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CONTENTS

STRUCTURAL ABNORMALITIES IN COPEPODA.

C. Dwight Marsh.

With Plate X, figs. 1–6.

Abnormal or freak structures in the genera of *Cyclops* and *Diaptomus* are remarkably rare. While there is great variability in the species of *Cyclops,* unusual structures seldom occur. In *Diaptomus,* which shows hardly any variability within species limits, freak organs are still more rare.

Very few references to such structures are made in the copepod literature.

Schauss,[1] 1908, p. 195, figures a shortened furcal ramus of *Cyclops vernalis* Fischer, evidently a case of regeneration after injury.

A similar case in *Cyclops serrulatus* Fischer is mentioned by Vosseler[2] in 1889.

Wolf,[3] 1905, pp. 203, and 204, discusses "Regenerationserscheinungen," and mentions finding two specimens of *Cyclops serrulatus* with one furcal ramus shortened. His case of regeneration in the furcal setae of *Cyclops fimbriatus* seems rather one of the instances of telescoping of portions of the setae which has been discussed by Schmeil and others, and probably is not the result of injury and regeneration.

Because of the rarity of abnormal structures it seems best to

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1 Beitrag zur Kenntnis der freilebenden Copepoden und Cladoceren der Umgegend von Bonn. Verhand. Naturhist. Ver. der preuss. Rheinland und Westfalens. 64 Jahrg. pp. 163-218.

2 Ueber einen Cyclops mit verkrüppelter Furka. Archiv. für Naturgeschichte, 55, p. 123, Taf. VI, fig. 16.

3 Die Fortpflanzungsverhaltnisse unserer einheimischen Copepoden. Zool. Jahrb. Abt. f. Syst. Bd. 22, pp. 101-280.

put on record a few that have been seen in the course of the author's systematic work on Copepoda.

Plate X, figure 1 is a seta on the endopodite of the fourth foot of a specimen of *Cyclops phaleratus* Koch. It is evident that the seta was injured and the lateral which has grown out is the result of a regenerative process. Likewise plate X, figure 2, may be explained as defective regeneration after an injury; this is the second segment of the exopodite of the fourth foot of *Cyclops serrulatus* Ficher. Normally there should be a single spine on the external margin instead of two.

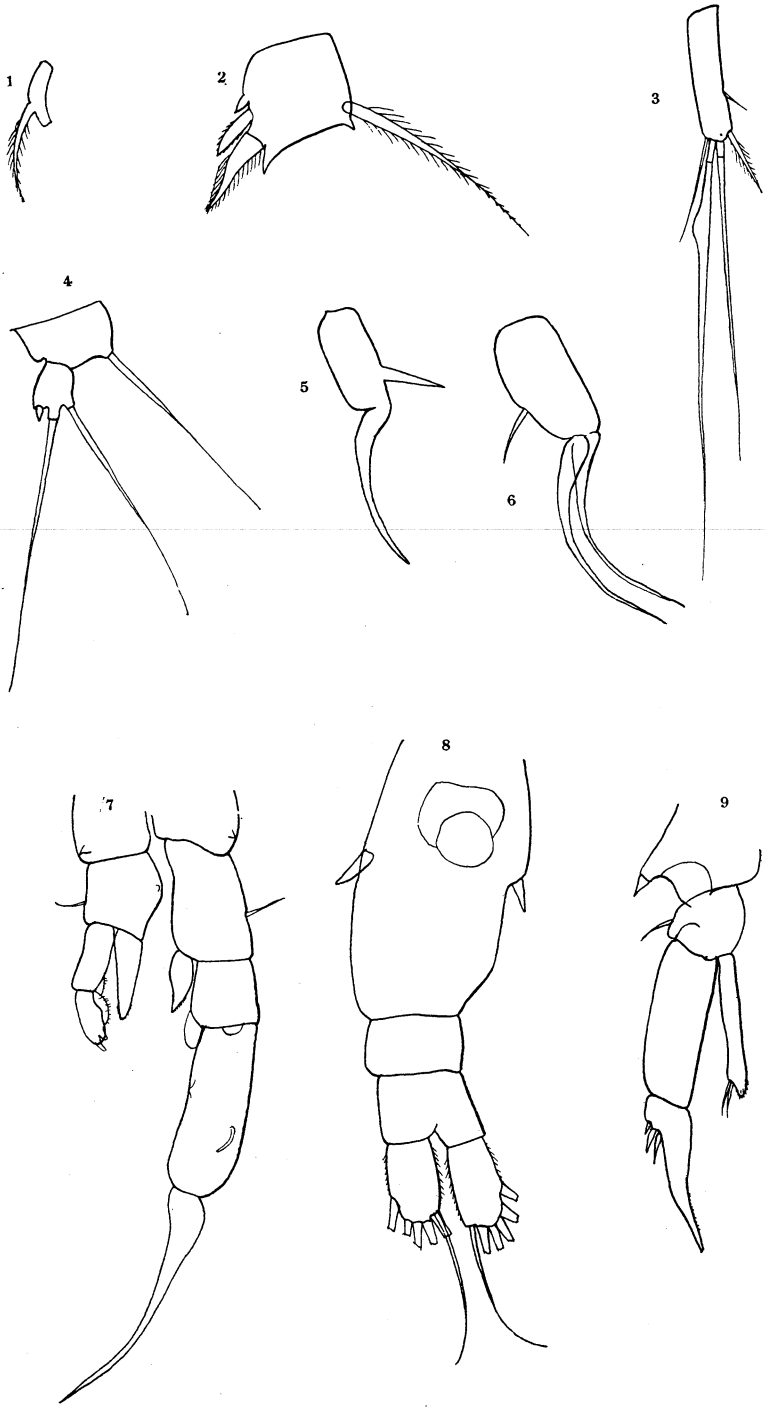
So, too, the abnormal terminal seta of *Cyclops viridis* var. *americanus* Marsh in plate X, figure 3, can be explained as the result of traumatism.

In plate X, figure 4, however, we have a real monstrosity. This is the fifth foot of a specimen of *Cyclops viridis* Jur. collected in Pennsylvania. The second segment is normally armed with a short spine and a single long seta. Here we have a spine and *two* setae. This was not the result of injury and regeneration, for both fifth feet were of the same form. In all other respects the animal had the usual structure of *Cyclops viridis*. If there were any question of hybridization, it seems probable that other structures would have been affected.

Plate X, figure 5, is the second segment of the exopodite of the right fifth foot of a male *Diaptomus pallidus* Herrick. Normally the lateral spine is on the outside of the segment. In this case it is on the inside. There is nothing to indicate that this is the result of injury.

Plate X, figure 6, is the second segment of the exopodite of the right fifth foot of a male *Diaptomus sicilis* Forbes. This has two terminal hooks instead of one. This specimen was from Green Lake, Wisconsin, and is the only one of the kind that has been seen, although great numbers of this species have been examined from many different localities.

Another unique abnormality was seen in a specimen of *Diaptomus minutus* Lillj. found in Stone Lake, Wisconsin. This was a female with nothing unusual about its structure except its antennae which were those of a male, the right one being geniculated like the typical male antenna.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ON A NEW SPECIES OF DIAPTOMUS FROM COLORADO.

C. Dwight Marsh.

DIAPTOMUS COLORADENSIS SP. NOV.

Plate X, figs. 7, 8 and 9.

Of medium size. The suture between the first and second cephalothoracic segments is quite distinct, and these two, forming the first apparent segment, are together somewhat shorter than the three following segments. The last cephalothoracic segment is expanded into large lateral processes, each side being armed with two small spines.

The first segment of the female abdomen (Plate X, fig. 8) slightly exceeds in length the rest of the abdomen. It is broad, dilated ventrally, and moderately dilated laterally. The lateral processes bear large spines which are turned towards the posterior end of the animal. The second segment is shorter than the third and the two together are considerably longer than the furca. The furcal rami are stout and ciliate on both the inner and the outer margins. The antennae reach beyond the end of the furca. The antepenultimate segment of the right male antenna is without any special appendage.

The fifth feet of the female (Plate X, fig. 9) are slender. The spines of the first basal segments are large and prominent. The lateral hairs of the second basal segments are of moderate length. The first segment of the exopodite is more than twice as long as wide. The second segment is long and slender, exceeding in length the first segment. The hook is slightly curved and denticulate on the inner margin. It is armed with three spines of which the inner is the longest. The two inner spines represent the third segment. The endopodite is slender and

somewhat shorter than the first segment of the exopodite. It is setose at the tip, and armed with two long terminal spines which are inserted well back from the end of the endopodite.

In the male fifth foot, (Plate X, fig. 7) the spines of the first basal segment are rather prominent and acute. The second basal segment of the right foot is about twice as long as broad; the lateral hair is situated a little beyond the middle of the segment. The first segment of the exopodote is quadrate, slightly longer than broad, and bears two curved hyaline processes, one, which is quite prominent, on the inner distal angle, and the other, much smaller, on the distal posterior edge. The second segment is more than twice as long as broad, is nearly straight, and is of about the same width throughout. The lateral spine is small, curved, and situated distad of the middle. Near the inner margin on the posterior surface is a small spine reminding one of the similar structure in the *oregonensis* group, although less pronounced. The terminal hook is rather stout, slightly curved, and, in length, exceeds, a little, the rest of the exopodite. It is finely denticulate on the inner margin. The right endopodite nearly equals in length the first segment of the exopodite. It is somewhat variable in shape, but is ordinarily rather broad and pointed at the tip. The end is armed with minute setae. The left foot reaches to the end of the first segment of the right exopodite. The second basal segment is as long as wide. The inner margin is strongly convex, and near this margin, about midway of the segment, is a small blunt spine. The lateral hair is situated near the distal end of the segment. The first segment of the left exopodite is longer than wide, its length in some cases being more than twice its width. The second segment is about two-thirds as long as the first, and has upon its inner surface a convex setose pad.; the segment is terminated with two digitiform processes, of which the outer is the longer. The endopodite is slender, one-segmented, more or less pointed, and reaches to about the middle of the second segment of the exopodite. The tip is distinctly setose.

Length of female 1.38 mm. Length of male 1.32 mm.

This has been found at Corona, Kremmling, Tolland, and Mount Carbon, Colorado.

