* is a very distinct little species, and when once seen, is not likely to be mistaken for any other. The high, narrow shell with the rapid expansion towards the base; the prominent, excentric deflected apex, almost reaching the posterior margin, the long convex anterior slope, and the peculiar posterior slope are very characteristic and separate it from all described species (Walker).

Shimekii is evidently rare in Wisconsin. Its small size has probably caused it to be overlooked, it being taken, possibly, for an immature form of some larger species. It should especially be looked for. Pilsbry (1890, p. 48; 1895, p. 63) has suggested that this species may be the non-septate form of a *Gundlachia,* perhaps *meekiana.* A careful study of the animal should be made to determine this point.

Subgenus LAEVAPEX Walker, 1903

Haldemania CLESSIN, Conch. Cab., ed. ii, pt. 299, Mon. Ancylus, p. 14, 1882. Type by designation: *Ancylus obscurus* HALDEMAN (not *Haldemania* TRYON, 1862). See Walker, Nautilus, XXXIII, p. 101, 1920).

Laevapex WALKER, Nautilus, XVII, p. 15, 1903. Type by designation: *Ancylus fuscus* ADAMS.

Shell more or less depressed, apex smooth, obtuse or subacute. Animal generally as in *Ferrissia,* ss.

KEY TO SPECIES OF LAEVAPEX

Apex subacute, turned to the right, left slope convex_____*kirklandi*
Apex bluntly rounded, left slope straight or but slightly convex____*fusca*

FERRISSIA FUSCA (C. B. Adams)

Plate XXIV, figures 10–13

Ancylus fuscus ADAMS, Bost. Journ. Nat. Hist., IV, p. 329, pl. iii, fig. 17, 1840; HALDEMAN, Mon. p. 12, pl. i, fig. 7, 1844; BINNEY, L. & F–W. Sh. N. A., II, p. 140, fig. 233, 1865.
Ancylus fuscus WALKER, Nautilus, XVII, p. 15, pl. i, figs. 1–9, 1903.

TYPE LOCALITY: Andover and Mansfield, Mass.

WISCONSIN RECORDS:

1860. *Ancylus diaphanus*? LAPHAM, p. 155. Milwaukee.
1865a. *Ancylus diaphanus* BINNEY, p. 141. Milwaukee.
1870. *Ancylus diaphanus* TRYON, p. 223. Wisconsin.
1906. *Ancylus diaphanus* CHADWICK, p. 85. Milwaukee.

SHELL (Fig. 171): Depressed, oval or slightly obovate, the right side somewhat flattened; anterior slope straight or but slightly curved; posterior slope very slightly convex; right lateral slope straight; left lateral slope straight or slightly convex; apex obtuse, smooth, not rising above the general contour of the shell, placed behind the middle of the shell and somewhat to the right; surface sculpture of faint growth lines and occasionally with interrupted transverse lines which frequently form more or less irregular riblets; color horn, translucent and shining.

L. 6.1; H. 1.9; D. 4.0 mm.	Green Lake	(U. of W.,	4728).
L. 6.1; H. 1.8; D. 4.0 mm.	"	"	"
L. 5.3; H. 1.7; D. 3.0 mm.	"	"	"
L. 5.0; H. 1.5; D. 3.2 mm.	"	"	"

ANIMAL: Similar to *parallela.*

GENITALIA AND JAW: See generic description.

RADULA (Fig. 174): Formula 20–1–20. Central tooth as in *parallela,* but slightly smaller; laterals tricuspid, with long and sharp endocone, mesocone, and ectocone; there are five accessory

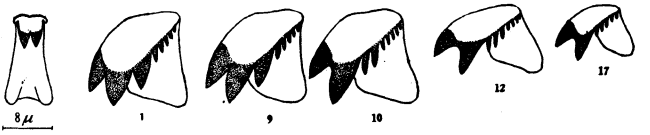


Fig. 174. Radula of *Ferrissia fusca.* Lake Winnebago.

ectoconic cusps on the outer side of the tooth; the 10th and 11th teeth are intermediate in character, with a short, wide endocone, a long, sharp mesocone, and two long, narrow cusps repre-

senting the split ectocone, which has in addition five small accessory cusps; the 12th tooth is a true marginal, with a wide endocone, a sharp mesocone, the other cusps as in the 10th tooth; the marginals are shorter and wider than the laterals; the marginals become smaller toward the outer edge of the membrane, and the ectocone and accessory cusps become subequal in size, long, narrow and sharp.

Walker's figure of the radula of *fusca* (1923, p. 15) shows 23–1–23 teeth but only 20–1–20 could be counted on the membrane of Wisconsin specimens. The teeth resemble those of *Ferrissia parallela.*

ECOLOGY: Adams found his specimens adhering to stones in a small rivulet. In Wisconsin, they have been found as follows: Silver Creek, on floating logs; Lake Butte des Morts, on Scirpus.

GENERAL DISTRIBUTION: Massachusetts west to the Mississippi Valley, south to New Orleans.

DISTRIBUTION IN WISCONSIN: At present known only from the eastern part of the State.

Fox Drainage: Silver Creek, near Green Lake, Green Lake Co.; Lakes Winnebago and Butte des Morts, Winnebago Co. (Baker).
Rock Drainage: Dutchman's Lake, Waukesha Co. (Cahn).
Lake Michigan Drainage: Menomonee River, Waukesha Co. (Cahn).

REMARKS: *Ferrissia fusca* is an abundant species in parts of the Mississippi Valley. Though variable in general form, width and elevation, the peculiar rounded, obtuse apex will aid greatly in distinguishing it from *kirklandi,* the only other smooth apex *Ferrissia* found in Wisconsin. Walker says, "It differs from *kirklandi* by its more depressed and more regularly oval shape and more nearly central, more obtuse, less prominent and less excentric apex". One variation is due largely to habitat; when it lives on the flat surface of a reed or other vegetation, the peritreme is flat and even all the way round; when it lives on the bullrush *(Scirpus)* the peritreme is like a saddle, the sides extending downward to meet the curve of the plant; this kind of habitat causes the shell to have a trough-like appearance when placed upside down, as remarked by Walker. Much of the variation in shape is due to the habitat.

FERRISSIA KIRKLANDI (Walker)

Plate XXIV, figures 19–21

Ancylus kirklandi WALKER, Nautilus, XVII, p. 29, pl. ii, figs. 1–12, 1903.

TYPE LOCALITY: Grand Rapids, Mich.

WISCONSIN RECORDS:

1926. *Ferrissia kirklandi* WINSLOW, p. 6. Little Arbor Vitae Lake.

SHELL (Fig. 171): Large for the genus, thin, translucent, horn-colored; broadly oval or obovate, sides nearly equally curved, ends broadly rounded; quite elevated; apex subacute, behind and to the right of the middle, and decidedly turned to the right; posterior and right slopes straight or slightly concave, anterior slope quite convex, left slope decidedly convex; surface with the growth lines regular and distinct and more or less rippled by transverse wrinkles, which frequently tend to form feeble, irregular radial riblets.

L. 8.0; H. 2.5; D. 5.5 mm.	Type.	
L. 7.9; H. 2.3; D. 5.0 mm.	Lake Mendota (U. of W.,	4729).
L. 5.8; H. 1.8; D. 4.0 mm.	" "	"
L. 6.9; H. 2.1; D. 4.0 mm.	Sturgeon Bay ("	4730).

RADULA (Fig. 175): Formula 23–1–23. Central tooth about as in *fusca;* laterals as in *fusca,* with the accessory ectocones only three in number; 10th tooth with split ectocone, the cusps unequal in size; the 16th tooth has a bifid or split endocone as well as the same unequal bifid ectocone of the 10th

Fig. 175. Radula of *Ferrissia kirklandi.* University Bay, Lake Mendota.

tooth; 17th and 18th teeth marginals with accessory endoconic and mesoconic accessory cusps; 20th tooth has a bifid endocone, a long and narrow mesocone, a small ectocone, and five unequal accessory ectoconal cusps. The cusps are all rather long and sharp.

The teeth of *kirklandi* resemble those of *tarda* in the splitting of the cusps in the marginals. The position of the accessory and interstitial teeth is somewhat variable as regards the place of the teeth on the membrane.

ECOLOGY: Sturgeon Bay, on naiad shells near shore.

GENERAL DISTRIBUTION: New Jersey and D. C., west to Arkansas, north to Michigan and Wisconsin. Toward the east the species is somewhat smaller in size.

DISTRIBUTION IN WISCONSIN: At present known only from the eastern and northern part of the State.

Green Bay Drainage: Sturgeon Bay, Door Co. (Baker).
Fox Drainage: Winnebago Lake, Winnebago Co. (Baker); Fox River, Brown Co. (Marston).
Wisconsin Drainage: Little Arbor Vitae Lake, Vilas Co. (Winslow).
Rock Drainage: University Bay, Lake Mendota, Dane Co. (Juday); Crawfish River, Aztalan and Lake Koshkonong, Jefferson Co. (Cahn).

REMARKS: *Ferrissia kirklandi* is distinguished by its large size, decidedly elevated shape and its prominent, subacute apex, which is decidedly turned to the right. There is some variation in shape, as shown by the measurements, some examples being more elongated with nearly parallel sides. There is also considerable difference in height. But in all cases the subacute, prominent apex and the convex, left slope are characteristic, and always distinguished it from *fusca*, in which the apex, even in the more elevated examples, is always bluntly rounded and the left always scarcely convex (Walker). Wisconsin *kirklandi* are large and fine specimens, exceeding all other *Ferrissia* found in the state in this respect.

Family PHYSIDAE Dall, 1870

DALL, Ann. Lyc. Nat. Hist. N. Y., IX, p. 355, 1870.
BAKER, Trans. Wis. Acad. Sci., XXII, p. 197, 1926.

SHELL: Spiral, sinistral, thin to thick, smooth or with well developed impressed spiral lines, shining or dull, spire elongated or very short.

ANIMAL: Sinistral, with the pulmonary, excretory, and genital orifices on the left side; without pseudobranch; foot narrow, pointed behind; head distinct, lobed in the center, the tentacles long, slender, cylindrical, placed at the outer corners of the head; eyes sessile at the inner base of the tentacles; front of body with vela area, auriculate, separated from the foot by a constriction; mantle plain or with few or many lobes or digitations, more or less reflected over the shell; jaw single, arched,

with a vertical fibrous process on the upper margin, the face of the jaw usually striated; radula with the teeth arranged in oblique rows, center tooth with lateral projections, multicuspid; lateral and marginal teeth comb-like, usually with large cusps alternating with smaller denticulations, and with a lobe or process at the upper, inner angle of the tooth; genitalia as described under the genus *Physella.*

DISTRIBUTION: North America, Europe, Asia, East Indies, Africa, Madagascar, New Caledonia, Australia.

KEY TO GENERA OF WISCONSIN PHYSIDAE

1. Shell elongated, slender, smooth, polished, inner edge of mantle simple, without digitations, not extending beyond edge of shell ---------- *Aplexa*
2. Shell more or less elongated, whorls usually somewhat inflated, with distinct or subobsolete spiral striae; inner edge of mantle with few or many lobes or digitations, extending over the columellar portion of the shell ---------- *Physella*

Genus PHYSELLA (Haldeman, 1842) Baker, 1926

Physella HALDEMAN, Mon., I, pp. 14, 38, 1842. TYPE: *Physa globosa* Hald.

Physodon HALDEMAN, Mon., pp. 14, 39, 1842. TYPE: *Physa microstoma* Hald.

Physella F. C. BAKER, Trans. Wis. Acad. Sci., XXII, p. 199, 1926.

SHELL: Sinistral, oblong or elongated, more or less translucent, surface dull to shining, spire acute or depressed, usually shorter than the aperture, which is contracted above

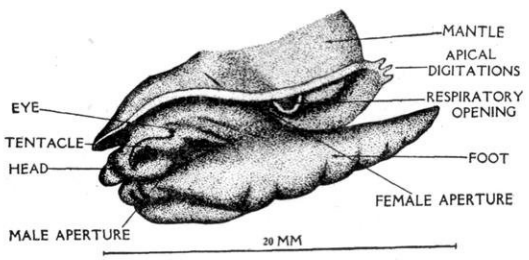


Fig. 176. Animal of *Physella parkeri.* Douglas Lake, Mich.

and rounded below; columella with an obscure plait or thickening, which gradually merges with the callus of the parietal wall; outer lip sharp, often thickened internally by a vertical callus; the inner lip is closely appressed to the columellar re-

gion either completely closing the umbilical region, or rarely, leaving a small chink or perforation; sculpture consisting of coarse or subobsolete spiral impressed lines.

ANIMAL: As described for the family, in general. The mantle is modified on the left side to form a large respiratory tube (fig. 176). The mouth is placed in the center of the so-called vela area at the junction of the two auricular lobes (see

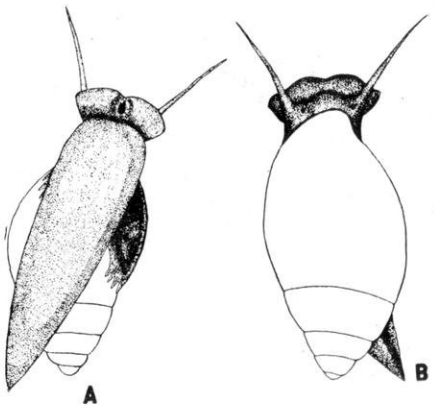


Fig. 177. Animal of *Physella gyrina*. A, below; B, above.

fig. 177). The mantle is reflected over the shell only on the parietal and columellar regions, a portion at each of these locations being digitate or lobed. These lobes vary in number from two to six or seven in the apical region to as many as ten in the columellar region. This variation may occur in a single species (as P. *gyrina hildrethiana*, fig. 178) and the number is

Fig. 178. Mantle Digitations of *Physella gyrina*.

not constant enough to furnish criteria for specific determination. At the lip edge the mantle simply forms a thickening and is not reflected over this part of the shell, as in the European *Physa*.

The digestive system (fig. 179) consists largely of a large crop and gizzard combined in a large rounded body, which contracts to form a long, sausage-shaped stomach. The stomach

and intestine are coiled around the crop. The digestive organs of *Physella* are quite different from those of *Planorbis,* in which the stomach and gizzard are of about equal diameter and

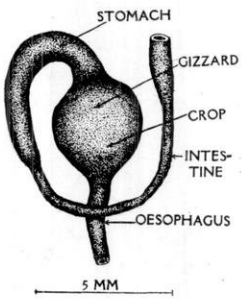


Fig. 179. Digestive Organs of *Physella.*

differently shaped, and the crop is much smaller. In *Lymnaea* there is a large bilobed gizzard on each side of the crop.

GENITALIA (Fig. 180): Male opening on left side just behind left tentacle; female opening at side of neck in front of respiratory tube. Male system consisting of a large praepu-

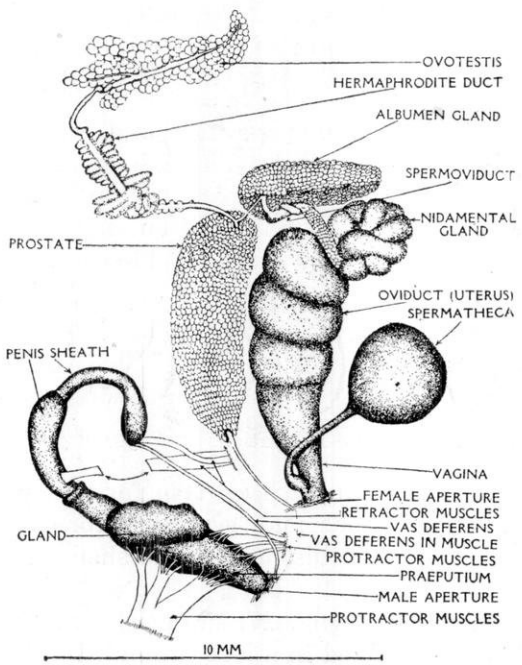


Fig. 180. Genitalia of *Physella ancillaria.* Devils Lake.

tium, a long penis sheath, often more than twice as long as praeputium, more or less contracted in the middle, and a long vas deferens which enters a wide, flattened prostate, the latter closely applied to the oviduct. There is a large gland of unknown function on the upper part of the praeputium which may be comparable to the enlargement into which the flagellum enters in *Helisoma*. This gland is hollow, with very thick, muscular walls (fig. 181 A). In section the praeputium

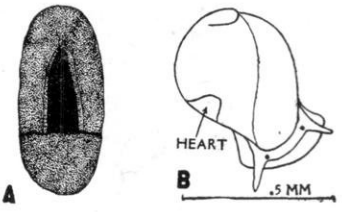


Fig. 181. A, Penial Gland. B, Newly hatched Young of *Physella*.

shows two muscular ridges or pillars (penial guides) and the gland near the upper part. There is usually a more or less well developed sarcobelum. The penis sheath is long and narrow with thick walls, and, in some species, with a constriction about midway between the praeputium and the apex of the sheath, causing this organ to have an external appearance of possessing an epiphallus (see fig. 186, 190). The penis is always very long, of large diameter at the upper part where it receives the vas deferens, gradually tapering to a sharp point just above the sarcobelum. There is a large retractor muscle attached to the praeputium, a narrow muscle attached to the penis sheath, their terminations united and inserted in the columellar muscle. The penis sheath is doubled over upon the praeputium in the natural position and held in place by the retractors. There is a large anterior protractor and a series of smaller posterior protractor muscles attached to the praeputium; these are more or less split into smaller branches.

Female system: There is a short, wide vagina and a large, wide, lobed oviduct, the uterine portion being very wide; the spermatheca is very large, globular, and connected with the vagina by a short, narrow duct. The nidamental gland is large, convoluted, and rounded; the spermoviduct is a short, wide, ribbon-like organ, somewhat convoluted before it enters the albumen gland. This gland is almost three times as wide

as long. A small duct connects the sperm-oviduct with the hermaphrodite duct. The latter is much swollen and lobed in the center, narrowing at each end as it enters the prostate and the ovotestis. The ovotestis is a long, wide much lobed organ. The color of the reproductive organs is yellowish or whitish. During the breeding season, the oviduct nidamental gland, albumen gland, and sometimes the prostate, become white and flocculent, at which time the general form of the organs cannot be determined.

There is little variation in the reproductive system as a whole. The female system appears to be very uniform. The male system shows differences in the relative dimensions of penis, penis sheath, and praeputium, though these are uniform within the species, but many of the species vary in this respect.

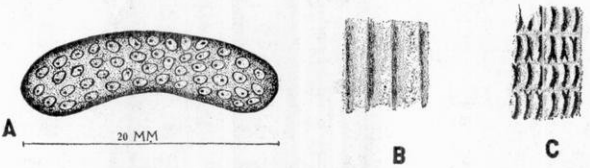


Fig. 182. A, Egg Capsule of *Physella*. B, Sculpture without Spiral Lines; C, Sculpture with Spiral Lines.

The eggs of *Physella* are laid in large, glairy masses, each mass containing from 130 to 200 eggs (fig. 182). They measure about 20 x 4 mm. In captivity, 15 individuals of *gyrina hildrethiana* laid 14 egg capsules in two days (April 23, 24). On June 3, 40 days later, young were observed, the shells measuring .5 mm. in length, vitreous in appearance and perfectly translucent, both shell and animal. The young, like the adult animal, are very active, gliding rapidly about, voraciously eating everything available (fig. 181 B). In twelve days the young had doubled in size, measuring 1 m. in length. In nature, the egg capsules are attached to almost any submerged object,—stones, logs, wood, and aquatic vegetation, the latter more rarely. Mature growth is attained by some species in a year, by others in two years, and it is possible that a few live three or more years. In some species (as *hildrethiana*) egg laying continues throughout the season, young of all ages being found throughout the summer and fall. Others reproduce only in the spring.

JAW (Fig. 183): The jaw of *Physella* is composed of a single plate, arched, and densely striated and apparently made up of many small, vertical plates placed side by side. There is a thickened fibrous process extending from the upper border. The lower border is minutely serrated. The jaws of the different species are remarkably uniform.

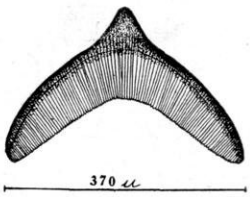


Fig. 183. Jaw of *Physella ancillaria*. Devils Lake.

RADULA (Fig. 184): The radula of Physidae belongs to the group known as Echinoglossa. The teeth are arranged on the radula membrane in oblique rows, descending to the lateral border in a more or less sigmoid curve. There is a small center tooth which is wide and has projecting processes both above

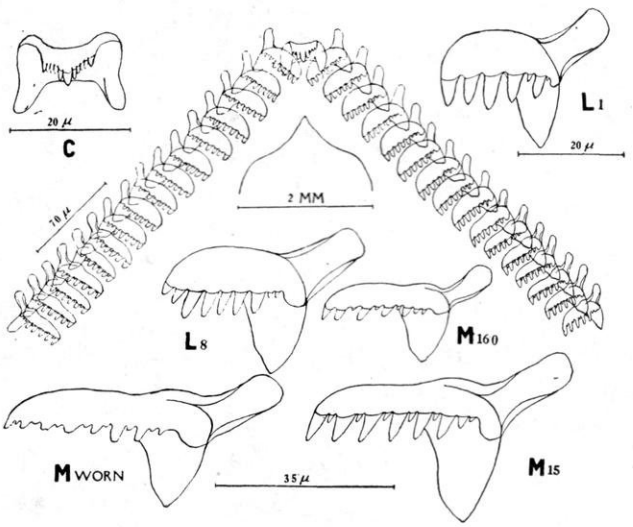


Fig. 184. Radula of *Physella ancillaria*. Devils Lake.

and below, causing a deep bay or sinus at top and bottom of the tooth; the reflection is wide and reaches to the bottom of the ventral sinus; the denticulations vary in number, consisting of a central cusp with several smaller lateral cusps placed at

varying heights above the central cusp. There are a small number of lateral teeth, usually 6 to 10; these are comb-like, the reflections wide and low, roundly arched above and with several (5 to 8) long, fang-like cusps, sometimes with smaller denticles between the larger cusps; the base of attachment is long and narrow, more or less acute at the posterior margin; there is attached to all of the side teeth a peculiar appendage or accessory plate which aids in holding the tooth securely to the radular membrane; this projects upward from the upper, outer corner of the tooth, and the reflection and base round out into it; it is differently shaped in different parts of the radular row, the lateral teeth having a short, wide appendage, while in the marginal teeth it is long and comparatively narrow. This appendage is correctly shown in but one published figure (Pilsbry, 1926, p. 328); it appears to be composed of a narrower upper portion attached to a wider base, the lower corner of the reflection rounding into it in every tooth examined. The marginal teeth are very numerous and are very long, very low, and have a depression in the upper border which forms a rounded ridge near the accessory appendage. The marginals near the outer edge of the membrane are always smaller than those near the center.

The number of teeth in a row vary from 115 to 175, and there may be as many as 150 rows. The teeth appear to be quite constant in form and denticulation within the species, but the different species differ widely. The size of the center tooth appears to be a specific character, as is also the number and position of the denticulations. The presence or absence of intermediate small denticulations between the large cusps also appears to be of diagnostic value. In some cases, certain related species have been separated easily by the characteristics of the radula while the form of the shell was so variable as to be without value in determination. The center teeth are very small and difficult to see clearly, which accounts for the faulty shape in those few figures published. Worn membranes have teeth which differ widely from those in unworn parts of the membrane. The side teeth all lie over each other very closely but there is a space at the apex of the two lateral rows in which is placed the center tooth. The sides of this, however, are partly obscured by the first lateral tooth, which is always smaller than the second lateral, and the lateral angles are therefore difficult to make out clearly in some species.

ECOLOGY: *Physella* is found in all kinds of bodies of water, from the ephemeral pools of woodlands to the largest lakes. In depth they occur from shallow water a few cm. in depth to the bottom of deep lakes. The optimum habitat, however, is from one to two meters. In the so-called summer-dry pools, and in all bodies of water that dry up more or less in the hot, dry months, the Physellae are compelled to hibernate by burrowing into cracks in the mud or into the mud itself, closing the aperture with mud attached to the mucus of the foot. Such species as inhabit this kind of an environment have several (2 to 5) rest marks, indicating that the individual has been compelled to hibernate over a dry period. This may vary in different seasons, and the same species may make only one or as many as four in a single season, depending upon the amount and intermittance of the rainfall. Such conditions are numerous in both Illinois and Wisconsin. Crandall has coined the terms annuan, biannuan, and triannuan for those species which appear to have attained their growth in one, two, or three seasons; but as these rest marks may indicate several resting stages in a single season, and not of different years, I do not believe that this characteristic can be logically used until we know more about the actual time the different species require to attain maturity. This is a good subject for investigation by experimental zoologists. See Dawson "The Biology of Physa" for accounts of the habitat relations of this group.

DISTRIBUTION: *Physella* is distributed throughout North America, Mexico, and parts of the West Indies. It is found everywhere throughout this range, in the Arctic regions and in high mountains, and even in desert regions.

REMARKS: A study of the animals of *Physa* from America and Europe indicate that the name *Physa* cannot be applied to the American forms of these sinistral shells. The type of *Physa* is the *Bulla fontinalis* of Linn. The animal of this species has a mantle which partly envelopes the shell, not only on the parietal and columella side, but on the outer lip area as well. The mantle of the left side extends well over the shell to the center of the dorsal side; the lower part is composed of one large lobe, while the upper part, which is digitate, covers the spire. The part of the mantle over the lip is digitate and extends well over this side of the shell (fig. 185). This digitate mantle is well shown in Lacaze Duthier's figure (1872, pl.

xix). In the mantle of the American Physae the digitate mantle is reflected only over a small part of the parietal wall and columella region, and the outer lip mantle edge is simply thickened and is not digitate or extended over the shell. The center tooth of *fontinalis* is also different from that of the American species, having a larger number of small denticulations on each side of the center cusp. The reflection is also wider than in the American species.

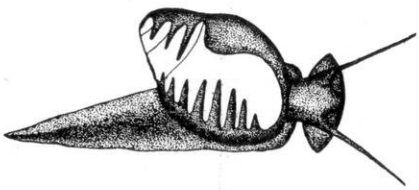


Fig. 185. Animal of *Physa fontinalis.* After Taylor.

In view of this difference between the type of the genus *Physa* and the American species, it seems necessary to place the latter in a separate group or genus. *Rivicola* of Fitzinger, 1833, is founded on the same type as *Physa, fontinalis.* In 1842, Haldeman defined two groups of *Physa, Physella* with the type *Physa globosa,* and *Physodon,* with the type *Physa microstoma.* While the characters given by Haldeman are trivial, the names seem available for the division of the group with a mantle only partly covering the shell. Haldeman's name is, therefore, here redefined to include these American species. *Physodon* is reserved for a subgenus which differs somewhat from *Physella* in its genitalia and in the general form of the shell.

Pilsbry (1926, p. 328) has recently defined a new group called *Petrophysa* in which the mantle is not digitate and the arrangement of the cusps of the radula is different from other American Physae. The type species, *zionis* Pilsbry, is found in Zion National Park on wet canyon walls. The difference in mantle and radula would seem to indicate that this group should be considered of generic rather than subgeneric rank, as in the case of *Aplexa,* which is not more sharply differentiated from the other American forms than is *Petrophysa.*

In placing the American forms in *Physella* it is recognized, of course, that the genitalia and radula, as well as mantle, of the type species, *globosa* Haldeman, is at present unknown, and

the reference must be tentative until the animal of that species has been examined. To what group other species of European (as well as other old-world) Physae may belong cannot be stated at present, no anatomical data being available for this purpose. *Physa acuta* Drap. is similar in form to some of the American species, but its genitalia, radula and general mantle form have not been described. It is probable that when the different species of Physoid snails are examined anatomically new groupings will be found necessary.

KEY TO SUBGENERA OF PHYSELLA

1. Shell large, usually rather thin, the columella twisted and with a plait or ridge; genitalia with the penis sheath having a constriction in the middle dividing it into two parts—*Physella* ss.
2. Shell small, usually rather thick and solid, the columella smooth without distinct twisted plait; genitalia without constriction in center of penis sheath, which gradually enlarges ——— *Physodon*

Subgenus PHYSELLA Haldeman, (1842) F. C. Baker, 1926.

Shell large, usually with twisted axis and more or less distinct columellar plait; male genitalia with small praeputium and very long, bilobed penis sheath, and a more or less elongated sarcobelum; the gland is placed on the side of the praeputium below the distal end. TYPE: *Physa globosa* Haldeman.

KEY TO SPECIES OF PHYSELLA*

1. a. Spire depressed, shell wide, last whorl very large, wide, inflated, aperture wide, expanded ——— 2
   b. Spire elongated, shell narrow and cylindrical, aperture narrow, elongated ——— 8
2. a. Spire very short, wide, aperture ⅘ length of shell——— 3
   b. Spire longer than 3, acute, aperture ¾ length of shell——— 7
3. a. Shell very thin, paper-like, whorls roundly swollen, width 8/10 or more of length ——— *laphami*
   b. Shell not thin and paper-like, width $\frac{7}{10}$ or less of length——— 4
4. a. Body whorl with more or less pronounced shoulder, shell usually rather thick, columella thickened, without twist or plait, spire whorls flat and sloping in an almost straight line to the shoulder ——— 5

* This key will help to distinguish mature, typical specimens of the species listed from Wisconsin. Immature forms and excentric variations will not always fall into any one of the sections and must be determined by the figures and descriptions. Variation is so great in this family that a key covering all of the mutations cannot be made that would be at all usable.

b. Body whorl rounded without shoulder, shell rather thin columella thin, twisted, with plait ---------- 6

5. a. Body whorl between suture and edge of outer lip shouldered or greatly rounded, spire dome-shaped ---------- *ancillaria*
   b. Body whorl between suture and edge of outer lip flat, spire broadly conical, shell very thick, solid ---------- *crassa*
6. a. Body whorl between suture and edge of outer lip long and flat, spire long, pointed, shell smaller than 5, very solid ---------- *magnalacustris*
   b. Spire short, dome-shaped, sutures impressed, aperture narrowly ovate ---------- *warreniana*
   c. Spire short, conical, sutures not much impressed, aperture greatly expanded or flaring ---------- *vinosa*
7. a. Color light yellowish corneous, surface shining, whorls rounded, aperture regularly rounded from body whorl to base ---------- *sayii*
   b. Color brownish or liver-color, surface dull, whorls slightly gibbous, aperture expanded, leaving the body whorl at a sharp angle ---------- *vinosa* (elongated)
8. a. Surface smooth, unmarked by spiral lines or with these lines subobsolete ---------- *heterostropha*
   b. Surface with distinct impressed spiral lines ---------- 9
9. a. Aperture less than ⅔ length of shell, spire rather long, and pointed ---------- 10
   b. Aperture more than ⅔ length of shell, spire short and obtuse ---------- 11
10. a. Spire broadly acute, shell more than 16 mm. long--- *hildrethiana*
    b. Spire acutely pointed, shell less than 10 mm. long--- *obrussoides*
11. a. Shell thin and more or less fragile, spire depressed, aperture widely ovate, the outer lip forming more or less of an angle with the body whorl ---------- 12
    b. Shell thick and rather solid, spire elevated, aperture narrowly ovate, the outer lip descending from the body whorl in an unbroken curve, the upper part of the outer lip not notably arched ---------- 13
12. a. Surface shining, color yellowish horn, body whorl cylindrical; center tooth of radula 17 μ long ---------- *bayfieldensis*
    b. Surface dull, color brownish, body whorl broader at the periphery than 25; center tooth 21 μ long---------- *chetekensis*
13. a. Spire elevated, aperture narrowly ovate, the curve of the shell at the aperture not being interrupted by the outer lip ---------- *elliptica*
    b. Spire not as elevated and shell at periphery wider than 26, whole shell not as cylindrical ---------- *aurea*

The study of the genus *Physa* is attended with great difficulty; the species are very variable in form and structure; and as well, often, in sculpture. It is unsafe to name any but the most striking forms from one or two specimens because of the

tendency to vary and to resemble other species in form. Usually, however, if a series of specimens be large enough, including age variation, a species may usually be quite definitely and correctly placed. The early authors, Say, Lea, Tryon, frequently described a species from one or two examples, and several names have been given to the extremes of variation of a single species for this reason.

The principal criteria in determining the species from the shell, which will be the only available criterion in most cases, are texture, including the surface features, whether dull or shining, coarse or fine; structure, including the manner in which the whorls lie over or abut against each other, the form of the outer lip and of the columella; and sculpture, including the surface markings as they appear under a magnifying glass of moderate power, lines of growth, whether placed close together or farther apart, whether spiral lines are present, and if so whether subobsolete or well developed. The height of the spire and the relative length of aperture to length of shell is also of importance, though this feature is often combined in the same species, as in *gyrina* for example. The two extremes of sculpture are shown in figure 182, illustrated by *heterostropha* (B), which has a smooth shell, and *gyrina hildrethiana* (A), which has a shell with heavily impressed spiral striae.

The radula is one of the best of criteria for the determination of the different species and when the radulae of all species are known it may be possible to prepare a definite key which will greatly aid in the determination of critical species. The size and denticulation of the center tooth appears to be of first importance in this respect. The writer believes that the majority of the names given to American Physas will stand either as species, or varieties, and that comparatively few names will be found to be actual synonyms.

Few attempts have been made to monograph the American Physas. Haldeman in 1841–44, described and illustrated those species known to him. Binney, in 1865, republished all of the original descriptions and gave type figures of the species known at that time, a most indispensable work giving data of great value at present found nowhere else. Tryon, in 1870, in the Continuation of Haldeman's Monograph, described and figured all of the species known at that time. Tryon was very con-

servative and placed several good species in the synonymy, including several of his own. These works are mostly unavailable to the average student at the present time. Excepting state lists and the monographing of the mollusks of small areas, these are the only general works that have been published. Foreign monographers have simply copied American descriptions and figures or have introduced errors from wrongly identified specimens.

In 1901, Crandall attempted a revision of the Physas east of the Rocky Mountains, and this paper is the best that has been published, embracing a careful, analytical discussion of each species, based upon a good collection and long experience in the study of these perplexing species. The study of Wisconsin Physae, based upon shell and anatomical criteria, has shown that in most cases Crandall's opinions are correct and are to be depended upon.

In 1912 a western author (see Hannibal) attempted a synopsis of the recent and tertiary freshwater Mollusca of the western region. This was based upon an "ontogenetic" classification. The resulting treatment has been most unfortunate in all cases and especially so of the Physas (pp. 163–165) which are all (some 40) species made synonyms of the European *fontinalis* and *acuta*. Verily, the science of Malacology has returned to Linnaean times on the west coast. This wholesale "slaughter" of the unoffending American species of tadpole snails has been thus ruthlessly made without even a suggestion of anatomical data, save some that is borrowed and this wholly misinterpreted. A few attempts at revision like this would place our subject in irremediable chaos.

PHYSELLA LAPHAMI Sp. Nov.

Plate XXV, figures 1–5

TYPE LOCALITY: Hancock, Waushara Co., Wisconsin.

WISCONSIN RECORDS: None.

SHELL: Large, very thin, tumid, imperforate, corneous; color light horn, surface dull to slightly shining; sculpture of fine growth lines which are coarse at irregular intervals giving a minutely costated effect, crossed by very fine impressed spiral lines which are evenly and closely spaced; whorls about 5, the last somewhat shouldered, very large; spire very short, broad,

acute; nucleus of about one small, dark brown or wine-colored whorl, smooth or slightly satin-finished in appearance; sutures not deeply impressed, the whorls being laid tightly against each other, forming a wide wrinkled band where it is appressed against the succeeding whorl; aperture large, 4/5 of the entire length of the shell, the outer edge regularly and broadly curved, often roundly shouldered above, somewhat effuse below; edge of lip thin with only a slight thickening within and without a marked red border; only a slight wash of callus on the parietal wall; columella straight, with a thickened fold which is often slightly twisted and plait-like.

L. 21.0; D. 15.0; Ap. L. 17.0; D. 9.0 mm. Hancock (U. of W., 4578). Type.
L. 20.0; D. 14.0; Ap. L. 17.0; D. 8.0 mm. Hancock (U. of W., 4578). Paratype.
L. 17.0; D. 13.0; Ap. L. 15.0; D. 7.0 mm. Hancock (U. of W., 4578). Paratype.
L. 15.5; D. 11.5; Ap. L. 12.5; D. 7.0 mm. Hancock (U. of W., 4578). Paratype.
L. 14.0; D. 9.0; Ap. L. 11.5; D. 5.0 mm. Hancock (U. of W., 4578). Paratype.
L. 11.0; D. 8.0; Ap. L. 9.5; D. 4.0 mm. Hancock (U. of W., 4578). Paratype.