This species is closely connected with *Tyrelli* and was at first thought to be identical with it. The differences, however, are constant and are of sufficient importance to justify a specific separation. The principal points of difference are as follows:

In the female fifth foot, the spines of the first basal segments are large instead of small as in *Tyrelli*. The endopodite is shorter than the first segment of the exopodite, while in *Tyrelli* it is longer. In the male fifth foot the distal margin of the first segment of the right exopodite has two hyaline processes, the one at the inner angle being quite large, while *Tyrelli* has one inconspicuous process on the inner distal angle. The lateral spine of the second segment of the right exopodite is rather strongly curved instead of nearly straight as in *Tyrelli*, and the blunt spine of the dorsal surface of this segment I have never seen in *Tyrelli*. The right endopodite is nearly as long as the first segment of the exopodite while in *Tyrelli* it is much shorter. The left endopodite of the male fifth foot is much stouter than in *Tyrelli*.

D. coloradensis is interesting as indicating a possibility of bridging over between the *oregonensis* and *tenuicaudatus* groups. In the Revision of the North American Species of *Diaptomus* the author stated* that *Tyrelli* apparently was most closely related to the *tenuicaudatus* group although not having any appendage of the antepenultimate segment of the right male antenna as in that group. The presence of the small blunt spine on the dorsal surface of the second segment of the exopodite of the male fifth foot in *coloradensis* is evidence of relationship to the *oregonensis* group. While, in the light of our present knowledge we can only make a guess at the phylogeny of *Tyrelli* and *coloradensis* it seems probable that they should be classed with the *oregonensis* group.

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* Trans. Wis. Acad. Sci., Letters, and Arts, XV, p. 396.

THE MOLLUSCAN FAUNA OF TOMAHAWK LAKE, WISCONSIN.

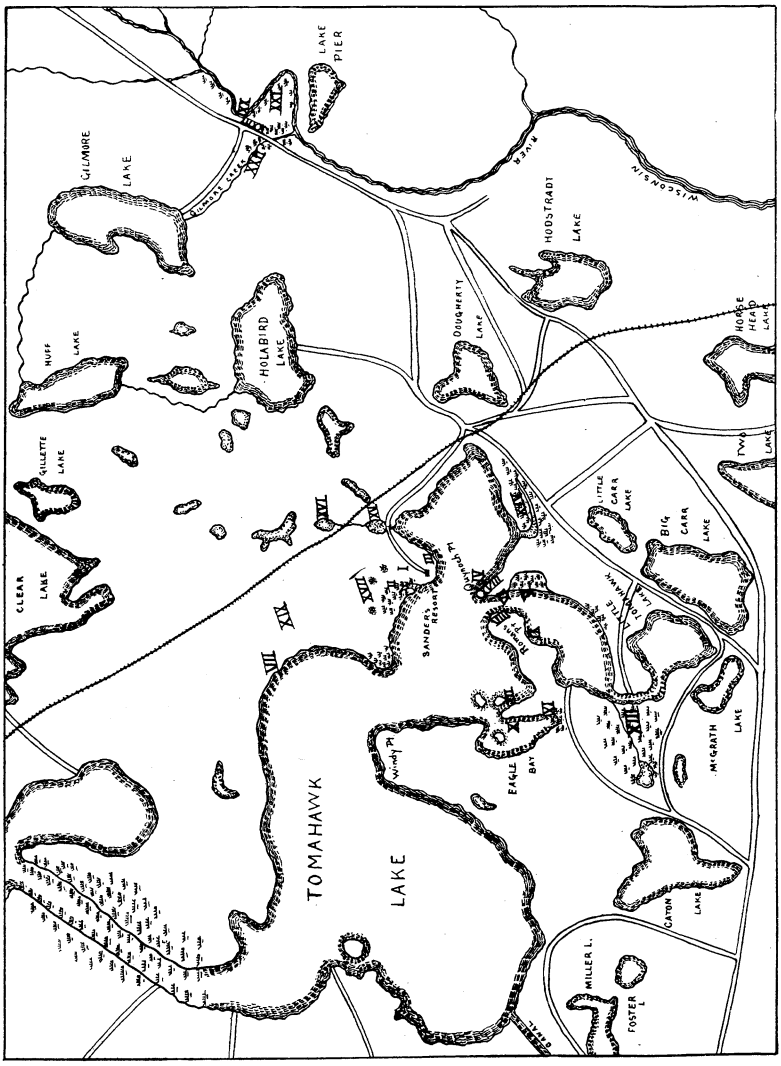
With Special Reference to its Ecology.

BY FRANK COLLINS BAKER.

Curator, The Chicago Academy of Sciences.

Of the states of the northern part of the Mississippi Valley, the Wisconsin molluscan fauna is the least known, although that of Minnesota is known but imperfectly. With this fact in mind, the writer planned his summer vacation of 1908 so that it included a three weeks' visit to Tomahawk Lake, in northeastern Wisconsin. But little systematic molluscan work has been done in Wisconsin, that of Mr. Chadwick ('02) being the most complete. Such work as that which Ruthven ('06), and Walker ('06, '09) have accomplished in the study of the Mollusca of Michigan is totally lacking.

The methods now in use for studying faunal areas are quite different from those in vogue a decade or more ago, the time honored annotated list being largely replaced by a discussion of the environment factors under which the organisms live. This ecological view point is of great value if properly interpreted, and when a large number of accurate papers based on studies of this kind have been published it will be possible to make many generalizations concerning the laws which govern the changes and formations of various habitats. The laws of succession are very interesting and very important and the study of these laws will help us not a little to understand the extinction of old species and the appearance of new ones in certain localities.


LAKE PIER
GILMORE LAKE
HUFF LAKE
HOLABIRD LAKE
HOOSTRADT LAKE
DOUGHERTY LAKE
HOOSE HEAD LAKE
TWO LAKE
GILLETTE LAKE
CLEAR LAKE
LITTLE CARR LAKE
BIG CARR LAKE
SANDER'S Resort
EAGLE BAY
McGRATH LAKE
TOMAHAWK LAKE
CATON LAKE
MILLER L.
FOSTER L.
WISCONSIN RIVER

An ecological study of the Mollusca entails not only a consideration of the mollusks themselves, but also of those animals and plants intimately associated with them, and the ecological study of any one group naturally includes, if exhaustively carried on, a fairly complete discussion of the biota of the area under consideration. Time and means, however, did not permit of an exhaustive study of the entire biota, and only a few animals, as well as some typical plants, were collected and noted.

My thanks are due the following persons: Mrs. Frank C. Baker, of Chicago; Mrs. Harry L. Burke, of Kansas City; Mr. Don Blanchard, of Chicago, and Mr. Claude Sanders, of Tomahawk Lake, for assistance in collecting; Mr. Bryant Walker, of Detroit, Michigan, and Dr. V. Sterki, of New Philadelphia, Ohio, for assistance in the determination of certain mollusks.

GENERAL TOPOGRAPHY.

Tomahawk Lake (plate XI) is situated on the line between Oneida and Villas counties. The drainage is into the Little Tomahawk River via Lake Kawaguesaga, a tributary of the Wisconsin River; the waters of this region, hence, belong to the Mississippi River drainage area. Tomahawk Lake is one of the numberous chains of lakes which dot this portion of the United States. It has been well said that no single area in the world includes so many lakes as does the country bordering the line between Canada and the United States, and Wisconsin may almost be said to lead in the number of its lakes, large and small.

The lake under discussion is situated in the area covered by the late Wisconsin ice sheet and the multitude of ponds and lakes is due to the agency of this huge glacier. The lake is over four miles long and about two miles wide at its widest point; its many bays and coves give it a shore line of over eighty miles. It occupies a depression of some thirty to about one hundred feet below the surrounding country, the banks in many places rising quite abruptly. The country surrounding the lake was originally covered with a heavy coniferous forest, but all that now remains is the area on the south side which has been set

aside as a state forest reservation. The lumbered portions to the north, east and west, are now covered with a second growth of deciduous woods, such as oak, maple and birch. (Fig. 1.)

Some years ago, a dam was constructed in an arm of Lake Kawaguesaga, west of the town of Minocqua, which raised the level of this lake and Tomahawk Lake three to four feet. This dam was built for the purpose of giving uniform flow to the Tomahawk River, and also to the Wisconsin River, for the transportation of lumber rafts. The result of raising the lake has been to submerge many low, flat tracts and convert them into swamps. One looks aghast at the wholesale manner in which fine trees have been killed by the rising of the water level, and the question it at once suggested as to why these trees were not cut and used before the dam was built; any competent engineer could have easily indicated the lands which would be submerged, and many thousands of feet of fine lumber might have been saved. These noble trees now stand in the shallow water, veritable skeletons whose bleached and outstretched arms proclaim man's short-sighted and wasteful use of nature's bountiful gifts.

The rising of the water and the consequent flooding of all points and low areas about the lake has produced a number of interesting habitats, besides providing several typical examples of molluscan succession. The time at the writer's disposal was too short to make a survey of the many lakes in the vicinity, large and small, or even to make more than a cursory reconnoissance of the western part of Tomahawk Lake. The large lake north of the thoroughfare, Lake Kawaguesaga, was not studied, although a comparison between this lake and Tomahawk Lake would doubtless produce some interesting results.

One day was spent in a study of the Wisconsin River at a point about four miles northeast of Tomahawk Lake. The river was high and swift and little work could be done on the Unionidæ. Gilmore Creek, a small tributary of the Wisconsin River, however, produced some interesting naiads. It is to be regretted that time was not available for a detailed examination of some of the larger lakes in the vicinity, which would doubt-

FIGURE 1

FIGURE 2

less reveal many interesting species not hitherto reported from Wisconsin.

Headquarters were established at Sanders' Resort on the north shore of the eastern arm of the lake and from this base all field operations were conducted. The Wisconsin River stations are mostly on land owned by Mr. Charles Sanders.

DISCUSSION OF BIOTA BY STATIONS

Station I. (Figure 2.)

Well-wooded area on high bluff above Sanders' Resort. The timber is second growth, following the cutting of the original coniferous forest, and consists principally of birch, maple, poplar and oak. The ground beneath this forest growth is thickly covered with rotting logs and bark, dead leaves and a thick carpet of vegetable mold. The hill slopes at a sharp angle, providing excellent drainage. Although there had been a prolonged drought the ground was moist under the leaves and large logs, showing that a well wooded tract of country holds the moisture, allowing it to seep through the soil and provide more or less permanent springs. These incipient forests were always dark and damp.

The small mollusks, as well as a number of beetles, were very abundant in this section, hiding under started bark, in crevices, under rotting logs and in any other place of concealment.

MOLLUSCA COLLECTED.

Zonitoides arboreus, very common.
Euconulus fulvus, rare.
Pyramidula cronkhitei catskillensis, common.
Pyramidula alternata, rare.
Helicodiscus parallelus, common.
Polygyra albolabris, very rare.
Strobilops virgo, common.