ANIMAL: No living or alcoholic specimens of *laphami* have been available for study. *Physella parkeri*, a related species living in the southern peninsula of Michigan, has a bluish-gray body flecked with small white spots, lighter on the neck. The mantle has several large black blotches which show conspicuously through the shell. The mantle has 4 apical and 2–3 columellar digitations.

GENITALIA: Not known. In *parkeri* the female organs are as in the genus. In the male organs, the praeputium is large and pyriform, with thick walls, two longitudinal muscular pillars, and a very large sarcobelum, half as large as the praeputium and hanging down in this organ like a sac; the praeputium gland is comparatively small; penis sheath 1½ times as long as the praeputium, with thin walls, the distal end enlarging to more than double the size of the proximal end; penis long, elongate-pyriform, much narrowed toward the end, the canal centrally located (fig. 186).

JAW: Not examined.

RADULA: Unknown. Formula of *parkeri* 131–1–131. The center tooth is slightly wider than high, the reflection 7–cuspid, arranged in a 2–1–1–1–2 series. The first nine teeth may be called laterals, the form of the body being a regular oval; the first lateral has 5 large cusps and 3 smaller cusps; the second lateral has 6 large cusps with a small cusp between each larger one; the marginals have the reflections much wider than high with a slight dip in the upper border; they are 6–cuspid with a

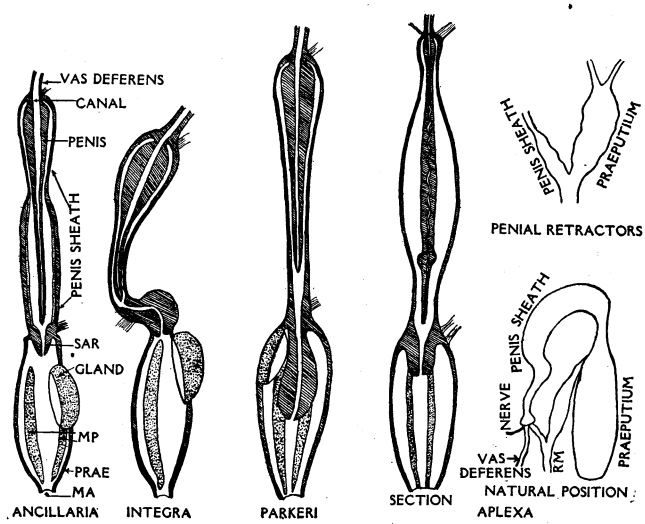


Fig. 186. Sections of Male Organs of *Physella.* MA, *male aperture;* PRAE, *praeputium;* SAR, *sarcobelum;* MP, *muscular pillars;* RM, *retractor muscles.*

smaller cusp between the larger ones; the teeth increase in width to the 75th tooth at which point they begin to decrease, the 125th tooth being about the width of the 10th tooth. The lateral appendage is wide in the first few laterals but becomes narrow and elongated before the marginals begin. Of a dozen membranes examined all showed great uniformity in number of teeth and in form and cuspidation (fig. 187).

ECOLOGY: Not recorded by the collector. *Parkeri* and *latchfordi* are lake species, as is also typical *lordi.* Many of the records from the west and southwest indicate river habitats. *Laphami* possibly inhabits rivers as there are few lakes near the localities cited for the Wisconsin specimens.

GENERAL DISTRIBUTION: Not known outside of Wisconsin.

DISTRIBUTION IN WISCONSIN: Known only from the type locality.

Wisconsin Drainage: Hancock, Waushara Co. (Bullock).

REMARKS: *Laphami* is related to *Physella lordi* (Baird), and at first was considered a form of that species. An examination of the specimens described and figured by Binney (L. & F–W. Sh. N. A., II, p. 76, fig. 127, U. S. Nat. Mus. No. 9310) shows that it is not this species, being very much thinner, the whorls rounded, body whorl without shoulder or angulation, the columella thin and twisted. It is not *parkeri* (pl. XXV, fig. 6), which appears distinct from *lordi* (see Clench, 1925), the

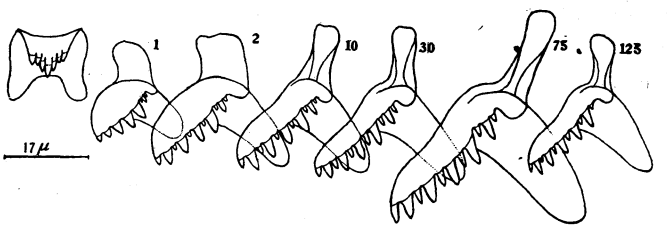


Fig. 187. Radula of *Physella parkeri.* Douglas Lake, Mich.

spire of that species being quite different from either *lordi* or *laphami,* and recalling *ancillaria,* to which it is evidently related, though specifically distinct, the two radulae being quite different. The nearest relative of *laphami* appears to be a *Physella* from Meech's Lake, Ottawa Co., Quebec, Canada, which has a thin shell, but the whorls are more gibbous, the spire wider, the axis heavier, and the color brown instead of yellowish. Occasional specimens of this shell are strongly shouldered as in *parkeri.* This *Physella* seems not to have been noticed and it should receive a name. It may be called *Physella latchfordi,* Sp. Nov., the type locality being Meech's Lake. The type measures L. 26.0; D. 20.0; Ap. L. 20.0; D. 10.0 mm. (Collection Baker, No. 1340). Collected by Hon. Justice F. R. Latchford, of Toronto, who first brought the form to the writer's attention, and to whom the species is dedicated (pl. XXV, figs. 7–8).

A *Physella* occurs in the southwest which is evidently a small form of *lordi.* Many specimens have rounded whorls without a shoulder and resemble *laphami,* but the shell is thicker, the columella region is wider and rounded and the axis is not as

much twisted. Occasional shouldered specimens indicate its relationship to *lordi* (U. S. Nat. Mus., specimens, No. 152368). There is great variation among the lordi-like shells of Arizona and New Mexico, and a good series showing age variation is needed to be sure of the affinities of the different forms. The lordi group includes the following forms, which must rank as species until the radula and genitalia are known for each.

Physella lordi (Baird), west of the Rocky Mountains, and the southwestern states.
Physella lordi utahensis Clench, Utah (1925, p. 2).
Physella parkeri (Currier), Michigan.
Physella latchfordi F. C. Baker, Canada.
Physella laphami F. C. Baker, Wisconsin.

Only the last is at present known from Wisconsin. *Parkeri* and *latchfordi* are figured for comparison and possible future identification. The thin-shelled *laphami* is very uniform, there being no variation among about thirty specimens representing all ages. The specific name is given to honor the name of one of Wisconsin's early students of animal life, Mr. I. A. Lapham.

PHYSELLA ANCILLARIA (Say)

Plate XXV, figures 9–17, 22, 23

Physa ancillaria SAY, Journ. Phil. Acad., V, p. 124, 1825; HALDEMAN, Mon. p. 27, pl. iii, figs. 1–8, 1843; BINNEY, L. & F. W. Sh. N. A., II, p. 81, figs. 139, 141, 1865; TRYON, Con. Hald. Mon., p. 146, pl. 8, fig. 1, 1870; CRANDALL, Nautilus, XV, p. 42, 1901.
Physa subarata MENKE, Syn. Méth., Ed. 2, p. 132, 1830.
Physa fragilis MIGHELS, Proc. Bost. Soc. N. H., I, p. 49, 1841; BINNEY, Op. Cit. p. 80, fig. 153, 1865; HALDEMAN, Mon., p. 31, pl. iv, figs. 11–13, 1843.
Physa obesa DEKAY, N. Y. Moll., p. 78, pl. v, fig. 86, 1843.

TYPE LOCALITY: *Ancillaria,* Delaware River, near Easton, Penn., and Connecticut River, above Hartford; *fragilis,* Monmouth, Maine; *obesa,* Mohawk and Hoosic rivers, Rennselaer Co., N. Y.; *subarata,* near Cincinnati, in the Ohio River.

WISCONSIN RECORDS:
1900a. *Physa heterostropha* BAKER, p. 176. Milwaukee (fossil).
1900a. *Physa ancillaria* BAKER, p. 176. Milwaukee (fossil).

SHELL: Large, thin to solid, somewhat cylindrical, imperforate; color greenish or yellowish horn to brownish or reddish; surface shining, often more or less streaked with brown or

black; sculpture of fine, close-set lines of growth crossed by more or less distinct impressed spiral lines, which may become almost obsolete on the body whorl; whorls 4½ to 5, somewhat compressed and flat-sided, body whorl strongly shouldered, very large; spire very short, broad, obtuse, the whorls slanting at an angle of 45°; nucleus small, of about one whorl, rounded, reddish, slightly punctate in sculpture; sutures scarcely impressed, the whorls laid against each other in such a manner as to leave a mere line of juncture; aperture large, 7/10 to 4/5 total length of shell, the outer lip compressed and flattened, distinctly shouldered above, rounded and effuse below, purplish or liver-colored inside; edge of lip thin, more or less thickened within by a heavy white or blue callus bordered on the inside with red or purple, the callus on the outside showing as a broad, white band; there is a thin wash of callus on the parietal wall; columella straight, with a heavy impressed fold forming a distinct plait.

L. 16.5; D. 11.5; Ap. L. 12.0; D. 6.0 mm.	Type form. Phil. (Coll. Baker, 1262).
L. 18.0; D. 12.5; Ap. L. 13.5; D. 7.0 mm.	Devils Lake (U. of W., 4579).
L. 16.5; D. 12.0; Ap. L. 13.0; D. 6.5 mm.	" " "
L. 15.0; D. 11.0; Ap. L. 11.0; D. 6.0 mm.	" " "
L. 13.0; D. 8.5; Ap. L. 9.6; D. 4.5 mm.	" " "

ANIMAL: See generic description. Color light lead on foot, head, and tentacles; neck yellowish white; mantle black with yellowish-white spots. Digitations of columella region eight in number, alternating long and narrow and short and pimple-like; apical digitations 5, usually four long and narrow and one short and wide.

GENITALIA: See generic description (see also fig. 186).

JAW: As in the genus.

RADULA (Fig. 184): See generic description. Formula 175–1–175. The central tooth has the formula 4–1–1–1–4 or 5–1–5. Binney's figure of the radula (fig. 141) does not show as many cusps as are present in Wisconsin specimens.

ECOLOGY: In the type locality, the Delaware River, this species lives on muddy flats which are left bare at low tide, and the animals burrow into the mud to escape the exposure to the air. On the wharves and objects in the water they follow the rise and fall of the tide and thus keep submerged. In the Con-

necticut River they live on muddy shores which are not affected by the tides.

In Devils Lake these snails live on the rocks bordering the shore descending to a depth of about five feet. The shore of the lake at these points descends to a depth of 40 feet, but the snails were not observed at greater depths nor were any dredged from the deeper parts of the lake. Devils Lake fills a part of the preglacial valley of the Wisconsin River.

In the Red Cedar River, *ancillaria* is found on rocks in shallow water, or on a sand bottom.

GENERAL DISTRIBUTION: New Jersey and Maine west to Minnesota, south to the Ohio River, north to Ontario and Manitoba. Binney gives the distribution as from New England to Louisiana, but no specimens have been seen from the extreme south. It may have been confused with *Physella crandalli,* a species common in the southwest, which sometimes greatly resembles *ancillaria.*

DISTRIBUTION IN WISCONSIN: Widely distributed over the State.

St. Croix Drainage: New Richmond, St. Croix Co. (Bullock); Yellow River, Spooner, Washburn Co. (Baker).

Chippewa Drainage: Ladysmith, Rusk Co. (Bullock); Red Cedar River, west of Chetek, Barron Co. (Baker); Chippewa Falls, Chippewa Co. (Bullock), Phillips, Price Co. (Bullock).

Menominee Drainage: Pine River, Florence Co. (Lapham, Smith. Inst. Coll.).

Wisconsin Drainage: Devils Lake, Sauk Co. (Baker).

Rock Drainage: Blanchardville, Lafayette Co. (Bullock).

REMARKS: *Ancillaria* may be known by its wide shell with flattened whorls, low, broad spire with flat, sloping whorls, the pronounced shoulder at the upper part of the body whorl; the lightly impressed sutures, and the thickened, twisted columella. There is no other Wisconsin shell like it, excepting *Physella vinosa,* which lacks the strong shoulder.

There is some variation in the *ancillaria* from different habitats. Delaware River forms have a thick shell, made necessary by the periodic exposure to the air by the fall of the tide. Connecticut River forms have a thinner shell which is yellowish in color. Devils Lake specimens are quite thin and have a brownish shell. The same is true of the Red Cedar River specimens.

The spire may vary somewhat in height and the shoulder in distinctness. I have never seen anything just like DeKay's

obesa as figured, but the description would include variations of *ancillaria* and this species from New York is similar to those from farther east. I follow Crandall in considering it a synonym of *ancillaria.*

Very thin specimens have been identified as Mighels' *fragilis,* but I do not think this approximation is correct. Regarding *fragilis,* Haldeman and Tryon consider it a good species, while Binney and Crandall consider it a form of *heterostropha.* The statement by Morse (1864, p. 43) would seem to be conclusive. He says "We have every reason to believe this shell to be a variety of *P. ancillaria.* The circumstances attending its discovery lead to this belief. The shell was found in a mill stream charged with wood dust from a neighboring saw mill. In the waters above the mill, *P. ancillaria* occurred in abundance, with no trace of *P. fragilis.* This mill was afterward destroyed, and synchronous with this event was the entire obliteration of *P. fragilis* and the recurrence of the normal *P. ancillaria;* nothing approaching this abnormal form has elsewhere been observed in the State". It seems evident that *fragilis* is to be considered a pathological form of *ancillaria.*

Specimens from Chippewa Falls are curiously deformed, the aperture being greatly expanded forming a wide, patulous opening. These occur with normal *ancillaria.* Such specimens, if found alone, would surely be described as a novelty (pl. XXV, figs. 22, 23). Such pathologic forms are rare among Wisconsin Physellas.

Certain fossil *Physella* from Milwaukee have been referred to both *warreniana* and *ancillaria.* They differ from both and are probably a Pleistocene variation of *sayii.* They have a somewhat shouldered body whorl and some specimens have a rather long spire. They are reserved for a special study of Pleistocene species.

PHYSELLA VINOSA (Gould)

Plate XXVI, figures 7–18

Physa vinosa GOULD, Proc. Bost. Soc. N. H., II, p. 263, fig., 1847; AGASSIZ Lake Sup., p. 244, pl. vii, figs. 10–11, 1850; BINNEY, L. & F. W. Sh. N. A., II, p. 80, fig. 137, 1865; TRYON, Con. Hald. Mon., p. 147, pl. 8, fig. 3, 1870.

TYPE LOCALITY: Michipicoten, Lake Superior.

WISCONSIN RECORDS: None.

SHELL: Of good size, ovate-globose, imperforate, thin; color brownish or reddish to yellowish-horn, surface shining; sculpture of distinct growth lines crossed by fine impressed spiral lines, rather widely spaced, subobsolete on last whorl; whorls 4½, the last very large, regularly rounded; spire very short, broad, acute in the young shell, more obtuse in mature specimens; nucleus of about one full whorl, dark wine colored, elevated, rapidly descending to the second whorl, punctate or pitted in sculpture; sutures slightly impressed, bordered by a white line which is impressed against the whorl above; aperture large, 4/5 to 5/6 of the entire length of the shell, ovate-lunate, the outer edge broadly and regularly curved, widest about the middle, liver brown color inside; edge of lip thin, with a slight callus within, bordered with red or chestnut; a light wash of white callus on the parietal wall; columella straight, with a rather thick callus which sometimes forms a twisted plait.

L. 14.0; D. 10.0; Ap. L. 11.5; D. 6.0 mm.	Bayfield	(U. of W.,	4585).
L. 13.0; D. 10.0; Ap. L. 10.5; D. 6.0 mm.	"	"	"
L. 12.0; D. 9.0; Ap. L. 10.0; D. 5.0 mm.	"	"	"
L. 14.1; D. 9.8; Ap. L. 10.7; D. 5.0 mm.	"	"	"
L. 13.2; D. 9.5; Ap. L. 11.0; D. 4.8 mm.	"	"	"
L. 11.5; D. 7.5; Ap. L. 9.0; D. 3.8 mm.	"	"	"
L. 8.0; D. 5.6; Ap. L. 5.9; D. 2.5 mm.	"	"	"

ANIMAL: Color yellowish-white, head and neck flecked with plumbeous. Columella digitations 6–7, apical digitations 3–5, the former wider and more triangular than the apical digitations which are long and finger-like. One specimen had 4 apical digitations, 3 of which were distinctly trilobed, the lobes bluntly pointed.

GENITALIA: Female organs as in the genus. Male organs, similar to those of *ancillaria,* the penis sheath much longer than praeputium.

JAW: As in the genus.

RADULA (Fig. 188): Formula, 135–1–135, the central tooth 3–1–1–1–3 (4–1–4). There are from 8 to 10 lateral teeth. The first lateral has 6 cusps, the second to eighth teeth have 5 cusps with a smaller cusp between. The marginals have 6 large cusps with a smaller cusp between each cusp. One membrane had very irregular cusps, as shown in figure 189, the outer cusp on the lateral teeth being smaller and more numerous than in normal membranes.

The radula of *vinosa* is much like that of *ancillaria*, the teeth being of about the same size. The central tooth of *ancillaria*, however, usually has 5–1–5 cusps while in *vinosa* there are but 4–1–4 cusps. Binney figures the lateral teeth of a species said to be *vinosa*, but this does not agree with the radula from the Bayfield specimens, which has six instead of four cusps as figured by Binney.

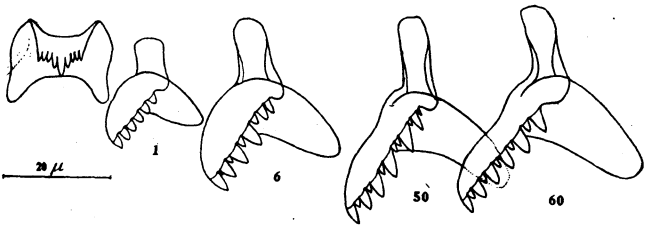


Fig. 188. Radula of *Physella vinosa*. Bayfield.

ECOLOGY: *Vinosa* is a rock inhabiting species, preferring the rough waters of the open lake. In the Bayfield region it is found on rocky and boulder shores in the most exposed situations. The maximum depth at which individuals were found did not exceed six feet below the surface, and one to three feet was the normal depth. Specimens from more protected places, as inlets and the mouth of creeks, had a much narrower shell with a longer spire.

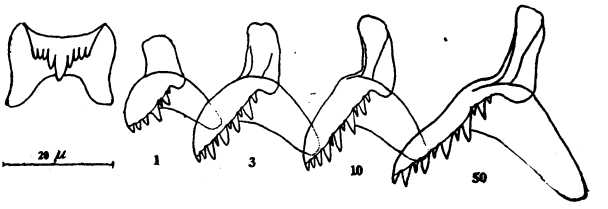


Fig. 189. Radula of *Physella vinosa*, variation. Bayfield.

GENERAL DISTRIBUTION: Lake Superior Region, east to Sault Ste. Marie.

DISTRIBUTION IN WISCONSIN: At present known only from the Lake Superior shore of the Bayfield peninsula, Bayfield Co. (Baker).

REMARKS: *Vinosa* may be known from *ancillaria* by its rounded body whorl without a shoulder, its dark colored shell (when living), its rounder, less flat-sided spire whorls, and somewhat deeper sutures. In the young shell, when the apex

is not eroded, the nucleus is seen to be higher and more loosely coiled in *vinosa*, that of *ancillaria* being flatter and depressed-rounded, not globular. This feature renders the apex of *vinosa* more pointed than that of *ancillaria*. The central tooth of the radula also differs, as already stated. *Magnalacustris* (pl. XXVI, fig. 1) is somewhat similar to *vinosa* in some of its forms, but is heavier, with a more sharply pyramidal spire and flat-sided whorls. There is some variation in the height of the spire, as in *ancillaria*, and also in the degree of inflation, some specimens being quite narrow.

Vinosa has puzzled most conchologists since its publication. Gould's original figure, copied by Binney, is of an old, very wide shell, while the figures in Agassiz' Lake Superior are of a young shell. Tryon's figure is of an average adult shell. Crandall (1901, p. 42) considers it a subspecies of *ancillaria* but the specimens from Bayfield seem to indicate that it should be accorded specific rank.

PHYSELLA SAYII (Tappan)

Plate XXV, figure 18; plate XXVI, figures 19–32; plate XXVII, figures 17–20

Physa sayii TAPPAN, Amer. Journ. Sci., (i), XXXV, p. 369, fig. 3, 1839; HALDEMAN, Mon. p. 28, pl. 3, figs. 9–10, 1843; BINNEY, L. & F. W. Sh. N. A., II, p. 80, fig. 136, 1865; TRYON, Con. Hald. Mon., p. 146, 1870; CRANDALL, Nautilus, XV, p. 43, 1901.

Physa warreniana LEA, Proc. Phil. Acad., p. 115, 1864; Journ. Phil. Acad., VI, p. 120, 1866; Obs., p. 20, 1867 (part); TRYON, Con. Hald. Mon., p. 146, 1870 (part).

TYPE LOCALITY: Lake Pepin, Portage Co., Ohio.

WISCONSIN RECORDS:

1860. *Physa heterostropha* LAPHAM, p. 155. Milwaukee.
1865a. *Physa heterostropha* BINNEY, p. 89. Milwaukee.
1866–67. *Physa warreniana* LEA, p. 120. Milwaukee.
1905. *Physa sayii* CHADWICK, p. 23. Milwaukee; Golden Lake, Waukesha Co.; Lake Winnebago near High Cliff.
1906. *Physa ampullacea* CHADWICK, p. 86. Milwaukee.
1911a. *Physa ancillaria warreniana* BAKER, p. 234. Tomahawk Lake.
1913b. *Physa ancillaria warreniana* BAKER, p. 68. Waukesha Co. (fossil).
1916. *Physa ancillaria warreniana* BAKER, p. 272. Tomahawk Lake.
1919a. *Physa oneida* BAKER, p. 13. Tomahawk Lake.
1920d. *Physa warreniana* BAKER, p. 121. Waukesha Co. (fossil).
1924. *Physa sayii* BAKER, p. 135. Lakes Winnebago and Butte des Morts.
1926. *Physa gyrina* WINSLOW, p. 6. Little Arbor Vitae Lake.

SHELL: Large, ovate or elongated, imperforate, thin, corneous; color light yellowish to brownish, translucent to opaque, fresh surface shining; sculpture of fine growth lines crossed by very distinct but fine spiral lines giving the surface a bright sheen; the growth lines are sometimes costate near the outer lip and the body whorl may be more or less malleated; whorls rather more than 5, the last very large, evenly rounded, rarely with a slight shoulder; spire short, acute, the spire whorls flatly rounded; nucleus small, of about one rounded, flatly dome-shaped whorl, wine colored, sculpture strongly punctate; sutures not impressed, bordered by a white band which is appressed closely to the whorl above; in the first three whorls there is a deeply impressed line just below the suture; aperture 7/10 of the length of the entire shell, the outer edge regularly but rather flatly curved, the upper part not shouldered but sloping at a steep angle; it is usually widest about the middle and is somewhat effuse below; edge of lip thin with a more or less thickened callus which is bordered with red or brown; there may be two or three former lip calluses on the body whorl; there is a slight wash of callus on the parietal wall; columella straight, somewhat thickened, folded and with a more or less developed plait.

L. 24.0; D. 13.0; Ap. L. 18.0; D. 7.0 mm.	DePere	(U. of W.,	4589).
L. 19.5; D. 12.0; Ap. L. 14.5; D. 7.0 mm.	"	"	"
L. 19.0; D. 12.0; Ap. L. 15.0; D. 7.5 mm.	"	"	"
L. 19.0; D. 11.0; Ap. L. 14.0; D. 6.0 mm.	"	"	"
L. 17.2; D. 11.5; Ap. L. 12.5; D. 6.5 mm.	"	"	"
L. 12.5; D. 7.5; Ap. L. 9.5; D. 4.5 mm.	"	"	"
L. 15.0; D. 10.5; Ap. L. 12.0; D. 6.2 mm.	Green L.	(U. of W.,	458o).

ANIMAL: Color yellowish or yellowish-white. In the young 4 mm. long the body is almost transparent, the foot yellowish white, the head whitish with an orange band down the center, bordered with brown on either side; there is a brown line extending from the base to the tip of the tentacles. The mantle has whitish or greenish spots. The eyes are black. The adult has 4–8 columella digitations and 4–5 apical digitations, the latter being very uniform in the specimens examined. All digitations were long and narrow.

GENITALIA: Female as in the genus. Male (fig. 190) with penis sheath about 2 times as long as praeputium, and double-lobed, enlarged at the distal end.

JAW: As in the genus.

RADULA (Fig. 191): Formula 125–1–125, the center tooth with 2–1–1–1–2 cusps. There are about six laterals each with six long cusps without intermediate smaller cusps. The mar-

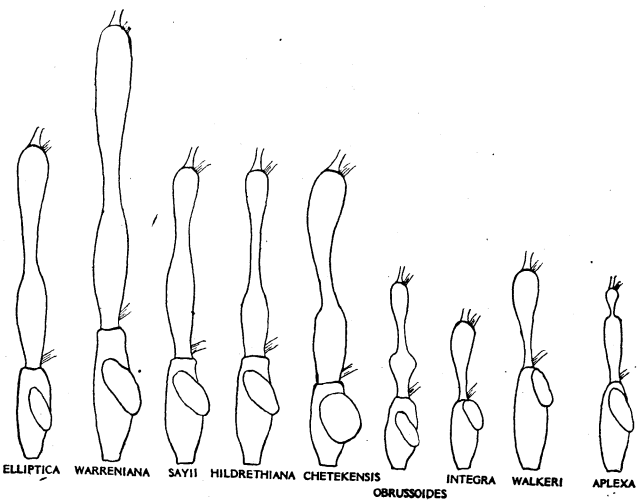


Fig. 190. Diagrams of Male Organs of *Physella* and *Aplexa.*

ginals have six large pointed cusps with a smaller cusp between each large cusp. The teeth are similar to those of *ancillaria* but smaller. The center tooth differs in having a less number of cusps. There are also less teeth in a single row than in the membrane of *ancillaria.*

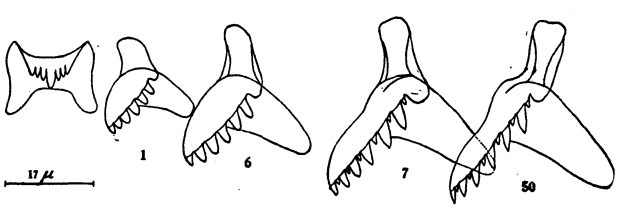


Fig. 191. Radula of *Physella sayii.* Lake Winnebago.

ECOLOGY: In Lake Winnebago it was found in the following habitats: Doemel Point, rocky bottom, shallow water; Miller Bay, sand with vegetation, .6 m. deep, gravel, .8 m. deep; Fahney Bay, sand bottom, .3 m. deep; off Long Point Island, mud bottom, 3.7 m. deep; mile east of Oshkosh, in lake, mud bottom, 5.5 m. deep; Lake Butte des Morts as follows: Off

Sunset Point, mud bottom, 3.4 m. deep; Plummers Point, boulder bottom, .5 m. deep. In Door County, near Sturgeon Bay, it was found on rocks on the open shore of Lake Michigan.

GENERAL DISTRIBUTION: New York west to Nebraska, Ontario south to the Ohio River.

DISTRIBUTION IN WISCONSIN: Well distributed over the State, but apparently more abundant in the eastern part.

Fox Drainage: De Pere and Green Bay, Brown Co. (Marston); Winnebago and Butte des Morts lakes, Winnebago Co. (Baker); Green Lake, Green Lake Co. (Baker); High Cliff, Winnebago Lake, Calumet Co. (Chadwick); ponds near Green Bay, Brown Co. (Pearse).

Lake Michigan Drainage: Milwaukee, Milwaukee Co. (Bullock, Chadwick, Lea, Lapham); Lake Michigan shore east of Sturgeon Bay; Sturgeon Bay above cemetery, Door Co. (Baker); Kenosha, Kenosha Co. (Wiswall); Marinette, Marinette Co. (Bullock).

Wisconsin Drainage: Nixon, Big Muskallonge, and Plum lakes, Vilas Co. (Cahn); Little Arbor Vitae Lake, Vilas Co. (Cahn, Winslow); Tomahawk Lake, Oneida Co. (Baker).

Rock Drainage: Oconomowoc Lake (Cahn, Lapham); Golden Lake (Chadwick); Keesus, Oconomowoc, Genesee, Lower Nashotah, Dutchmans, Golden, Pewaukee, Ashippun, Mud lakes, Waukesha Co. (Cahn).

Chippewa Drainage: Nixon Lake, Vilas Co. (Cahn).

REMARKS: *Physella sayii* is distinguished by its large, rather thin, more or less inflated shell with pointed spire, rounded body whorl, and distinct sculpture. It is related to *ancillaria* and some shells taken alone might be referred to that species (as pl. XXVI, fig. 24). *Sayii* rarely has even slightly shouldered whorls, as is normal in *ancillaria,* in which the whorls are more flat-sided, the spire more depressed, and the sutures less well defined. The shell of *ancillaria* is widest at the shoulder of the body whorl while in *sayii* it is widest at about the middle of the aperture.

Sayii, like most species of this variable genus, is dimorphic in having both long and short-spired forms, but as these all occur in the same lot from one locality, they have no systematic value. This variation is well shown on the plate. *Sayii* has been confused with *warreniana,* but the two forms seem to represent different species. *Sayii* is one of the most characteristic and widely distributed species of the genus, and there should be little difficulty in recognizing it from all other species. It is very common in eastern Wisconsin, which seems to be its metropolis in this State, and is found in Lake Michigan from Illinois and Indiana northward and around the Door

County peninsula into Green Bay and northward as far as Marinette.

The description and figure of *plicata* DeKay (N. Y. Moll., p. 78, pl. V, fig. 85, 1843) appear more like *sayii* than *heterostropha,* the large size, pointed spire, and transverse raised lines all being like *sayii* and unlike *heterostropha.*

The Lake Winnebago *sayii,* as well as those from some of the smaller lakes average somewhat smaller than those from near Lake Michigan. Green Lake specimens have a tendency to become heavily shouldered (fig. 18, pl. XXV). Some lake forms have been referred to *sayii* and *ancillaria* that are here assigned to *crassa.*

PHYSELLA SAYII CRASSA (Walker)

Plate XXV, figures 19–21, 24–27

Physa ancillaria var. *crassa* WALKER, Nautilus, XIV, p. 98, 1901.

TYPE LOCALITY: Higgins Lake, Roscommon Co., Mich.

WISCONSIN RECORDS:

1897. *Physa ancillaria* WISWALL, p. 48. Southern Wisconsin.
1918. *Physa ancillaria* MUTTKOWSKI, p. 474. Lake Mendota.

SHELL: Oval or obovate, thick, solid, opaque, shining, longitudinal striae very fine, transverse striae minute or subobsolete; white, more or less tinged with vinous or pale purple, darker toward the apex which is dark brown; whorls 4–5, regularly and rapidly increasing, the first minute, the last very large, roundly shouldered and frequently flattened laterally; spire short, scarcely elevated above the general contour of the shell; suture but slightly impressed, bordered below with white; aperture large, but slightly shorter than the shell, widest in the center, somewhat narrowed below and slightly effuse at the junction of the basal lip with the columella; outer lip broadly rounded, thin, acute, thickened within by a strong callus which is yellowish-brown within and white externally; interior of body whorl light yellowish-brown or liver color; extremities of lip connected by a thin callus which is broadly reflected over the body whorl; columella strong, white, nearly straight, but slightly twisted (Walker).

L. 17.5; D. 12.5; Ap. L. 14.0; D. 0.0 mm. Type.
L. 15.0; D. 12.5; Ap. L. 13.5; D. 0.0 mm. Type.
L. 10.0; D. 6.5; Ap. L. 8.5; D. 4.0 mm. Kenosha (Coll. Baker, 1546).
L. 9.2; D. 6.0; Ap. L. 8.0; D. 3.5 mm. " " "

ANIMAL: Not examined.

ECOLOGY: Apparently a lake species, this being the only habitat thus far reported. No ecological notes are available.

GENERAL DISTRIBUTION: Michigan and Wisconsin.

DISTRIBUTION IN WISCONSIN: At present known only from the eastern part of the State.

Lake Michigan Drainage: Kenosha, Kenosha Co. (Wiswall).
Rock Drainage: Lakes Monona and Mendota, Dane Co. (Baird, Bullock, Muttkowski, Wagner); Lake La Belle, Waukesha Co. (Cahn).

REMARKS: Typically, *crassa* is more opaque, much heavier, with a shorter spire, more rounded shoulder of the whorls, and a more regularly rounded outer lip. The spire is also more depressed and the shell is much smaller. Wisconsin specimens, on the average, are smaller than specimens from the type locality in Higgins Lake.

Crassa is probably a variety of *sayii* rather than of *ancillaria, sayii* being a lake form while *ancillaria* is a river form. In Lake La Belle, the form is *crassa* and not *sayii,* while in most of the other small lakes the form is typical *sayii.* In Oconomowoc, as well as in Green Lake, the *sayii* vary toward the *crassa* form, although the individuals are not as thick and heavy. The *Physella* inhabiting Lakes Mendota and Monona have been identified by good authority as *ancillaria,* but appear rather to be a form of *crassa.* The Lake Winnebago shells vary toward the small, thick form. These forms are intermediate in character and indicate the relationship of *crassa* to *sayii.*

PHYSELLA MAGNALACUSTRIS (Walker)

Plate XXVI, figures 1–6

Physa ancillaria var. *magnalacustris* WALKER, Nautilus, XIV, p. 97, 1901.

TYPE LOCALITY: Frankfort, Benzie Co., Mich.

WISCONSIN RECORDS: None.

SHELL: Subglobose, thick, solid, semi-opaque; incremental striae fine, stronger toward the suture and somewhat irregular; transverse striae very minute or subobsolete; purplish-horn color, darker toward the apex, which is dark brown or black; body whorl with one or more broad white varicose

bands, more or less suffused with white toward the lip and at the base; whorls 5, regularly and rapidly increasing, the first minute, the last very large, regularly rounded, not shouldered, the greatest width being in the center; spire slightly elevated, acute; suture but slightly impressed, margined below with white; aperture large, expanded below so that the greatest width is below the center; outer lip thin, sharp, more or less expanded and broadly rounded below; thickened within by a deep yellowish-brown or liver-colored callus, which appears externally as a broad white band, extremities connected by a thin callus, which is broadly reflected over the body whorl; columella white, straight, scarcely twisted (Walker).

L. 17.5; D. 12.5; Ap. L. 14.5; D. 0.0 mm.	Type.
L. 12.6; D. 11.0; Ap. L. 11.5; D. 0.0 mm.	Type.
L. 13.5; D. 8.5; Ap. L. 10.0; D. 5.0 mm.	Sturgeon Bay (U. of W., 4583).
L. 13.0; D. 8.0; Ap. L. 10.0; D. 5.0 mm.	" " "
L. 12.0; D. 8.0; Ap. L. 8.2; D. 4.0 mm.	" " "
L. 12.4; D. 8.6; Ap. L. 8.5; D. 5.0 mm.	" " "
L. 13.0; D. 9.0; Ap. L. 9.5; D. 5.0 mm.	" " "

ANIMAL: Not examined.

ECOLOGY: This form is the characteristic Physa of the lake shore, and is commonly found clinging to the large stones along the rocky or stony beaches (Walker). On the Lake Michigan shore of Wisconsin, east of Sturgeon Bay, this species lives in great abundance on the rocky ledges of the wave-beaten shore, always in shallow water.

GENERAL DISTRIBUTION: A species of the Great Lakes found on the Michigan shore of lakes Huron and Michigan and the Wisconsin shore of Lake Michigan.

DISTRIBUTION IN WISCONSIN: At present known only from the lake shore in Door Co. Sturgeon Bay (Baker); Detroit Harbor, Ephraim (Bullock).

REMARKS: Of this species Walker says: "Its thick wine-colored or purplish shell with prominent white varicose bands, basally expanded aperture, and regularly curved outline from the apex to the columella, give it an aspect peculiarly its own, and render it easily distinguishable from the typical form or any of the allied species".

Clench has suggested that *magnalacustris* is a variety of *sayii* rather than of *ancillaria, sayii* being generally a lake shell while *ancillaria* is a river shell. The figures on the plate

indicate the close relationship of these two forms and Mr. Clench may be right in this opinion (compare figure 1 with figures 27 and 32). Wisconsin material varies more than do Michigan specimens. The shell is thick and the spire is sometimes indistinctly shouldered. The color varies from brownish-white to dark brown or chestnut, purple specimens also being represented, the outer lip is not as much expanded as in the Michigan specimens. However, it appears to the writer that it should be considered distinct from either *ancillaria* or *sayii*, and constitute a separate species of the genus inhabiting the Great Lakes. Winslow (1926, p. 16) has listed it as distinct from these related species.

PHYSELLA WARRENIANA (Lea)

Plate XXVI, figures 33–37; plate XXVII, figures 14–16

Physa warreniana LEA, Proc. Phil. Acad., p. 115, 1864; Journ. Phil. Acad., VI, p. 120, pl. 24, fig. 81, 1866; Obs., XI, p. 120, pl. 24, fig. 81, 1867; TRYON, Con. Hald. Mon., p. 146, 1870 (part).

TYPE LOCALITY: Loup Fork of the Platte River, Nebraska.

WISCONSIN RECORDS:

1904c. *Physa gyrina* BAKER, p. 103. Witches Gulch, Kilbourn.

SHELL: Of medium size, rather cylindrical, slightly inflated, thin, transparent to opaque, imperforate; color light whitish horn to brownish, surface shining; sculpture of distinct growth lines crossed by rather heavy impressed spiral lines, well marked on the last whorl, giving the surface a bright sheen; whorls 5, the last very large, not shouldered; spire short, dome-shaped, obtuse, the whorls slightly rounded; nucleus small, about one whorl, dark wine-colored, slightly punctate, the dark color frequently descending to the second whorl; sutures impressed, frequently bordered below by a band of dark wine-color; aperture large, ¾ the length of the entire shell, the outer edge flatly rounded or sometimes compressed, narrowed above, broadly rounded below, somewhat effuse, the widest part of the aperture being much below the middle; outer lip thin, acute, bordered on the inside by a distinct callus colored dark wine-red; on mature shells there is frequently a second band about midway of the body whorl representing a former lip; this is bordered on one side by a wide white band; parietal wall with a very slight wash of callus; columella straight,

slightly thickened and twisted, the inner lip being folded over and impressed into the umbilical region.

L. 14.0; D. 8.6; Ap. L. 10.5; D. 4.5 mm.	Chetek River	(U. of W.,	4591).
L. 13.0; D. 7.6; Ap. L. 10.0; D. 4.0 mm.	"	"	"
L. 12.0; D. 8.0; Ap. L. 10.0; D. 4.0 mm.	"	"	"
L. 11.5; D. 7.0; Ap. L. 8.0; D. 4.0 mm.	"	"	"
L. 7.1; D. 5.0; Ap. L. 5.5; D. 2.5 mm.	"	"	"

ANIMAL: General color dark plumbeous. Digitations, columella 8 (variable in form), apical 5–6, uniformly long and narrow.

GENITALIA (Fig. 190): Male organs very long, praeputium much shorter than penis sheath which is 2½ times length of praeputium; the penis sheath is contracted about midway of its length, forming a spindle-shaped organ. Female organs as in the genus.

JAW: As usual.

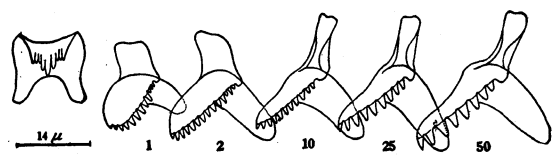


Fig. 192. Radula of *Physella warreniana*. Chetek River.

RADULA (Fig. 192): Formula, 150–1–150, central tooth, 2–1–1–1–2, the center cusp large. Lateral teeth (usually about six in number) with 5–6 cusps, the outermost small, the inner ones large, with smaller cusps between them; the marginals usually have 5 large cusps with smaller cusps between and at the extreme end. In some radulae, the small cusps may be double between certain large cusps. The teeth are fairly uniform in denticulation and size. The teeth differ from those of *sayii* in being smaller and in having small cusps between the larger cusps in the laterals. The teeth of *ancillaria* are almost twice as large, the laterals are without smaller cusps between the larger ones, and the center tooth has a larger number of side cusps. There is also a difference in the number of teeth in a row, *sayii* with 125, *warreniana* with 150, and *ancillaria* with 175. The radula is, on the whole, more nearly related to *sayii* than to *ancillaria*.

ECOLOGY: In Chetek River, *warreniana* lives on rocks and in vegetation *(Vallisneria)* in shallow water, a foot to a meter

in depth, in summer. In spring the water is deeper, but the snails then migrate nearer the shore and there find the required depth. In Chetek Lake the snails live on logs, vegetation, and on sandy shores, in from .3–1 m. depth of water.

GENERAL DISTRIBUTION: Nebraska east to Wisconsin; the distribution is imperfectly known, owing to its confusion with *sayii* and *ancillaria.*

DISTRIBUTION IN WISCONSIN: Northern and eastern part of the State, mostly in rivers.

Chippewa Drainage: Chetek River, Lakes Chetek, Prairie, and Pokegama, Barron Co. (Baker).

St. Croix Drainage: Grantsburg, Burnett Co.; New Richmond, St. Croix Co. (Bullock); Shell Lake, Washburn Co. (Baker).

Wisconsin Drainage: Wisconsin River, above Kilbourn, Juneau Co.; Witches Gulch, Adams Co.; Dell Creek near Delton and Mirror Lake, Sauk Co. (Baker); Wisconsin River, near Portage, Columbia Co. (Bullock).

REMARKS: *Physella warreniana* has been more or less misunderstood for many years. Lea's figure indicates a shell with a rounded, dome-like, depressed spire with more or less rounded whorls, quite different from the acutely pointed spire of *sayii.* True *sayii* contains many individuals which have a short spire but this is usually pointed and the whorls are flat-sided, not rounded. The body whorl of *warreniana* is also usually wider in proportion to its length than in *sayii.* Lea confused his *warreniana* with *sayii,* the shells quoted from Milwaukee in Obs. p. 120 being true *sayii* and not *warreniana.* The original shells of the Lea collection have been examined (U. S. Nat. Mus., No. 119922, see pl. XXVI, fig. 30, 31). They are like the shells of *sayii* from DePere, figured on plate XXVI. *Sayii* from Milwaukee has been identified as *heterostropha* and *hildrethiana* by Lapham (vide specimens in U. S. Nat. Mus. Collection). Tryon also confused the Milwaukee specimens with *warreniana* and his figure looks more like *sayii* than *warreniana.*

Warreniana has been made a variety of *sayii* by several competent students and it seems more nearly related to this species than to any other. It has also been grouped as a variety of *ancillaria* (Baker, op. cit.), but its radula is different from either of these species and it would seem best to consider it a separate species. It is normally a river species while *sayii* is

normally a lake species, several of the lake habitats of *warreniana* having been made by artificial damming of rivers and creeks (as at Chetek). It was once thought to be included with a New York species, *oneida*, described from Oneida Lake (Baker, 1919a, p. 13), but this approximation was incorrect, the radula showing that it has no relationship with that species, which also has an almost smooth shell while *warreniana* has heavy spiral lines.

The specimens from Shell Lake, the only lake habitat in which this species appears to live, are small and all specimens obtained were without the animal and in shore debris. They appear to be a form of *warreniana* and are included here until more can be known about the animal.

PHYSELLA CHETEKENSIS Sp. Nov.

Plate XXVII, figures 8–13

TYPE LOCALITY: Moose Ear Creek, between Taber and Chetek lakes, Barron Co., Wisconsin.

SHELL: of medium size, ovate, cylindrical, thin, imperforate; color brownish corneous, surface dull; sculpture of fine growth lines crossed by distinct spiral striae; there are no rest period bands; whorls 5, the last large, cylindrical; spire short, pointed or obtuse, the whorls flatly rounded; nucleus small, of one whorl, flattened, punctate, rich red wine colored; sutures well impressed; aperture ovate or elongated, about 7/10 the length of the shell, much narrowed above, broadly rounded below, outer edge flattened or flatly rounded; outer lip thin, with a slight reddish callus bordering the internal edge; parietal wall without callus; columella straight or slightly oblique, the inner lip turned over into the umbilical region forming a rounded but slight columellar axis.

L. 12.5; D. 7.0; Ap. L. 9.2; D. 3.9 mm.	Type (U. of W., 4595).
L. 12.5; D. 7.0; Ap. L. 9.0; D. 4.0 mm.	Paratype (U. of W., 4596).
L. 13.2; D. 8.0; Ap. L. 10.0; D. 4.8 mm.	" " "
L. 12.0; D. 7.0; Ap. L. 8.0; D. 3.5 mm.	Paratype (U. of I., Z16696).
L. 12.0; D. 7.0; Ap. L. 9.0; D. 4.0 mm.	" " "
L. 10.0; D. 5.5; Ap. L. 6.5; D. 2.5 mm.	" " "

ANIMAL: General color grayish or blackish. Mantle digitations, columella, 7, apical 5, all very uniform, long and finger-like.

GENITALIA (Fig. 190): Male organ divided into distinct penis sheath and praeputium. Praeputium very wide, cylindrical, the gland very large; penis sheath 2½ times as long as praeputium and about same diameter, enlarging slightly toward the distal end and constricted midway of its length. Female organs as in the genus.

JAW: As in the genus.

Radula (Fig. 193): Formula 140–1–140; center tooth, 2–2–1–2–2; center tooth with large center cusp, the smaller side cusps graduating in height toward the upper part of the reflection; 10 laterals; first lateral small, with 5 unequal cusps; following laterals larger, 6–cuspid, the inner cusp with a small denticle on either side; marginals 6-cuspid with a small den-

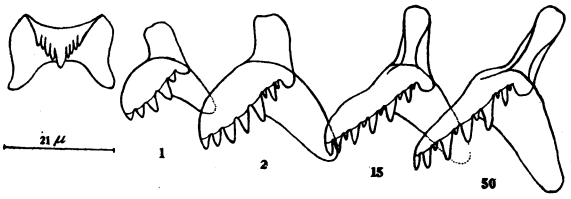


Fig. 193. Radula of *Physella chetekensis*. Moose Ear Creek, Chetek.

ticle between each cusp, excepting the two outer cusps, the outermost being smaller than the preceding cusp. The radula of *chetekensis* most nearly resembles that of *vinosa* in the size of the central tooth and of the lateral teeth. The denticulation, however, is more like that of *warreniana*, but the teeth are larger.

ECOLOGY: Moose Ear Creek where riffles, with water 8–20 cm. deep and bottom stony and sandy, alternate with quiet, deeper places, where depth is about 1 m. and bottom clay or mud. *Physella chetekensis* lives on the rocks and the sand bottom in rapid current in the shallow places.

GENERAL DISTRIBUTION: This species is at present known only from Wisconsin, but should be found also in Minnesota and Michigan, and probably in Canada.

DISTRIBUTION IN WISCONSIN: Moose Ear Creek, near Chetek Lake, Barron Co., drainage of Chippewa River (Baker).

REMARKS: *Chetekensis* was at first thought to be a very thin form of *warreniana*, that species being the principal *Physella* in Chetek Lake, into which Moose Ear Creek enters. The shell, however, is much thinner, narrower, the spire is

more elevated and pointed, and the aperture narrower. It lacks the dome-shaped spire so characteristic of *warreniana.* The radula is different both in size and denticulation of the teeth and the formula is smaller (*warreniana* 150–1–150, center tooth 2–1–1–1–2). The male organ of the genitalia is also different, the relative size of praeputium and penis sheath being different. The radula is more like that of *vinosa* in size, but the small denticulations of the lateral teeth are different. The shell, however, is totally unlike that of *vinosa.*

Chetekensis is related to *warreniana,* as shown by its radula. The relationships of the Physellae fauna of the Chetek region is very interesting, three apparently distinct species occurring —*ancillaria* in Red Cedar River, *warreniana* in Chetek River and Chetek Lake, and *chetekensis* in Moose Ear Creek. Lake Chetek has been formed artificially by damming old Chetek River, and the resulting lakes—Prairie, Chetek, Pokegoma, Mud—have produced quite a change in the molluscan fauna, the molluscan fauna having been compelled to adapt themselves to a lake from a creek or small river environment. All of the species mentioned, though related, differ in shell, radula, and genitalia.

PHYSELLA BAYFIELDENSIS Sp. Nov.

Plate XXVII, figures 1–7

TYPE LOCALITY: Pike Creek, near Bayfield, Bayfield Co., Wis.

SHELL: Of medium size, long-ovate, very thin, imperforate; color light yellowish horn; surface shining; sculpture of very fine lines of growth crossed by fine impressed spiral lines; whorls 5, the last long, compressed, cylindrical; spire short, broadly acute, sometimes somewhat dome shaped, the whorls flatly-rounded; nucleus small, of about one whorl, roundly depressed, shining, very lightly punctate, various shades of red or brown; sutures well impressed, margined below by a distinct light zone; aperture narrowly ovate, contracted above, rounded below, about ¾ the length of the entire shell, the outer edge flattened or slightly arched; outer lip thin, with a red-bordered zone on the inner side in mature shells; parietal wall with a thin wash of callus; columella straight, the inner lip turned over and appressed to the umbilical region; axis twisted and in adult specimens the area is slightly thickened.

L. 12.5; D. 7.1; Ap. L. 9.3; D. 4.0 mm. **Pike Creek** (U. of W., 4592). Type.
L. 13.3; D. 7.5; Ap. L. 10.0; D. 4.1 mm. **Pike Creek** (U. of W., 4593). Paratype.
L. 11.9; D. 6.6; Ap. L. 9.0; D. 3.5 mm. **Pike Creek** (U. of W., 4593). Paratype.
L. 11.0; D. 6.0; Ap. L. 8.0; D. 3.0 mm. **Pike Creek** (U. of W., 4593). Paratype.
L. 8.0; D. 4.5; Ap. L. 5.5; D. 2.0 mm. **Pike Creek** (U. of W., 4593). Paratype.

ANIMAL: Digitations of mantle, columella, 3 to 7; apical, 5 to 7. In two lots from Pike Creek, there were three large triangular lobes on the columella and 5–6 digitations, longer than the columella lobes but still triangular in form at the apex. Specimens from Chicago Creek had 6–7 columella lobes and 7 apical lobes, the latter all finger-like, but the columella lobes with 3 finger-like and 3 widely triangular.

GENITALIA: Penis sheath much longer than praeputium, greatly enlarged at distal end and contracted in the middle.

JAW: As usual in the genus.

RADULA (Fig. 194): Formula 120–1–120; formula of center tooth, 2–1–1–1–2; median cusp of center tooth very large and wide, side cusps smaller, the two outer cusps placed high up on the reflection; laterals 8–10; first laterals small, about as wide as center tooth, with 7 cusps diminishing in size toward the outer end; second lateral much larger than first, 6–cuspid, with a small denticle on each side of the inner cusp, the outer two cusps also being smaller than the others; other laterals 7–cuspid, the three inner cusps having a smaller denticle between them; marginals all 7–cuspid with small denticles between the three inner cusps, the four outer cusps without intermediate denticles; all cusps long and sharp. The teeth and cusps are very uniform in shape and size.

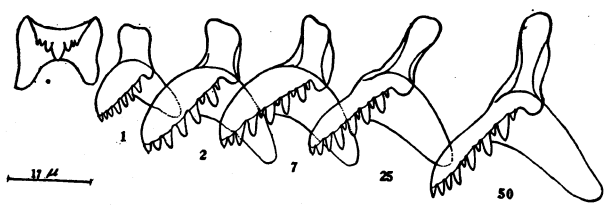


Fig. 194. Radula of *Physella bayfieldensis*. Chicago Creek, Bayfield.

The radula of *bayfieldensis* differs from that of *gyrina hildrethiana* in having larger teeth with 7 instead of 6 large cusps. The center tooth is also very different, having the formula 2–2–1–2–2, the lower five cusps being almost in a straight row; the center cusp is also much smaller than in the center tooth of *bayfieldensis*. The radula of *bayfieldensis* more nearly resembles that of *sayii* than that of *hildrethiana*, the formula and size and shape of the teeth being very similar.

ECOLOGY: Pike Creek, on logs and pieces of wood, water, .3 to .6 m. deep, sand bottom; outflow from Hatchery pond, Salmo, in rapid, shallow stream on mud bottom or on small boulders; Chicago Creek, half mile above Lake Superior, small brook from hills, widening at mouth, rapidly flowing over stones, forming rapids and falls of small size, the water cold, *Physella* on rocks in rapids and falls with caddis fly larvae; observed feeding on brown algae.

DISTRIBUTION: Not at present known outside of Wisconsin.

DISTRIBUTION IN WISCONSIN: Known only from northern part of State bordering Lake Superior. Chicago Creek, Pike Creek, Red Cliff Creek, lake behind Big Bay beach, Madeline Island, all Bayfield Co. (Baker).

REMARKS: The shell of *bayfieldensis* may be known by its light yellowish horn color, regularly ovate and cylindrical form, acute, broadly conic spire, very thin texture, and impressed sutures. There is some variation in height of spire, some specimens having a rather long acute termination, while in others the spire is depressed and somewhat dome-shaped. It is easily confused with some short-spired forms of *gyrina hildrethiana*, but that form is much thicker, the sutures are not as much impressed, the spire not as acute, and the sculpture is usually finer.

Bayfieldensis was at first thought to be a variety of Tryon's *oleacea*, but an examination of a specimen from the type locality, submitted by Dr. Pilsbry (pl. XXVIII, fig. 19), shows conclusively that it is not that species. The figured type of *oleacea* is from Alabama and not from Lake Superior and this must be taken as the type locality. *Oleacea* is thought to be the same as *crocata* Lea, but the figure of the latter appears to be somewhat different from that of the type locality specimen figured in this monograph. The Lake Superior specimens referred to by Tryon are thought to be young *gyrina* (Winslow,

1926, p. 3). Nothing just like *oleacea* has been seen from Wisconsin. The present species is more like a small form of *sayii*, with which it agrees in the size and general form of the radula, though the tendency of the spire to become very acute and somewhat turreted is quite unlike any of the *sayii* specimens examined. The shell is also much smaller than *sayii* and the habitat very different.

PHYSELLA OBRUSSOIDES Sp. Nov.

Plate XXVII, figures 25–29

TYPE LOCALITY: Oshkosh, Winnebago Co., in Winnebago Lake, Hatchery Bay.

SHELL: Small, ovate, thin, minutely perforate; color yellowish or brownish, surface shining; whorls 5, the last rather large, shouldered; spire long, acute, the whorls shouldered; sculpture of fine growth lines crossed by fine spiral impressed lines; nucleus small, flatly rounded, of one whorl, punctate, brownish, sometimes reddish in color; sutures well impressed; aperture large, ovate, somewhat ear-shaped, contracted above, broadly rounded below, 6/10 the length of the shell, the outer edge flattened and almost straight; outer lip sharp, not thickened on the inside, arched at the upper part where it joins the body whorl; parietal wall with but little wash of callus; columella straight, the inner lip turned over and appressed to the umbilical region, leaving a very small chink or umbilicus; the columella is triangular, widening above.

L. 9.6; D. 5.0; Ap. L. 5.5; D. 2.5 mm. Type. Hatchery Bay (U. of W., 4598).
L. 8.0; D. 4.5; Ap. L. 5.0; D. 2.2 mm. Paratype. Hatchery Bay (U. of W., 4599).
L. 7.0; D. 4.0; Ap. L. 4.5; D. 2.0 mm. Paratype. Hatchery Bay (U. of W., 4599).
L. 7.5; D. 4.0; Ap. L. 4.9; D. 1.6 mm. Paratype. Hatchery Bay (U. of W., 4599).
L. 7.6; D. 3.9; Ap. L. 5.0; D. 1.5 mm. Paratype. Hatchery Bay (U. of W., 4599).

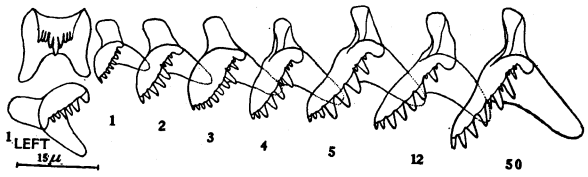
ANIMAL: Digitations, 4–5 columella; 2–4 apical. All digitations are bluntly pointed, often wide and triangular, and short or long.

GENITALIA (Fig. 190): Male organ, penis sheath almost twice as long as praeputium, greatly enlarged or bulbous at the lower

part and with a marked narrowing above this swelling; it again enlarges at the distal end. The male organs differ from those of other species in the short, bulbous shape of the lower part of the penis sheath. Female organs mostly as usual in the genus. Spermatheca pear-shaped, much longer than wide.

JAW: As in the genus.

RADULA (Fig. 195): Formula 125–1–125; center tooth 3–2–1–2–3. Center tooth as high as broad, the three center cusps larger than the side cusps; laterals only four; the first small, 7–cuspid, the cusps small and subequal; second lateral larger, 6–cuspid, the inner cusp with a small denticle on each side; third lateral 9–cuspid, the inner cusp with small side denticles, the outer cusps smaller than the middle cusps; fourth lateral modified to marginal form, 6–cuspid, with two inner



195. Radula of *Physella obrussoides.* Oshkosh.

small denticles and one outer small denticle; fifth tooth a true marginal, though somewhat high, 7–cuspid, three outer cusps small, inner cusp with small denticles; the following marginals 7–cuspid, the outer cusps becoming more equal in length, the inner cusp always with side denticles; at the 27th tooth there are small denticles between the three inner cusps; there are no indications of intermediate small denticles between any of the cusps in the preceding teeth, excepting the inner cusp which always has them.

In one membrane, the left first lateral was much larger than the right lateral and had but six cusps, the two inner cusps being smaller than the others; all of the left first laterals in one membrane were of this character (see fig.). The radula of *obrussoides* is unlike that of any other *Physella* yet described.

ECOLOGY: In vegetation or on stones on shore, in small, partly protected bay; water, .3 to .6 m. deep, bottom sand and coarse gravel. Vegetation consisting of *Scirpus, Vallianeria,* and *Potamogeton,* with a quantity of fllamentous algae.

GENERAL DISTRIBUTION: Not at present known outside of Wisconsin.

DISTRIBUTION IN WISCONSIN: Known only from the type locality, a small bay at fish hatchery, Oshkosh, Lake Winnebago, Winnebago Co.

REMARKS: This small *Physella* does not resemble any other species of the genus. At first sight, it looks like a reversed *Galba obrussa*, the form of the columella and especially the presence of a small umbilical chink being quite similar. The shouldered whorls of the spire are also like *obrussa*, and this similarity has suggested the specific name, *obrussoides*. Both the genitalia and the radula are different from any other species of *Physella*. Three species of *Physella* are found in Winnebago Lake, *sayii, integra billingsi,* and *obrussoides,* each differing from the others in shell, radula, and genitalia.

There is some variation in the shell of this little species, mature or old specimens having the body whorl quite wide and the aperture roundly ovate. In younger specimens the body whorl is more compressed and the aperture is narrower. The spire is always acute, though varying somewhat in length, and the whorls are always shouldered. The interior of the aperture varies in color from dark gray to reddish brown.

PHYSELLA HETEROSTROPHA (Say)

Plate XXVII, figures 21–24

Limnea heterostropha SAY, Amer. Ed. Nich. Encyc., pl. i, fig. 6 (1817).
Physa heterostropha SAY, Journ. Phil. Acad., II, p. 172, 1821; HALDEMAN, Mon. p. 23, pl. ii, figs. 1–9, 1843; BINNEY, L. & F. W. Sh. N. A., II, p. 84, figs. 144, 145, 1865; TRYON, Con. Hald. Mon., pp. 148, 151, 1870; CRANDALL, Nautilus, XV, p. 28, 1901.
Physa fontana HALD., Mon. Pt. 2, p. 3 of cover, 1841; Mon. p. 26, 1843; BINNEY, Op. Cit., p. 85, 1865.
Physa charpentieri KÜSTER, in Chemn., Ed. 2, p. 23, pl. 4, figs. 1–6, 1862; BINNEY, Op. Cit., p. 87, fig. 150, 1865.

TYPE LOCALITY: *Heterostropha,* Delaware River, near Philadelphia, Pa.; *fontana,* cold springs in Pennsylvania; *charpentieri,* Baltimore, Md.

WISCONSIN RECORDS: None.

SHELL: Of medium size, thin, elongated, somewhat cylindrical, sometimes inflated, more or less translucent, imperforate; color yellowish horn or chestnut, surface shining but

rarely polished; sculpture of distinct growth lines; spiral sculpture subobsolete, faintly visible with a hand lens; whorls about 5, the last very large, compressed or flatly rounded; spire rather long, pointed, acute, the whorls flatly rounded; nucleus small, of one whorl, rounded, yellowish or slightly reddish, punctate in sculpture, well exserted above the second whorl; sutures impressed; aperture large, 7/10 the length of the entire shell, the outer lip flattened and slightly shouldered above, broadly rounded below, narrowed above, horn color on the inside; edge of lip thin, with a slight callus bordering the inside, bordered with red; there is a thin wash of callus on the parietal wall; columella a little oblique, impressed, thickened, but not twisted.

L. 11.5; D. 7.0; Ap. L. 8.0; D. 3.6 mm. Philadelphia (Baker, 147, ex Pilsbry).
L. 10.6; D. 6.4; Ap. L. 7.1; D. 3.2 mm. Philadelphia (Baker, 147, ex Pilsbry).
L. 15.5; D. 10.0; Ap. L. 11.0; D. 5.0 mm. Philadelphia (Hinkley Coll.)
L. 15.0; D. 9.0; Ap. L. 11.0; D. 4.5 mm. " "

ANIMAL: Not examined. Philadelphia specimens are rather dark grayish or yellowish, dotted with whitish. Mantle with 3–4 apical digitations and 4–6 columella digitations.

GENITALIA AND RADULA: Not examined.

ECOLOGY: In Philadelphia, this species is found in ditches and small brooks. It originally inhabited the Delaware River in company with *Stagnicola catascopium,* but sewage has now greatly modified this original habitat. Say describes the habitat as follows: "may be found plentifully, during the recess of the tide, about the small streams through which the marshy grounds are drained". It was found on a mud bottom.

GENERAL DISTRIBUTION: Eastern, and perhaps, central states.

DISTRIBUTION IN WISCONSIN: Not known.

REMARKS: *Physella heterostropha* is perhaps the most misunderstood mollusk in America. Almost every species of Physa has been referred to it, from the Atlantic to the Pacific, and the literature is absolutely worthless for determining distribution. Crandall's description and interpretation is, perhaps, the best yet made, but this author included one form, *lata,* which seems sufficiently distinct from typical *heterostropha.* Haldeman, on plate 2 of his monograph, has given excel-

lent figures of this species, which distinguish it from other species. Specimens from Philadelphia, collected by Dr. H. A. Pilsbry and Robert Walton, are like Haldeman's figures. Binney's figure of Say's type is also distinctive. *Heterostropha* may be known by its smooth and shining surface, pointed spire, flatly convex whorls, which are peculiarly sloping, rather deep sutures, and usually, somewhat gibbous shoulder of the last whorl. The columella is slightly oblique in most specimens. Nearly all of the specimens examined have had a decollated spire.

Heterostropha is a common species in the Atlantic states but becomes rarer toward the west and does not reach the Mississippi River. It is rare or wanting in Illinois, but apparently typical specimens have been seen from Michigan and Indiana. No authentic specimens have been seen from Wisconsin but as the species is believed to occur in Michigan, it may eventually be found in this State. It is accordingly described and figured.

Of the species referred to *heterostropha, charpentieri* Küster seems an absolute synonym, as is also *fontana* Hald. Lea's *inflata* has been referred by Binney to *heterostropha,* but while it greatly resembles this species, it also resembles *lata* and might properly replace Tryon's *lata* if the two should ultimately be found to be the same. *Heterostropha* from Ashland, Va., resembles *inflata* somewhat, though the specimens seem good examples of *heterostropha.*

Menke's *striata* (Syn. Méth., Ed. 2, p. 132, 1830) appears to be a recognizable variety of *heterostropha,* characterized by having the spiral sculpture very coarse and with a shorter, more obtuse spire. The types were from Goshen, Mass., and specimens are in the Baker collection from Rhode Island and Massachusetts.

PHYSELLA GYRINA (Say)

Plate XXVII, figures 30–35, 37–40; plate XXVIII, figures 1, 5, 6

Physa gyrina SAY, Journ. Phil. Acad., II, p. 171, 1821; HALDEMAN, Mon. p. 32, 1843 (part); BINNEY, L. & F–W. Sh. N. A., II, p. 77, fig. 130, 1865; CRANDALL, Nautilus, XV, p. 45, 1901.

TYPE LOCALITY: Bowyer Creek, near Council Bluffs, Iowa.

WISCONSIN RECORDS:

1865a. *Physa gyrina* BINNEY, p. 79. Farwells Mills, Madison; Racine; Milwaukee.

1897. *Physa gyrina* WISWALL, p. 48. Southern Wisconsin.
1906. *Physa gyrina* CHADWICK, pp. 23, 86. Milwaukee; Kenosha; Manitowoc Co.
1911a. *Physa gyrina* BAKER, p. 234. Wisconsin River, Oneida Co.

SHELL: Large, elongated or sub-cylindrical, rather thick, subperforate to perforate; color yellowish corneous to ashy, surface dull; sculpture of coarse growth lines crossed by conspicuous, heavily impressed spiral lines; whorls 5–6, the last rather large, compressed or slightly inflated; spire rather long, acute, the whorls well rounded, the penultimate whorl enlarged disproportionately; nucleus small, flatly rounded, of rather more than one whorl, sculpture punctate, usually red wine colored; sutures impressed; aperture rather large, loop-shaped, 5/10 to 7/10 the length of the entire shell, the outer lip flatly rounded; outer lip with thin edge, internally thickened by a callus which is bordered internally by a wide band of red; the lip joins the body whorl at a rather acute angle; parietal wall with a distinct, wide callus; columella straight, thickened, the inner lip turned over and appressed to the umbilical region, forming a wide, flat, columellar region, which is rarely twisted or with a plait; there are usually three white rest period marks on the shell.

L. 19.0; D. 11.0; Ap. L. 11.8; D. 5.5 mm.	Galena, Mo. (U. of I., Z16990).
L. 24.0; D. 11.8; Ap. L. 13.3; D. 6.5 mm.	Kansas City, Mo. (U. of I., Z16991).
L. 19.2; D. 10.9; Ap. L. 12.4; D. 5.5 mm.	Du Bois, Ill. (U. of I., Z16992).
L. 20.0; D. 12.0; Ap. L. 15.0; D. 6.0 mm.	Brown Co. (U. of W., 4600).
L. 18.0; D. 10.0; Ap. L. 11.2; D. 5.0 mm.	" "
L. 13.2; D. 7.6; Ap. L. 9.0; D. 4.0 mm.	" "

ANIMAL: Color blackish or yellowish gray, dotted or flecked with whitish or yellowish; front of head with two yellowish spots of good size, composed of very small dots; mantle brown or blackish, spotted with yellowish, which are distinctly seen through the translucent shell. Digitations of mantle, apical 4–6, columella, 4–7; the more usual number is 4–5 apical and 6–7 columella. Among 250 specimens examined from various places, the apical ranged from 2 to 5 and the columella from 4 to 10; 100 specimens had 4 apical and 6 columella, 25 had 4 apical and 5 columella, and 30 had 5 apical and 8 columella; 6 specimens had 4 apical and 10 columella (see Baker, 1901c, p. 228). All of the mantles vary in the shape and size of the digitations, these lobes varying from mere bulgings to

long, finger-like projections; many are wide and triangular in shape.

GENITALIA: Male organ with penis sheath almost twice as long as praeputium, the sheath being greatly contracted in the upper third of its length, but enlarged at distal end; gland rather narrow, elongated. Female organs not differing notably from the general form in the genus.

JAW: As usual in the genus. See *hildrethiana.*

RADULA (See fig. 196): Formula 115–1–115 to 120–1–120; formula of center tooth 2–2–1–2–2; center cusp of center tooth larger than side cusps, outer cusps placed rather high up on the reflection; laterals six, the first with six cusps, two of which are large, the others smaller; there are two small den-

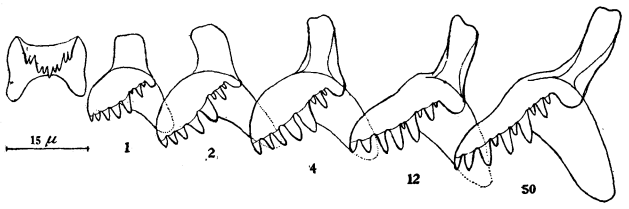


Fig. 196. Radula of *Physella gyrina.* Salt Fork, near Urbana, Ill.

ticulations, one on each side of the inner cusp; second lateral larger than first with six cusps as in the first lateral; fourth lateral similar but larger; marginals larger than laterals, 6-cuspid, smaller denticles appearing between the three inner cusps but not between the three outer cusps; all cusps are long and fang-like.

There is some variation in the number of teeth in a membrane. Specimens from Chicago counted but 95–1–95, while Urbana specimens gave 115 to 120 (var. *hildrethiana*). There appears to be no difference between *gyrina* and *hildrethiana* in the form of the radula. The so-called secondary teeth of former papers (Moll. Chi. Area, p. 313, etc.) are now known to be simply appendages of the lateral and marginal teeth.

ECOLOGY: Say's type came from a creek. Hinkley has collected it in a creek near Du Bois, Ill., and it occurs in this kind of a habitat in Wisconsin. It appears to be characteristic of slow-moving and stagnant bodies of water, in shallow water, usually on a mud bottom. It has been found in overflows from large rivers, in small ponds behind river and lake beaches; such

localities occur along the Wisconsin River in Oneida County and in Brown County.

GENERAL DISTRIBUTION: From the Arctic regions south to Alabama and Texas. The typical form is characteristic of the Mississippi Valley where it reaches its greatest perfection.

DISTRIBUTION IN WISCONSIN: Generally distributed over the State.

Superior Drainage: Ashland Junction, Bayfield Co. (Bullock).

St. Croix Drainage: New Richmond, St. Croix Co. (Bullock); Osceola, Polk Co. (Clench).

Chippewa Drainage: Phillips, Price Co. (Bullock).

Black Drainage: Medford, Taylor Co.; Loyal, Clark Co. (Bullock).

Mississippi Drainage: Bloomington, Grant Co. (Bullock).

Lake Michigan Drainage: Racine, Racine Co. (Hoy, Marston); Milwaukee, Milwaukee Co. (Chadwick, Lapham); East Twin River, at Two Rivers, Manitowoc Co. (Chadwick); Kenosha, Kenosha Co. (Chadwick, Wiswall); Menominee River, 2 m. above Underwood Creek, Marinette Co. (Clench); Menomonee River, Waukesha Co. (Cahn).

Wisconsin Drainage: Marshfield, Wood Co. (Bullock); Wisconsin River pools, Oneida Co. (Baker).

Rock Drainage: Farwells Mills, Madison, Dane Co. (Baird); stream south of Lake Wingra, Dane Co. (Bullock); Oconomowoc River; near Nelsons Lake, Waukesha Co.; Rock River, near Ixonia, Jefferson Co. (Cahn).

Fox Drainage: Spring Lake, Green Lake Co. (Baker); Chilton, Calumet Co. (Bullock).

REMARKS: Typical *gyrina* may be at once distinguished by its large, heavy shell with its coarse sculpture, especially the spiral impressed lines, the conspicuous enlargement of the penultimate whorl, causing the spire to appear shortened up, its loop-shaped aperture, and heavy columellar callus. Crandall was the first student in recent years to properly differentiate the true characteristics of *gyrina,* though his statement that the type form is confined largely to the territory west of the Mississippi River is not borne out by an examination of material from the eastern and central states. The type form occurs abundantly in Illinois and Indiana, as well as in bordering states.

Many references to *gyrina* refer to variety *hildrethiana* as the creek and swale forms have not generally been differentiated. Most of the references to *heterostropha* in the literature refer to *gyrina* or its varieties. *Gyrina* is one of the most characteristic tadpole snails when its true nature is understood.