Station II. (Figure 3.)

Substation I.

A small bay, or bayou, west of Sanders' Resort. The water is from a foot to five or six feet in depth, and is filled with logs, which have been brought for use in Sanders' saw mill. Mollusks are abundant on the logs or in the shallow water near the shore.

MOLLUSCA COLLECTED.

Lymnæa emarginata wisconsinensis.
Planorbis binneyi.
Planorbis bicarinatus striatus.
Planorbis campanulatus rudentis.
Physa ancillaria warreniana.
Campeloma decisum.

Substation 2.

The swampy shores of substation I, caused by the raising of the water level of the lake. The water is shallow (a few inches to a foot in depth), the bottom is composed of soft, sticky mud of clayey character and is filled with algæ. Near the shore there is an area of *Typha latifolia,* which extends westward for a considerable distance. Above the Typha society there is the same second growth of forest as that mentioned under StationI.

MOLLUSCA COLLECTED.

Lymnæa columella.
Lymnæa lanceata.
Lymnæa obrussa.
Planorbis hirsutus.
Segmentina armigera.
Succinea retusa.
Musculium securis.
Pisidium abditum.

FIGURE 3

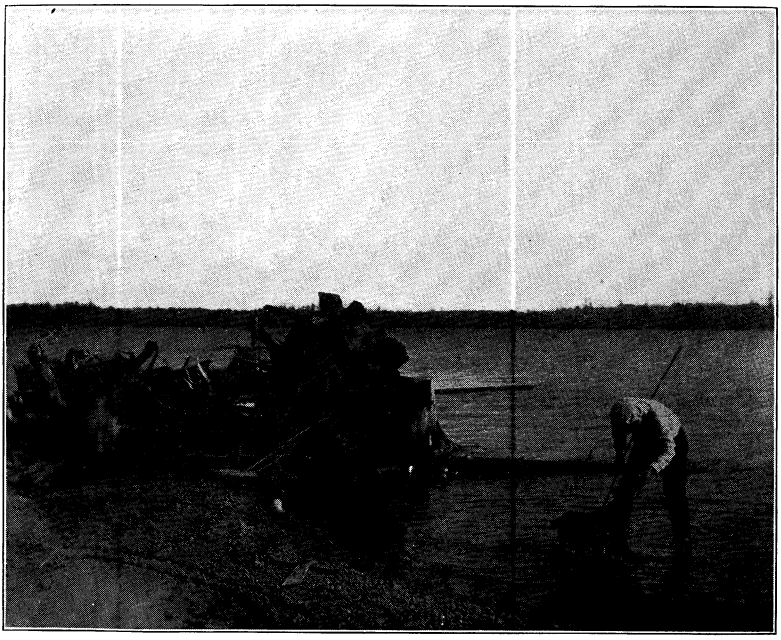


FIGURE 4

Station III. (Figure 4.)

Exposed north shore of Tomahawk Lake, near Sanders' Resort. The bottom is sandy and gradually deepens to ten or fifteen feet when it becomes very deep, at one place being reported as dropping suddenly to a depth of sixty feet. It is very shallow for a distance of fifteen or twenty feet, and especially so on a long point extending southeasterly into the lake for a distance of some thirty feet the water being scarcely a foot deep on the bar but falling suddenly to sixty feet just off the end of the point.

The sandy shore, thought in a most exposed situation, and subject to heavy surf action during northwesterly storms forms a well tenanted habitat for *Lymnæa emarginata, Campeloma decisum, Planorbis bicarinatus striatus* and *Physa ancillaria warreniana.* In the deep water many naiads abound. During heavy wind or storms the water is thrown over the ridge of sand forming the beach and collects in little pools which are inhabited by *Lymnæa* and *Physa,* with an occasional *Campeloma* washed in by the waves. These small pools were also good habitats for the Leopard Frog *(Rana pipiens).*

MOLLUSCA COLLECTED.

In Deep Water.

Anodonta grandis footiana.
Anodonta marginata.
Lampsilis luteola.

In Shallow Water.

Sphærium simile.
Amnicola cincinnatiensis.
Campeloma decisum.
Physa ancillaria warreniana.
Planorbis bicarinatus striatus.
Planorbis campanulatus.
Planorbis campanulatus rudentis.
Lymnæa emarginata wisconsinensis.

Of the above, *Amnicola* was represented only by dead shells, washed from some other habitat.

Station IV. (Figure 5.)

Substation 1.

South shore of Tomahawk Lake near Quynock Point, opposite Sanders' Resort. A small embayment affords a typical habitat for several mollusks. The bottom is of firm sand; the water near the shore is from ten to twenty inches in depth, rapidly deepening to ten, fifteen, twenty or more feet toward the lake. *Lymnæa emarginata wisconsinensis* is plentifully scattered over the sandy bottom, *Lymnæa stagnalis lillianæ* and *Planorbis binneyi* are abundant on the sandy bottom and on floating logs, and several species of naiads live in five to ten feet of water. Evidences of the muskrats' presence were seen in the shape of little piles of dead shells along the shore.

MOLLUSCA COLLECTED.

In Deep Water.

Lampsilis luteola.
Anodonta grandis footiana.
Anodonta marginata.

In Shallow Water.

Lymnæa stagnalis lillianæ.
Lymnæa emarginata wisconsinensis.
Planorbis binneyi.
Planorbis campanulatus.
Planorbis campanulatus rudentis.
Physa ancillaria warreniana.

Substation 2.

The shore of Substation 1 is swampy with a heavy growth of *Typha latifolia* and back of this plant society the ground rises and is heavily wooded with a coniferous forest. *Planorbis* and *Lymnæa* occur in fair number in this habitat, which is in great contrast with that of Substation 1.

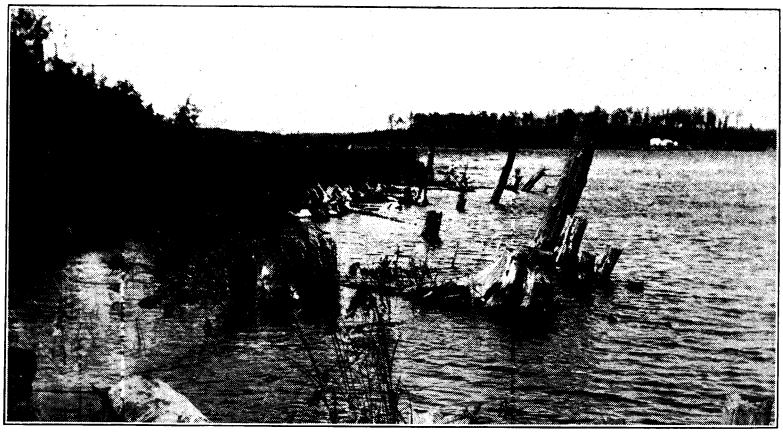


FIGURE 5

FIGURE 6

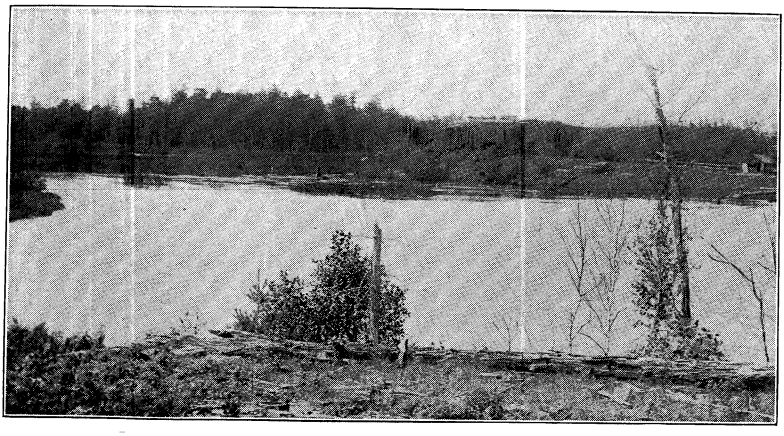


FIGURE 7

MOLLUSCA COLLECTED.

Planorbis trivolvis.
Lymnæa lanceata.

STATION V.

A large bay south of Quynock Point, formed by the raising of the level of the lake. A heavy sand bar, formed by wave action, encloses the bay. The water on the bar is from a foot to eighteen inches in depth; in the bay it increases to four and five feet and outside of the bar on the lake side, it deepens rapidly. The entrance to the bay is further closed by a large number of logs which form a tangled mass on the sand bar. The rising of the water has killed all of the trees formerly occupying the low area and the trunks of these dead trees stand in the water.

The enclosed bay affords an excellent habitat for a plant society consisting of pondweed *(Potamogeton),* white pond lily *(Castalia odorata)* and yellow pond lily *(Nymphœa advena).* Near the shore a *Typha latifolia* society is developing. Back of the shore the land rises abruptly and is thickly wooded, birch, spruce, pine and hemlock being the predominating trees.

The pond-lily society affords a habitat for *Planorbis binneyi, Physa ancillaria, Lymnæa lanceata, Amnicola cincinnatiensis* and *Ancylus parallelus.* The under side of the lily leaf is usually chosen as a resting place, and is doubtless used as a feeding ground also. *Musculium securis* and *Planorbis* are plentiful in algæ, the bay being filed with this plant near the shore. The logs are tenanted by *Planorbis binneyi, Physa ancillaria warreniana* and *Lymnæa lanceata.*

MOLLUSCA COLLECTED.

Musculium securis.
Planorbis hirsutus.
Planorbis binneyi.
Lymnæa lanceata.
Ancylus parallelus.
Physa ancillaria warreniana.
Amnicola cincinnatiensis.

Station VI.

Sand Bar and Exposed Lake Shore North of Station V.

This habitat is occupied principally by *Lymnœa emarginata wisconsinensis* which thickly covers the sand and the rocks of the shore.

MOLLUSCA COLLECTED.

Lymnœa emarginata wisconsinensis.
Planorbis campanulatus.
Planorbis campanulatus rudentis.
Physa ancillaria warreniana.

Station VII. (Figure 6.)

Exposed shore north side of lake, three miles west of Sanders' Resort (old logging camp No. 7). The beach is sandy, shallow and slopes gradually into deep water. The land back of the beach is elevated three feet or more above the beach and forms a flat plain for a considerable distance. Several species of mollusks live on this exposed beach, their dead shells with other debris forming a distinct line at high water mark. *Lymnœa emarginata wisconsinensis* is here the most abundant mollusk, and its shell shows all degrees of variation between elongated and globose. *Lymnœa stagnalis lillianæ* also shows much variation in the form of the shell. *Amnicola* consisted only of dead, bleached shells which had doubtless been washed from a nearby habitat.

MOLLUSCA COLLECTED.

Campeloma decisum (living and dead).
Amnicola cincinnatiensis (dead).
Physa ancillaria warreniana (dead).
Planorbis campanulatus (living and dead).
Planorbis campanulatus rudentis (living and dead).
Planorbis bicarinatus striatus (living and dead).
Lymnœa stagnalis lillianæ (living and dead).
Lymnœa emarginata wisconsinensis (living and dead).

Station VIII.

Point of land opposite (west of) Quynock Point. The beach is shallow and sandy; it is exposed to the full force of the waves on the north and west side, but on the south and southwest side it is more or less protected, and in this situation the majority of the mollusks live. A few hardy individuals of *Lymnæa emarginata wisconsinensis* brave the roughness of the west side.

Mollusca collected.

Lymnæa emarginata wisconsinensis.
Planorbis bicarinatus striatus.
Physa ancillaria warreniana.
Campeloma decisum.

Station IX.

Protected bay-like area on east side of long point opposite Quynock Point. The water is shallow (5 to 18 inches in depth) and the botton is sandy. Back of this is a swampy area. Several species of *Lymnæa, Planorbis* and *Physa* inhabit the sandy beach in shallow water. A few individuals prefer the logs which are scattered about.

Mollusca collected.

Lymnæa stagnalis lillianæ.
Lymnæa lanceata.
Planorbis binneyi.
Planorbis campanulatus.
Planorbis campanulatus rudentis.
Physa ancillaria warreniana.

Station X.

Eagle Bay, a small enclosed bay on the south side of Tomahawk Lake, about three-quarters of a mile long and less than a quarter of a mile wide. The shores are sandy and rapidly fall away into deep water. On the sandy shores several mollusks live in considerable number.

MOLLUSKS COLLECTED.

Lymnæa stagnalis lillianæ.
Planorbis campanulatus.
Planorbis campanulatus rudentis.
Physa ancillaria warreniana.
Anodonta marginata.
Lampsilis luteola.

Station XI.

The southern end of Eagle Bay is very swampy, a condition due in large measure to the rising of the lake. The swamp is bordered by a *Typha latifolia* society. The water is shallow and is filled with floating logs, while stumps and trunks of dead trees are standing in profusion. The bottom is of carbonaceous mud and the open spaces are ocupied by a plant society consisting of *Castalia odorata* and *Nymphœa advena.* The pondweed *(Potamageton)* is also present. *Lymnæa columella* lives on the under side of pond-lily leaves while *Lymnæa lanceata* prefers the sandy, or muddy, shore in shallow water.

MOLLUSCA COLLECTED.

Lymnæa columella.
Lymnæa lanceata.

Station XII.

An island, situated at the mouth of Eagle Bay. The shores are sandy and the water quite shallow. On the southeastern side of the island, where there is protection from the westerly storms, considerable driftwood has collected, which is inhabited by several mollusks.

MOLLUSCA COLLECTED.

Planorbis campanulatus rudentis.
Planorbis bicarinatus striatus.
Physa ancillaria warreniana.

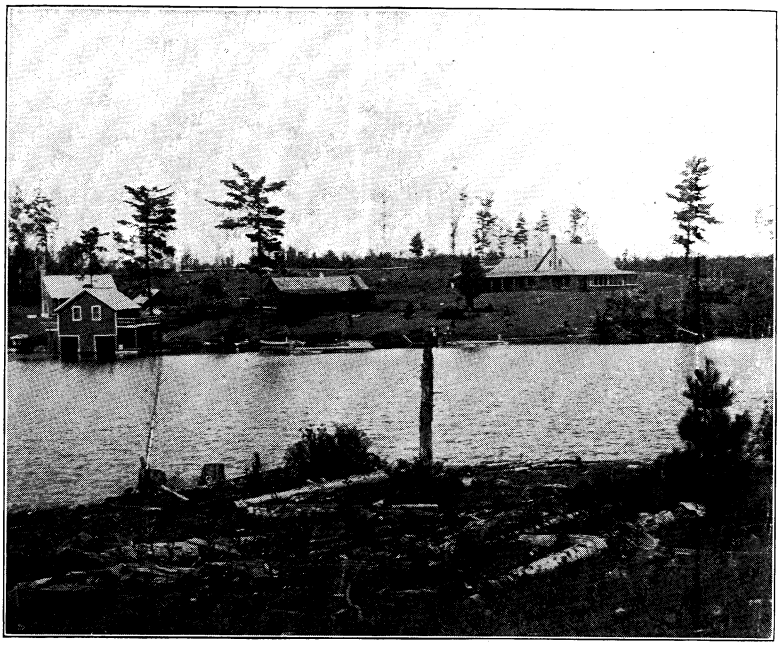


FIGURE 8

FIGURE 9

Station XIII. (Figures 7, 8, 9.)

Swamp at head of thoroughfare between Tomahawk and Little Tomahawk Lake. The swamp is of large size (Figure 7) extending in a westerly direction well into the wooded portion of the country. A deep creek meanders through the swamp, but outside of this the water is very shallow in many places, scarcely covering the boggy bottom, which in places extends above the water, forming miniature islands of soft, starchy consistency.

The deep water of the thoroughfare is inhabited by a pond-lily society consisting of *Castalia odorata, Nymphæa advena* and *Potamogeton natans.* The swampy portion is thickly covered with a *Typha latifolia* society with a few *Scirpus lacustris.* The shores rise abruptly from the swamp and are thickly clothed with a spruce, hemlock, cedar and birch forest. As in all of the bays of Tomahawk Lake, this swamp is filled, near the shore, with the dead trunks of trees killed by the rising of the water.

This station was one of the best for molluscan life, the eight species tabulated, living here in large numbers.

Substation 1.

Shore, Floating Logs or Boggy Islands Near the Shore.

Planorbis binneyi.
Lymnæa lanceata.
Lymnæa megasoma.
Lymnæa stagnalis appressa.

Bulimnea megasoma was found on the boggy islands and on logs near the shore, one or two specimens only being seen in one place, the species not being gregarious, apparently.

Substation 2.

Castalia-Nymphæa Plant Society.

Amnicola cincinnatiensis.
Physa ancillaria warreniana.
Planorbis campanulatus.
Lymnæa columella.

Station XIV.

Creek at east end of Lake, near town of Tomahawk Lake. The creek is on the south side and extends well into the shore where a wide area of swamp has been formed by the rising of the water level. The creek is quite deep, but the swamp is barely covered with water in many places, though spots occur where the water is several feet deep; the bottom is covered with soft mud. A *Castalia odorata* and *Nymphæa advena* society occupies the creek while a heavy *Typha latifolia* society with *Pontederia cordata* occupies the swampy portion

Substation I.

The following mollusks were common on the under side of the lily pads:

Lymnæa columella.
Ancylus parallelus.
Physa ancillaria warreniana (young).
Planorbis parvus.
Amnicola cincinnatiensis.

Substation 2.

On logs and on the shore in the shallow water of the flooded area, where the habitat is protected from the rough water of the mouth of the creek.

MOLLUSCA COLLECTED.

Lymnæa lanceata.
Planorbis bicarinatus unicarinatus.
Planorbis trivolvis.

Substation 3..

Entrance to creek, which is deep, the shores sandy and the water shallow for some ten or twelve feet where it becomes quite deep. The snails were observed on sticks and logs and on the sandy bottom. The naiads were plentiful on the sandy beach in water from ten to thirty inches in depth.

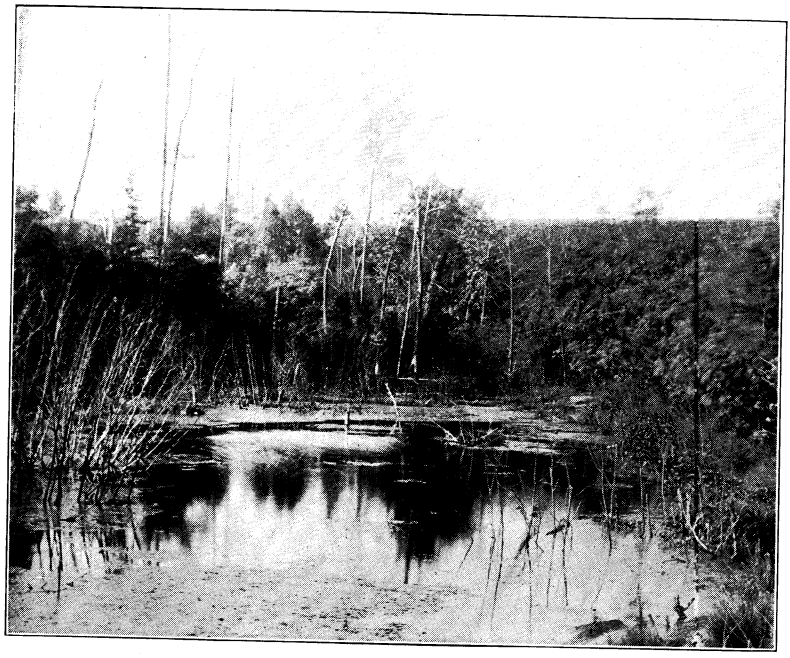


FIGURE 10

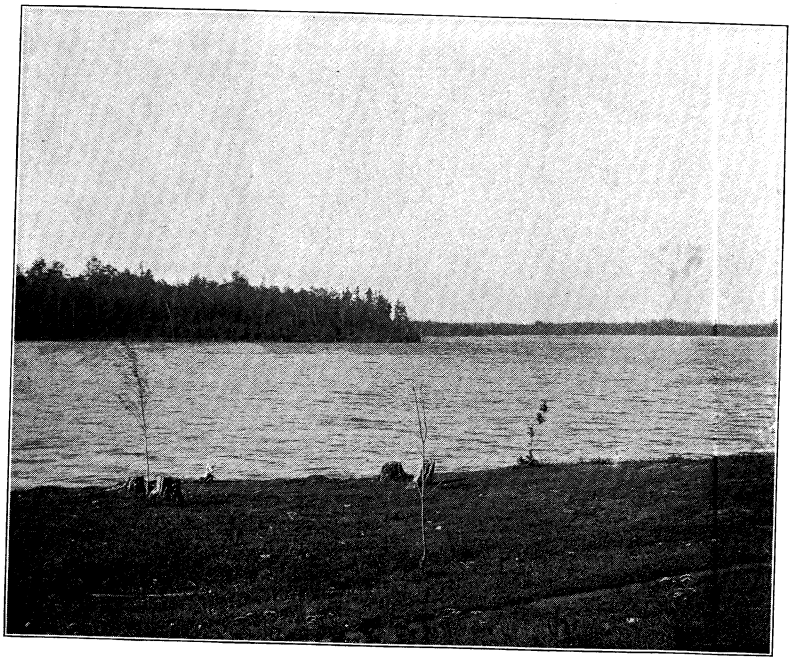


FIGURE 11

MOLLUSCA COLLECTED.