A form of *gyrina* common in western Missouri and Kansas should be known as *Physella gyrina hawni* (Lea). It is smaller than *gyrina,* has a lighter color, finer lines of growth, a shining surface, with fine cross striae, and a narrower shell. This form appears to be the same as the *albofilata* of Ancey. The references are as follows:

Physa hawni LEA, Proc. Phil. Acad., p. 114, 1864; Journ. Phil. Acad., VI, p. 165, pl. 24, fig. 84, 1866.

Physa albofilata ANCEY, in Sampson, Rep. Geol. Surv. Ark., II, p. 194, 1891.

TYPE LOCALITIES: *Hawni,* Verdigris River, Kansas; *albofilata,* West Leatherwood, Creek, Eureka Springs, Carroll Co., Ark.

PHYSELLA GYRINA HILDRETHIANA (Lea)

Plate XXVII, figure 36; plate XXVIII, figures 2–4, 7–14

Physa hildrethiana LEA, Proc. Amer. Phil. Soc., II, p. 32, 1841; BINNEY, L. & F–W. Sh. N. A., II, p. 78, fig. 132, 1865; TRYON, Con. Hald. Mon., p. 162, pl. 9, fig. 5, 1870; DALL, Alaska Moll., p. 102, fig. 79, 1905; CRANDALL, Nautilus, XV, p. 45, 1901.

Physa altonensis LEA, Proc. Phil. Acad., p. 114, 1864; Journ. Phil. Acad., VI, p. 164, pl. 24, fig. 82, 1866; Obs., XI, p. 120, pl. 24, fig. 82, 1867.

Physa oleacea of authors, not Tryon.

TYPE LOCALITY: *Hildrethiana,* a lake in Illinois; *altonensis,* Alton, Ill.

WISCONSIN RECORDS:

1906. *Physa gyrina elliptica* CHADWICK, pp. 23, 86. Near Milwaukee.
1906. *Physa gyrina* CHADWICK, p. 86. Milwaukee.
1906. *Physa sayii* CHADWICK, p. 86. Menomonee marshes, Kinnickinnic River.
1924. *Physa gyrina hildrethiana* BAKER, p. 135. Oshkosh.
1924. *Physa gyrina oleacea* BAKER, p. 135. Near Lake Butte des Morts.

SHELL: Differing from typical *gyrina* in being generally thinner, with finer spiral lines, surface more polished; shell usually narrower, more elongated, the aperture not as distinctly loop-shaped; shell usually darker colored; the body whorl of *gyrina* is usually more swollen and gibbous than in *hildrethiana;* columellar fold not as heavy.

L. 22.0; D. 10.5; Ap. L. 13.5; D. 5.0 mm. Milwaukee (Lapham, U. S. N. M., 28, 271).
L. 16.0; D. 8.5; Ap. L. 11.0; D. 4.0 mm. De Pere (U. of W., 4601).
L. 18.0; D. 9.0; Ap. L. 12.0; D. 5.0 mm. Near Oshkosh (U. of W., 4605).
L. 13.0; D. 8.0; Ap. L. 10.0; D. 4.0 mm. Near Butte des Morts (U. of W., 4604). Immature.

ANIMAL: As in *gyrina.*

ECOLOGY: *Hildrethiana* is characteristic of swales and summer-dry ponds, where it is deprived of moisture for a large part of the year. The variety in such localities rarely reaches maturity, the usual form being a small, short, shell with dome-shaped spire, greatly resembling *oleacea* and *elliptica.* These small forms usually show no rest marks, living only as long as the water remains in the pool. Mature shells may often be found by digging in the mud or in cracks in the bottom of the pool where the mollusk has descended for moisture. Large specimens may have as many as four rest marks on the shell. In some sloughs the water may become very low in summer but does not completely disappear. In such locations *hildrethiana* attains its finest development (see Baker, 1924, for descriptions of habitats near Oshkosh).

GENERAL DISTRIBUTION: *Hildrethiana* is common east of the Mississippi River from western New York and Pennsylvania to Illinois and south to Alabama. Occurs also in Iowa and possibly in other states west of the Mississippi River. In New York State, the form *cylindrica* Newcomb largely takes its place.

DISTRIBUTION IN WISCONSIN: The distribution is not well known owing, probably, to mixing with typical *gyrina.* Recorded only from the eastern part of the State.

Fox Drainage: De Pere, Brown Co.; Brown Co. (Marston); woodland pools near Lake Butte des Morts and Oshkosh, Winnebago Co. (Baker); near Winnebago Lake, Calumet Co. (Chadwick).

Lake Michigan Drainage: Near Milwaukee, Milwaukee Co. (Chadwick, Lapham).

REMARKS: *Hildrethiana* may be distinguished from typical *gyrina* by its more delicate sculpture, thinner shell, and less distinctly looped aperture. It is usually a much narrower shell. This variety is an ecological form, produced by its peculiar habitat in pools and sloughs which become more or less dry in summer. It is especially characteristic of woodland

pools, in which occur *Stagnicola caperata, Aplexa hypnorum,* and *Sphaerium occidentale.* In such places the *hildrethiana* are usually immature, the pool drying up before the shells become more than half grown (see pl. XXVIII, figs. 10–14). Typical *gyrina* is an inhabitant of creeks and slow-moving rivers, or pools in the overflow of rivers, in situations which do not become dry in summer.

The short-spired form (immature) of *hildrethiana* has been thought to be the same as Tryon's *oleacea,* and statements to this effect have been published by the writer and others. The examination of a specimen from the original lot, contributed by Dr. H. A. Pilsbry, indicates that this approximation is not correct and that *oleacea* is a distinct species. The original figure is of the Alabama specimens which must be taken as the type locality (see pl. XXVIII, fig. 19).

PHYSELLA ELLIPTICA (Lea)

Plate XXVIII, figures 15–18

Physa elliptica LEA, Trans. Amer. Phil. Soc., V, p. 115, pl. xix, fig. 83, 1837; BINNEY, L. & F–W. Sh. N. A., II, p. 78, fig. 131, 1865; TRYON, Con. Hald. Mon., p. 163, pl. 9, fig. 9, 1870; CRANDALL, Nautilus, XV, p. 54, 1901.

Physa febigerii LEA, Proc. Phil. Acad., p. 114, 1864; Journ. Phil. Acad., VI, p. 174, pl. 24, fig. 99, 1866; Obs., XI, p. 130, pl. 24, fig. 99, 1866; TRYON, Con. Hald. Mon., p. 163, pl. 9, fig. 13, 1870.

Physa nicklinii LEA, Proc. Phil. Acad., p. 114, 1864; Trans. Phil. Acad., VI, p. 175, pl. 24, fig. 101, 1866; Obs., XI, p. 131, pl. 24, fig. 101, 1866; TRYON, Con. Hald. Mon., p. 163, pl. 9, fig. 14, 1870.

TYPE LOCALITY: *elliptica,* unknown; *febigerii,* Logan Co., Ohio; *nicklinii,* Callaghan's, Alleghany Co., Va.

WISCONSIN RECORDS: None.

SHELL: Small, elliptical, translucent, imperforate; color yellowish or brownish horn, sometimes quite red, surface shining to pellucid; there is usually one rest-period band on the shell; sculpture of very fine lines of growth crossed by equally fine spiral lines giving the surface a beautiful satin-finish aspect, more or less pronounced in different specimens; whorls about 5, the last very large, cylindrical; spire short, very obtuse, dome-shaped, the whorls flatly rounded; nucleus small, depressed-rounded, of about one whorl, smooth and polished, rich wine colored, the color sometimes descending to the second whorl;

sutures not much impressed, bordered below by a distinct, white zone; aperture long and narrow, about 6/10 the total length of the shell, straight or roundly flattened at the outer edge; outer lip forming an almost uninterrupted curve from base to spire, thickened on the inside by a heavy callus which is edged internally by a red band; parietal wall with only a very thin wash of callus; columella slightly oblique, thickened, the inner lip tightly appressed to the umbilical region, forming a wide, rounded, thick area; the columella and the callus of the outer lip are continuous in mature specimens.

L. 13.0; D. 7.0; Ap. L. 8.2; D. 3.0 mm.	Sturgeon Bay	(U. of W.,	4606).
L. 11.2; D. 6.1; Ap. L. 8.0; D. 2.6 mm.	"	"	"
L. 11.0; D. 6.0; Ap. L. 7.0; D. 3.0 mm.	"	"	"
L. 9.0; D. 5.0; Ap. L. 5.0; D. 1.6 mm.	"	"	"
L. 6.0; D. 3.0; Ap. L. 3.5; D. 1.4 mm.	"	"	"

ANIMAL: Dark lead color generally. Digitations of mantle, columella 5–6, apical, 5–6. The number is very uniform, but the form is variable, in some cases being uniformly finger-like, in others short, wide and roundly triangular, and in still others there may be an alternation of large and small lobes.

GENITALIA (Fig. 190): Male organ with penis sheath 2½ times length of praeputium; penis sheath with usual median constriction. Female organs as in the genus.

JAW: As usual.

RADULA (Fig. 197): Formula 140–1–140; center tooth 2–1–1–1–2; center tooth with middle cusp longer and larger than side cusps; about eight laterals; first lateral small, with 5 cusps of unequal size, and a small denticle on each side of

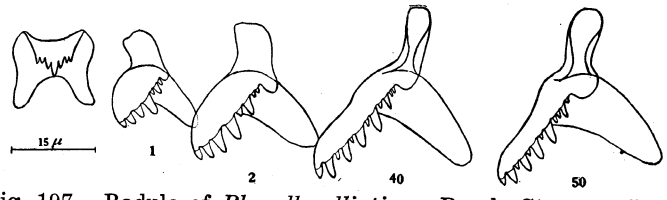


Fig. 197. Radula of *Physella elliptica.* Brook, Sturgeon Bay.

the inner cusp; rest of laterals larger than first, 5-cuspid, unequal in size, with one outer and two inner small denticles at the inner cusp; marginals with 6 cusps, a small denticle between each excepting the small outer cusp, and with the small denticles at the inner cusp as in the lateral teeth; this condi-

tion is reversed in some teeth, as shown in the 50th tooth of the figure; the cusps are all very long and sharp.

The radula of *elliptica* resembles that of *bayfieldensis;* the cusps of the center tooth are finer and the tooth is slightly smaller, as are the other teeth. There are 7 cusps in *bayfieldensis* while there are but 5–6 in *elliptica.* The center tooth of *hildrethiana* is very different.

ECOLOGY: Small brook flowing into Sturgeon Bay cove, limestone bottom, water 10–50 cm. deep, mud bottom, mollusks on limestone and in mud (Baker); Monticello, in stagnant water along railroad track, abundant (Bullock).

GENERAL DISTRIBUTION: Crandall gives the distribution as east of the Mississippi River and north of Tennessee. As it has been confused with *gyrina,* its exact range is at present incomplete.

DISTRIBUTION IN WISCONSIN: Found in widely separated localities; evidently sporadic.

St. Croix Drainage: Grantsburg, Burnett Co. (Bullock).
Chippewa Drainage: Phillips, Price Co. (Bullock).
Lake Michigan Drainage: Root River, Horlicks Mills, Racine Co. (Clench).
Rock Drainage: Monticello, Green Co. (Bullock); Rock River, west of Oconomowoc, Jefferson Co. (Cahn).
Fox Drainage: Terrell's gravel pit pond, Winnebago Co. (Baker).
Green Bay: Brook, Sturgeon Bay, Door Co. (Baker). Port Washington, Door Co. (Grosvenor, U. S. Nat. Mus.).

REMARKS: Crandall has stated his belief that there is not a more distinct species in the genus than *elliptica,* and I agree with him. Its regularly elliptical shape, short, dome-shaped spire, shining surface, and heavy columella will readily distinguish it. Though about the same size as *bayfieldensis,* that species is thinner, the spire is much shorter and broader, the surface less shining, and the sculpture coarser. The radulae of the two species are different. Immature *hildrethiana* have more of a loop-shaped aperture, a dull surface with coarse sculpture, and the sutures are more deeply impressed. The radula of *hildrethiana* is also quite different.

Lea's figure is poor as is also his description, but there is little doubt that it represents the species later called *febigerii,* of which he gives a good figure. *Nicklinii* is apparently a narrow form of the same species, examples of which occur in

every large series. Currier's *deformis* and Crandall's *minor* appear to be the same thing, and if so, Currier's name should be used. Both came from Grand Rapids, Mich. This small form has not been seen in Wisconsin. *Elliptica* appears to be found only in isolated localities in Wisconsin, though where it occurs it is abundant.

PHYSELLA ELLIPTICA AUREA (Lea)

Plate XXVIII, figures 20–23

Physa aurea LEA, Trans. Amer. Phil. Soc., VI, p. 18, pl. xxiii, fig. 106, 1839; Obs., II, p. 18, 1839; BINNEY, L. & F–W. Sh. N. A., II, p. 86, fig. 148, 1865; TRYON, Con. Hald. Mon., p. 163, pl. 9, fig. 10, 1870; CRANDALL, Nautilus, p. 55, 1901.

Physa troostiana LEA, Proc. Amer. Phil. Soc., II, p. 32, 1841; Trans. Amer. Phil. Soc., IX, p. 7, 1844; Obs., IV, p. 7, 1844; BINNEY, L. & F–W. Sh. N. A., II, p. 93, fig. 159, 1865; TRYON, Con. Hald. Mon., p. 163, pl. 9, fig. 11, 1870.

TYPE LOCALITY: *aurea,* Hot Spring, Bath Co., Va.; *troostiana,* near Nashville, Tenn.

WISCONSIN RECORDS: None.

SHELL: Differing from typical *elliptica* in being wider, having a shorter spire and wider aperture. The color is usually light yellowish horn, polished, and the shell is very translucent; the sculpture is usually lighter than that of *elliptica.*

L. 10.1; D. 6.0; Ap. L. 0.0; D. 0.0 mm.	Troostiana, type.
L. 12.5; D. 7.5; Ap. L. 0.0; D. 0.0 mm.	Aurea, type.
L. 9.0; D. 5.1; Ap. L. 6.0; D. 2.0 mm.	Sandstone Bay (U. of W., 4607).
L. 8.0; D. 4.5; Ap. L. 5.5; D. 2.0 mm.	" " "

ANIMAL: Not examined.

ECOLOGY: In small brook flowing into Green Lake, water 1 m. deep, mud bottom. The original habitat of *aurea* is interesting and is thus described by Lea (Binney, p. 86): "Mr. Nicklin informed me that he found the *Physa aurea* in a little watercourse by which a hot and cold spring discharge their mingled waters. The former exhibits a temperature of 106° and the latter of about 56° of the scale of Fahrenheit. Near the meeting of the waters, one side of the little stream is cold and the other side hot; and multitudes of these beautiful Physae are to be found on both sides of the line of junction, avail-

ing themselves of the power which the locality affords them of changing their climate according to their fancy".

GENERAL DISTRIBUTION: Probably the same as that of *elliptica.*

DISTRIBUTION IN WISCONSIN: At present known only from a small brook emptying into Sandstone Bay, Green Lake, Green Lake Co. (Baker).

REMARKS: *Aurea* appears to be a variety of *elliptica* distinguished by being wider and with a shorter, wider spire. There are intermediate forms in almost every large series of either *elliptica* or *aurea.* It is not common in Wisconsin. *Physa troostiana* appears to be identical with *aurea.*

Subgenus PHYSODON (Haldeman 1842) Baker 1926

Shell with the columella forming a wide, more or less flat expansion, the axis without a distinct twist or plait; there may be one or two small denticles on the columella. Male organ of genitalia without the constriction in the center of the penis sheath, the latter not much longer than the praeputium; no distinct sarcobelum, but the walls of the penis sheath above the praeputium are much thickened and form a rounded sac; penis large and cylindrical at the upper part, tapering rather abruptly below the middle to about one-fourth upper diameter, forming a slender tube with the vas deferens centrally located (fig. 186).

TYPE: *Physa microstoma* Haldeman.

The group of Physellae typified by *microstoma, integra* and *walkeri* appears to form a natural division of the genus. The genitalia only of *integra* and *walkeri* are known, but the form of the shell suggests the inclusion of *microstoma, michiganensis,* and *anatina* in the same assemblage, thus avoiding the coining of an additional group name. The approximation must necessarily be tentative until the anatomy of *microstoma* is known.

KEY TO SPECIES OF PHYSODON IN WISCONSIN

1. a. Shell wide, with loop-shaped or ear-shaped aperture, wide and broadly conic spire, thick, rather heavy shell, and coarse sculpture ---------- 2
   b. Shell narrow, with elongate-ovate aperture, narrow, acute spire, usually thin shell, and fine sculpture ---------- 3

2. a. Adult shell exceeding 11 mm. in length, spire broadly acute or conic, sculpture very coarse, aperture distinctly ear-shaped, sutures deeply impressed, spire whorls rounded---*integra*
   b. Adult shell less than 11 mm. in length, spire acute, sculpture fine, aperture long-ovate, sutures not deeply impressed, spire whorls flat-sided ---*billingsii*
   c. Adult shell less than 11 mm. in length but spire greatly depressed, very broad, aperture dilated, sculpture rather coarse ---*brevispira*
3. a. Shell cylindrical, aperture long-ovate, almost straight along the outer margin, surface bright and polished, sutures well impressed ---*michiganensis*
   b. Shell long-ovate, aperture broadly ovate, the outer margin rounded or effuse, surface dull, not shining, sutures not much impressed ---*walkeri*

PHYSELLA INTEGRA (Haldeman)

Plate XXVIII, figures 24–31

Physa integra HALDEMAN, Mon. No. 3, p. 3 of cover, 1841; p. 33, pl. iv, figs. 7–8, 1843; BAKER, Moll. Chicago Area, p. 315, pl. xxxiv, fig. 6, 1902.

Bulinus integer BINNEY, L. & F–W. Sh. N. A., II, p. 101, fig. 172, 1865.

Physa integer TRYON, Con. Hald. Mon., p. 167, 1870; Crandall, Nautilus, p. 56, 1901.

TYPE LOCALITY: Indiana.

WISCONSIN RECORDS:

1906. *Physa integra* CHADWICK, p. 23. Milwaukee and vicinity; Golden Lake.

1924. *Physa integra* BAKER, p. 135. Lake Butte des Morts.

SHELL: Of good size, elongate-ovate, thick, more or less solid, imperforate; color yellowish corneous or white, sometimes brownish; surface usually dull, but shining in light-colored specimens; there may be as many as seven white vertical streaks on the outside of the shell representing former lip edges; sculpture coarse, growth lines raised into coarse, more or less equidistant fine ridges; spiral lines subobsolete but fairly well developed in some individuals; whorls 5, rounded, the last usually large, a little shouldered; neucleus small, rounded, of one whorl, slightly punctate, light brown in color; sutures deeply impressed; aperture ear-shaped, angled above, well rounded below, 6/10 to 7/10 the length of the entire shell, more or less shouldered at the upper part; outer lip greatly

thickened within by a heavy, wide, white callus which is conspicuous on the outer edge of the lip; there may be a wide, brownish border on the inside of this callus; callus on the parietal wall thin to rather thick; columella a trifle oblique, very thick, the inner lip folded over into the umbilical region forming a wide, flat expansion which is continuous with the outer lip; there is frequently a plait-like ridge on the columella produced by the deep depression of the inner lip at its junction with the parietal wall.

L. 15.8; D. 9.0; Ap. L. 9.2; D. 4.1 mm.	Alton, Ill. (Baker Coll., No. 1456).
L. 13.1; D. 8.9; Ap. L. 9.5; D. 4.5 mm.	" " "
L. 13.3; D. 8.1; Ap. L. 8.3; D. 4.0 mm.	Sturgeon Bay (U. of W., 4608).
L. 12.0; D. 7.0; Ap. L. 7.8; D. 3.9 mm.	" " "
L. 10.1; D. 6.5; Ap. L. 7.0; D. 3.5 mm.	" " "
L. 7.0; D. 4.0; Ap. L. 4.0; D. 1.7 mm.	" " "
L. 12.0; D. 7.6; Ap. L. 7.0; D. 3.5 mm.	Oconomowoc L. (U. of I., Z16749).
L. 12.0; D. 7.0; Ap. L. 7.2; D. 3.2 mm.	" " "

ANIMAL: Mantle digitations variable, the combination in four specimens being, columella, 4, 4, 7, 7; special, 4, 3, 3, 5.

GENITALIA (Fig. 190): Male organ with penis sheath simple, without median constriction, and but little longer than the praeputium. The gland is small and is placed on the upper part of the praeputium near the penis sheath. The female organs do not differ from those in other species of the genus.

JAW: As in the genus.

RADULA (Fig. 198): Formula 130–1–130. Formula of central tooth, 2–1–1–1–2, the cusps very small, the three center ones grouped together, at the end of the reflection, the two side teeth higher up; first lateral smaller than second, with three

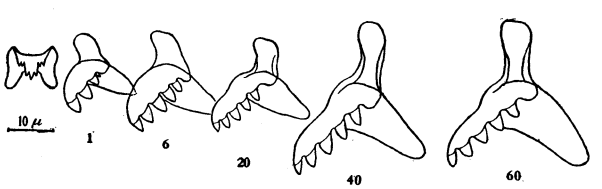


Fig. 198. Radula of *Physella integra*. Mirror Lake.

wide cusps and one small cusp; second to eighth laterals wide, with five large cusps; marginals all 5–cuspid, the cusps large and wide; there are no indications of smaller cusps between the larger ones on any radula examined. The radula of *integra*

has smaller teeth than those of *walkeri* and the denticulation of the center tooth is quite different, the lateral teeth are smaller with fewer and larger cusps, and the marginals are slightly smaller and have fewer cusps. *Integra* also lacks the smaller cusps on either side of the inner cusp which are present in *walkeri.* The radulae of the two species are the best citeria for their separation. In the Mollusca of the Chicago Area (p. 316) the statement is made that there are six large cusps on each tooth. This is an error, there being but five, in the present membranes examined. The large swelling on the inner side of the reflection was evidently mistaken for a cusp.

ECOLOGY: Mirror Lake, at edge of dam, on shore, in water 5 to 25 cm. deep, on mud bottom; Sturgeon Bay, sandy and gravelly shore, water .4 to 2 m. deep; Green Bay, sand bottom, 1.5 m. deep; dredged dead from 39.5 m. depth. In Oneida Lake, N. Y., *integra* occurred on boulder, sand, clay, and mud bottoms in water .5 to 3 m deep. This indicates a wide range of habitat, parallelling the wide range in variation of the form of the shell.

GENERAL DISTRIBUTION: Crandall gives the distribution as from the Great Lakes to the Gulf, occupying a belt from central Arkansas to central Kansas. It has not been reported from south of the Ohio River. It is common in Ontario, Michigan, New York, Ohio, Indiana, Minnesota, South Dakota, and Illinois. Its distribution is different from any other Physa in Wisconsin.

DISTRIBUTION IN WISCONSIN: Apparently widely distributed and known from the following drainage: St. Croix, Chippewa, Black, Mississippi, Wisconsin, Fox, Rock, and Fox of Illinois rivers; streams draining into Lake Michigan.

REMARKS: *Integra* is a distinct and usually an easily recognized species. Its heavy shell, with coarse texture, its wide spire whorls, heavy wide columella expansion, ear-shaped aperture, deeply impressed sutures, and the conspicuous white marks of former lip calluses on the shell render it recognizable from other species as a rule. It is a larger shell than *walkeri,* has a much wider, usually shorter spire, the aperture is ear-shaped instead of rounded, and the columella is wider and more solid than in *walkeri.*

While the species is usually easily distinguishable from all others in Wisconsin at least, there is great variation in the form

of the shell within the species. The spire may be long or short, causing the shell to vary from elongate to ovate. In the young shell, the columella is thin and more or less twisted and the spire is narrow and often very acute. Some specimens may be scalariform and have a very long spire. Some of this variation is shown in the figures. Many specimens are difficult to separate from the variety *billingsii,* which appears to be largely an eastern form, replacing *integra* in some places. There seems to be every gradation, in some lots, between the typical *integra* and the variety *billingsii,* as is shown in the discussion of that variety.

PHYSELLA INTEGRA BILLINGSII (Heron)

Plate XXVIII, figures 35, 36, 40–46

Physa billingsii HERON, Trans. Ottawa Field Club, I, p. 62, pl. 2, fig. 5, 1880.

Physa integra billingsii CRANDALL, Nautilus, XV, p. 56, 1901.

Physa heterostropha BAKER, Moll. Chi. Area, p. 308, pl. xxxiv, fig. 2, 1902.

TYPE LOCALITY: Billing's Bridge, Ottawa, Ontario, Canada.

WISCONSIN RECORDS:

1924. *Physa integra billingsii* F. C. BAKER, p. 135. Lakes Winnebago and Butte des Morts.

SHELL: Differing from typical *integra* in being smaller, usually less solid, the sutures less deeply impressed and the whorls more flat-sided; the surface sculpture is finer, the shell frequently shining, and the white varices of *integra* usually absent; the aperture is not usually as distinctly ear-shaped, and the outer lip is more regularly curved, sometimes semicircular, the aperture somewhat expanded; the spire may be short or long, is usually acute, but not scalariform; the columella is not as heavy as in *integra* and there is sometimes more of a twist in the columella; color usually greenish, ashy-horn, or brownish.

L. 11.0; D. 6.5; Ap. L. 7.0; D. 4.0 mm. Creek near Ottawa, Ont. (Baker coll., 1733).

L. 10.3; D. 6.5; Ap. L. 7.2; D. 3.5 mm. Creek near Ottawa, Ont. (Baker coll., 1733).

L. 10.0; D. 6.0; Ap. L. 6.0; D. 3.0 mm. Winnebago L. (U. of W., 4612).

L. 9.5; D. 6.0; Ap. L. 6.0; D. 2.5 mm. " "

L. 8.9; D. 5.0; Ap. L. 5.1; D. 2.0 mm. Brown Co. (U. of W., 4611).
L. 9.0; D. 5.6; Ap. L. 6.0; D. 2.5 mm. Charlevoix, Mich. (Baker Coll., 1600).

ANIMAL: Not examined.

ECOLOGY: No living specimens have been seen. In Winnebago Lake, dead specimens were dredged from the following locations: .6 m., boulder and sand bottom; .8 m., sand bottom. In the Apostle Islands it occurs abundantly in beach debris on the open shore of Lake Superior; in the southern end of Lake Michigan it is similarly found. Heron's locality was in the Ottawa River.

DISTRIBUTION: A form of the Great Lakes and of the rivers and bodies of water connected therewith.

DISTRIBUTION IN WISCONSIN: Known only from the eastern and northern part of the State, in the drainages of Lakes Superior and Michigan.

Lake Superior: Apostle Islands and Bayfield shore, Bayfield Co. (Baker).
Lake Michigan: Lake shore between Illinois and Wisconsin (Baker).
Fox Drainage to Lake Michigan: Lakes Winnebago and Butte des Morts, Winnebago Co. (Baker).

REMARKS: *Billingsii* appears to be a miniature form of *integra* differing in size, sculpture, and form of whorls and aperture. It is characteristic of the rivers, bays, and lakes connected with the Great Lakes. Heron's figure represents a maximum specimen as regards elevation of spire, the average individual having the aperture somewhat longer than the spire. In lots of shells from the Rideau River near Ottawa there is every gradation between long and short-spired forms. *Billingsii* has been thought to be an absolute synonym of *integra,* but it appears to have individual characteristics and habitat preferences which make it an easily recognized variety of *integra,* as indicated by Crandall many years ago. *Integra* is typically a river species while *billingsii* is mainly a lake form, at least in Wisconsin. Lake Winnebago shells are absolutely indistinguishable from specimens from near Ottawa. Many of the shells of *integra* in the small lake region of southeastern Wisconsin vary toward *billingsii,* but are better referred to the typical form.

PHYSELLA BREVISPIRA (Lea)

Plate XXVIII, figures 37, 38

Physa brevispira LEA, Proc. Phil. Acad., p. 125, 1869; Journ. Phil. Acad., VI, p. 173, pl. 24, fig. 98, 1866; Obs., p. 129, pl. 24, fig. 98, 1866; TRYON, Con. Hald. Mon., p. 158, pl. 8, fig. 8, 1870; CRANDALL, Nautilus, XV, p. 57, 1901.

TYPE LOCALITY: Ottawa River, Ontario.

WISCONSIN RECORDS: None.

SHELL: Globosely-ovate, rather thick, imperforate; color light to dark purplish, with one or more white varical bands; sculpture of distinct growth lines crossed by well-marked spiral lines; whorls about 4, the spire whorls flat-sided, the body whorl large, globose; nucleus light to dark wine color; spire very short, wide, with a slope of 45 degrees, sutures well marked; aperture ovate, dilated, widest in the middle, occupying about 7/9 of the length of the shell; outer lip thickened within by a white callus; only a slight wash of callus on the parietal wall; columella thickened, impressed in the middle but without a distinct plait, and forming a wide expansion over the umbilical region.

L. 9.0; D. 6.0; Ap. L. 0.0; D. 0.0 mm. Lea's measurements (.35 by .25 inch).
L. 9.5; D. 6.6; Ap. L. 6.5; D. 3.0 mm. Peshtigo (U. of W., 4610).
L. 9.4; D. 6.0; Ap. L. 6.8; D. 2.8 mm. " "

ANIMAL: Not examined.

ECOLOGY: Not known.

DISTRIBUTION: Crandall gives Ontario west to Michigan.

DISTRIBUTION IN WISCONSIN: Apparently confined to Lake Michigan drainage. At present known only from Peshtigo, Marinette Co. (Bullock).

REMARKS: *Brevispira* is distinguished by its depressed spire and large, dilated aperture. It resembles some forms of *billingsii,* but has a wider, shorter spire, the whorls of which are not as high as those of *billingsii.* The figures of *niagarensis* and *brevispira* given by Lea somewhat resemble each other, but specimens from the type locality of *niagarensis* show that that species has an almost smooth shell like *heterostropha* and the spire is peculiarly dome-shaped. I agree with Crandall that *niagarensis* is a distinct species and not a synonym or

even a variety of *integra*. *Brevispira* varies in height of spire but retains its coarse sculpture and wide aperture. It appears to be a species peculiar to the Great Lakes region, occupying the lake shores and the streams and bays entering into these lakes. The long-spired forms inhabiting lake bays, referred to *billingsii* by Crandall, and to which they bear the closest resemblance, sometimes vary toward *brevispira*, and there may be a closer relationship than is at present apparent. An examination of the radula would be of interest in this connection.

PHYSELLA WALKERI (Crandall)

Plate XXVIII, figures 32–34, 39, 47–52

Physa walkeri CRANDALL, Nautilus, XV, p. 57, pl. 2, fig. 5, 1901; BAKER, Trans. Acad. Sci. St. Louis, XVI, p. 8, pl. 1, figs. 5, 6, 1906.

TYPE LOCALITY: Petoskey, Mich.

WISCONSIN RECORDS:

1897. *Physa heterostropha* WISWALL, p. 48. Southern Wisconsin.
1906. *Physa heterostropha* CHADWICK, p. 85. Kenosha (Wiswall list).
1913b. *Physa walkeri* BAKER, p. 68. Waukesha (fossil).
1918. *Physa heterostropha* MUTTKOWSKI, p. 474. Lake Mendota.

SHELL: Of medium size, elongate-ovate, thin to rather thick, somewhat inflated, imperforate; color ashy horn, surface dull to shining; sculpture of coarse growth lines, often ridged on the last whorl, and with very faint traces of spiral lines; some specimens are malleated on the last whorl; whorls 4½, the last very large, rounded; spire acute, rather long, the whorls rounded; nucleus of good size, knob-shaped, usually red wine-colored, sculpture of fine punctations; sutures very deeply impressed; aperture ovate, acute above, rounded below, 3/5 length of entire shell, often effuse or flaring; outer lip regularly rounded, bordered internally by a wide white or saffron-colored callus; parietal wall with a wash of callus of varying thickness; columella slightly oblique, the inner lip folded over to form a heavy callus which is impressed in the middle, forming a slight plait.

L. 10.0; D. 6.0; Ap. L. 0.0; D. 0.0 mm. Type.
L. 11.0; D. 6.1; Ap. L. 7.0; D. 3.5 mm. Alpena, Mich. (Baker coll., 1319).
L. 11.0; D. 6.0; Ap. L. 7.0; D. 3.5 mm. Brown Co., Wis. (Marston Coll., U. of W., 4615).

L. 11.0; D. 6.0; Ap. L. 7.0; D. 3.5 mm. Brown Co. (Marston coll., U. of U. of W., 4615).
L. 8.5; D. 5.0; Ap. L. 5.5; D. 2.5 mm. Brown Co., Wis. (Marston Coll., U. of W., 4615).

ANIMAL: Of a generally dark color. Mantle with five columellar digitations and 3–4 apical digitations, the former quite uniform.

GENITALIA (Fig. 190): The male organs are like those of *integra,* differing in the larger size of the praeputium, which about equals the penis sheath in length.

JAW: As in the genus.

RADULA (Fig. 199): Formula, 125–1–125 (or 130–1–130). Center tooth with a small median cusp with five very small cusps on either side, all cusps being in the same plane. There are about six laterals, the first lateral being but two-thirds the size of the others, with four large and three small cusps; sec-

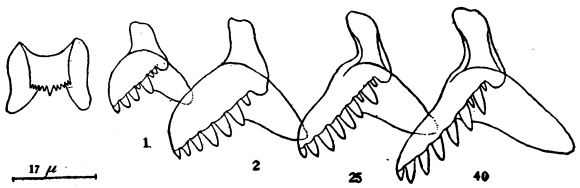


Fig. 199. Radula of *Physella walkeri.* Oconomowoc River.

ond lateral with three large cusps in the center, with three small distal cusps; marginals with seven distinct cusps, the inner cusp with a smaller cusp on either side. The wide reflection of the center tooth with its fine cusps is the peculiar feature of this radula; also the absence of smaller cusps between the large ones.

ECOLOGY: At Bayfield, *walkeri* occurred in Pike Creek on rocks in a small, swift stream of cold water.

GENERAL DISTRIBUTION: The distribution of *walkeri* is not well known. It has been seen from Michigan, Minnesota, Wisconsin, South Dakota, Illinois, Indiana, and Ontario.

DISTRIBUTION IN WISCONSIN: *Walkeri* is rather well distributed over the State.

Lake Superior Drainage: Bayfield, Bayfield Co. (Bullock); Pike Creek, 3 M. north of Bayfield (Baker).
Lake Michigan Drainage: Racine, Racine Co. (P. R. Hoy); Kenosha, Kenosha Co. (Wiswall).

Rock Drainage: Merrill Springs, Lake Mendota, Dane Co. (Pearse); Oconomowoc Lake outlet, Waukesha Co. (Cahn). Lake Mendota (Baker, Muttkowski).

Fox Drainage: Brown Co. (Marston); small stream near Lake Butte des Morts. Winnebago Co. (Baker).

REMARKS: *Walkeri* is related to both *michiganensis* and *integra.* The spire is more elevated, narrower, and more acute than that of *integra,* the shell is smaller, the sutures not as heavily impressed, the sculpture is finer, and the aperture is more nearly ovate, not distinctly ear-shaped. The whole shell is much narrower than that of *integra.* It is even more closely related to *michiganensis* and some individuals are extremely difficult to place if studied in small series. A large series usually leaves no doubt concerning the correct designation of the group. The *walkeri* from Brown County are often of this character, some of the specimens, taken alone, being quite readily referred to *michiganensis* (pl XXVIII, fig. 49–50). *Walkeri* varies from this long, narrow type to the wide, more typical form, and there is also variation in the height of spire and the thickness of shell.

Michiganensis has a more regular, narrower shell, the aperture is not distinctly arched, the sutures are less impressed and the whorls more flat-sided, the sutures being more oblique. The texture of the shell is also finer. The difference in the spire whorls and in the aperture will usually separate the two species. An examination of the radula would help materially in defining the two species, that of *michiganensis* not at present being known. Specimens have been received under the name of *heterostropha,* but that species is quite different in form of aperture, spire, and columella. *Walkeri* is a widespread species in Wisconsin, extending well over the state.

Walkeri is also closely related to *billingsi* and the true relationship of these two forms is not clear. Both are lake variations of *integra* and both pass through about the same range of variation. *Walkeri,* however, is thinner, and usually has a more acurate spire than *billingsi.* The type figure of the latter is not typical, the usual form being much wider and with a shorter spire, similar to figs 40–42 on pl. XXVIII.

PHYSELLA MICHIGANENSIS (Clench)

Plate XIX, figures 5–7, 16

Physa michiganensis CLENCH, Oc. Papers, Mus. Zool., Univ. Mich., 168, p. 4, pl. I, fig. 4, 1926.

TYPE LOCALITY: Stream 1 mile west of Geddes, Washtenaw Co., Mich.

WISCONSIN RECORDS: None.

SHELL: Of medium size, subfusiform or elongate-ovate, thin, translucent, imperforate; color light yellowish corneous, surfacing shining; sculpture of fine growth lines with more or less faint traces of spiral lines; whorls about five, flatly rounded, body whorl large, more or less cylindrical; spire long, acute, the whorls flatly rounded; nucleus rather large, turban-shaped, rather darker than the rest of the shell, of one whorl, sculpture of very fine punctations; sutures well impressed; aperture large, narrowed above, widely rounded below, rather elongate-ovate in form, about 7/10 the length of the shell, the outer lip rather broadly rounded; edge of lip (palatal) thin, with usually a well-marked callus bordering the edge which is marked with saffron or purplish in some specimens; only a thin wash of callus forming the parietal lip; columella slightly inclined to the left in an upward direction, narrow, slightly twisted, rather abruptly terminating at the center of the body whorl; varicose bands rare or absent, usually white when present.

L. 9.5; D. 6.0; Ap. L. 6.0; D. 2.5 mm.	Type from Michigan.
L. 10.5; D. 5.5; Ap. L. 7.0; D. 2.7 mm.	Indiana (Baker coll., 1323).
L. 12.5; D. 7.0; Ap. L. 9.0; D. 3.7 mm.	New Richmond, Wis. (U. of W., 4616).
L. 10.5; D. 5.5; Ap. L. 7.0; D. 2.7 mm.	Rockford, Ill. (U. of Ill., Z17535).

ANIMAL: Not examined.

ECOLOGY: Purely a small creek form (Clench).

GENERAL DISTRIBUTION: Probably includes Michigan, Wisconsin, northern Illinois, Indiana, and Ohio.

DISTRIBUTION IN WISCONSIN: At present unknown but probably widely distributed in small creeks. Its absence from the collections is noteworthy.

St. Croix Drainage: New Richmond, St. Croix Co. (Bullock).

REMARKS: *Michiganensis* may be known by its cylindrical, subfusiform, regularly long-ovate shape, shining surface, acute and narrow spire, and well-impressed sutures. It is more cylindrical than either *integra* or *walkeri*, usually has a narrower shell, which is lighter colored, more polished and of finer texture, and the aperture is more regularly ovate, not ear-shaped. As remarked by Clench, it is related to *walkeri* and seems to be a creek variation of the *integra* type.

Michiganensis resembles *anatina* Lea, being less shining, smaller, with more deeply impressed sutures, and more corneous in color, *anatina* being of a peculiar amber color with more reddish edging the varicose bands. The aperture also is different, the columella terminating more abruptly on the body whorl, forming a distinct angle at this point. This new species includes the records of *anatina* from Michigan and also from the northern part of Illinois. Whether it also includes those from the southern part of the state cannot be determined at present, material from this region not being available. *Anatina*, as determined by Clench, is at present confined to the territory west of the Mississippi from Iowa and Nebraska south to Texas, east of the Rocky Mountains. The center of distribution would seem to be in Kansas and Oklahoma. A specimen of *anatina* from Oklahoma is figured for comparison (pl. XIX, fig. 7).

Genus APLEXA Fleming, 1820

Aplexa FLEMING, Brewster's Edinb. Encycl., XIV, p. 617, 1820. Type: *Bulla hypnorum* LINN.

SHELL: Sinistral, elongated, slender, smooth, shining; spire acute; lip simple, sharp; columella thin, but slightly twisted.

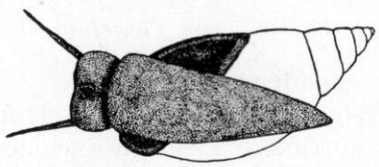


Fig. 200. Animal of *Aplexa*. Lake Butte des Morts.

ANIMAL (Fig. 200): Similar to *Physella*, with a long foot, rounded before and pointed behind; mantle not reflected over the shell and without digitations or lobes. The foot is shorter than the shell.

GENITALIA (Fig. 186): Generative orifice on left side separated as in *Physella;* organs generally as in *Physella;* spermatheca very long, longer than its duct; male organ with penis sheath twice as long as praeputium; the penis sheath is much swollen or spindle-shaped in the center, where it has the same diameter as the praeputium; below and above this swollen part it is much narrower; the distal end is somewhat enlarged again where it receives the vas deferens. Internally, the praeputium has thick walls, two muscular pillars, and a dependent sarcobelum of small size; the penis is very long and narrow, slightly enlarged for a part of its median length, with a distinct narrow ridge or ring surrounding the lower part about a quarter of the distance from base to summit, below which it rapidly narrows to a point; the vas deferens is distinctly, irregularly coiled in the center of the penis, becoming straight below the ridge and having a centrally located outlet.

There is a large, heavy retractor attached to the praeputium, which enters the latter by two or more branches, and a smaller penis sheath retractor; both retractors are united before entering the columella muscle, forming one band of tissue. In the natural position the penis sheath is doubled over the praeputium and held in this form by the two muscles as shown in figure 186. The upper part of the penis sheath is sometimes distinctly pyriform above the central swollen portion, as shown in figure 190. The gland noted in *Physella* is also present on the praeputium. *Aplexa* differs from *Physella* in the form of the penis and in the bulbous swelling of the penis sheath in the middle.

JAW (Fig. 201): Cartilaginous, thin, very wide and low, arched above, bluntly-shaped below the ends attenuated; there are no accessory plates.

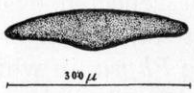


Fig. 201. Jaw of *Aplexa hypnorum.*

RADULA (Fig. 202): Formula of *hypnorum* 175–1–175 (center tooth 3–1–1–1–3); center tooth as broad as high, and shaped as in *Physella;* cusps of the center series larger than those of the lateral series; about nine laterals; first laterals

small, dorsal margin well arched, reflection rather wide, 12–cuspid, the center series being long and sharp, with an inner and outer series of smaller cusps; second lateral larger than first, with a depression in the dorsal border, indicating a transition to the form of the marginal teeth, reflection wide and low, 14–cuspid, the cusps long, sharp, and subequal; 10th tooth a marginal, wide and low, 11–cuspid, the cusps all long and sharp; 25th marginal with 9 cusps; 50th marginal with 9 equal cusps. The teeth decrease in size toward the lateral margin of the membrane as in *Physella.*

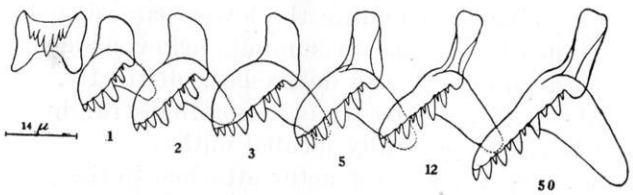


Fig. 202. Radula of *Aplexa hypnorum.* Lake Butte des Morts.

The radula of *Aplexa* differs from that of *Physella* in having more numerous, sharper cusps, without intermediate smaller denticulations between the larger cusps; the lateral appendages are similar to those of *Physella.* The description given in Mollusca of the Chicago Area, p. 318, is partly defective in the shape of the teeth and cusps and in the size and shape of the appendage or lateral attatchment. The number of teeth in a row is also erroneous, the formula being too low, probably due to studying an incomplete membrane.

DISTRIBUTION: Holarctic-Europe, Asia, America.

REMARKS: The three genera *Physa, Physella,* and *Aplexa* form a perfect series of development from the simple mantle of *Aplexa,* which is not reflected over the shell, through the digitate mantle of *Physella,* which is reflected over the shell partly on the left side, to *Physa,* in which the mantle is digitate on both sides and greatly reflected over the shell. There are corresponding differences in the radula, and in a less degree, in the genitalia.

APLEXA HYPNORUM (Linné)

Plate XIX, figures 1–4

Bulla hypnorum LINNE, Fauna Suecica, Ed. I, No. 1303, 1746; Syst. Nat., Ed. X, p. 727, 1758.

Aplexa hypnorum SOWERBY, Genera, Fasc. VII, 1822; DALL, Alaska Moll., p. 106, fig. 81, 1905; BAKER, Moll. Chi. Area, p. 317, pl. xxxii, fig. 16, 1902.

Physa hypnorum HALDEMAN, Mon., p. 36, pl. 5, figs. 4–9, 1842.

Bulinus hypnorum BINNEY, L. & F–W. Sh. N. A., II, p. 99, fig. 170, 1865; TRYON, Con. Hald. Mon., p. 169, 1870.

Physa elongata SAY, Journ. Phil. Acad., II, p. 171, 1821; DEKAY, Zool. N. Y., p. 81, pl. xxxvi, fig. 346, 1843.

Physa elongatina LEWIS, Proc. Bost. Soc., V, pp. 122, 298, 1855.

TYPE LOCALITY: *Hypnorum,* Europe; *elongata,* Illinois.

WISCONSIN RECORDS:

1860. *Physa elongata* LAPHAM, p. 155. Milwaukee.
1865a. *Bulinus hypnorum* BINNEY, p. 101. Milwaukee.
1897. *Aplexa hypnorum* WISWALL, p. 48. Southern Wisconsin.
1906. *Aplexa hypnorum* CHADWICK, p. 23. Milwaukee.
1906. *Aplexa hypnorum* CHADWICK, p. 87. Menomonee Valley; Kenosha; Lindwurm, Milwaukee.
1911a. *Aplexa hypnorum* BAKER, p. 234. Wisconsin River, Oneida Co.
1924. *Aplexa hypnorum* BAKER, p. 135. Near Oshkosh.

SHELL: Of medium size, greatly elongated, thin, transparent, imperforate; color light brownish horn, often marked by narrow streaks, frequently with a glint of copper, surface polished, glistening; sculpture, lines of growth scarcely visible with a lens, without any indication of spiral lines; whorls rather more than six, the last long, narrow, compressed; spire long and pointed, whorls rounded; nucleus rather large, flatly rounded, partly embraced by the second whorl, below which part of the nucleus is sunken, smooth or but slightly punctate, corneous like the rest of the shell; sutures well impressed, bordered below by a narrow white zone; aperture of medium size, about half the length of the shell, narrowly elongated, the outer edge flattened, outer lip thin, regularly rounded from the body whorl, the lower part somewhat expanded, without internal callus; only a very thin wash of callus on the parietal wall; columella oblique, narrow, arched below, slightly twisted; the inner lip is tightly appressed to the umbilical region.

L. 16.3; D. 6.5; Ap. L. 8.6; D. 3.3 mm. Kenosha (Baker coll., No. 1495).
L. 14.0; D. 6.0; Ap. L. 7.3; D. 2.6 mm. " " "

L. 12.0; D. 5.0; Ap. L. 6.0; D. 2.3 mm.	Marinette	(U. of W.,	4617).
L. 10.5; D. 4.9; Ap. L. 5.0; D. 2.0 mm.	"	"	"
L. 10.0; D. 4.3; Ap. L. 4.3; D. 2.0 mm.	"	"	"
L. 7.0; D. 3.0; Ap. L. 3.2; D. 1.2 mm.	"	"	"

ANIMAL: See generic description.

ECOLOGY: *Aplexa hypnorum* is a species of swales and intermittent streams or stagnant pools in Wisconsin, as far as present data goes. It is especially abundant in woodland pools which become dry in summer, in company with *Stagnicola caperata, Physella hildrethiana,* and *Sphaerium occidentale.* It occurs in some localities (as in a ravine bordering the Mississippi River near St. Paul, Minn.) in small clean brooks where the water is a few cm. deep and the bottom of mud.

GENERAL DISTRIBUTION: Throughout North America from east of the Cascade Mountains to the Atlantic and from Alaska and Hudson Bay south to the vicinity of the Ohio River. Also found in Northern Europe and Asia.

DISTRIBUTION IN WISCONSIN: Probably to be found throughout the State in suitable localities.

Lake Michigan Drainage: Milwaukee, Milwaukee Co. (Bullock, Chadwick, Lapham); Menomonee Valley, Milwaukee Co. (Bryant, Chadwick); Marinette, Marinette Co. (Bullock); Kenosha, Kenosha Co. (Wiswall, Chadwick).

Fox Drainage: Swale near Oshkosh, and Lake Butte des Morts, Winnebago Co.; near Green Lake, Green Lake Co. (Baker).

Wisconsin Drainage: Pools along Wisconsin River, Oneida Co. (Baker).

Rock Drainage: Windsor, Dane Co. (Bullock).

St. Croix Drainage: North of Shell Lake, Washburn Co. (Baker).

REMARKS: *Aplexa hypnorum* is at once distinguished from *Physella* by its narrow, acutely spired, polished shell. There is no Wisconsin *Physella* that approaches it in this respect. The American form is absolutely synonymous with the European, showing the same variation in length of spire, aperture, and width of aperture. A specimen from Guildford, Surrey, England is figured for comparison. It does not seem to be commonly distributed in Wisconsin, although abundant wherever found. It is characteristic of swales, stagnant pools, and ephemeral ponds, with *Stagnicola caperata, Physella hildrethiana,* and *Sphaerium occidentale,* forming a peculiar ecological fauna.

Two varieties of *hypnorum* have been differentiated, *glabra* De Kay, type localities Conn., N. Y., and Mich., and *tryoni* Currier, type locality Grand Rapids, Mich. Both forms have a wider shell than *hypnorum,* and neither has thus far been found in Wisconsin or Illinois. The references are as follows:

Physa glabra DEKAY, N. Y. Moll., p. 80, pl. 5, fig. 83, 1843 (= *Physa elongatina* LEWIS, Proc. Bost. Soc. N. H., V, pp. 122, 298, 1855).
Bulinus tryoni CURRIER, Amer. Journ. Conch., III, p. 112, pl. 6, fig. 2, 1867.

ADDENDA

VALVATA WINNEBAGOENSIS Nov. Sp.

Plate I, figures 11–13

TYPE LOCALITY: Miller Bay, Lake Winnebago.

WISCONSIN RECORDS:

1906. *Valvata tricarinata* CHADWICK, p. 89 (part). Lake Winnebago, near High Cliff.
1920. *Valvata tricarinata* BAKER, p. 134 (part). Lake Winnebago.
1928. *Valvata bicarinata normalis* BAKER (non WALKER), p. 20. Lake Winnebago.

SHELL: Depressed with 3½ shining whorls, strongly tricarinate, the carinae forming strongly developed keels which have a pinched appearance; sculpture of very strong growth lines; upper surface flattened, the spire whorls (2½) coiled in a flat plane, but elevated above the general level of the body whorl, as a rule; sutures deeply indented, the upper surface of the whorls being flat or slightly sloping upward and turning downward into the suture; base widely umbilicated, with the sharp, keel-like carinae bordering the umbilicus and encircling the base of the body whorl in the center; aperture rounded, greatly modified by the three keels. Measurements as recorded on p. 20, the first being type, the rest paratypes.

A restudy of the Lake Winnebago *Valvata* referred to *bicarinata normalis* on page 20 of this part, in connection with a large series of true *bicarinata* and *normalis,* both recent and fossil, from Illinois, shows that the approximation is quite incorrect, the Winnebago form representing an undescribed species, characterized by strongly tricarinate shell, wide umbilicus, depressed spire with flat whorls, and the charp, keel-like nature

of the carinae. The Lake Winnebago material varies all the way from elevated to flattened spire, as recorded on p. 21. The radula of true *bicarinata* from Illinois is quite different from that of *winnebagoensis,* the center tooth being very much larger (85 μ wide) and with the formula 15–1–15, as in *tricarinata. Normalis* is similar. *Bicarinata* appears to be a river form and not found in lakes. The same may be said of *normalis. Perdepressa* and *connectans,* however, are lake forms and an examination of their radulae may show that they are not related particularly to *bicarinata.* The size of the center tooth of the radula appears to be a good character for the separation of some species of *Valvata. Bicarinata* has the largest tooth (85 μ) while *winnebagoensis* has the smallest (45 μ). These facts change entirely the second column of the table of measurements of the center teeth at the bottom of page 30. The size of the teeth of *bicarinata, connectans,* and *perdepressa* were assumed from that of the supposed *normalis* from Lake Winnebago, the other varieties of the different species not varying in the size of the center tooth. In the other cases cited on page 30 specimens of each of the species and varieties have been examined for the size of the teeth, none have been assumed. These indicate that *winnebagoensis* stands rather by itself, its center tooth being larger than that of any other species. The citation of *normalis* from near Milwaukee, by Chadwick, should be referred to *tricarinata perconfusa* (see p. 20).

GONIOBASIS LIVESCENS (Menke)

Under radula on p. 181, the lateral tooth has five or six cusps, similar to those shown under *Pleurocera acuta.* The inner cusps cannot be well seen until the reflection is laid back and the cusps are spread out, as in the figure of *acuta* (fig. 84).

Genus HELISOMA Swainson

On p. 312, near bottom of page, the figure reference should be 147 instead of 145.

EXPLANATION OF PLATES

PLATE I

Figs. 1–3. *Valvata tricarinata* (Say). Lake Chetek. U. of W., 4554.

Fig. 4. *Valvata tricarinata perconfusa* Walker. Prairie Lake, near Chetek. U. of W., 4705.

Fig. 5. *Valvata tricarinata unicarinata* DeKay. Lake Chetek. U. of W., 4706.

Fig. 6. *Valvata bicarinata* Lea. Iowa City, Iowa. U. of I., Z17867.

Fig. 7. *Valvata tricarinata mediocarinata* var. nov. Holotype. Lower Asylum Bay, Lake Winnebago. U. of W., 4707.

Figs. 8, 9. *Valvata tricarinata basalis* Vanatta. Winnebago Lake near Oshkosh. U. of W., 4708.

Figs. 10, 14. *Valvata tricarinata simplex* Gould. Lake Winnebago near Oshkosh. U. of W., 4709.

Figs. 11–13. *Valvata bicarinata normalis* Walker. Winnebago Lake near Oshkosh. U. of W., 4555.

Figs. 15–18. *Valvata bicarinata perdepressa* Walker. Lake Ontario, near Charlotte, N. Y. U. of I., Z24075.

Fig. 19. *Valvata sincera* Say. Berens Island, Lake Winnipeg, Man. U. of I., Z24076.

Figs. 20, 21. *Valvata sincera* Say. High Island Harbor, Lake Michigan. U. of I., Z24077.

Fig. 22. *Valvata sincera* Say. Lake Winnebago near Oshkosh. U. of W., 4710.

Figs. 23–25. *Valvata sincera danielsi* Walker. Bay View near Milwaukee (fossil). Variation in height of spire. U. of I., Z24078.

Fig. 26. *Valvata sincera nylanderi* Dall. Bayfield. U. of W., 4556.

Fig. 27. *Valvata sincera nylanderi* Dall. Wiarton, Georgian Bay. U. of I., Z24079.

Figs. 28–30. *Valvata lewisii* Currier. Prairie Lake, near Chetek. U. of W., 4557.

Fig. 31. *Valvata sincera danielsi* Walker. Green Lake, 10 m. U. of W., 4558.

Fig. 32. *Valvata lewisii helicoidea* Dall. Mackenzie River. U. of I., Z13078.

Fig. 33. *Valvata lewisii helicoidea* Dall. Winnipeg, Man. U. of I., Z24080.

Fig. 34. *Valvata lewisii helicoidea* Dall. Bayfield. U. of W., 4561.

Fig. 35. *Valvata lewisii helicoidea* Dall. Prairie Lake near Chetek. U. of W., 4560.

All figures enlarged 4 diameters.

PLATE II

Figs. 1–5. *Campeloma milesii* (Lea). Yellow River, Spooner, Wis. U. of W., 4565.

Fig. 6. *Viviparus subpurpureus* (Say). Mississippi River, near Davenport, Iowa. Male. U. of I., Z15414.

Fig. 7. *Viviparus subpurpureus* (Say). Same locality, female. U. of I., Z15413.

Figs. 8–11. *Viviparus subpurpureus* (Say). Havana, Illinois River, Ill. U. of I., Z3906.

Figs. 12, 13, 16, 17. *Viviparus contectoides* W. G. B. Grundy Co., Ill. U. of I., Z15411.

Figs. 14, 15. *Viviparus contectoides* W. G. B. Bass Lake, Ind. U. of I., Z15412.

Fig. 18. *Viviparus intertextus illinoisensis* var. nov. Havana, Illinois River, Ill. Holotype. U. of I., Z18025.

Figs. 19–21. *Viviparus intertextus illinoisensis* nov. var. Havana, Illinois River, Ill. Paratypes. U. of I., Z18245.

Figs. 22–24. *Viviparus intertextus* (Say). New Orleans, La. Type locality. U. of I., Z15415.

Figures about natural size.

PLATE III

Lioplax subcarinata wisconsinensis var. nov.

Figs. 1–3. Omro, Fox River. Males. U. of W., 4575. Figs. 4–6. Omro. Females. U. of W., 4575. Figs. 7, 8. Brown Co., lower Fox River. Type and paratype. U. of W., 437. Fig. 9. Winnebago Lake, near Oshkosh. U. of W., 4576.

Campeloma integrum (Say)

Figs. 10–18. Mississippi River near Fairport, Iowa. Figs. 10–12, males (U. of I., Z15477, 18261, 18260). Fig. 13, female (U. of I., Z15478); figs. 14–18, females (U. of I., Z18262).

Campeloma crassulum Rafinesque

Figs. 19, 20. DePue, Illinois River, Ill. (U. of I., Z10985). Fig. 21. Wabash River, Ind. (U. of I., Z14459).

All figures slightly enlarged.

PLATE IV

Figs. 1–8. *Campeloma integrum* (Say). Merrimack, Wisconsin River. U. of W., 4566.

Fig. 9. *Campeloma rufum* (Haldeman). Wisconsin River above Kilbourn. U. of W., 4571.

Fig. 10. *Campeloma integrum* (Say). Dell Creek, below Kilbourn. U. of W., 4577.

PLATE IV—Continued

Fig. 11. *Campeloma rufum* (Haldeman). Yahara River, near Madison. U. of W., 4569.

Figs. 12, 13. *Campeloma rufum* (Say). Oconomowoc River, Waukesha Co. U. of I., Z15475.

Figs. 14–18. *Campeloma rufum* (Haldeman). Fox River, two miles below Portage. U. of W., 4567.

Figs. 19, 20. *Campeloma rufum* (Haldeman). Winnebago Lake, near Oshkosh. U. of W., 4568.

Figs. 21, 22. *Campeloma rufum* (Haldeman). Sturgeon Bay. Lake form. U. of W., 4570. Fig. 22. Reversed (U. of W., 4570).

Figures about natural size.

PLATE V

Figs. 1–5. *Campeloma decisum* (Say). Red Cedar River, near Chetek. U. of W., 4562.

Fig. 6. *Campeloma decisum* (Say). Phillips. U. of W., 4704.

Fig. 7. *Campeloma decisum* (Say). Moose Ear Creek, near Chetek. U. of W., 4564.

Figs. 8–12. *Campeloma rufum gibbum* Currier. Detroit Harbor, Door Co. U. of W., 4572.

Fig. 13. *Campeloma brevispirum* var. nov. Mirror Lake, Sauk Co. Holotype. U. of W., 4573.

Figs. 14–17. *Campeloma brevispirum* var. nov. Mirror Lake. Paratypes. U. of W., 4573.

Fig. 18. *Campeloma brevispirum* var. nov. Delton, Dell Creek, Sauk Co. U. of W., 4574.

Fig. 19. *Viviparus contectoides* W. G. B. Embryonic shell.

Fig. 20, 21. *Viviparus intertextus* (Say). Embryonic shell.

Figs. 22, 23. *Bulimus tentaculatus magnalacustris* var. nov. Lake Winnebago near Oshkosh; 22, type, U. of I., Z18637; 23, paratype, Z18638.

Figs. 24, 25. *Bulimus tentaculatus* (Linn.). Ditch near Scarborough, England. U. of I., Z22504.

Figs. 26–30. *Bulimus tentaculatus magnalacustris* var. nov. Lake Winnebago near Oshkosh. 26, 27, males; 28–30, females. U. of I., Z22595.

Fig. 31. *Bulimus tentaculatus magnalacustris* var. nov. Pleistocene fossil. Deposit in Chicago, Ill. U. of I., Z22506.

Figs. 1–18, about natural size; 19–21, greatly enlarged; 22–31, enlarged about 1½ diameters.

PLATE VI

Figs. 1–4. *Amnicola limosa* (Say). Bayfield. U. of W., 4527.

Figs. 5, 6. *Amnicola limosa* (Say). Variation toward *porata*. Lake Butte des Morts. U. of W., 4530.

PLATE VI—Continued

Figs. 7, 8. *Amnicola limosa porata* (Say). Chetek Lake. U. of W., 4528.

Figs. 9–11. *Amnicola limosa superiorensis* var. nov. Bayfield. U. of W., 4529.

Figs. 12, 13. *Amnicola limosa parva* (Lea). Pettis Co., Mo. U. of I., Z14285.

Fig. 14. *Amnicola limosa parva* (Lea). Chicago, Ill. U. of I.

Fig. 15. *Amnicola lustrica perlustrica* var. nov. Lake Michigan shore east of Sturgeon Bay. U. of W., 4535.

Figs. 16, 17. *Amnicola lustrica* Pilsbry. Lake Chetek, U. of W., 4533.

Fig. 18. *Amnicola limosa porata* (Say). Lake Chetek. Male. U. of W., 4740.

Fig. 19. *Amnicola gelida* Baker. Holotype. Morris, Ill. U. of I., P926.

Figs. 20–23. *Amnicola gelida* Baker. Spring Lake, near Green Lake. U. of W., 4537.

Figs. 24, 25. *Amnicole oneida* Pilsbry. Oneida Lake. Lower South Bay. Type locality. U. of I., Z22513.

Fig. 26. *Amnicola lustrica* Pilsbry. Lake Winnebago, near Oshkosh. U. of W., 4539.

Fig. 27. *Amnicola lustrica* Pilsbry. Lake Butte des Morts. U. of I., Z12668.

Fig. 28. *Amnicola oneida* Pilsbry. Devils Lake. U. of W., 4540. Female.

Figs. 29, 30. *Amnicola oneida* Pilsbry. Devils Lake. U. of W., 4540. Males.

Fig. 31. *Amnicola lustrica* Pilsbry. Lake Butte des Morts. U. of W., 4538.

Fig. 32. *Amnicola greenensis* sp. nov. Green Lake. Paratype. U. of W., 4545.

Fig. 33. *Amnicola greenensis* sp. nov. Green Lake. Holotype. U. of W., 4544.

Fig. 34. *Amnicola leightoni* F. C. Baker. Near Rush Lake, Logan Co., Ohio. Holotype. U. of I., P598.

Fig. 35. *Amnicola leightoni* F. C. Baker. Rush Lake. Paratype. U. of I., P600.

Figs. 36–39. *Amnicola leightoni* F. C. Baker. Green Lake. U. of W., 4546.

Figs. 40, 41. *Cincinnatia cincinnatiensis* (Anthony). De Pere, Fox River. U. of W., 439a.

Figs. 42, 43. *Cincinnatia cincinnatiensis judayi* F. C. Baker. Lake Winnebago, off Doemel Point. 42, male; 43, female. Type and paratype. U. of I., Z12561.

All figures enlarged about four diameters.

PLATE VII

Figs. 1, 2. *Amnicola walkeri* Pilsbry. Bayfield; 1, male; 2, female. U. of W., 4541.

Figs. 3, 4. *Amnicola walkeri* Pilsbry. Lake Winnebago, near Oshkosh; 3, male; 4, female. U. of W., 4542.

Fig. 5. *Amnicola precurser* sp. nov. Green Lake. U. of W., 4543.

Figs. 6–8. *Amnicola pilsbryi* Walker. Lawtons Slough, De Pere. U. of W., 433.

Figs. 9–12. *Stimpsonia nickliniana* (Lea). Near Michigan City, Ind. U. of I., Z16524.

Figs. 13, 14. *Stimpsonia nickliniana attenuata* (Haldeman). Northern Illinois. U. of I., Z16526.

Figs. 15–17. *Cincinnatia cincinnatiensis* (Anthony). Fox River, Brown Co. U. of W., 474.

Figs. 18, 19. *Pomatiopsis cincinnatiensis* (Lea). Kankakee River, Ill. U. of I., Z16621.

Figs. 20, 21. *Cincinnatia emarginata lacustris* var. nov. Lake Winnebago, near Oshkosh. U. of W., 4531. 20, male, type; 21, immature, paratype.

Figs. 22, 23. *Amnicola limosa superiorensis* var. nov. Bayfield. U. of W., 4532.

Fig. 24. *Pyrgulopsis scalariformis* (Wolf). Shoal Creek, near Florence, Ala. U. of I., Z16522.

Fig. 25. *Pyrgulopsis scalariformis* (Wolf). Rock River, near Rock Island, Ill. Type locality. U. of I., Z16523.

Figs. 26, 27. *Pyrgulopsis scalariformis* (Wolf). Rock Island, Ill. U. of I., Z18382.

Figs. 28, 29. *Pyrgulopsis letsoni* (Walker). Chicago Pleistocene deposits. U. of I., P280.

Figs. 30–32. *Hoyia sheldoni* (Pilsbry). Off Racine. Part of original lot from Marston coll. U. of W., 397a.

Figs. 33–35. *Somatogyrus depressus* (Tryon). De Pere, Fox River. U. of W., 4550.

Figs. 36–38. *Somatogyrus depressus* (Tryon). De Pere. U. of W., 4551.

Fig. 39. *Somatogyrus depressus* (Tryon). Green Bay. U. of W., 448a.

Figs. 40, 41. *Birgella subglobosa* (Say). Immature. 40, male; 41, female. Winnebago Lake.

Figs. 42–45. *Pomatiopsis lapidaria* (Say). Salt Fork, Homer Park, Ill. U. of I., Z11346a.

All figures enlarged about 4 diameters.

PLATE VIII

Figs. 1–3. *Amnicola limosa porata* (Say). Little Arbor Vitae Lake. Males. U. of I., Z19439. About × 3.

Figs. 4–8. *Birgella subglobosa* (Say). Lake Winnebago, near Oshkosh. U. of W., 4453. × 3.

PLATE VIII—Continued

Fig. 9. *Birgella subglobosa* (Say). Lake Butte des Morts. U. of W., 4552. × 3.

Figs. 10, 11. *Birgella subglobosa isogona* (Say). Fox River, Ill. U. of W., 473a. × 3.

Fig. 12. *Birgella subglobosa isogona* (Say). Big Muddy River, Blairsville, Ill. U. of I., Z16332. × 3.

Figs. 13–18. *Somatogyrus tryoni* P. & B. Pipersville Rapids, Wis. Paratypes. U. of I., 22511. × 3.

Figs. 19, 20. *Bulimnea megasoma* (Say). Oconto, Wis. U. of W., 4703.

Figs. 21–23. *Bulimnea megasoma* (Say). Moose Ear Creek. U. of W., 4702. Figs. 19–23 about natural size.

Figs. 24–26. *Planorbula crassilabris* Walker. Greenfield, Wayne Co., Mich. Baker coll., 1200. About × 4.

Figs. 27–30. *Planorbula armigera* (Say). Bayfield. U. of W., 4569. × 4.

PLATE IX

Pleurocera acuta tracta (Anthony)

Figs. 1–7. Winnebago Lake, near Oshkosh. U. of W., 4514.

Fig. 8. Yahara River, near Madison. U. of W., 4515.

Fig. 9. Bark River, Waukesha Co. U. of I., Z15334.

Fig. 10. Lake Pepin, Mississippi River. U. of W., 4516.

Fig. 11. Lower Dells, near Kilbourn. U. of W., 4517.

Fig. 12. Sangamon River, near Mahomet, Ill. Variety. U. of I., Z15335.

Fig. 13. Sangamon River, Ill. U. of I., Z15337.

Fig. 14. *Pleurocera acuta* Raf. Bayfield. U. of W., 4522.

Goniobasis livescens (Menke)

Figs. 15–17. Sturgeon Bay, Door Co. Fig. 16 varying toward *michiganensis*. U. of W., 4519.

Figs. 18–22. Sturgeon Bay, below bridge. U. of W., 4518.

Fig. 23. Sturgeon Bay, above bridge. Near *michiganensis*. U. of W., 4521.

Figs. 24–26. Sturgeon Bay, outer part. U. of W., 4519.

Goniobasis livescens michiganensis var. nov.

Figs. 27–32. Lake Michigan shore, east of Sturgeon Bay. Fig. 31, type; others paratypes. U. of W., 4520.

Goniobasis livescens barronensis var. nov.

Figs. 33–36. Red Cedar River, west of Chetek. Fig. 33, type; others paratypes. U. of W., 4622.

All figures slightly enlarged.

PLATE X

Figs. 1, 2. *Stagnicola woodruffi* (Baker). Millers, Ind. Baker coll., 1720.

Figs. 3–5. *Stagnicola woodruffi* (Baker). Kenosha, Wis. Baker coll., 794.

Figs. 6–8. *Acella haldemani* (Desh. Binney). Oneida Lake, N. Y. Baker coll., 431.

Figs. 9–12, 20. *Pseudosuccinea columella* (Say). Clinton, Ohio. Baker coll., 407.

Figs. 13, 14. *Stagnicola catascopium* (Say). Prairie Lake, near Chetek. U. of W., 4700.

Figs. 15–19. *Stagnicola catascopium* (Say). Prairie Lake, near Chetek. U. of W., 4699.

Figs. 21–30. Opercula of Viviparidae. Fig. 21, *Campeloma milesii;* 22, *Campeloma rufum;* 23, *Campeloma brevispirum,* reversed; 24, *Viviparus subpurpureus;* 25, *Campeloma decisum;* 26, *Campeloma integrum;* 27, *Campeloma rufum gibbum;* 28, *Campeloma brevispirum;* 29, *Viviparus intertextus;* 30, *Viviparus contectoides.*

All figures enlarged about two diameters.

PLATE XI

Fig. 1. *Stagnicola bulimoides cockerelli* (Pilsbry).
Fig. 2. *Fossaria obrussa* (Say).
Fig. 3. *Pseudosuccinea columella* (Say).
Fig. 4. *Stagnicola palustris* (Müller).
Fig. 5. *Bulimnea megasoma* (Say).
Fig. 6. *Lymnaea stagnalis jugularis* (Say).
Fig. 7. *Radix auricularia* (Linn.).
Fig. 8. *Acella haldemani* ('Desh.' Binney).
Figs. 9–13. *Lymnaea stagnalis jugularis* Say. Oconto. U. of W., 4672.

Figures slightly enlarged.

PLATE XII

Lymnaea stagnalis jugularis Say

Figs. 1, 2. Winnebago Lake, near Oshkosh. Young and immature. U. of W., 4674. Fig. 3. Oconto. U. of W., 4675. Fig. 4. Bayfield, beach pool. U. of I., Z13679a. Figs. 11, 12. Hancock. U. of W., 4676.

Lymnaea stagnalis perampla Walker

Fig. 5. Houghton Lake, Mich. Cotype. Chi. Acad. Sci., 23924. Figs. 6, 7. Green Lake. U. of W., 4673.

Lymnaea stagnalis lillianae F. C. Baker

Figs. 8–10. Tomahawk Lake. Cotypes. Baker coll., 384.

PLATE XII—Continued

Lymnaea stagnalis sanctaemariae Walker

Fig. 13. Siskowit Lake, Isle Royale, Lake Superior. Chi. Acad. Sci., 23727.

Figures slightly enlarged.

PLATE XIII

Stagnicola palustris (Müller)

Figs. 1, 2. Lancashire, Eng. Baker coll., 1710. Fig. 8. Holbendorf, Germany. Baker coll., 1709.

Stagnicola palustris elodes (Say)

Figs. 3, 4. De Pere, Brown Co. U. of W., 4677. Figs. 5–7. Chilton. U. of W., 4678. Figs. 9–13. Doemel Point, beach pool, Winnebago Lake. U. of W., 4679.

Stagnicola umbrosa (Say)

Figs. 14–19. Lake Mendota. U. of W., 4680. Figs. 20–22. Fox River, Omro. U. of W., 4681.

Stagnicola umbrosa jolietensis (F. C. Baker)

Figs. 23–26. Lake Mendota. U. of W., 4683.

Pisidium superius Sterki

Figs. 27–29. Mountain Lake, Marquette Co., Mich. Cotypes. U. of I., Z19468. Fig. 30. Lake Geneva. U. of W., 4736.

Figs. 1–26 slightly enlarged. Figs. 27–30 enlarged about 4 diameters.

PLATE XIV

Stagnicola reflexa (Say)

Figs. 1–4. Near Oshkosh, in swale. U. of W., 4686. Figs. 5, 6. Calumet Lake, Ill. Baker coll., 333.