Anodonta grandis footiana.
Anodonta marginata.
Planorbis binneyi.
Planorbis campanulatus.
Lymnæa stagnalis lillianæ.

Station XV. (Figure 10.)

Swampy pond at Sanders' "minnow-box," north side of lake, near Sanders' Resort. This station has been artificially produced by damming a little creek which flows from a small lake north of the Northwestern Railroad embankment. This barrier has caused the formantion of a shallow, stagnant pond, from six inches to about four feet in depth. The bottom is now very muddy, although originally hard and firm, showing the rapid decay and acumulation of plant humus. The water is thickly filled with *Chara* and the surface with *Spirogyra.* A large amount of duckweed *(Spirodela)* is scattered over the surface, as well as a species of *Lemna.* The trees surrounding this pond are nearly all second growth and embrace birch, oak, elm and poplar. The photograph shows a number of dead bushes, killed by the rising of the water.

Mollusks were common either swimming near the surface or crawling over the bottom. The vegetation on the surface of the pond was so thick that it was necessary to clear a patch of water before the mollusks could be seen. *Planorbis* was more frequently seen on the bottom, while *Lymnæa* seemed to prefer sticks or old logs in the water, or the vegetation. *Physa* was observed on the bottom or on logs, while *Musculium* was found only in the vegetation. *Segmentina* was seen only on logs and sticks.

MOLLUSCA COLLECTED.

Lymnæa lanceata.
Planorbis bicarinatus unicarinatus.
Planorbis trivolvis.
Segmentina armigera.
Physa ancillaria warreniana.
Musculium securis.

Station XVI.

Bass Lake one mile north of Sanders' Resort. A small lake, with soft, mucky bottom, occupying a deep hollow or kettle hole. A stream flows from the lake into the artificial pond at Station XV. The only mollusk observed was *Physa ancillaria warreniania.*

Station XVII.

Small pools in swales (kettle holes) west of Sanders' Resort. The whole country is rolling, and every depression contains a small pond or swampy pool. The ground is very marshy, the vegetation consisting of *Iris* and *Typha,* besides a kind of swamp grass. The plants in this vicinity were literally swarming with aphids. *Pisidium* was the principal mollusk observed, though a few *Ancylus* and *Planorbis* were secured from the surface of sticks.

MOLLUSCA COLLECTED.

Ancylus parallelus.
Planorbis parvus.
Pisidium abditum.
Pisidium roperi.
Musculium rosaceum.

FIGURE 12

FIGURE 13

Station XVIII. (Figures 11, 12.)

Woods on Quynock Point. This piece of woodland is a part of the Wisconsin forest reservation and is nearly all virgin forest, with the vast accumulation of debris characteristic of such a region. Among the forest trees are white pine, spruce, hemlock, white cedar, birch and poplar. The curious ground pine *(Lycopodium obscurum)* is also common. The ground is covered with moss and the trees with lichens. Rotten logs are scattered over the ground in endless profusion affording excellent concealment for the smaller helices. Curiously enough, no shells were found in birch logs, but were plentiful in pine and poplar logs. Mollusks were numerous in individuals but few in species.

MOLLUSCA COLLECTED.

Zonitoides arboreus.
Pyramidula cronkhitei catskillensis.
Strobilops virgo.

Station XIX. (Figure 13.)

Virgin woods near logging camp No. 7, known locally as the cyclone woods. The character of this habitat is the same as that of the Quynock Point station. The trees are also the same, with the addition of oak, maple and balsam fir.

MOLLUSCA COLLECTED.

Zonitoides arboreus.
Strobilops virgo.
Pyramidula cronkhitei catskillensis.
Helicodiscus parallelus.

Station XX.

Wisconsin River, four miles northeast of Sanders' Resort. The river meanders here considerably, the curves being long and sweeping. The river bottom is sandy mud. The flood plain

varies in extent from a few feet to a quarter of a mile in width, in the latter case a marsh being formed. The banks of the river are lined with heavy thickets with here and there a forest growth of maple, birch, etc., extending to the water. Several species of swamp grass occupy the flood plain, and *Iris* and *Typha* societies are scattered over the area, in the vicinity of pools.

The river has a very swift current, forming an ideal environment for naiads, a number of species of which live in this habitat. The larger and heavier mussels live in deep water, but *Lampsilis luteola,* together with *Sphærium* and *Campeloma,* seem to prefer the shallows near the shore. *Campeloma* was also plentifully distributed over the surface of floating logs. *Lymnæa humilis modicella* was observed to cover the exposed mud flats along the edge of the water.

STATION I.

Deep Water of Wisconsin River.

Lampsilis ligamentina.
Lampsilis recta.
Lampsilis ventricosa.
Quadrula undulata.

Substation 2.

Shallow Water Along Shore of River.

Lampsilis luteola.
Sphærium striatinum.
Pisidium virginicum.
Campeloma decisum.

Substation 3.

Muddy Flats Above High Water.

Lymnæa humilis modicella.
Succinea retusa.

Station XXI.

Swampy tracts along margin of river, separated from the latter by a high ridge. These depressions vary in extent from a few feet to several hundred feet in diameter, and also vary in depth. The vegetation consists of swamp grass, *Iris* and *Typha*.

MOLLUSCA COLLECTED.

Sphærium occidentale.
Musculium partumeium.
Pisidium subrotundum.
Physa gyrina.
Aplexa hypnorum.
Planorbis hirsutus.
Segmentina armigera.
Vitrea hammonis.

It is noteworthy that the mollusk fauna of this station is similar to that noted in some of the summer dry ponds of the Skokie Marsh area in Illinois.

Station XXII.

Gilmore Creek, a small tributary of the Wisconsin River, emptying into the latter four miles northeast of Sanders' Resort. The water is shallow, from a few inches to two or three feet in depth, and the bottom consists of clean, firm sand. The current is swift and the water clear. Naiads are abundant buried in the sand in company with *Campeloma*. Muskrat heaps are a common sight, showing that this animal resorts frequently to this region for its food supply. The preponderance of pelecypods at this station is notable.

MOLLUSCA COLLECTED.

Lampsilis luteola.
Lampsilis ventricosa.
Lampsilis ligamentina.
Strophitus edentulus.
Anodonta grandis footiana.
Anodonta marginata.
Anodonta implicata.
Symphynota costata.
Symphynota compressa.
Campeloma decisum.

Station XXIII.

Mucky slough in marsh near mouth of Gilmore Creek. The water is shallow (eight inches to a foot or more) and the muddy bottom, which is composed of soft, impalpable, black mud formed from vegetable decomposition, is from two to six feet in depth. The pool is bordered by *Iris, Typha* and swamp grass and is partly filled with old logs.

This slough is the best habitat for *Bulimnea megasoma* which has come under the writer's observation, the specimens being numerous as well as large and of fine color. The individuals were observed attached to logs and other floating debris, as well as on the soft mucky bottom. *Planorbis binneyi* and *Bulimnea* were the only mollusks present.

COMPARISON OF THE FRESH-WATER MOLLUSCAN LIFE OF THE DIFFERENT STATIONS.

(See Table.)

The twenty-three stations and twelve substations previously considered contain a variety of molluscan life. Upon analyzing this life, a division is at once apparent, based on the kind of habitat. This analysis is tabulated below.

Species living on sandy shore subject more or less to rough water.

Lampsilis luteola.
Anodonta marginata.
Anodonta grandis footiana.
Sphærium simile.
Campeloma decisum.
Physa ancillaria warreniana.
Planorbis campanulatus.
Planorbis campanulatus rudentis.
Planorbis bicarinatus striatus.
Planorbis binneyi.
Lymnæa stagnalis lillianæ.
Lymnæa stagnalis wisconsinensis.

Species living in enclosed or sheltered bays which are connected with the open lake and in which the water never becomes stagnant.

Anodonta grandis footiana.
Anodonta marginata.
Physa ancillaria warreniana.
Planorbis campanulatus.
Planorbis campanulatus rudentis.
Planorbis bicarinatus striatus.
Planorbis binneyi.
Lymnæa stagnalis lillianæ.
Lymnæa lanceata.

Species living on *Castalia-Nymphœa* society is clear water of creek or in enclosed bay.

Amnicola cincinnatiensis.
Physa ancillaria warreniana.
Ancylus parallelus.
Planorbis parvus.
Planorbis hirsutus.
Planorbis campanulatus.
Planorbis campanulatus rudentis.
Lymnæa columella.

Species living in swampy ponds or in Typha plant societies where the water is more or less stagnant.

Sphærium occidentale.
Musculium partumeium.
Musculium securis.
Pisidium subrotundum.
Pisidium abditum.
Physa gyrina.
Aplexa hypnorum.
Ancylus parallelus.
Segmentina armigera.
Planorbis hirsutus.
Planorbis bicarinatus unicarinatus.
Planorbis trivolvis.
Planorbis binneyi.
Lymnæa stagnalis appressa.
Lymnæa columella.
Lymnæa megasoma.
Lymnæa lanceata.
Lymnæa obrussa.

Species living in swales.

Musculium rosaceum.
Pisidium abditum.
Pisidium roperi.
Ancylus parallelus.
Planorbis parvus.

Species living in river with swift current.

Lampsilis ventricosa.
Lampsilis luteola.
Lampsilis ligamentina.
Lampsilis recta.
Quadrula undulata.
Sphærium striatinum.
Pisidium virginicum.
Campeloma decisum.

Species living in creek with sandy bottom and clear, cold water; current swift.

Lampsilis ventricosa.
Lampsilis luteola.
Lampsilis ligamentina.
Strophitus edentulus.
Anodonta marginata.
Anodonta implicata.
Anodonta grandis footiana.
Symphynota costata.
Symphynota compressa.
Campeloma decisum.

These tables may be further analyzed as follows:

	Total number.	Peculiar to this habitat.
1. Open shore	12	4
2. Enclosed or sheltered bays	9	..
3. Castalia—Nymphæa society	8	..
4. Swampy ponds	18	15
5. Swales	5	2
6. Swift current of river	7	4
7. Swift current of creek	10	4

It will be seen that number four (swampy ponds) produces the greatest number of species (18) as well as the greatest number of peculiar forms (15). The open shore produces twelve species with but four peculiar. A number of species also live in several of the habitats.