Stagnicola exilis (Lea)

Figs. 7–9. Grantsburg. U. of W., 4686. Figs. 10, 11. Green Bay. U. of W., 4688.

Stagnicola lanceata (Gould)

Figs. 12, 13. Tomahawk Lake, in slough. Baker coll., 749. Figs. 14, 15, Tomahawk Lake. Baker coll., 750.

Stagnicola winnebagoensis (F. C. Baker)

Fig. 16. Near Oshkosh, in Winnebago Lake. Type. U. of I., Z11826. Figs. 17–19. Near Oshkosh, Lake Winnebago. Paratypes. U. of I., Z11826. Fig. 20. Near Oshkosh. Paratype. U. of W., 4689.

Stagnicola nashotahensis (F. C. Baker)

Figs. 21–24. Green Lake. U. of W., 4690. Figs. 25–26. Nashotah Lake, marl specimens. Paratypes. Baker coll., 223.

Figures slightly enlarged.

PLATE XV

Stagnicola emarginata (Say)

Figs. 1–3. Mud Lake, Aroostook Co., Me. Baker coll., 234.

Stagnicola emarginata canadensis (Sowerby)

Figs. 4, 5. Detroit Harbor, Door Co. U. of W., 4691; Figs. 6–11. Sturgeon Bay, Door Co. U. of W., 4692.

Stagnicola emarginata angulata (Sowerby)

Figs. 12, 13. Near Madison. U. of W., 4693. Figs. 14–18. Lake Noquebay, Marinette Co. U. of W., 4694.

Stagnicola emarginata wisconsinensis (F. C. Baker)

Figs. 19–24. Tomahawk Lake, Oneida Co. Baker coll., 814. Fig. 25. Little Arbor Vitae Lake, Vilas Co. U. of I., Z18639.

Figures slightly enlarged.

PLATE XVI

Figs. 1–5. *Goniobasis livescens correcta* (Brot). Neosha Lake, Dodge Co. U. of I., Z22512.

Fig. 6. *Fossaria obrussa peninsulae* (Walker). Type. Walker coll., 24269.

Fig. 7. *Fossaria parva* (Lea). Des Moines, Iowa. Chi. Acad. Sci., 23136.

Fig. 8. *Fossaria modicella* (Say). Alpena, Mich. Chi. Acad. Sci., 23955.

Fig. 9. *Fossaria exigua* (Lea). Aroostook Co., Maine. Chi. Acad. Sci., 23293.

Fig. 10. *Fossaria modicella rustica* (Lea). Cedar Lake, Montcalm Co., Mich. Walker coll.

Fig. 11. *Fossaria dalli* (F. C. Baker). Lake James, Steuben Co., Ind. Type. Chi. Acad. Sci., 23125.

Fig. 12. *Fossaria obrussa decampi* (Streng). Ann. Arbor, Mich. Chi. Acad. Sci., 23303.

Fig. 13. *Fossaria galbana* (Say). White Pond, N. J. Type locality. Chi. Acad. Sci., 23311.

Fig. 14. *Fossaria obrussa* (Say). Lemont, Ill. Chi. Acad. Sci., 23967.

Figs. 15–20. *Stagnicola emarginata* (Say). Plum Lake, Vilas Co. U. of I., Z22516.

Figs. 21–26. *Stagnicola emarginata vilasensis* F. C. Baker. Big Muskallonge Lake, Vilas Co. Fig. 23, type, U. of I., Z21678. Other figs., paratypes, U. of I., Z21679.

Figs. 6–14, enlarged about twice; other figs. slightly enlarged.

PLATE XVII

Figs. 1–11. *Stagnicola walkeriana* (F. C. Baker). 1–7, Madeline Island, Lake Superior. 4, type, U. of W., 4695; 1, 3, 5, 6, paratypes. U. of W., 4695; 2, 7, paratypes, U. of I., Z19437. Figs. 8–11. Lake Michigan Shore, near Sturgeon Bay. U. of W., 4696.

Figs. 12–14. *Stagnicola umbrosa* (Say). Lake Mendota. Young and immature. U. of W., 4682.

Fig. 15. *Stagnicola reflexa* (Say). Near Oshkosh. Immature. U. of W., 4684.

Fig. 16. *Stagnicola exilis* (Lea). Grantsburg. Immature. U. of W., 4685.

Fig. 17. *Stagnicola lanceata* (Gould). Tomahawk Lake. Immature. Baker coll., 749.

Fig. 18. *Stagnicola nashotahensis* (F. C. Baker). Green Lake. Immature. U. of W., 4690.

Fig. 19. *Stagnicola emarginata canadensis* (Sowerby). Detroit Harbor. Immature. U. of W., 4691.

Fig. 20. *Stagnicola emarginata wisconsinensis* (F. C. Baker). Tomahawk Lake. Immature. Baker coll., 814.

Figs. 21–27. *Stagnicola catascopium* (Say). Red Cedar River. U. of W., 4697.

Figs. 28–30. *Stagnicola catascopium* (Say). Chippewa Falls. U. of W., 4698.

Figs. 31, 35. *Bulimnea megasoma* (Say). Figs. of animal. Whitfield, Bull. Amer. Mus. Nat. Hist., I, pl. 5, figs. 2, 3.

Figs. 32–34. *Lymnaea stagnalis sanctaemariae* Walker. Little Arbor Vitae Lake. 32, U. of W., 4723, 33, 34, U. of I., Z18638.

Figs. 31, 35, slightly reduced; all others slightly enlarged.

PLATE XVIII

Fossaria parva (Lea)

Figs. 1–4. Des Moines, Iowa. Baker coll., 1711. Fig. 5. Lake Butte des Morts, marshy shore. U. of W., 4711.

Fossaria modicella (Say)

Fig. 6. Chippewa Falls. U. of W., 4712. Figs. 7–10. Silver Lake, Ill. Baker coll., 1721.

Fossaria modicella rustica (Lea)

Fig. 11. Phillips. U. of W., 4713. Fig. 12. Ashland Junction. U. of W., 4714. Fig. 13. Joliet, Ill. Baker coll., 557.

Fossaria obrussa (Say)

Figs. 14–17. Lemont, Ill. Baker coll., 635. Figs. 18–21. De Pere, Brown Co. U. of W., 4715. Figs. 22–24. University Bay, near Madison. U. of W., 4716.

PLATE XVIII—Continued

Fossaria obrussa peninsulae (Walker)

Fig. 25. Union River, Ontonagan Co., Mich. Cotype. Baker coll., 641.

Figs. 26–29. Selma, near Bayfield. U. of W., 4717.

Fossaria obrussa decampi (Streng)

Figs. 30–33. Spring Lake, near Green Lake. U. of W., 4718.

Fossaria exigua (Lea).

Figs. 34, 35. Tyrell's gravel pit pond, near Lake Butte des Morts. U. of W., 4719. Figs. 36, 37. Sturgeon Bay, Door Co. U. of W., 4720.

Fossaria galbana (Say)

Fig. 40. White Pond, N. J. Type locality. Baker coll., 653. Figs. 41, 42. Milwaukee, near Bay View. Baker coll. 199 (Fossil).

Fossari sayi nov. sp.

Figs. 38, 39. Squaw Island, near Buffalo, N. Y. Baker coll., 270a. Types.

Stagnicola caperata (Say)

Figs. 43–47. Near Oshkosh, in swale. U. of W., 4701.

All figures enlarged about two diameters.

PLATE XIX

Fig. 1. *Aplexa hypnorum* (Linn.). Near Scarborough, England. Baker coll., 1722.

Figs. 2–4. ***Aplexa hypnorum*** (Linn.). Marinette. U. of W., 4517.

Fig. 5. ***Physella anatina*** (Lea). Oklahoma, Baker coll., 1723.

Fig. 6. ***Physella michigansensis*** (Clench). New Richmond. U. of W., 4616.

Fig. 7. ***Physella michigansensis*** (Clench). New Harmony, Ind. Baker coll., 1323.

Figs. 8, 9. ***Helisoma antrosa*** (Conrad). Prairie Lake, near Chetek. U. of W., 4620.

Fig. 10. ***Helisoma antrosa*** (Conrad). Prairie Lake. Campanulate lip. U. of W., 4622.

Fig. 11. ***Helisoma antrosa*** (Conrad). Cotter, Arkansas. U. of I., Z5945a.

Fig. 12. ***Helisoma antrosa*** (Conrad). Farmer, Shelby Co., Alabama. U. of I., Z18463.

Figs. 13, 14. ***Helisoma antrosa*** (Conrad). Wisconsin River, Upper Dells, near Kilbourn.

Fig. 15. ***Helisoma antrosa*** (Conrad). Chippewa Falls. U. of W., 4628.

Fig. 16. ***Physella michiganensis*** (Clench). Rockford, Ill. U. of I., Z17535.

PLATE XIX—Continued

Fig. 17. *Helisoma antrosa unicarinata* (Haldeman). Philadelphia, Pa. Near type region. Baker coll., 1717.

Figs. 18, 19. *Helisoma antrosa unicarinata* (Hald.). Moose Ear Creek, near Chetek. U. of W., 4735.

Fig. 20. *Helisoma antrosa sayi* var. nov. Type. Tomahawk Lake. Baker coll., 945.

Figs. 21, 22. *Helisoma antrosa sayi* var. nov. Tomahawk Lake. Paratypes. U. of I., Z19899.

Fig. 23. *Helisoma antrosa sayi* var. nov. Winnebago Lake, near Oshkosh. U. of W., 4625.

Figs. 24, 25. *Helisoma antrosa percarinata* (Walker). Sturgeon Bay. U. of W., 4732.

Figs. 26, 27. *Helisoma antrosa percarinata* (Walker). Crystal Lake, Benzie Co. Mich. Type locality. Baker coll., 986.

Figs. 28–31. *Helisoma antrosa striata* (Baker). Milwaukee, marl deposits. Baker coll., Coldspring Park. Types. Baker coll., 1723.

Figs. 32–36. *Helisoma antrosa shellensis* var. nov. Shell Lake, Washburn Co. U. of W., 4627. Fig. 32, type; 33, paratype. U. of I., paratypes, 34–36, Z19354.

Fig. 37. *Helisoma antrosa portagensis Baker.* Portage Lake, Maine. Holotype. Baker coll., 1712.

Figs. 38, 39. *Helisoma corpulenta* (Say). Minnesota. Young and immature. Baker coll., 1102.

Figs. 40, 41. *Helisoma corpulenta* (Say). Rainy Lake, Ontario. A type locality. Baker coll., 1101.

All figures slightly enlarged.

PLATE XX

Figs. 1, 2. *Helisoma trivolvis* (Say). Marinette. U. of W., 4633.

Figs. 3, 4. *Helisoma trivolvis* (Say). Lake Butte des Morts. U. of W., 4635; figs. 5, 6, same locality, 4636. Figs. 1–6, lake forms.

Figs. 7–11. *Helisoma trivolvis* (Say). Wisconsin River, Big Dells above Kilbourn. U. of W., 4629.

Fig. 12. *Helisoma trivolvis* (Say). Tomahawk Lake. Expanded aperture. Baker coll., 1724.

Fig. 13. *Helisoma trivolvis* (Say). Bayfield. U. of W., 4631.

Figs. 14–18. *Helisoma trivolvis pilsbryi* F. C. Baker. Lake Chetek, Barron Co. U. of W., 4637.

Fig. 19. *Helisoma trivolvis pilsbryi* F. C. Baker. Tomahawk Lake, Oneida Co. Holotype. Baker coll., 846.

Figs. 20, 21. *Helisoma trivolvis pilsbryi* F. C. Baker. Tomahawk Lake. Paratypes. Baker coll., 843.

Figs. 22, 23. *Helisoma trivolvis* (Say). Bayfield. U. of W., 4638.

Figs. 24, 25. *Helisoma pseudotrivolvis* (Baker). Salt Fork, near Urbana, Ill. U. of I., Z11393.

PLATE XX—Continued

Fig. 26. *Helisoma pseudotrivolvis* (Baker). Fort Howard. U. of W., 4648.

Fig. 27. *Helisoma pseudotrivolvis* (Baker). Holotype. Salt Fork, Urbana, Ill. U. of I., Z11292a.

Figs. 28, 29. *Helisoma pseudotrivolvis* (Baker). Paratypes. Salt Fork, Ill. U. of I., 11292a.

Figs. 30, 31. *Helisoma pseudotrivolvis* (Baker). Stark Co., Ill. Baker coll., 2309.

Fig. 32. *Helisoma pseudotrivolvis* (Baker). Lake Monona. U. of W., 4649.

Figures slightly enlarged.

PLATE XXI

Helisoma campanulata (Say)

Figs. 1, 2, 4, 9. Lake Delavan. Baker coll., 1012. Figs. 5, 8. Wisconsin River, above Kilbourn. U. of W., 4640. Figs. 13, 14. Sturgeon Bay. Small form. U. of W., 4642.

Helisoma campanulata wisconsinensis (Winslow)

Figs. 6, 7. Lake Pokegoma, near Chetek. U. of W., 4639. Immature. Fig. 10. Lake Chetek. U. of W., 4641. Fig. 15. Bayfield. U. of W., 4644. Fig. 19. Tomahawk Lake, U. of I., Z17539. Fig. 20. Tomahawk Lake, U. of W., 4644. Figs. 21–24. Tomahawk Lake. Baker Coll., 1718, 1719, 1725.

Helisoma campanulata ferrissi (F. C. Baker)

Figs. 11, 12. Joliet, Ill. Types. U. of I., P1068. Figs. 3, 16–18. Joliet, Ill. From type lot. U. of I., P966.

Helisoma smithii (F. C. Baker)

Fig. 25. Douglas Lake, Mich. Type. Baker coll., 1054. Figs. 26, 27. Paratypes. Baker coll., 1728. Figs. 28, 29. Douglas Lake, Mich. U. of W., 4645.

Helisoma truncata (Miles)

Figs. 30, 31. Green Bay. Immature and young. U. of W., 4646. Figs. 32–36. Sturgeon Bay. U. of W., 4647. Figs. 37, 38. Winnebago Lake, near Oshkosh. U. of I., Z12805.

Helisoma trivolvis winslowi F. C. Baker

Figs. 39–42. Little Arbor Vitae Lake, Vilas Co. 41, 42, Paratypes. U. of I., Z18637. Figs. 39–40, U. of I., Z19398.

Figures slightly enlarged.

PLATE XXII

Figs. 1–6. *Helisoma antrosa cahni* F. C. Baker. Big Muskallonge Lake, Vilas Co. 1. Type. 2–5. Paratypes. U. of I., Z21124.

Figs. 7, 8. *Helisoma campanulata davisi* (Winslow). Dry lake bed east of White Lake, Oakland Co., Mich. U. of I., Z22517.

Fig. 9. *Helisoma campanulata rudentis* (Dall). Knee Lake, Keewatin. Cotype. U. S. Nat. Mus., 365574.

Figs. 10–17. *Gyraulus altissimus* (F. C. Baker). 10–12. Milwaukee. Baker coll., 1714. 13–15. Milwaukee. U. of W., 4670. 16, 17. Urbana, Ill. Paratypes. Pleistocene deposits. U. of I., Z10776.

Figs. 18–21. *Gyraulus umbilicatellus* (Ckll.). Plummers Point, Lake Butte des Morts. U. of W., 4671.

Fig. 22. Egg capsule of *Bulimnea megasoma* (Say). Pool near Moose Ear Creek, Barron Co. U. of W., 4733. Enlarged.

Fig. 23. *Stagnicola palustris elodes* (Say). Egg capsules. Brewerton, N. Y. Oneida Lake. U. of I., Z19461.

Fig. 24. *Helisoma truncata* (Miles). Egg capsule. Lake Butte des Morts. U. of W., 4737.

Figs. 1–9, 24, 25, slightly enlarged; figs. 10–21, enlarged about 4 diameters; 22, 23, greatly enlarged.

PLATE XXIII

Menetus exacuous (Say)

Figs. 1–3. Lake Chetek, near Chetek, U. of W., 4660. Figs. 4, 5. Mercer Co., Ill. U. of I., Z17689.

Menetus exacuous megas (Dall)

Fig. 6. Chicago Creek, near Bayfield. U. of W., 4661. Fig. 7. Lake Monona, near Madison. U. of I., Z17688.

Gyraulus hirsutus (Gould)

Fig. 8. Neponset, Mass. Baker coll., 1123. Figs. 9–14. Tomahawk Lake. Baker coll., 1130, 1729.

Gyraulus deflectus (Say)

Figs. 15–21. Lake Winnebago, near Oshkosh. 21 immature. U. of W., 4662, 4663.

Gyraulus deflectus obliquus (DeKay)

Figs. 22–26. Lake Pokegoma, near Chetek. 25, immature. U. of W., 4664, 4665.

Gyraulus parvus (Say)

Fig. 27. Philadelphia, Penn. Type locality. Baker coll., 66. Figs. 28–31. Lake Winnebago, near Oshkosh. U. of W., 4666, 4667. Fig. 39. Bay Settlement, near Green Bay. Baker coll., 1181.

PLATE XXIII—Continued

Gyraulus circumstriatus walkeri (Vanatta)

Fig. 32. Winnebago Lake, near Oshkosh. U. of W., 4668. Fig. 33. Oswego, N. Y. Baker coll., 1730.

Gyraulus arcticus (Möller)

Figs. 34–37. Horn River, British America. U. of I., Z13072a. Fig. 38. Chetek Lake. U. of W., 4669.

All figures enlarged about 4 diameters.

PLATE XXIV

Figs. 1, 2. *Ferrissia paralella* (Say). Red Cliff Creek, Bayfield Co. U. of W.,. 4724.

Figs. 3–5. *Ferrissia paralella* (Say). Lake Butte des Morts. U. of W., 4725.

Figs. 6, 7. *Ferrissia tarda* (Say). Sturgeon Bay, Door Co. U. of W., 4727.

Figs. 8, 9. *Ferrissia tarda* (Say). Red Cedar River, west of Chetek. U. of W., 4726.

Figs. 10–13. *Ferrissia fusca* (C. B. Adams). Silver Creek, near Green Lake. U. of W., 4728.

Figs. 14–15. *Ferrissia shimekii* (Pilsbry). Winnebago Lake, Long Point Island. U. of W., 4731.

Figs. 16–18. *Ferrissia rivularis* (Say). Salt Fork Vermilion River, near Urbana, Ill. Baker coll., 1731.

Figs. 19, 20. *Ferrissia kirklandi* (Walker). Lake Mendota. U. of W., 4729.

Fig. 21. *Ferrissia kirklandi* (Walker). Sturgeon Bay. U. of W., 4730.

Figs. 14, 15 enlarged about five diameters; the others a little more than three diameters.

PLATE XXV

Physella laphami sp. nov.

Fig. 1. Type, figs. 2–5, Paratypes. Hancock. U. of W., 4578a, 4578b.

Physella parkeri (Currier)

Fig. 6. Douglas Lake, Mich. U. of I., Z16665.

Physella latchfordi sp. nov.

Figs. 7, 8. Type, Paratype. Meechs Lake, Ottawa, Canada. Baker coll., 1340.

Physella ancillaria (Say)

Fig. 9. Delaware River, Philadelphia, Pa., near original locality. Baker coll., 1262. Figs. 10–17. Devils Lake. U. of W., 4579. Figs. 22, 23. Chippewa Falls. Deformed. U. of W., 4582.

PLATE XXV—Continued

Physella sayii (Tappan)

Fig. 18. West shore Green Lake. U. of W., 4580.

Physella sayii crassa (Walker)

Figs. 19–21. Lake Mendota. U. of W., 4581. Figs. 24–26. Kenosha. Baker coll., 1546. Fig. 27. Higgins Lake, Roscommon Co., Mich. From type lot. Baker coll., 1727.

All figures slightly enlarged.

PLATE XXVI

Physella magnalacustris (Walker)

Fig. 1. Frankfort, Benzie Co., Mich. Type locality. Baker coll., 1726. Figs. 2–5. Lake Michigan shore near Sturgeon Bay. U. of W., 4583. Fig. 6. Sturgeon Bay. U. of W., 4584.

Physella vinosa (Gould)

Figs. 7–13. Lake shore, near Bayfield. U. of W., 4585. Fig. 14. Pool behind beach, Bayfield. U. of W., 4586. Figs. 15–18. North side Madeline Island. U. of W., 4587.

Physella sayii (Tappan)

Figs. 19–23. Winnebago Lake, near Oshkosh. U. of W., 4588. Figs. 24–29. DePere, Brown Co., U. of W., 4589. 32. De Pere. U. of W., 4590. Figs. 30, 31. Milwaukee. Lea's original specimens referred to *warreniana*. U. S. N. M., 119922, ex. Grosvenor.

Physella warreniana (Lea)

Figs. 33–37. Chetek River, near Chetek, U. of W., 4591.

All figures slightly enlarged.

PLATE XXVII

Physella bayfieldensis sp. nov.

Figs. 1–5. Pike Creek, near Salmo, Bayfield Co. Type and Paratypes. U. of W., 4592, 4593. Figs. 6, 7. Hatchery creek, Salmo. U. of W., 4594.

Physella chetekensis sp. nov.

Figs. 8–10. Moose Ear Creek, near Chetek. Paratypes. U. of I., Z16996. Figs. 11–13. Moose Ear Creek. Type and Paratypes. U. of W., 4595, 4596.

Physella warreniana (Lea)

Figs. 14–16. Wisconsin River, above Kilbourn. U. of W., 4597.

PLATE XXVII—Continued

Physella sayii (Tappan)

Figs. 17–19. Tomahawk Lake. Baker coll., 1476. Fig. 20. Tomahawk Lake. U. of I., Z16994.

Physella heterostropha (Say)

Fig. 21. Near Philadelphia, Pa. U. of I., Z16995. Figs. 22–24. Ditch along B. & O. Ry., near Philadelphia. Baker coll., 147.

Physella obrussoides sp. nov.

Figs. 25–29. Oshkosh, Winnebago Lake near fish hatchery. Type and Paratypes. U. of W., 4598, 4599.

Physella gyrina (Say)

Fig. 30. Kansas City, Mo. U. of I., Z16991. Figs. 31, 32. James River, Galena, Mo. U. of I., Z16990. Figs. 33–35. Du Bois, Ill. U. of I., Z16992. Figs. 37–40. Brown Co. U. of W., 4600.

Physella gyrina hildrethiana (Lea)

Fig. 36. Milwaukee. U. S. Nat. Mus., 28271.

All figures slightly enlarged.

PLATE XXVIII

Physella gyrina (Say)

Fig. 1. Brown Co. U. of W., 4600. Figs. 5, 6. Chilton. U. of W., 4602.

Physella gyrina hildrethiana (Lea)

Figs. 2–4. De Pere, Brown Co. U. of W., 4601. Figs. 7–9. Sun Prairie. U. of W., 4603. Figs. 10–13. Woods on Plummers Point, Lake Butte des Morts. Immature, swale form. U. of W., 4604. Fig. 14. Swale north of Oshkosh. U. of W., 4605.

Physella oleacea (Tryon)

Fig. 19. Bridgeport, Ala. Type locality. Wheatley coll., ex. Pilsbry. U. of I., Z18027.

Physella elliptica (Lea).

Figs. 15–18. Small Brook, Sturgeon Bay. U. of W., 4506.

Physella elliptica aurea (Lea)

Figs. 20, 21. Sandstone Bay, Green Lake. U. of W., 4607. Figs. 22, 23, Howard City, Mich. U. of I., Z16702.

Physella integra (Haldeman)

Figs. 24–26. Alton, Ill. Baker coll., 1456. Figs. 27–29. Sturgeon Bay. U. of W., 4608. Oconomowoc Lake. U. of I., Z16749.

PLATE XXVIII—Continued

Physella integra billingsii (Heron)

Figs. 35, 36. Charlevoix, Mich. Baker coll., 1600. (Vide Crandall). Figs. 40–43. Lake Winnebago, near Oshkosh. U. of W., 4612, 4613. Figs. 44–46. Madeline Island, near Bayfield. U. of W., 4614.

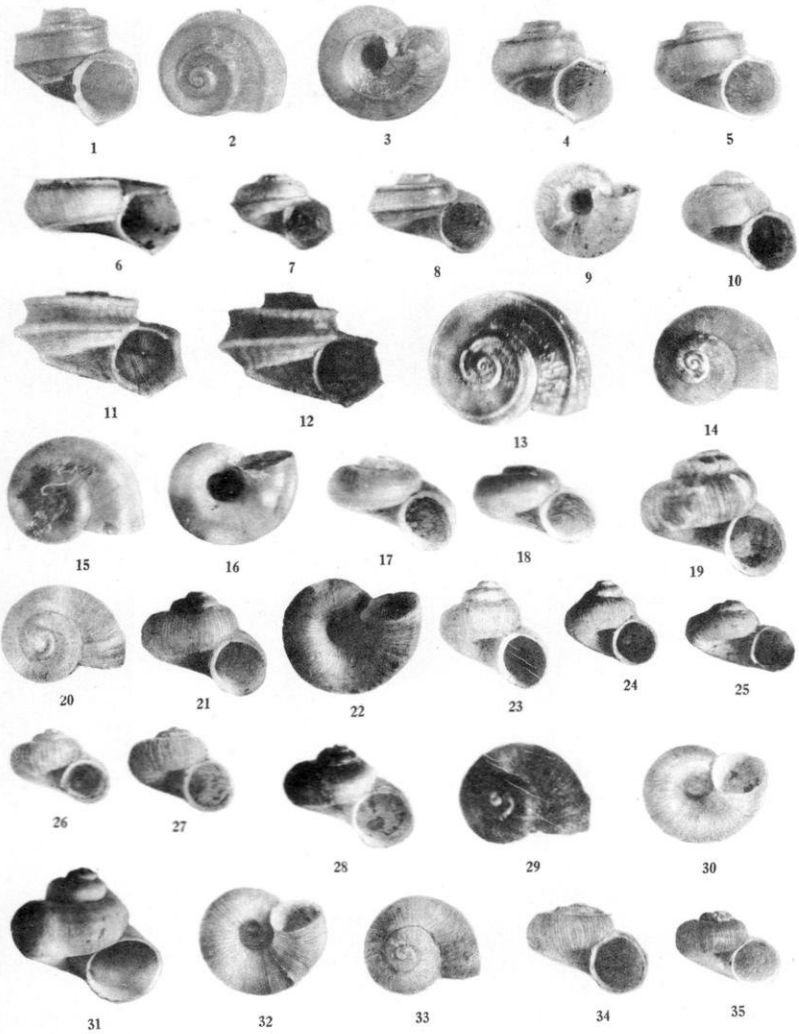
Physella walkeri (Crandall)

Figs. 32–34. Lake Mendota, near Madison. U. of W., 4609. Brown Co. U. of W., 4611. Fig. 47. Alpena, Mich. Baker coll., 1319. 48–51. Brown Co. U. of W., 4615. Fig. 52. Outlet of Oconomowoc Lake. U. of I., Z17027.

Physella brevispira (Lea)

Figs. 37, 38. Peshtigo, Marinette Co. U. of W., 4610.