Anodonta marginata in 1, 2, 7.
Anodonta grandis footiana in 1, 2, 7.

Lampsilis luteola in 1, 6, 7.
Lampsilis ventricosa in 6, 7.
Lampsilis ligamentina in 6, 7.
Campeloma decisum in 1, 6, 7.
Physa ancillaria warreniana in 1, 2, 3.
Planorbis campanulatus rudentis in 1, 2, 3.
Planorbis bicarinatus striatus in 1, 2.
Planorbis binneyi in 1 2, 4.
Planorbis parvus in 3, 5.
Ancylus parallelus in 3, 4, 5.
Lymnæa stagnalis lillianæ in 1, 2.
Lymnæa lanceata in 2, 4.
Lymnæa columella in 3, 4.

The largest number of species was produced by Stations III and XXII, each having ten. These stations are respectively the open shore and the cold, clear creek. 6, 7 and 8 species were common in several stations. It is of interest to note that though fifty-three species were secured from the entire area, yet the largest number of species from any one area was ten, a few produced six and seven, and while the majority were less than five, the average for the twenty-three stations was about six. This low average is indicative of a wide range of habitat variation, a condition which has already been seen to exist in this area.

MOLLUSCAN SUCCESSION.

Tomahawk Lake presents a unique example of molluscan succession, a condition due to the raising of the water for storage purposes. So markedly has this change of level altered the shore in many places that a complete revolution has taken place in the biota. Originally, the lake was encircled by sandy shores with but few swampy areas. The elevation of the lake level has changed this condition in many places, and at the present time swamps are abundant along the shore. All of the low flats have been submerged, the points extending under water for a considerable distance as sandy beaches and the low flats forming swamps or bays, the dead trees standing in three or four feet of water.

Succession here has been in reverse order from that usually seen, i. e., the encroaching of one plant and animal society upon another, causing in the case of a pond, its gradual filling up and destruction. It has here been a change from dry land to swamps. However, it will be studied from the usual point and its artificial origin will be ignored in the present discussion. Stations V, XI and XIV, are the best examples of succession.

Primal Condition, the Open Lake Shore.

(Figures 4, 5.)

In this primal stage, the shore is bordered by a shelving, shallow, sandy beach, which is subject to wave action to a greater or less degree. Such mollusks as the following occupy this habitat:

Lampsilis luteola.
Anodonta marginata.
Anodonta grandis footiana.
Sphærium simile.
Compeloma decisum.
Physa ancillaria warreniana.

Planorbis campanulatus.
Planorbis campanulatus rudentis.
Planorbis bicarinatus striatus.
Planorbis binneyi.
Lymnœa stagnalis lillianæ.
Lymnœa emarginata wisconsinensis.

Enclosed Bay Succession.

(Figure 9.)

The rise of the water overflows the lower portions of the shore, producing enclosed bays, which soon become filled with such plants as pondweed *(Potamogeton)*, white pond-lily *(Castalia odorata)* and yellow pond-lily *(Nymphœa advena)*. The mollusks of such a habitat are:

Anodonta grandis footiana.
Anodonta marginata.
Amnicola cincinnatiensis.
Physa ancillaria warreniana.
Ancylus parallelus.
Planorbis hirsutus.
Planorbis campanulatus.
Planorbis campanulatus rudentis.
Planorbis bicarinatus striatus.
Planorbis binneyi.
Lymnœa stagnalis lillianæ.
Lymnæa columella.
Lymnæa lanceata.

It will be noted that four species *(Lampsilis, Sphœrium, Campeloma* and *Lymnœa emarginata wisconsinensis)* have disappeared, while five species *(Amnicola, Ancylus, Planorbis hirsutus, Lymnæa columella* and *Lymnaea lanceata)* have been added. This change of species well illustrates the influence of a changing environment.

Swamp Succession. (Figure 3).

The water rises still higher and overflows meadow-like areas producing large open swamps (as at station XIII) or, small-ponded areas. The water is shallow, the bottom is usually muddy or boggy and the vegetation consists chiefly of *Typha latifolia* and several species of sedge. A considerable change is noted in the character of the mollusks.

Musculium securis.
Pisidium abditum.
Pisidium subrotundum.
Ancylus parallelus.
Segmentina armigera.
Planorbis hirsutus.
Planorbis bicarinatus unicarinatus.
Planorbis trivolvis.
Planorbis binneyi.
Lymnæa stagnalis appressa.
Lymnæa megasoma.
Lymnæa lanceata.
Succinea retusa.

It will be noted that the Pelecypods are represented only by the small *Musculium* and *Pisidium* and the Gastropods all belong to the fresh-water Pulmonates (excepting *Succinea.)* Only four species are the same as those in the previous succession (*Ancylus, Planorbis hirsutus, Planorbis binneyi, Lymnæa lanceata),* nine species or about 66 per cent. being new to the environment. Only one species, *Planorbis binneyi,* persists throughout the last three successions.

Swale Succession.

Should the level of the water fall a foot or more, a fourth succession would develop in certain places, in which small swampy pools or swales would be developed. Such a habitat

would contain (as several stations in this area have been found to).

Musculium rosaceum.
Pisidium roperi.
Ancylus parallelus.
Planorbis parvus.

The fresh-water species have here been reduced to five species.

Land Shell Succession.

Figure 13.

Should this area become dry it would soon be covered with such trees as birch, white spruce, tamarack, etc., and the following land mollusks would completely replace the fresh-water pulmonates.

Helicodiscus parallelus.
Pyramidula cronkhitei catskillensis.
Zonitoides arboreus.
Vitrea hammonis.
Strobilops virgo.

Though not observed continuously in one place, the above five successions have been seen within a radius of one mile; the first three, however, have occurred in one small area, during the few years which have passed since the water was raised.

TAXONOMY.

An analysis of the fifty-three species of mollusks recorded in the systematic catalog reveals several interesting facts. It is at once seen that the Gastropods (32) exceed the Pelecypods (21) almost three to two. The Gastropods divide naturally into three groups as follows:

Prosobranchiates	2
Land pulmonates	9
Fresh-water pulmonates	21

The large preponderance of the fresh-water pulmonates is noteworthy. A large portion of this excess is divided between Planorbis and Lymna, each with seven and eight species* respectively. This is to be expected, however, as these genera are typically northern in distribution, the number of species increasing largely in the boreal zone. Of the naiads, the Wisconsin River and its tributaries produced nine species while the lake produced but three, which is in accord with the well known fact that this family is typically an inhabitant of rivers.

The mollusk fauna of this region includes two elements; first, the species which are widely distributed throughout the greater portion of North America, and, second, those species which are purely boreal in distribution. These two elements may be compared in the subjoined tables.

Widely Distributed Species.

Lampsilis luteola.
ventricosa.
ligamentina.
recta.
Strophitus edentulus.
Anodonta marginata.
implicata.
grandis footiana.
Symphynota costata.
compressa.

* In this analysis varieties are treated as species for convenience.

Quadrula undulata.
Sphærium simile.
striatinum.
occidentale.
Musculium partumeium.
securis.
rosaceum.
Pisidium abditum.
roperi.
virginicum.
subrotundum
Campeloma decisum.
Amnicola cincinnatiensis.
Physa gyrina.
Aplexa hypnorum.
Ancylus parallelus.
Segementia armigera.
Planorbis parvus.
hirsutus.
trivolvis.
bicarinatus unicariatus.
bicarinatus striatus.
campanulatus.
Lymnæa stagnalis appressa.
columella.
humilis modicella.
obrussa.
Succinea retusa.
Strobilops virgo.
Helicodiscus parallelus.
Pyramidula alternata.
Vitrea hammonis.
Euconulus fulvus.
Zonitoides arboreus.
Polygyra albolabris.

BOREAL SPECIES.

Planorbis campanulatus rudentis.
Planorbis binneyi.
Physa ancillaria warreniana.
Lymnæa stagnalis lillianæ.
Lymnæa megasoma.
Lymnæa lanceata.
Lymnæa emarginata wisconsinensis.
Pyamidula cronkhitei catskillensis.

The very great preponderance of the widely distributed (45) over the boreal (8) species is brought out strikingly in the tables. The land shells secured from this region are of no special interest, being of general distribution throughout a large portion of the United States and Canada. The same may be said of the Pelecypods.

Among the fresh-water pulmonates, however, there are several species of unusual interest. Two new forms of Lymnæa

were discovered, besides a recently described variety of Planorbis not before recorded from the state. Comparing the catalog with Chadwick's published list, it is found that a number of species have not been previously recorded from the state. These additions (13) to the Wisconsin fauna are as follows:

Strobilops virgo.
Lymnæa stagnalis lillianæ.
Lymnæa lanceata.
Lymnæa emarginata wisconsinensis[1].
Planorbis binneyi[2].
Planorbis bicarinatus unicarinatus.
Planorbis campanulatus rudentis.
Anodonta marginata.
Musculium securis.
Musculium rosaceum.
Pisidium abditum.
Pisidium roperi.
Pisidium subrotundum.

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1 Bull. Wis. Nat. Hist. Soc., IV, pp. 67–99.
1 The species reported on p. 80 of Chadwick's list as *decollata* is *emarginata angulata* Sowb.
2 No. 51a of Chadwick's list is this species.

SYSTEMATIC CATALOG OF SPECIES.

(See Table.)

Class **PELECYPODA.**

ORDER PRIONODESMACEA.

Superfamily NAIADACEA.

Family UNIONIDAE.

Genus **Lampsilis** Rafinesque.

1. *Lampsilis ventricosa* (Barnes).

   Station XX[1], XXII. Apparently not common as only three specimens were found.

2. *Lampsilis luteola* (Lamarck).

   Stations III, IV[1], X, XX[2], XXII. The luteolas inhabiting Tomahawk Lake and vicinity are apparently closely related to Marsh's *superiorensis,* which is undoubtedly a variety or race of *luteola*[1]. Some specimens answer well to the original description and figures. The shape of the shell, however, is rather of the *luteola* type than of the *superiorensis* type. The specimens are all small (60 to 70 mill.) and vary from unicolored to distinctly rayed. The surface varies from smooth and shining to rough and scabrous. The hinge teeth are thin, especially the cardinal teeth, which are rather weak. All of the stations in which this species was found were of the rough water type.

3. *Lampsilis ligamentina* (Lamarck).

   Station XX[1], XXII. Specimens of this species from the Wisconsin River are quite normal, though small, and distinctly rayed. The Gilmore Creek examples are more quadrangular in outline and less distinctly rayed. Both inhabit swiftly running water.

4. *Lampsilis recta* (Lamarck).

   Station XX[1].

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1 Nautilus, x, p. 103, pl. 1, figs. 1, 2, 5, 1897.

Genus **Strophitus** Rafinesque.

5. *Strophitus edentulus* (Say).

Station XXII. The examples of this species are rather small and the shells are thinner than in individuals from farther south.

Genus **Anodonta** (Bruguiére) Lamarck.

6. *Anodonta marginata* (Say).

Stations III, IV[1], X, XIV[3], XXII. The individuals of this Anodonta are usually very uniform. At Station X the specimens vary from the usual cylindrical shape to one approaching Anthony's *irisans,* with a marked postero-dorsal ridge. All inhabit rough or running water. This is a common species in Wisconsin, though not mentioned in Chadwick's list.

7. *Anodonta implicata* (Say).

Station XXII. Apparently typical.

8. *Anodonta grandis footiana* (Lea).

Stations III, IV[1], XIV[3], XXII. This race is quite typical and shows little variation. The stations are all in rough or running water, which accounts, in some measure, for the small size and uniformity of the individuals. At Station III, the open lake shore, *footiana* forms a large bed, associated with *Lampsilis luteola.* which the muskrats have made good use of. A hollow tree trunk on the shore of this lake was found filled with the empty shells of *Anodonta* and *Lampsilis,* evidently representing the "dining hall"of a muskrat.

Genus **Symphynota** Lea.

9. *Symphynota costata* (Barnes).

Station XXII. Common and typical.

10. *Symphynota compressa* (Lea).

Station XXII. One specimen of *compressa* was found in a lot of *costata.* It is evidently rare at this station.

Genus **Quadrula** (Rafinesque) Agassiz.

11. *Quadrula undulata* (Barnes).
Station XX[1]. Only one specimen found.

Order TELEODESMACEA.

Superfamily CYRENACEA.

Family SPHAERIIDAE.

Genus **Sphaerium** Scopoli.

12. *Sphærium striatinum* (Lamarck).
Station XX[2]. Common on sandy bottom, near high-water line.
13. *Sphærium simile.* (Say).
Station III. A single valve of this species was found on the lake share.
14. *Sphærium occidentale.* Prime.
Station XXI. Common and typical in swamps bordering the Wisconsin River.

Genus **Musculium** Link.

15. *Musculium partumeium* (Say).
Station XXI. All the specimens secured were immature.
16. *Musculium securis* (Prime).
Stations II[2], V, XV. The specimens secured are all rather small, none exceeding seven mill. in length. All were collected in swampy bays or ponds. Not mentioned in Chadwick's list.
17. *Musculium rosaceum.* (Prime).
Station XVII. A frequent species in the small pools which occupy most of the kettle holes in this region.

Genus **Pisidium** Pfeiffer, 1824.

18. *Pisidium abditum* Hald.
Station II[2], XVII. Common and variable.
19. *Pisidium roperi* Sterki.
Station XVII. Common associated with the last species.

20. *Pisidium subrotundum* Sterki.

Station XXI. Fairly abundant in swampy places along the Wisconsin River.

21. *Pisidium virginicum* Gmelin.

Station XX^2. Common in the sandy shore of the Wisconsin River, in shallow water associated with *Sphærium striatinum, Campeloma* and *Lampsilis luteola.*

Numbers 17, 18 and 19 are not in Chadwick's list.

Class **GASTROPODA.**

Order PROSOBRANCHIATA.

Family VIVIPARIDAE.

Genus **Campeloma** Rafinesque.

22. *Campeloma decisum* (Say).

Stations II^1, III, VII, VIII, XX^2, XXII. *Campeloma decisum* is abundant in this region on sandy shores in rough or rapidly moving water. The Wisconsin River habitat was the best and furnished the largest and finest specimens. The current here is very swift and the Campelomas bury themselves completely in the sand or rest on the lee side of anchored logs. Some specimens approach *Campeloma milesi,* but lack the peculiar rounded whorls so characteristic of the Michigan species.

Family AMNICOLIDAE.

Genus **Amnicola** Gould and Haldeman.

23. *Amnicola cincinnatiensis* (Lea).

At Stations V, XII^2 and XIV^1 this species lives in abundance, its habitat being the under side of lily leaves. At stations III and VII the dead shells were found in shore debris, evidently washed from the sheltered bays.

Sub-Class EUTHYNEURA.

Order PULMONATA.

Sub-Order BASOMMATOPHORA.

Family PHYSIDAE.

Genus **Physa** Draparnaud.

24. *Physa ancillaria warreniana* Lea.

Stations II[1], III, IV[1], V, VI, VII, VIII, IX, X, XII, XIII[2], XIV[1], XV, XVI.

This *Physa* lives in either a protected bay or on an exposed shore; the protected bays, however, are frequently subject to rough conditions when the winds are from the unprotected side, which is often the case. Stations VIII and XII, both protected bays, produced the finest specimens. The normal habitat appears to be a sandy shore, but logs and other submerged objects are resorted to.

Warreniana appears to be a race of *ancillaria* rather than of *sayii*. Specimens in Tomahawk Lake vary toward this species *(ancillaria)* in the wide aperature, low spire, and shouldered body whorl. The specimens secured were mostly of small size and were very solid.

25. *Physa gyrina* Say.

Station XXI. Swamp bordering the Wisconsin River. All of the specimens secured are immature.

Genus **Aplexa** Fleming.

26. *Aplexa hypnorum* (Linné).

Station XXI. Typical, but not common.

Family ANCYLIDAE.

Genus **Ancylus** Geoffroy.

27. *Ancylus parallelus* Haldeman.

Stations V, XIV[1], XVII. This species occupied two habitats. At stations V and XIV it was found on the

under side of lily pads and the shell is rather flat and broad, while at station XVII it was found on old sticks in bogy swales and the shell is higher and more compressed than are the specimens from the two previous habitats. The effect of environment is quite clearly marked on the shells of these two diverse habitats. The ancyli were very abundant at all three stations.

Family PLANORBIDAE.

Genus **Segmentina** Fleming.

28. *Segmentina armigera* (Say).

Stations II^2, XV, XXI. All specimens were collected in swampy ponds. At Stations II_2, they were found abundantly in the upper marshy portions of the bay.

Genus **Planorbis** Müller.

Subgenus **Gyraulus** *Agassiz.*

29. *Planorbis parvus* Say.

Stations XIV^1, XVII. Rather rare on lily pads (Station XIV^1,) and dead sticks in swales (Station XVII).

30. *Planorbis hirsutus* Gould.

Stations II^2, V, XXI. All stations were quiet water habitats, and the species was fairly common in each.

The relation of *hirsutus* to *deflectus, albus* and *draparnaldi* is not quite clear, and perfect specimens of all these species are not at hand to make satisfactory comparisons. *Deflectus* is frequently spiraly striated and hirsute and any considerable lot of *hirsutus* contains specimens with a subcarniate periphery. In a large series of *hirsutus* all gradations may be found between the two forms, as these are usually understood. The deflection of the aperture occurs in all the smaller planorbes and cannot be taken as a specific character. An examination of the types of *deflectus* and *hirsutus* in addition to a study of lots of shells from many localities would doubtless straighten out the matter.

Subgenus **Helisoma** Swainson.

31. *Planorbis campanulatus* Say.

Stations III, IV[1], VI, VII, IX, X, XIII[2], XIV[3].

This *Planorbis* apparently prefers a habitat where wave action is marked. It is the commonest *Planorbis* in this region, living on the sandy, or pebbly shore in a few inches of water.

32. *Planorbis campanulatus rudentis* Dall.

Stations II[1] III, IV[1], VI, VII, IX, X, XII.

A large number of the *campanulatus* in Tomahawk Lake appear to be referable to Dall's *rudentis* (Alaska Moll. p. 90) characterized by a large shell and particularly by the elevation of the apical whorls above the body whorl, much as in *Planorbis multivolvis* Case. The apical whorls are flat as in typical *campanulatus,* the deflected body whorl beginning at about one-third of the last whorl. In typical *campanulatus* the whorls are usually coiled in the same plane, the apical whorls being a little below the dorsal margin of the body whorl. The specimens mentioned by Walker, from Siskowit Lake, Isle Royale, are probably also this variety (An. Rep. Mich. Geol. Surv. p. 293). The Tomahawk Lake *campanulatus* are more variable than specimens from New York and Illinois.

33. *Planorbis bicarinatus striatus* Baker.

Stations II[1] III, VII, VIII, XII. Very common on logs and on sand and pebbles in a few inches of water. Prefers open shores.

All of the *bicarinatus* living in Tomahawk Lake seem referable to this race. The spiral striation is very conspicuous and is well marked on the majority of the specimens secured. In typical *bicarinatus* from New York state (near Owasco Lake) the spiral sculpture is faint or lacking.

34. *Planorbis bicarinatus unicarinatus* Haldeman.

Stations XIV[2], XV. This distinct race was seen only in a swampy bay and the quiet waters of a small creek,

habitats quite different from those occupied by *Planorbis bicarinatus striatus*. *Unicarinatus* is spiraly striated much as is variety *striatus*, though not to so marked a degree. The habitat of this species is the muddy bottom of a pond or on sticks and other debris at the mouth of the creek.

35. *Planorbis binneyi* Tryon.

Stations II[1], IV[1], V, IX, XIII[1], XIV[3], XXIII. *Binneyi*, inhabits several diverse habitats. Stations II[1], IX, XIII[1], XIV[3], were more or less sheltered bays where there was little wave action; the shells live for the most part on logs and floating debris, but a few prefer the sandy bottom in about a foot of water. Station IV[1] was an exposed bay, open to the full force of the waves and this Planorbis lived here in considerable number. Station V was an enclosed bay occupied by a pond-lily society; this habitat is equivalent to the sheltered bay as the lake waters have free access to it. *Binneyi* occupied the logs in this bay. Station XIII was a mucky slough in a marsh, and the Planorbis were seen clinging to logs or crawling over the muddy bottom in eight to twelve inches of water. The specimens from this habitat are not horn colored, as is the case with those from the other habitats but of a reddish tinge, due probably to the iron in the water. The difference between this habitat and those of Tomahawk Lake is marked, yet there is no difference in the form of the shells.

Planorbis binneyi is a common species of the northern tier of states and has been seen by the writer from western Massachusetts to Oregon. Chadwick's reference (Wisconsin Moll. p. 83) to *Planorbis trivolvis* Say, large form, probably refers to this species.