All figures slightly enlarged.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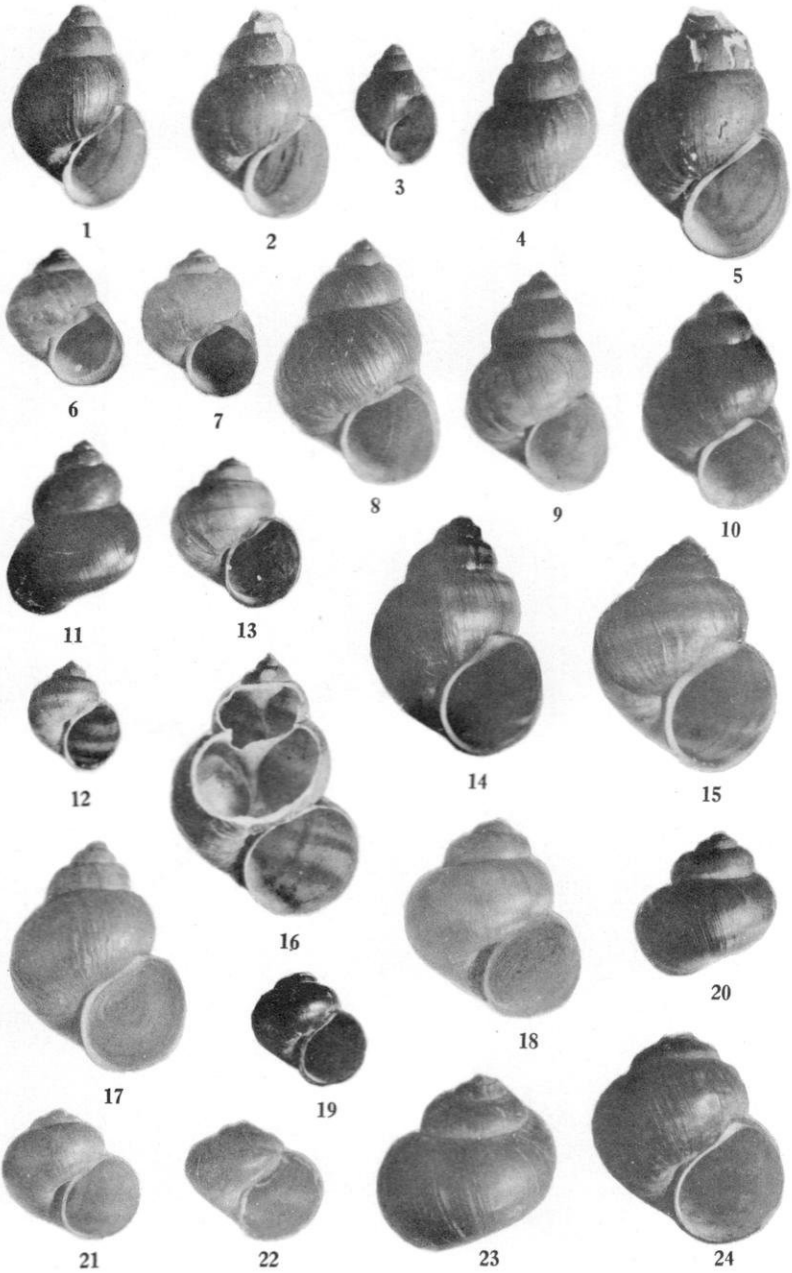
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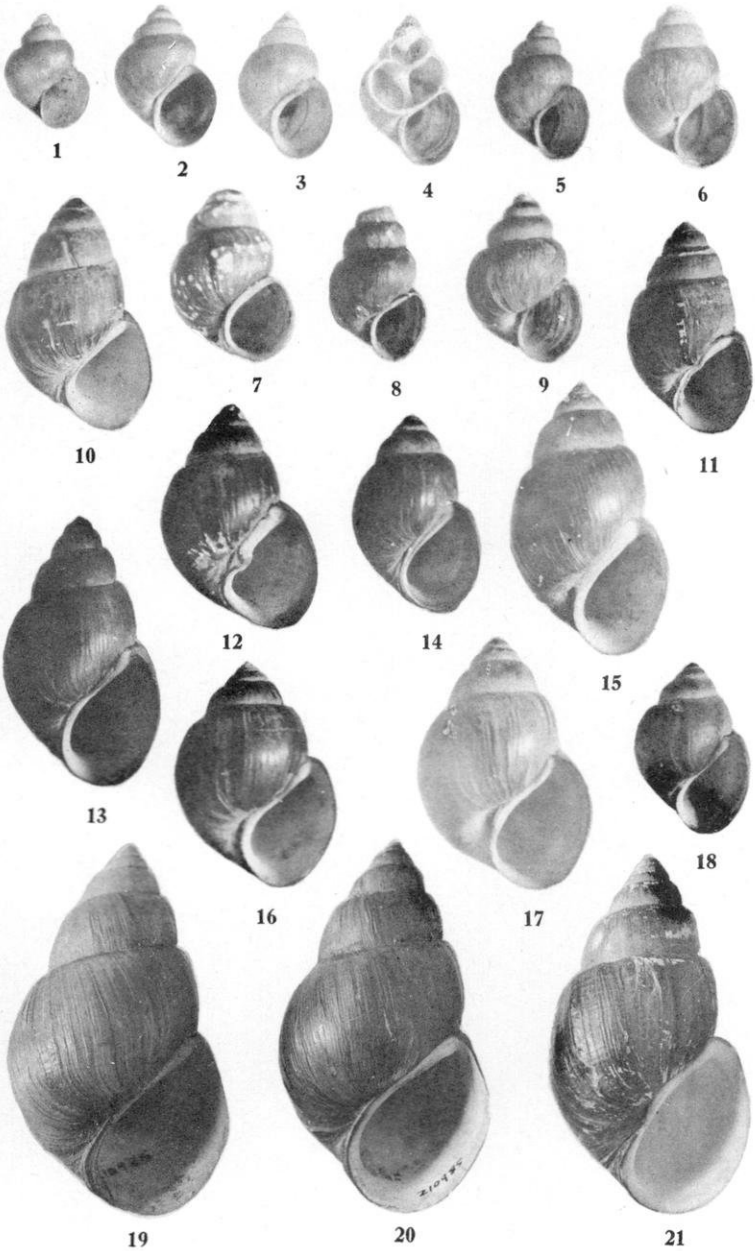
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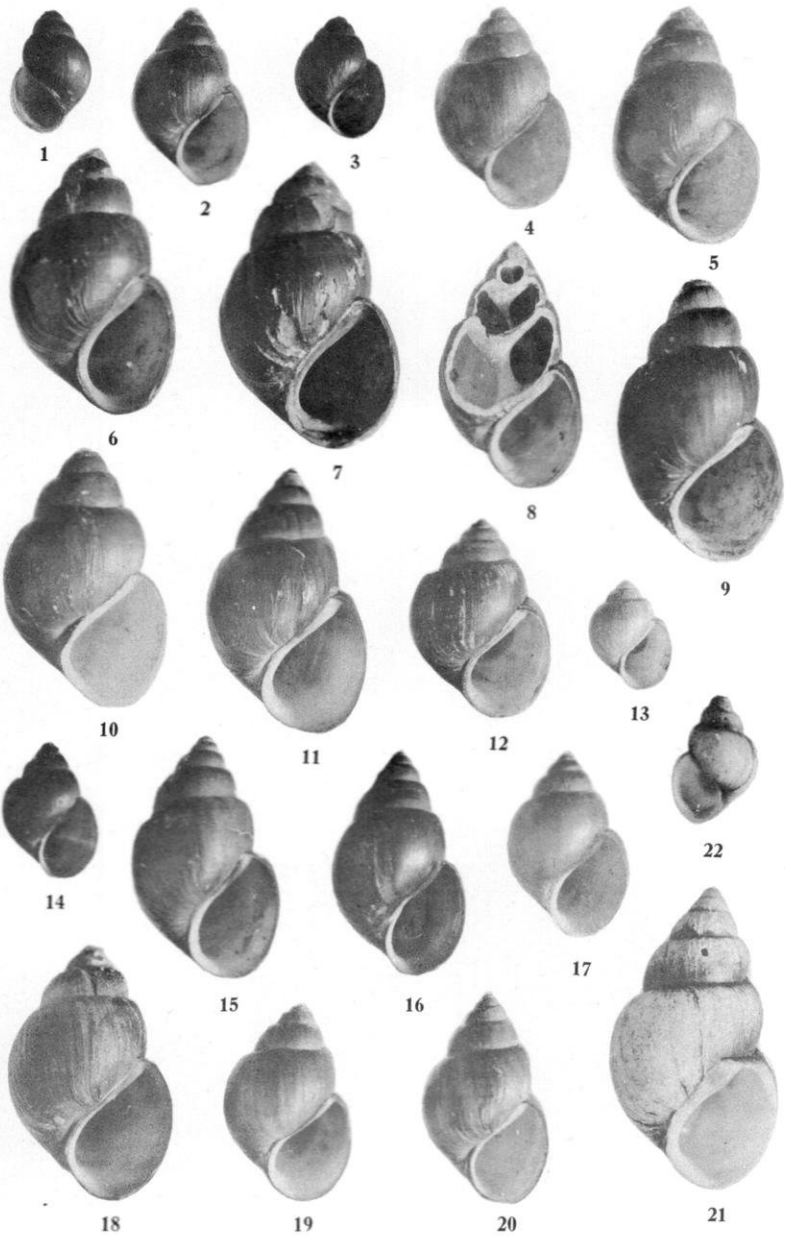
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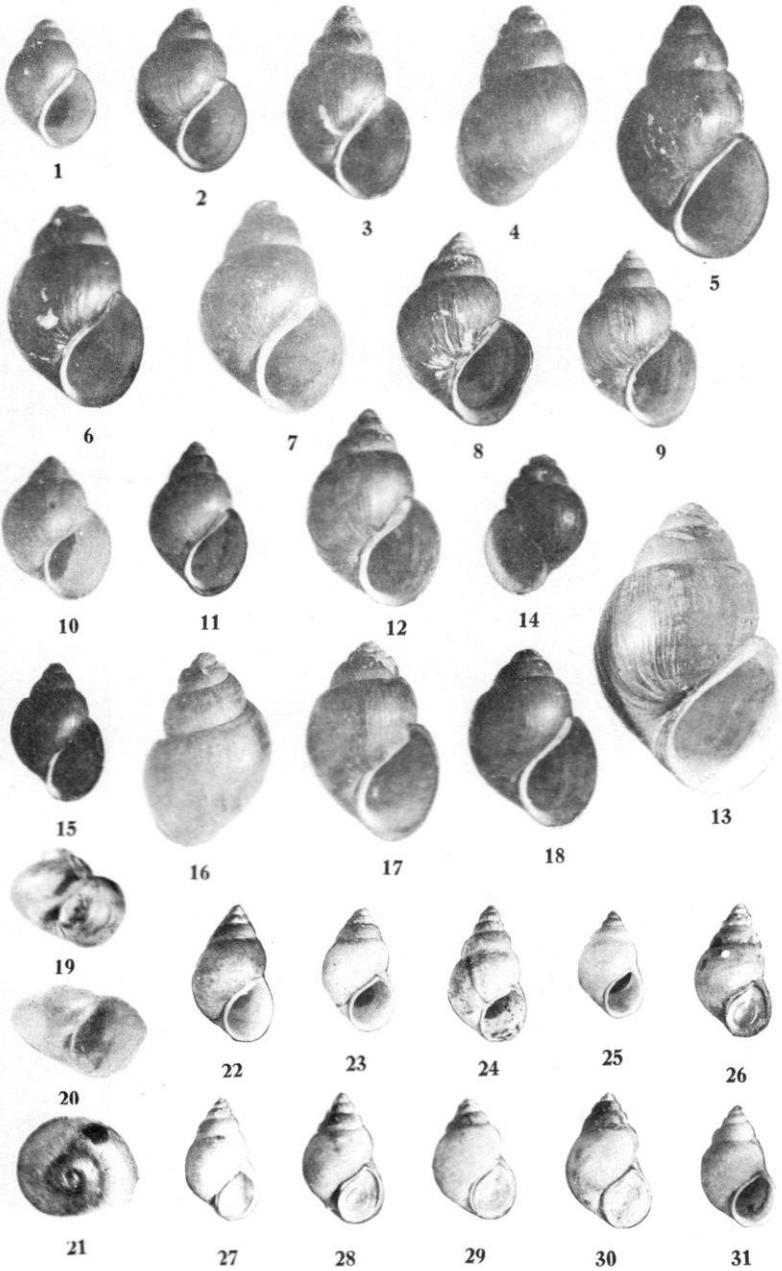
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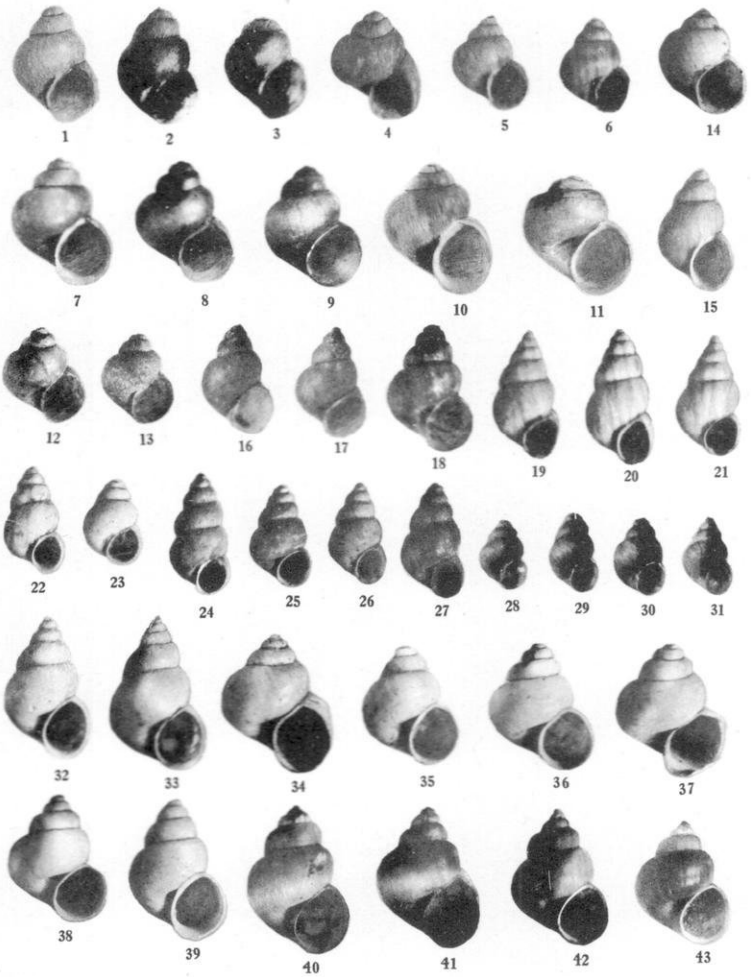
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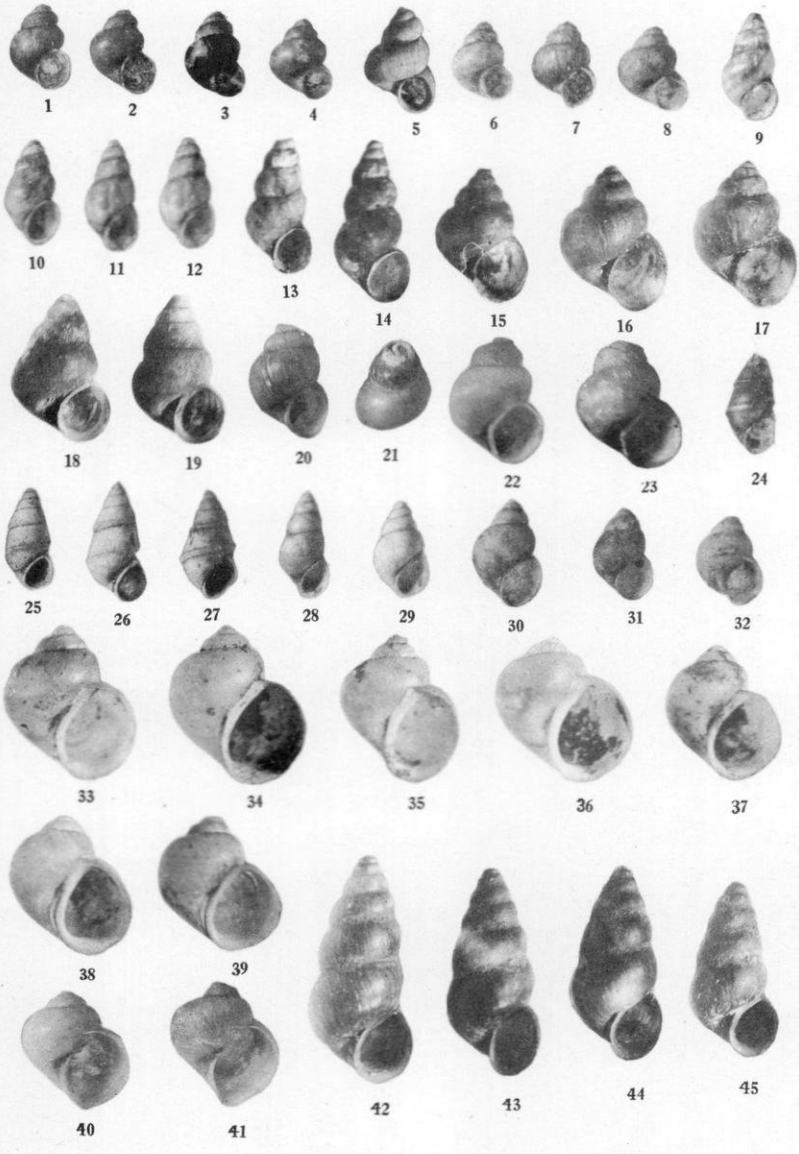
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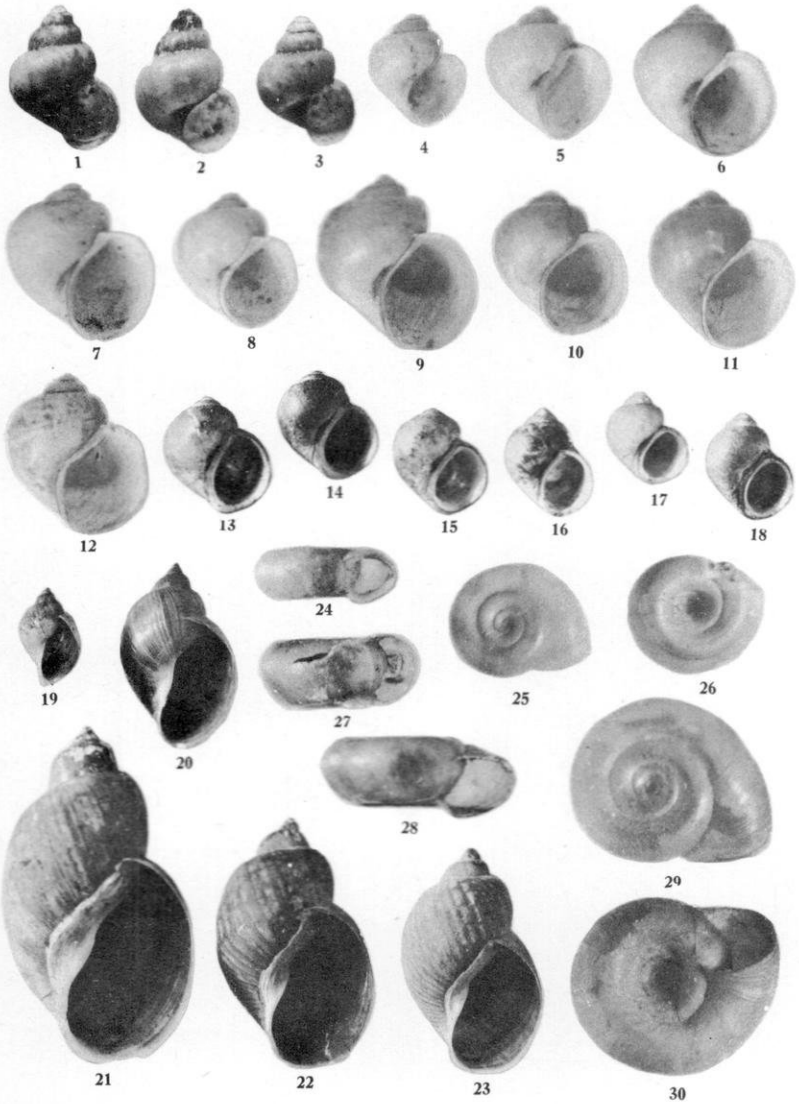
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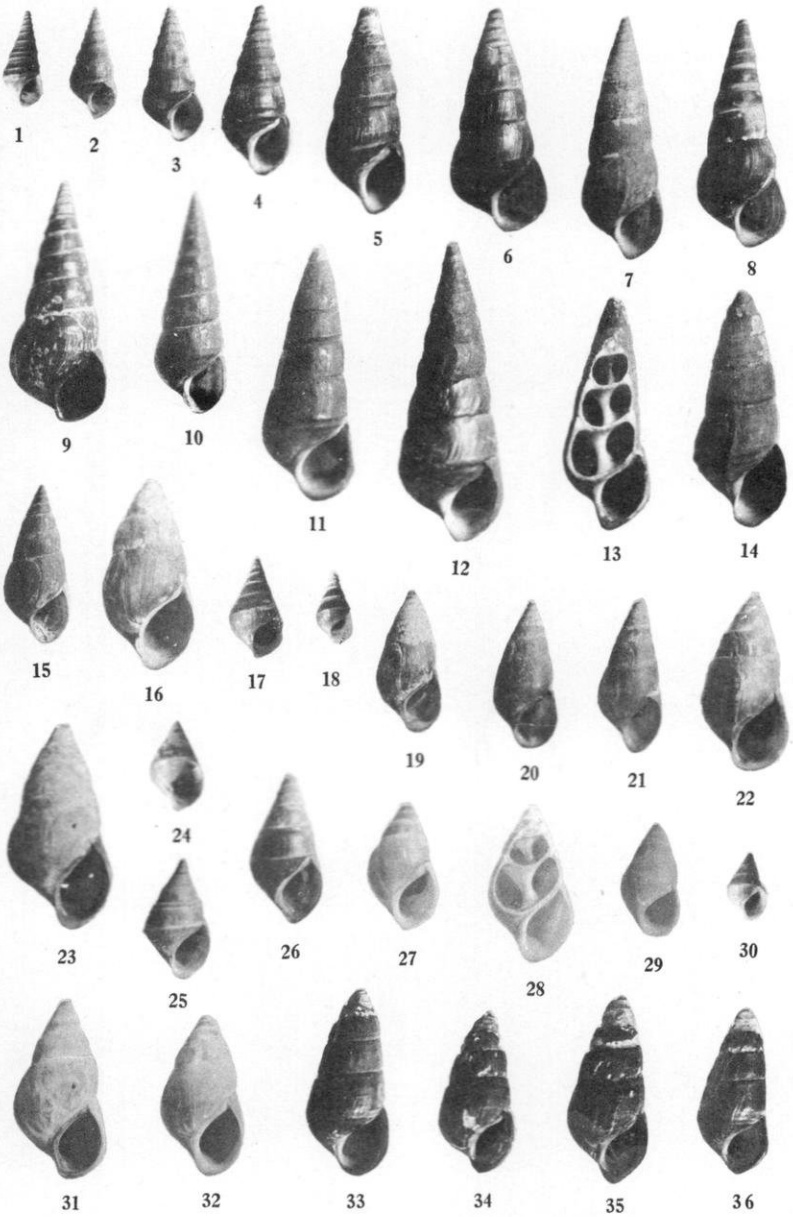
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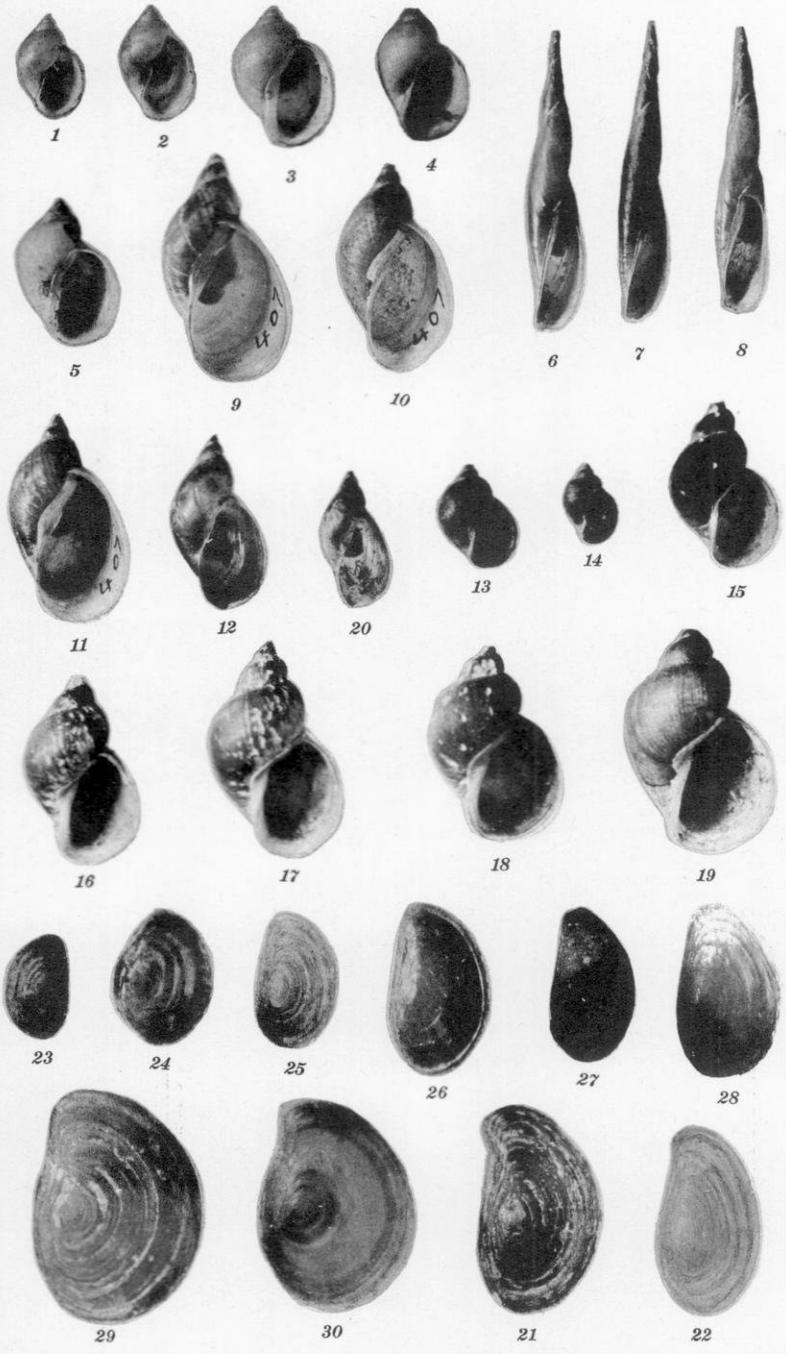
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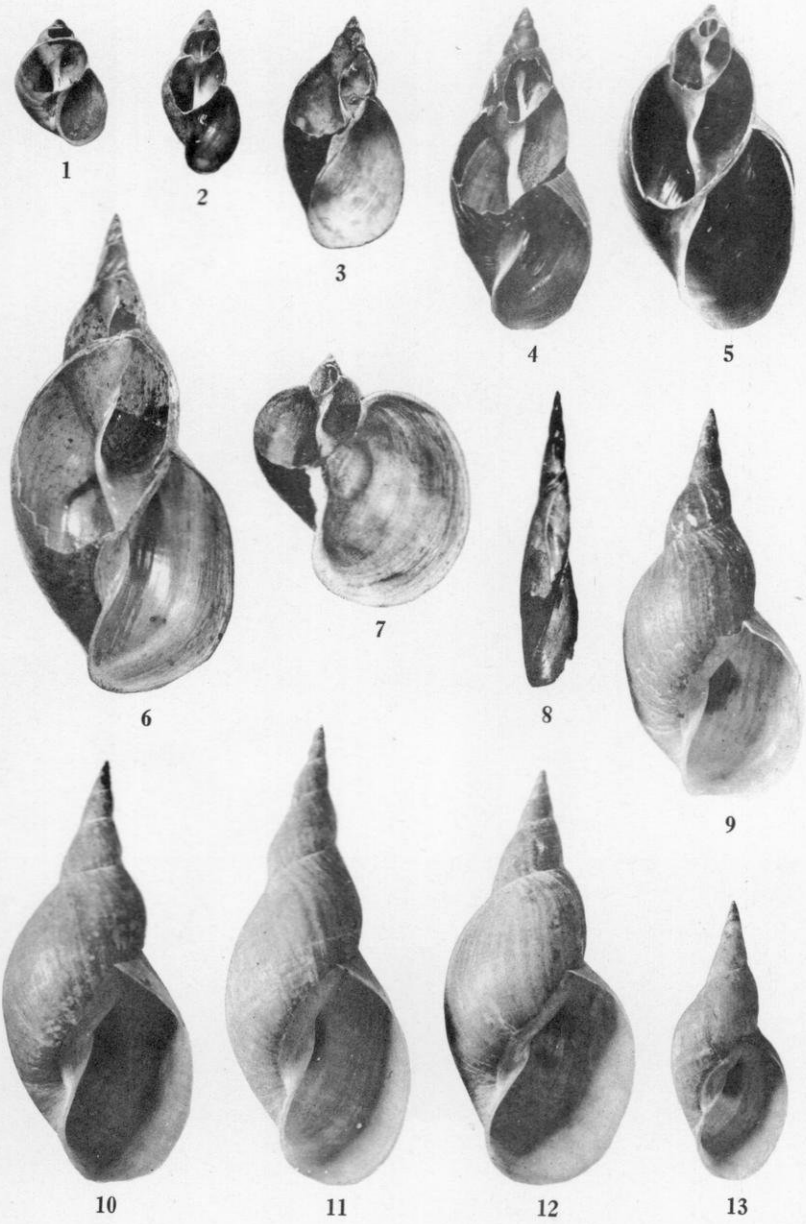
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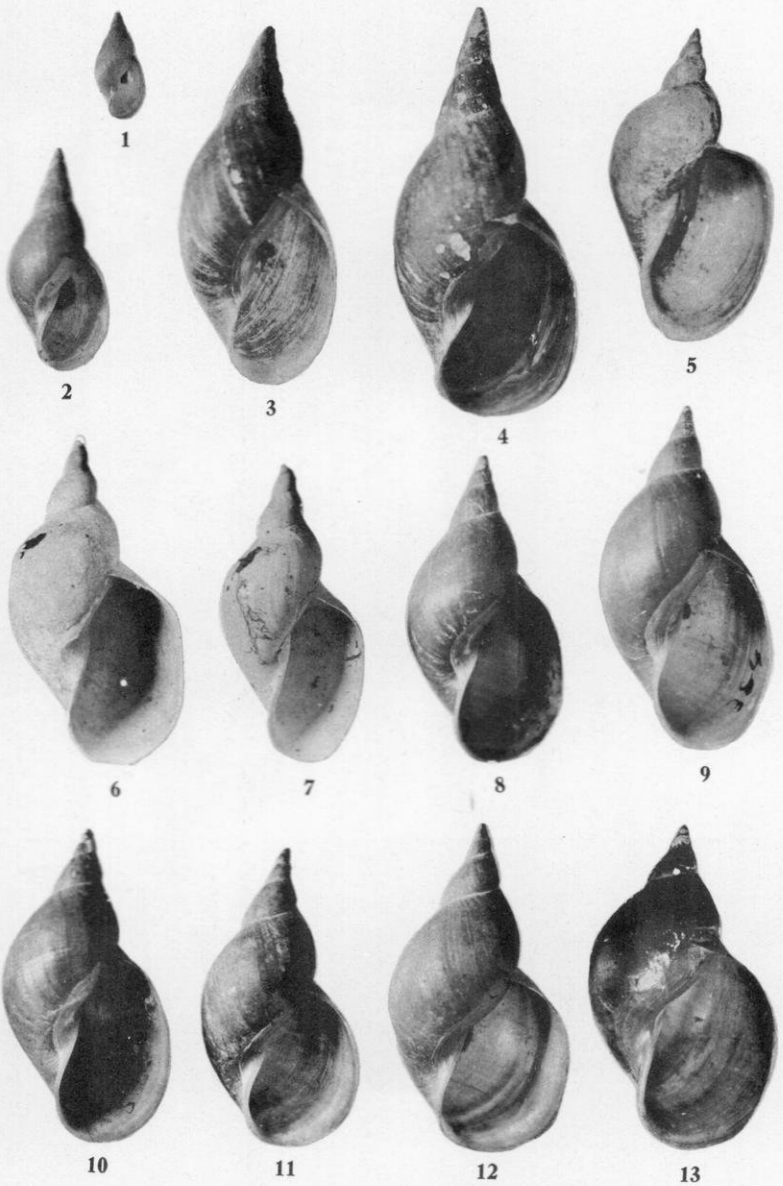
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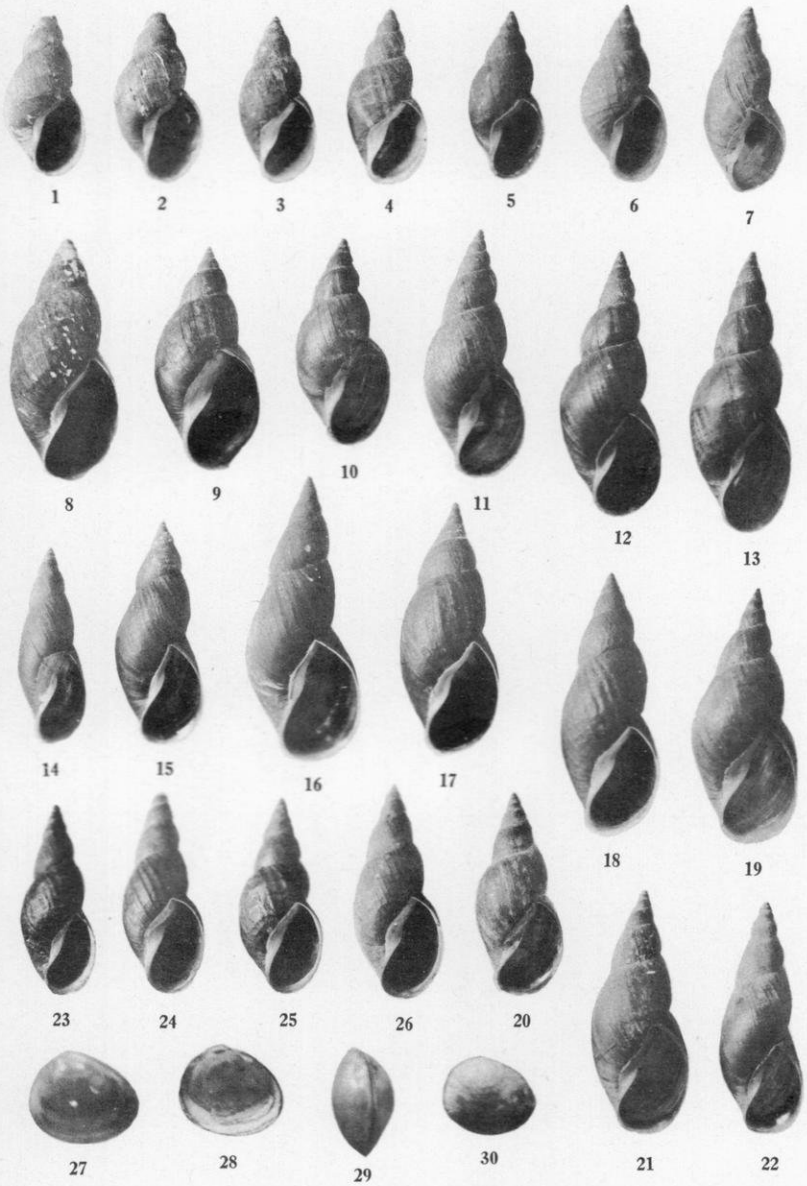
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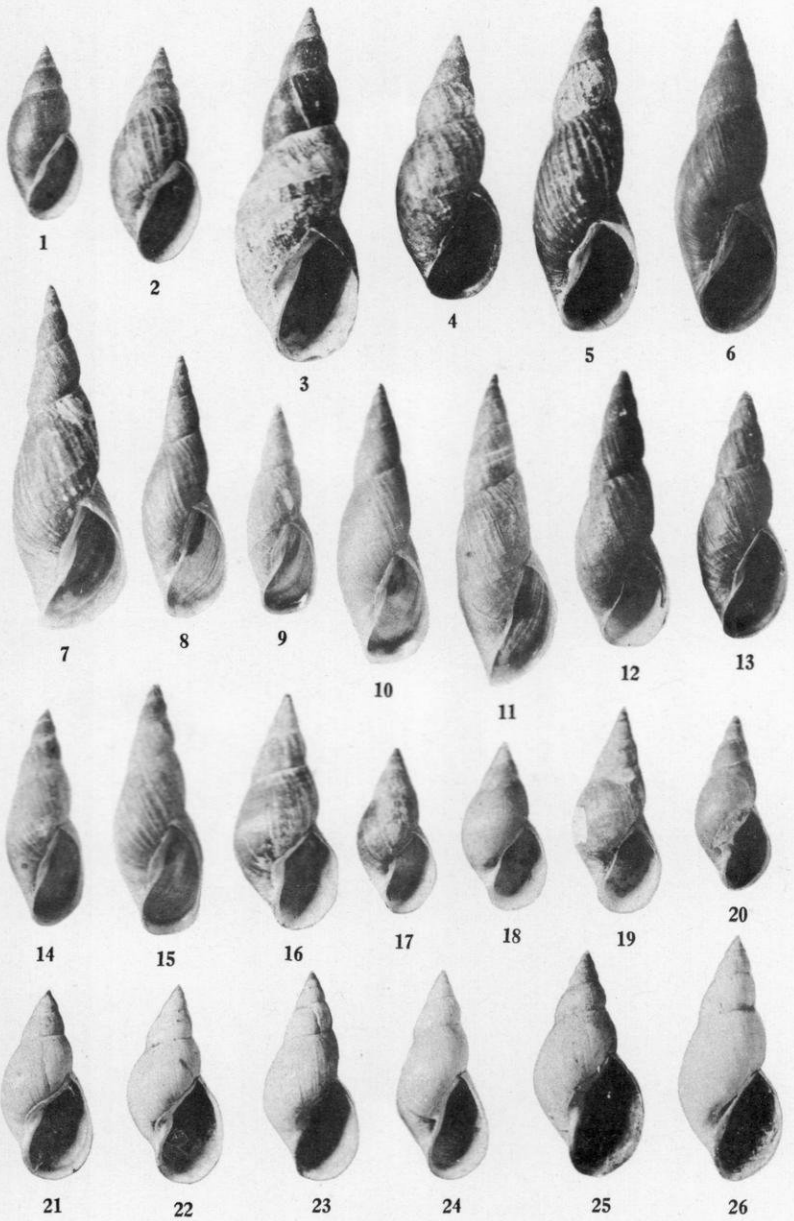
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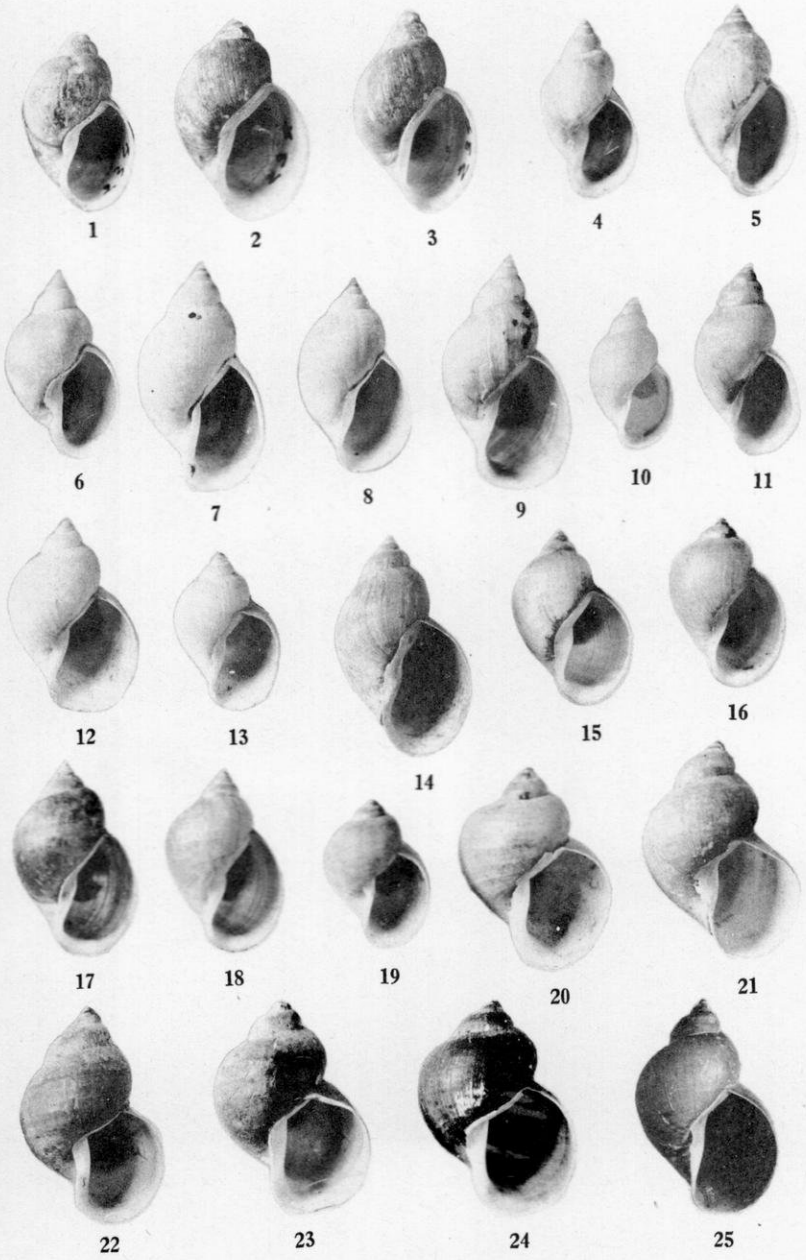
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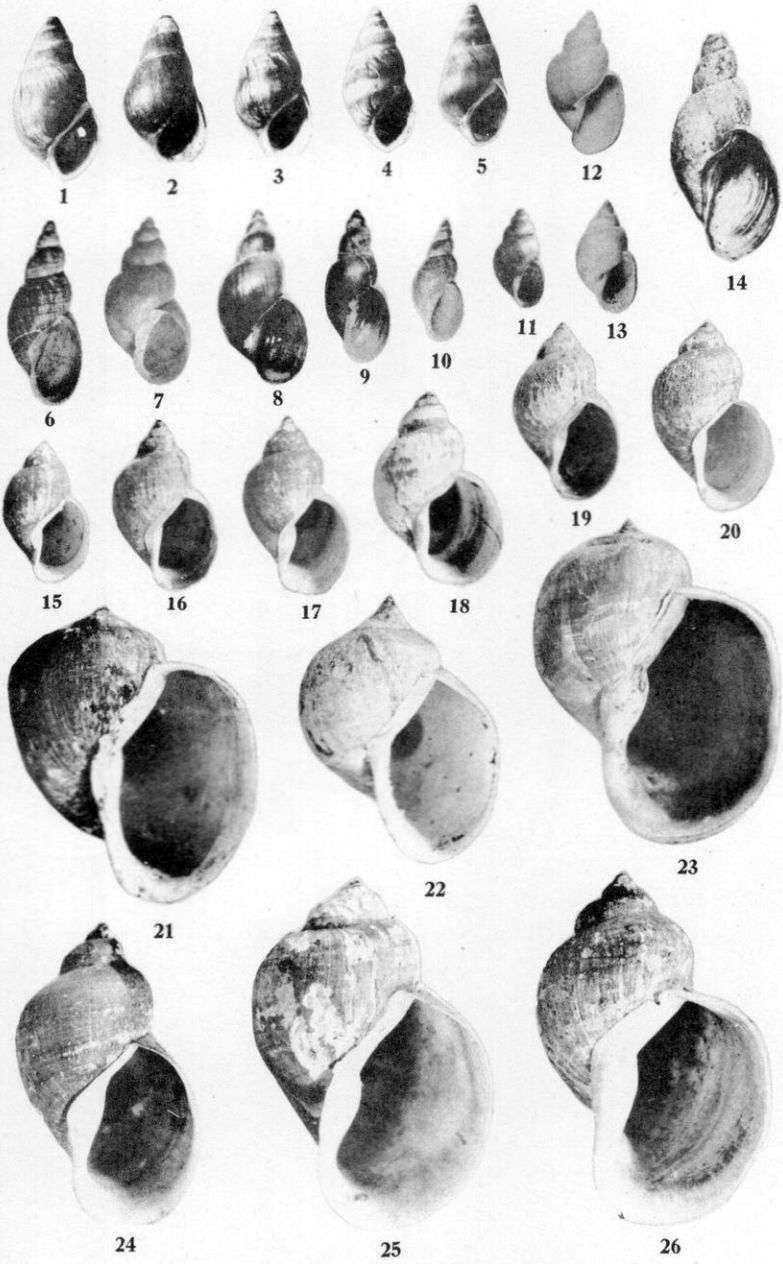
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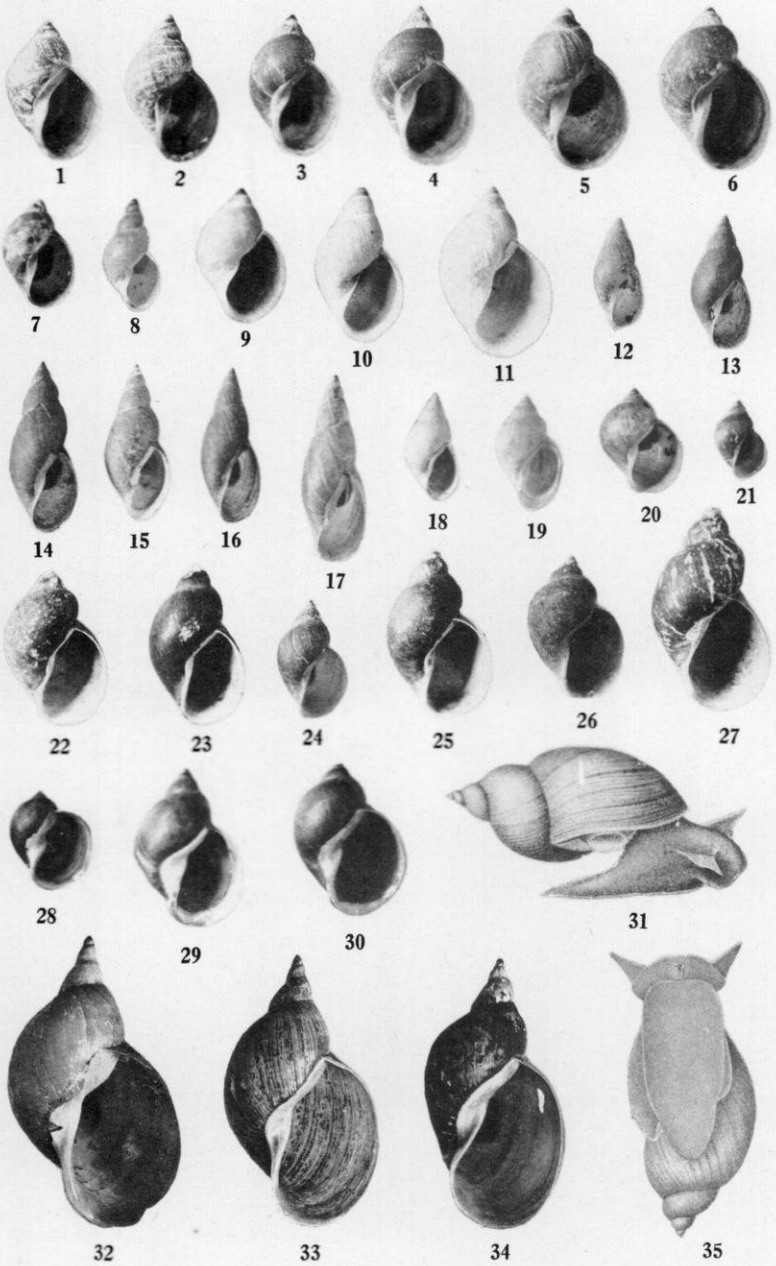
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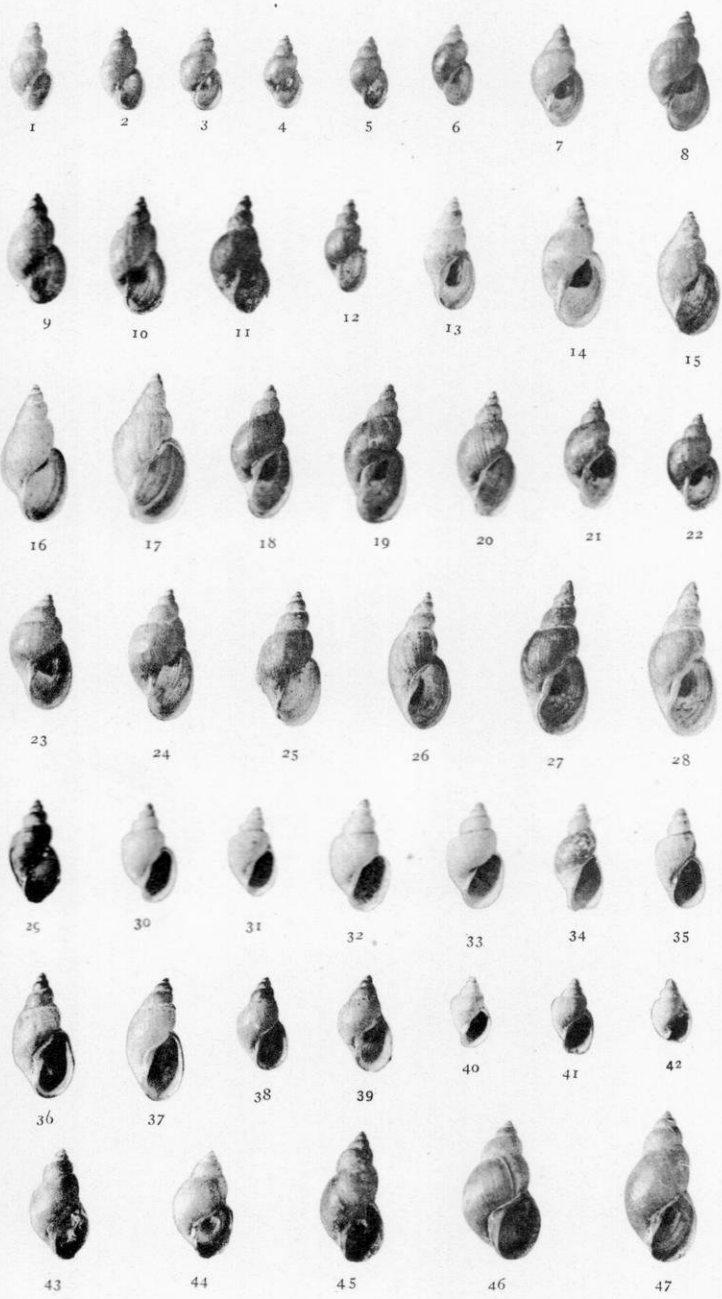
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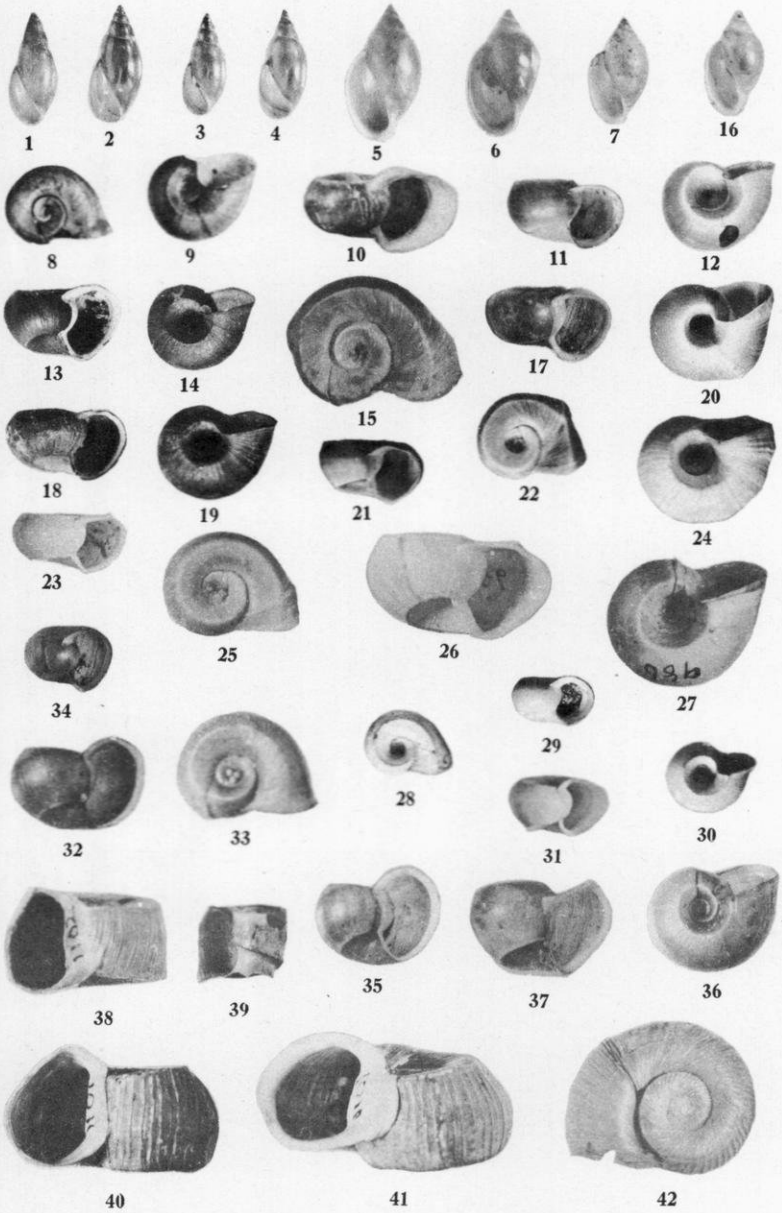
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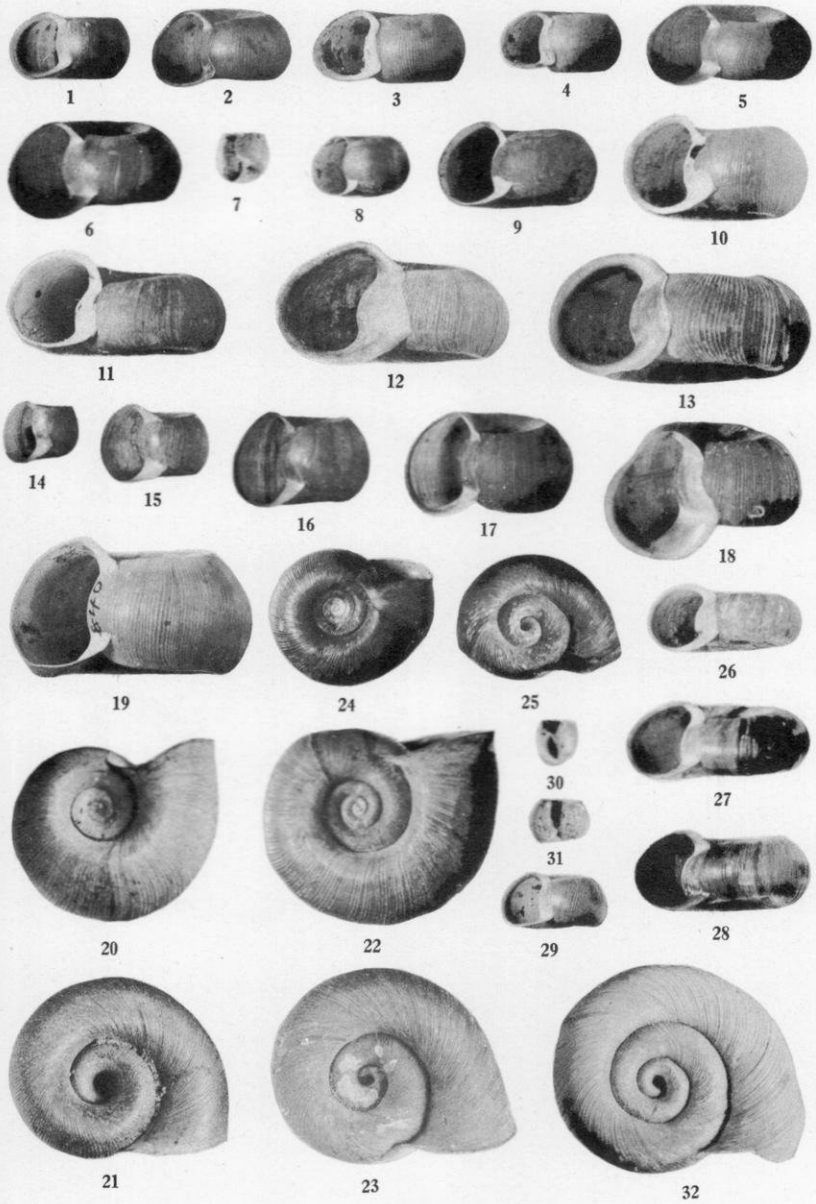
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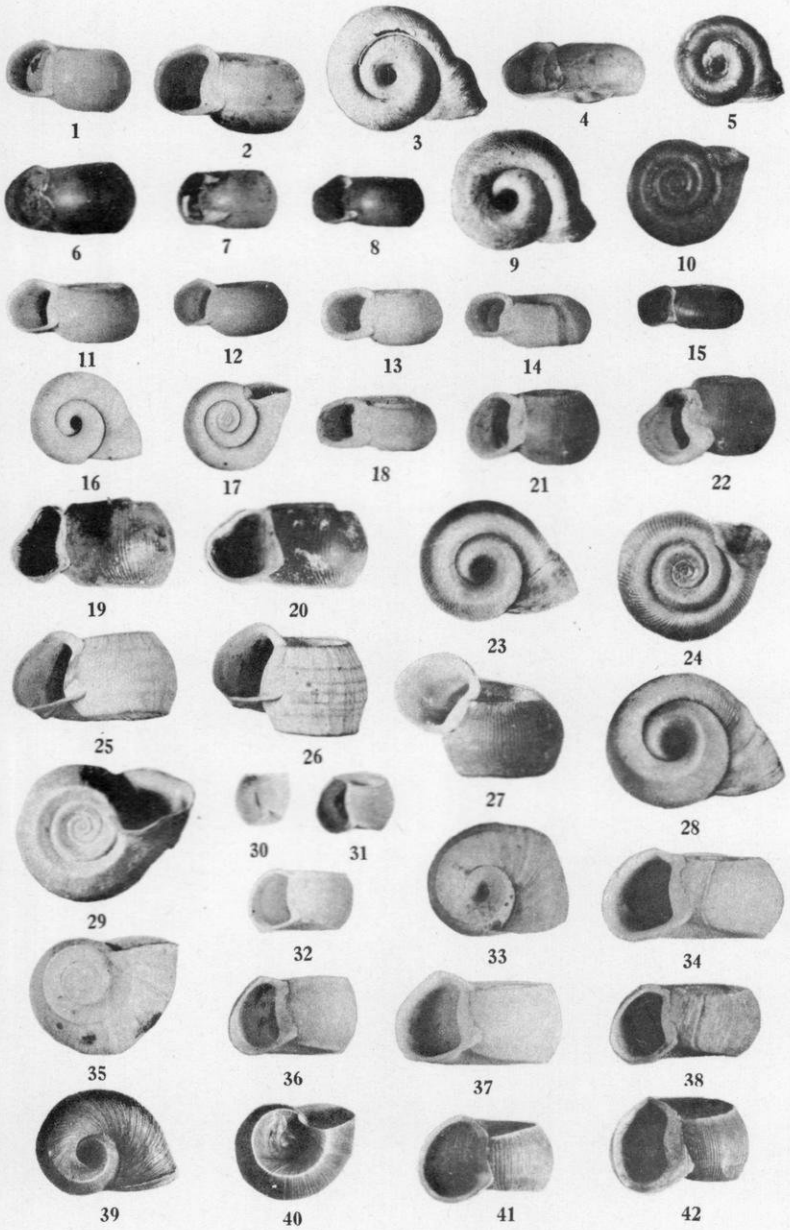
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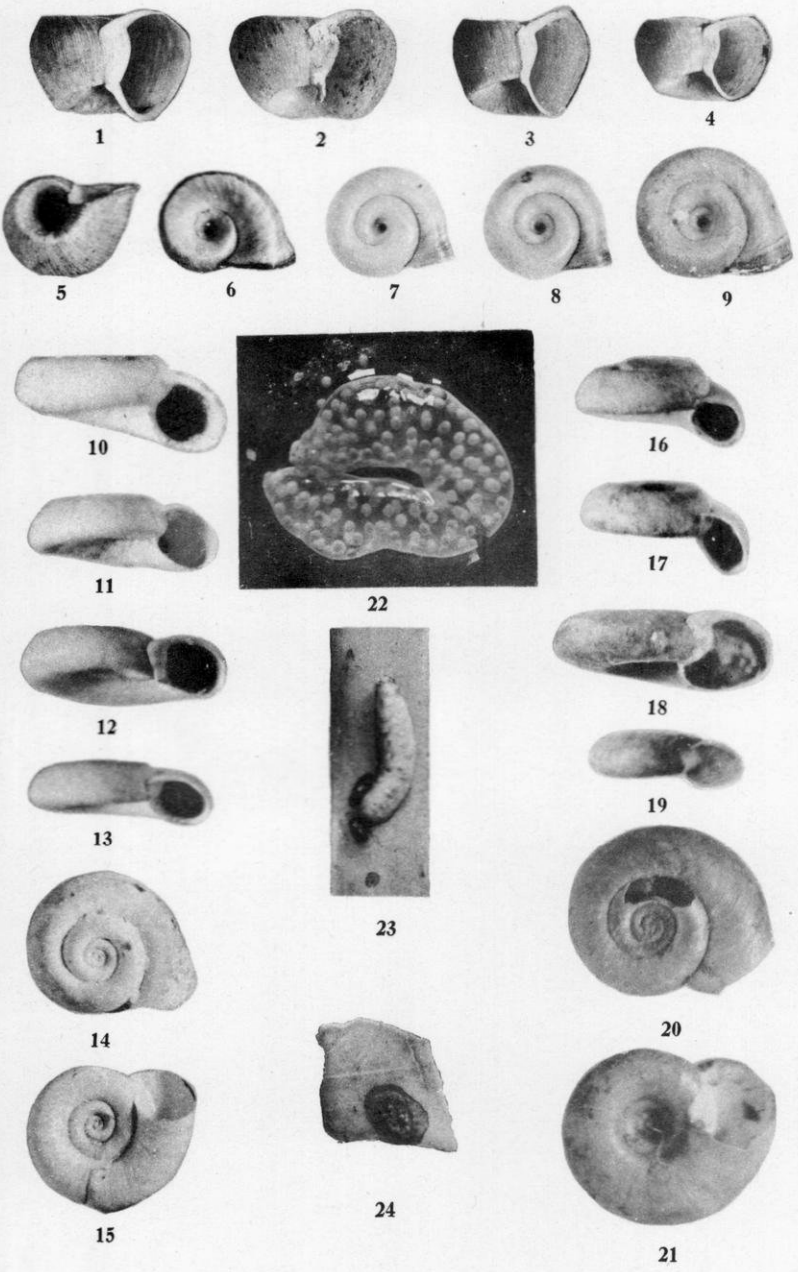
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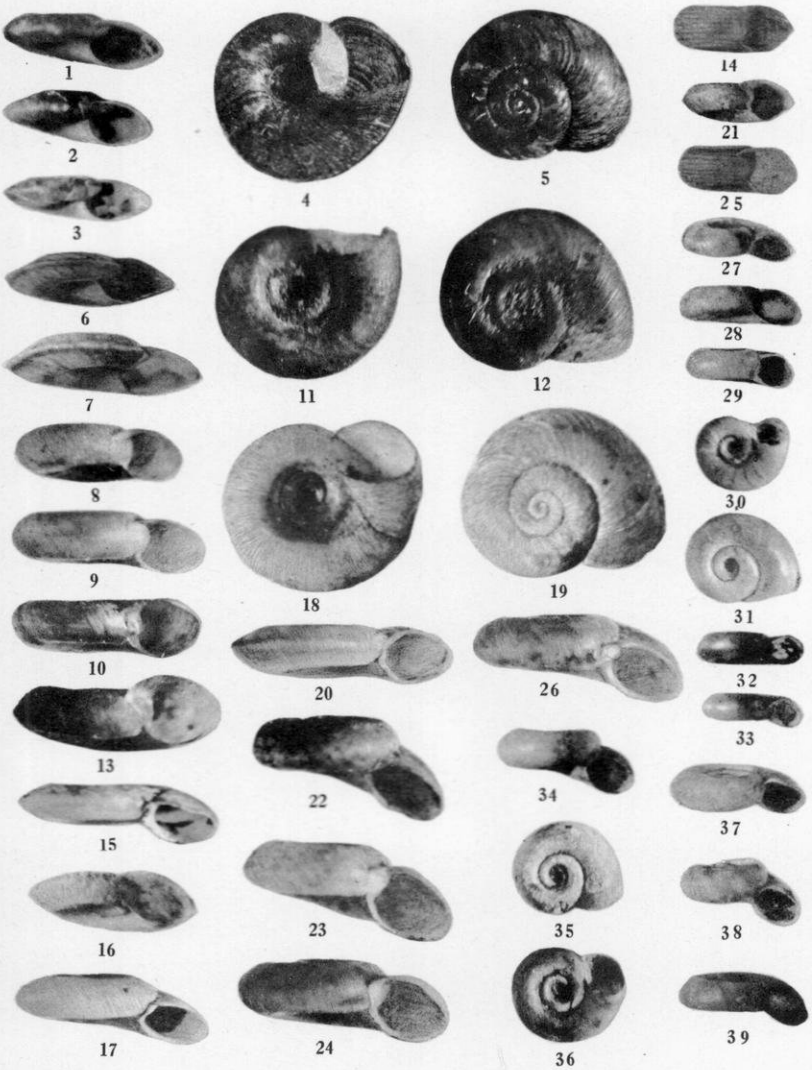
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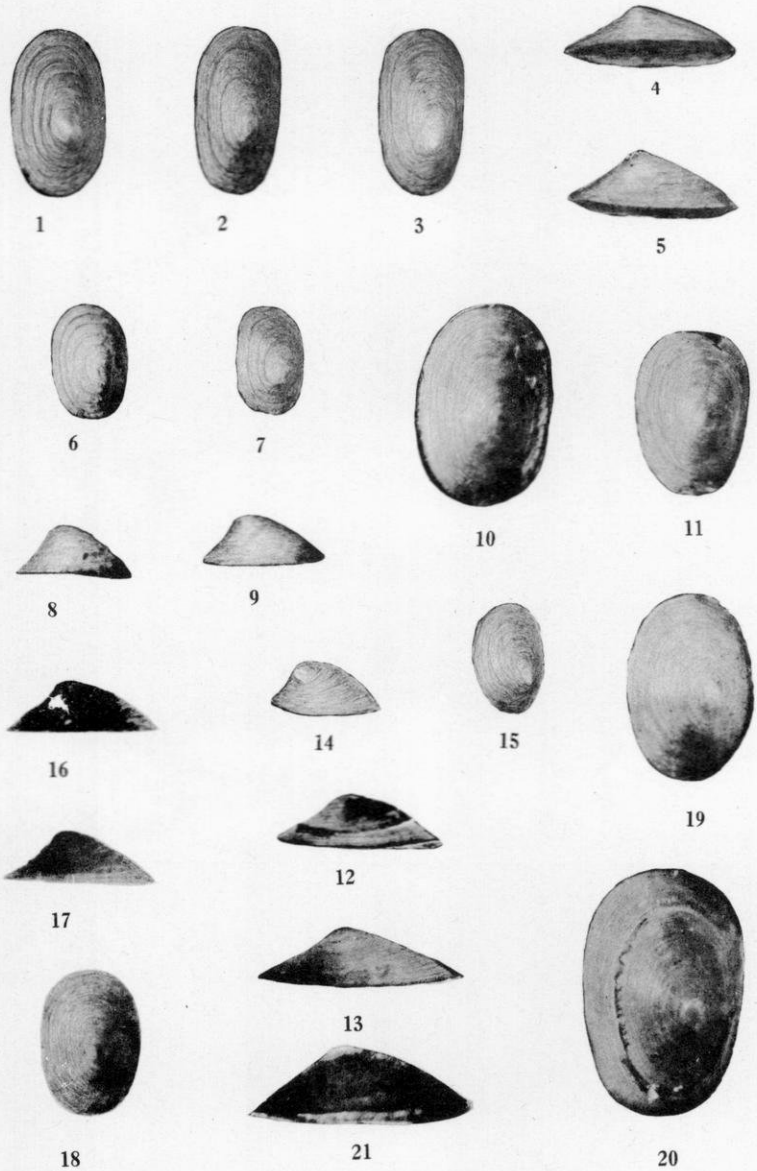
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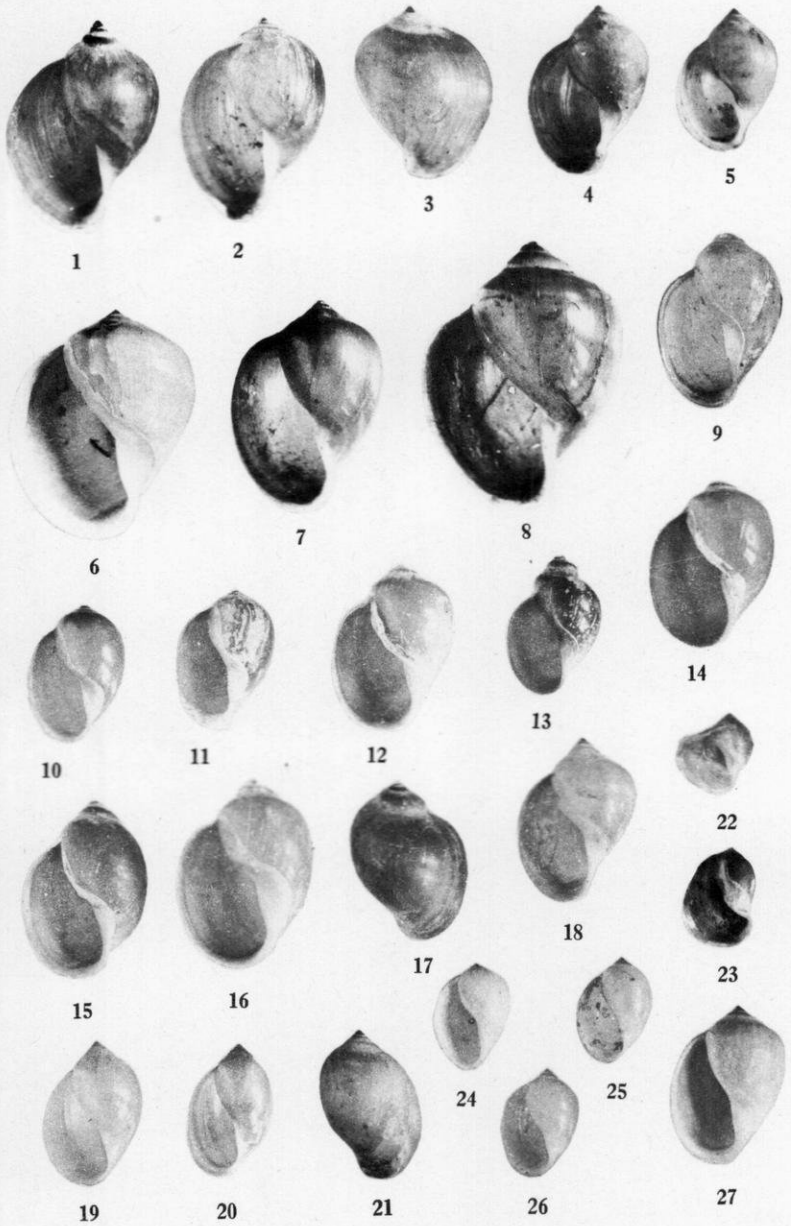
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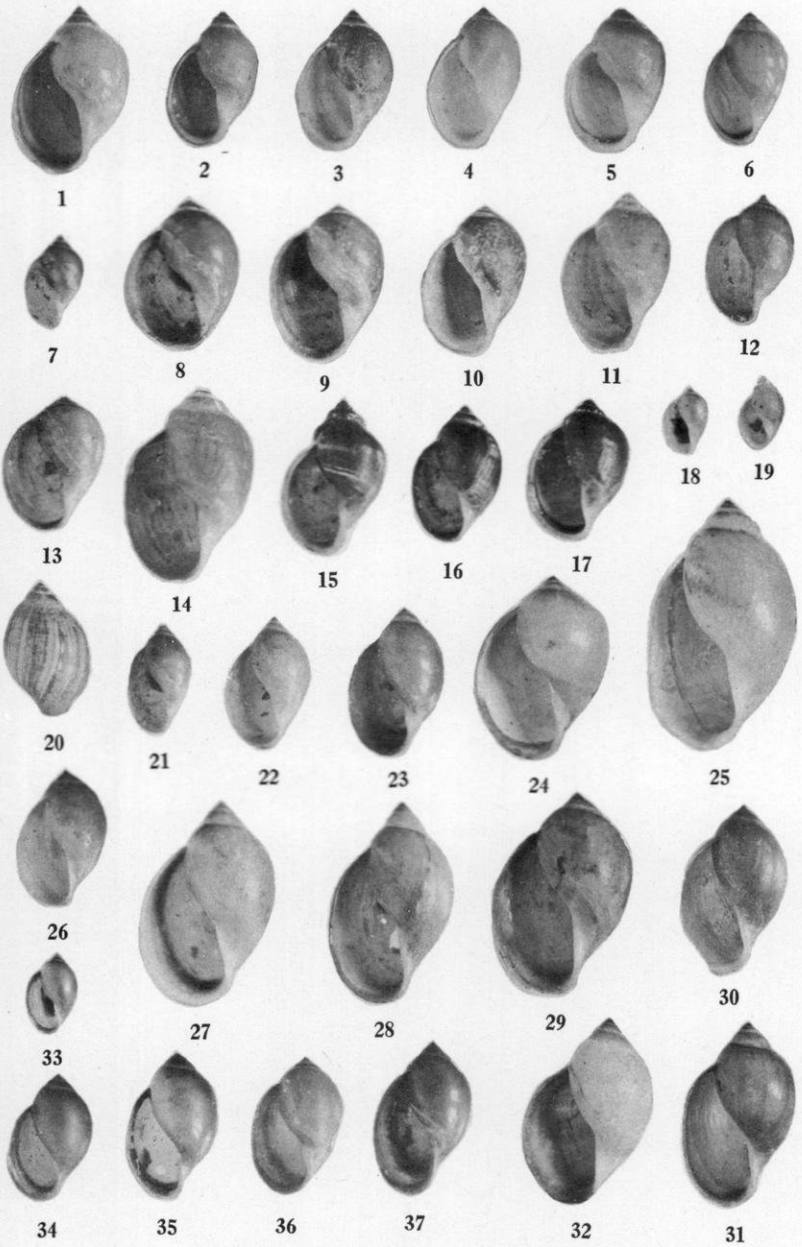
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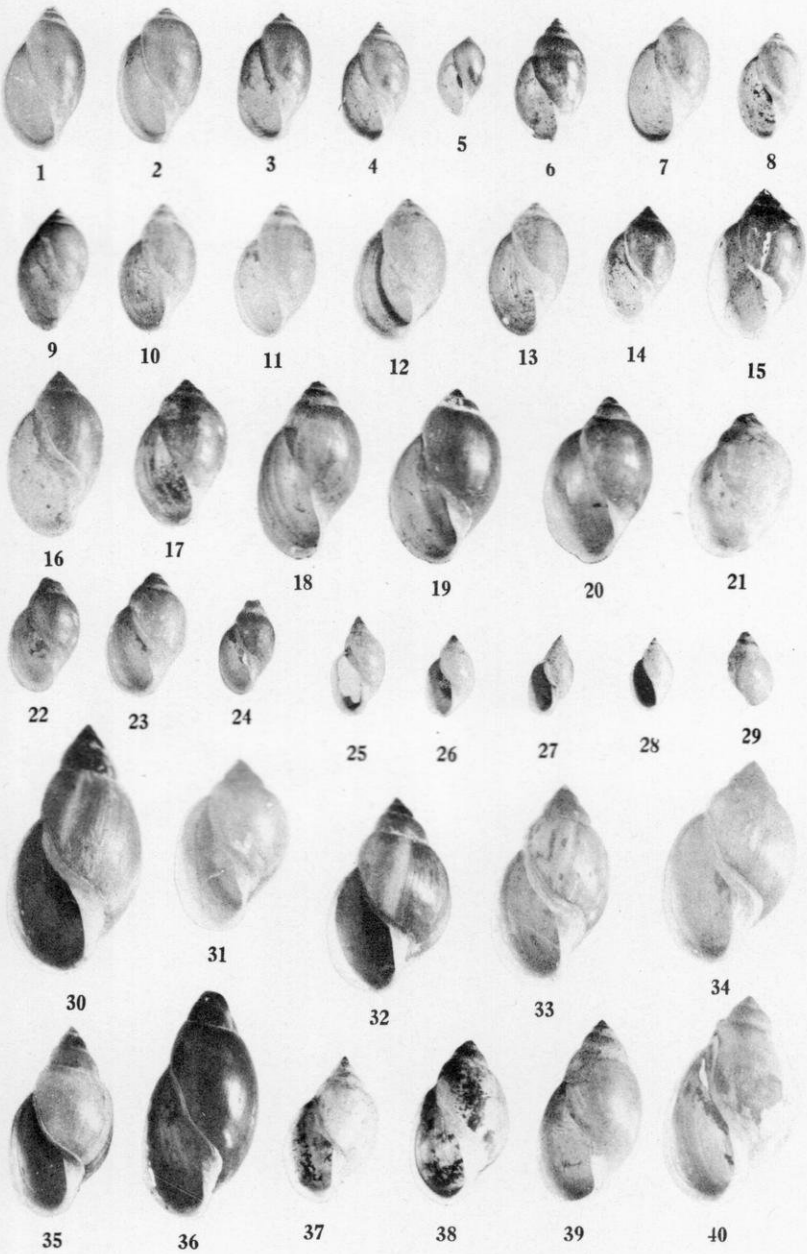
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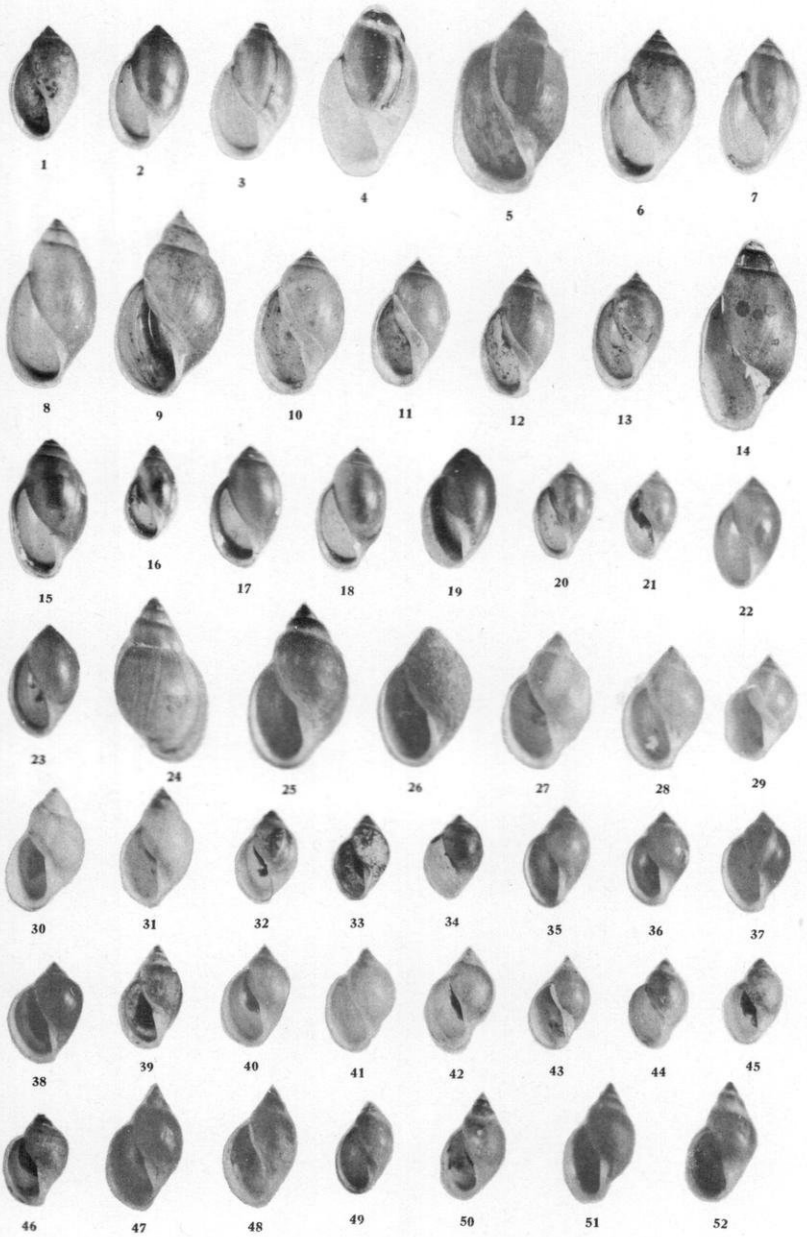
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INDEX OF PART I

New names of genera, groups, species, and subspecies are printed in heavy-faced type; also the reference to the page on which a diagnosis appears.