Dall's statement (Alaska Moll. p. 88) that *binneyi* "is not known east of the Rocky Mountains" is erroneous, as it is a common *Planorbis* in the northeastern part of the United States. It is apparently a species which ranges from Oregon to Massachusetts, and from southern Wisconsin and New York northward. It has been identified as *corpulentus* Say, but that is quite a different species.

(See Walker, Nautilus, XIII, p. 133; Baker, Nautilus, XXII, p. 41). *Binneyi* is related to *Palnorbis ammon* Gould, but is apparently distinct.

36. *Planorbis trivolvis* Say.

Stations IV[2], XIV[2], XV. This species inhabits only quiet bodies of water which are more or less swampy. In such a habitat it is always abundant. The *trivolvis* of Tomahawk Lake are very large and the fully mature examples suggest such names as *megasoma* DeKay and *macrostomus* Whiteaves which are probably to be considered but different phases of development.

Family Lymnaeidae.

Genus **Lymnaea** Lamarck.

37. *Lymnœa stagnalis appressa* Say.

Station XIII[1]. *Stagnalis appressa* lives only in the more open part of a swamp-bordered thoroughfare. The shells are here quite uniform and closely resemble the typical form. At Station XIII[1] the habitat was a protected, lake-like bay at the head of a wide thoroughfare and the shells were found on floating logs or on the sandy bottom in shallow water.

38. *Lymnœa stagnalis lillianæ* Baker.

Station IV[1], VII, IX, X, XIV[3]. All of these stations were on more or less exposed shores, subject to the force of the waves. *Lillianæ* is typically an inhabitant of sandy shores, in shallow water, where it is subject to heavy wave action. When any number of specimens were found, the habitat was invariably an exposed beach. 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.

Specimens living in protected bays have a longer spire and more closely resembles *appressa,* clearly showing that *lillianæ* is a modification of this race.

Genus **Pseudosuccinea** Baker.

39. *Pseudosuccinea columella* (Say).

Stations II[2], XI, XIII[2], XIV[1]. *Columella* always occupies a still water or swampy habitat, its situs being usually the under side of lily leaves or on floating debris.

Genus **Bulimnea** Haldeman.

40. *Bulimnea megasoma* (Say).

Stations XIII,[1] XXIII. This large, fine Lymnæa lives in swamps 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, afford the best habitat for *megasoma,* where it 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 six or more feet in depth. *Megasoma* lives on the surface of the mud and on old logs which the lumbermen have left in the swamp. It would seem that the characteristic habitat of this species is a swamp or marshy pond or bay.

The individuals of this species are very large and fine, a length of 47 mill. being frequently attained. The epidermis is olive green or greenish chestnut, and the surface of the last whorl is either heavily malleated or shows more or less equidistant riblets parallel with the growth lines. The spire varies from elevated to depressed.

Genus **Galba** Schrank.

41. *Galba humilis modicella* (Say).

Station XX[3]. Common just above the water line on the muddy flats bordering the Wisconsin River.

42. *Galba obrussa* (Say).

Station II[2]. This species was seen only on debris above the water on the shore of a sheltered bay.

43. *Galba lanceata* (Gould).

Stations II[2], IV[2], V, IX, XI, XIII[1], XIV[2], XV. This species normally lives only in large swampy bays protected from rough water. It is most abundant in quiet bodies of water where there is little wave action, where it lives on logs, on the stems of Typa or on floating vegetation. Though quoted as a synonym of both *reflexa* and *exilis,* this species is unquestionably recognizable as a species; it is one of the most abundant species in Tomahawk Lake. Not in Chadwick's list.

44. *Galba emarginata wisconsinensis* (Baker).

Stations II[1], III, IV[1], VI, VII, VIII. This recently distinguished race of *emarginata* is characteristic of the exposed, wave-beaten shores of the large lake. It lives on the sandy or pebbly shores, in water from a few inches to several feet in depth. By wading along the sandy beach thousands may be collected in water but a few inches in depth. The habitats 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. The individuals were irregularly scattered over the surface, crawling over the sand where a distinct tract was left, or lying half buried in the sand. Two different color varieties of the animal were observed, one almost black and the other yellowish or even orange.

Emarginata wisconsinensis is by far the most abundant shell in Tomahawk Lake, where in many places it forms windrows of dead shells on the shore after a northwesterly

storm. There is great variation in the length of the spire which may be elevated or greatly depressed. All specimens agree, however, in having a pronouncedly globose body whorl. The reference to *Lymaœa decollata* Mighels, from Madison, by Chadwick (p. 81) is founded on specimens of *Galbra emarginata angulata* Sowb., which is plentiful in the lakes near Madison.

Sub-Order STYLOMMATOPHORA

Family SUCCINEIDAE.

Genus **Succinea** Draparnaud.

45. *Succinea retusa* Lea.

Station II, XX[3]. In wet places, on debris or water plants. Apparently not common.

Family PUPILLIDAE.

Genus **Strobilops** Pilsbry.

46. *Strobilops virgo Pilsbry.*

Stations I, XVIII, XIX. Common in damp places under logs, in started bark and crevices and on mouldy and decaying leaves. Station I is a young deciduous forest while XVIII and XIX are virgin woods of pine, spruce, cedar, birch, etc. In these two habitats the shells were found on rotting birch logs, but not on pine logs. *Strobilops virgo* is very abundant in the forested area about Tomahawk Lake.

Family ENDODONTIDAE.

Genus **Helicodiscus** Morse.

47. *Helicodiscus parallelus* (Say).

Stations I, XIX. Associated with *Strobilops virgo,* common.

Genus **Pyramidula** Fitzinger.

Subgenus **Patula** Held.

48. *Pyramidula cronkhitei catskillensis* (Pilsbry).

Stations I, XVIII, XIX. Common associated with the two above mentioned species. None of the typical form were seem, all being good examples of *catskillensis.*

49. *Pyramidula alternata* (Say).

Station I. A few specimens of this common land snail were collected in the young deciduous forest near Sanders' Resort. They were found on the under side of decaying logs.

Family ZONITIDAE.

Genus **Vitrea** Fitzinger.

50. *Vitrea hammonis* (Ström).

Station XXI. A single specimen was found on the edge of a muddy pool.

Genus **Euconulus** Reinhardt.

51. *Euconulus fulvus* (Müller).

Station I. Common, associated with *Strobilops* and *Helicodiscus.*

Genus **Zonitoides** Lehmann.

52. *Zonitoides arboreus* (Say).

Stations I, XVIII, XIX. This is by far the commonest land snail in this region and is associated with *Strobilops, Pyramidula cronkhitei catskillensis, Euconulus* and *Helicodiscus.*

Family Helicidae.

Genus Polygyra (Say) Pilsbry.

53. *Polygyra albolabris* (Say).

Station I. Three dead specimens of this large land snail were found on the hillside above Sanders' Resort. It is apparently rare in this area.

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Name of Species.	I	Wooded bluff (deciduous.	II	1. Sheltered bay.	2. Swamp. Typha society.	III	Exposed shore of lake.	IV	1. Exposed shore of lake.	2. Swamp, Typha society.	V	Pond-like bay, enclosed	VI	Exposed shore of lake.	VII	Exposed shore of lake.	VIII	Exposed shore of lake.	IX	Sheltered bay, Typha society.	X	Exposed shore of bay.	XI	Swamp. Typha society.	XII	Sheltered shore of lake.	XIII	1. Shore of swamp.	2. Castalia-Nymphaea society.	XIV	1. Castalia-Nymphaea society.	2. Shore of swamp.	3. Sheltered mouth of creek.	XV	Swampy pond.	XVI	Clear pond.	XVII	Swales.	XVIII	Coniferous forest.	XIX	Coniferous-deciduous forest.	XX	1. Deep water of river current swift.	2. Shallow water of river current swift.	3. Mud flats above water.	XXI	Swamps along river.	XXII	Creek with swift current.	XXIII	Boggy swamp.
Lampsilis ventricosa	....	x	....	x	....	....	x	....	x	....	....	x	....	x	....	x	....	x	....	x	....	x	....	x	....	x	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
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bicarinatus unicarinatus																		x		x										
binneyi		x			x		x				x				x			x		x									x
trivolvis						x												x		x										
Lymnæa stagnalis appressa															x															
stagnalis lillianae					x				x		x	x							x											
columella			x										x			x	x													
megasoma															x															x
humilis modicella																												x		
obrussa			x																											
lanceata			x			x	x				x		x		x			x		x									
emarginata wisconsinensis		x		x	x			x	x	x																				
Succinea retusa			x																								x			
Strobilops virgo	x																						x	x						
Helicodiscus parallelus	x																							x						
Pyramidula cronkhitei catskillensis	x																						x	x						
alternata	x																													
Vitrea hammonis																												x		
Euconulus fulvus	x																													
Zonitoides arboreus	x																						x	x						
Polygyra albolabris	x																													
	7	6	8	10	9	2	7	4	7	4	6	6	2	3	4	4	5	3	5	6	1	5	3	4	4	4	2	8	10	2

EXPLANATION OF PLATES.

Plate XI. Sketch map of Tomahawk Lake and Vicinity, showing location of stations.

Fig. 1. The north shore of Tomahawk Lake, showing aspect of the country after lumbering operations have ceased.

Fig. 2. Station I. Wooded area near Sanders' Resort. Second growth of timber—birch, oak and maple.

Fig. 3. Station II. Small bay west of Sanders' Resort. Note Typha latifolia plant society bordering bay.

Fig. 4. Station III. Exposed north shore of lake near Sanders' Resort. Note the bare shore.

Fig. 5. Station IV. Embayment near Quynock Point, south side of lake.

Fig. 6. Station VII. Exposed lake shore near Camp No. 7. North shore of lake.

Fig. 7. Station XIII. Thoroughfare between Tomahawk and Little Tomahawk lakes. Swamp in background in upper left hand corner.

Fig. 8. Station XIII. Thoroughfare between Tomahawk and Little Tomahawk Lake.

Fig. 9. Station XIII. Bay-like area near Little Tomahawk Lake. Note Nymphæa plant society covering surface of water. Dead trees caused by rising of lake level.

Fig. 10. Station XV. Sanders' Minnow-box pond. Formed artificially by daming a small creek. The trees and shrubs were killed by the rising of the water.

Fig. 11. Station XVIII. Woods on Quynock Point from Sanders' Resort. View taken across lake.

Fig. 12. Station XVIII. Virgin woods n Quynock Point. Part of the Wisconsin state forest reservation on south shore of lake.

Fig. 13. Station XIX. Virgin woods near Camp No. 7. Known locally as the cyclone woods.