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TABLE OF CONTENTS

A BRIEF HISTORY
OF THE DEVELOPMENT OF BOTANY AND OF THE DEPARTMENT OF BOTANY AT THE UNIVERSITY OF WISCONSIN TO 1900

GEO. S. BRYAN

PART I

Wisconsin entered the Union in 1848. A clause in the state constitution, approved by its citizens that same year, provided for the "establishment of a state university at or near the seat of state government." Promptly in the early summer of 1848 the state legislature passed an act incorporating the University and vesting its government and control in a Board of Regents. In an official sense the University was born on July 26, 1848, when Governor Nelson Dewey signed this legislative act.

The Board of Regents met first in Madison on October 7, 1848, and again on January 16, 1849, At these meetings the following preliminary steps were taken toward the organization of the University: (1) The selection of a site for the University; (2) The establishment of a preparatory school in connection with the university department of science, literature and the arts, manifestly a necessary step, because, as yet, there were few secondary schools in the state capable of qualifying students to enter classes to be established at the University; (3) The election of a Chancellor; and (4) The regents deemed it "expedient and important" that *efforts should be made* at *once* to *begin* the *formation* of a *cabinet* of *natural history*. To this end the board accepted the offer of Mr. Horace A. Tenney, a young journalist and public-spirited citizen of Madison, to undertake such a collection, and empowered him to spend a limited sum of money for this purpose. Early in 1849 Tenney was able to report to the board that he had collected: "50 specimen of minerals; 46 fossils; and 12 natural curiosities, chiefly Indian arrow heads and axes."

At the same time he submitted to the board the following letter from Increase A. Lapham, a young civil engineer of Milwaukee, and an enthusiastic naturalist: "I have sent you by Mr. Z. A. Cotton, representative from this part of our city, a box of specimens for the proposed cabinet of the University of Wisconsin.

"I propose further to present the University a pretty extensive Herbarium or collection of dried plants—about one thousand or fifteen hundred species—embracing nearly all those heretofore found in Wisconsin, together with others from the United States, and from Europe, provided the Regents will pay the expenses of the paper and portfolios necessary to contain the plants. This will not exceed ten cents for each plant."

It becomes evident from the foregoing that even in the earliest infancy of the University, the Board of Regents had an active interest in, and corncern for, the development of the various branches of natural history. Nor was the newly appointed Chancellor Lathrop unmindful. In his report for the year 1850 he made an impassioned plea for a "Department of the Practical Applications of Science" and particularly as related to agriculture. "It is impossible that the annual yield of land and labor should not be greatly increased in quantity and improved in quality by the universal diffusion among cultivators of a knowledge of the analysis of the soils, of the action of manures, of the elements which enter in the composition of grasses, grains and other agricultural products severally, of the Natural History of plants and animals, and the relation of light, heat, moisture, gravity, etc., to the processes of organic life . . . Agricultural Science, like all other sciences, can only be acquired by study and research. The discipline of the school is essential to its acquisition. Without it the farming processes fall to the low level of routine and drudgery. With it Agriculture rises to the dignity of a profession." In his report for the next year (1851) Chancellor Lathrop again urged the endowment of a chair of the "Applications of Science to Agriculture and the Useful Arts." And among the "Ordinances ordained by the regents" this same year there occurs the following: "6. That there be hereby constituted a Professorship of Chemistry and Natural History; and that it be the duty of the chair to render courses of instruction in Chemistry and its applications, in Mineralogy, Geology, the Natural History of plants and animals, and Human Physiology . . ."

Although the Chancellor and the regents were anxious to fill such a chair, money was lacking to pay the salary. The young institution was having a desperate struggle to make ends meet. Its income was derived wholly from student fees and from the *interest* on moneys received from the sale of lands donated by the Federal Government. From this income the regents had had to find funds for the purchase of sufficient land for the campus and to begin the construction of suitable buildings.

As early as January, 1850, the building committee of the regents had fixed upon the following plan in laying out the buildings and grounds:

"1. A main edifice fronting toward the capitol, three stories high, surmounted by an observatory for astronomical observations; . . . containing thirteen rooms for public recitation, lecture, library, cabinet, etc., and also two dwelling houses for officers of the Institution.

"2. An avenue two hundred fifty feet wide, extending from the main edifice to the east line of the grounds and bordered by double rows of trees.

"3. Four dormitory buildings, two on each side of the above mentioned avenue, lower down the hill—each building four stories high—and containing thirty-two studies for the use of students—two students to be assigned to each study.

"4. Two carriage ways fifty feet wide, bordered with trees, flanking each of the extreme dormitory buildings and both parallel to the wide avenue."

This ambitious and artistic building plan was of necessity carried out slowly and was never completely realized. The first of the dormitories, North Hall, was finished in 1851 and, opposite it across the "wide avenue," South Hall was not ready for occupancy until the fall of 1855. The "main edifice," now the much changed and rebuilt central part of Bascom Hall, was brought to completion in the summer of 1859.

These building activities constituted a heavy drain on the slender resources of the young institution, and left little in the way of funds for the expansion of the staff.

It was not until 1853 that the regents had what seemed to be sufficient funds in hand to pay the salary of someone to occupy the "Chair of Chemistry and Natural History." They elected Ezra S. Carr, M. D. of Vermont. He promptly declined the invitation and in a letter to Chancellor Lathrop said: "It would have gratified me had the income of the chair . . . been sufficient to enable me to remove at once to Madison." In a report to the Board of Regents that year the Chancellor comments: "It is quite obvious that this maximum salary of a Professor in our University, $1000 per annum, will not secure to this chair the desired usefulness and distinction."

The board continued its search and early in 1854 announced that S. P. Lathrop, M. D. of Beloit had accepted the position. Prof. Lathrop came to the University for the spring term "in order that scientific instruction might be supplied to the first graduating class." (8) It is also related that he gave the first lectures in chemistry with the aid of apparatus borrowed from Beloit College.

The *Report of the Board of Regents* for 1854 states that the Senior Class had had in the spring term of that year a course in "Botany and Philosophy." This is the first reference to a course in Botany offered at the University and, apparently, it was given by Lathrop. But the new Professor of Chemistry and Natural History was not a well man. His health rapidly failed and he died in December having held his position for less than a year.

The vacancy was not filled at once. After a delay of nearly a year the board announced that Professor Carr had again been offered the chair and this time had accepted. In the *Report of the Board of Regents* we find this quaint notation, "Ezra S. Carr, M. D. Inaugurated January 16, 1856. The Faculty is now full." (6 professors—148 students.)

Ezra S. Carr was born in Steppentown, N. Y., March, 1819. He was graduated from the Rensselaer Polytechnic School in Troy and was immediately appointed an assistant in the geological survey of New York. When not actively engaged in the field he continued scientific and medical studies at the University of Albany. He removed to Vermont and in 1842 received the degree of doctor of medicine from Castleton Medical College, Vermont, and was immediately appointed Professor of Chemistry and Natural History in the institution. From 1846 to 1850 he divided his time, giving lectures at both Castleton and the medical school at Philadelphia. In 1853 he became Professor of Chemistry and Pharmacy at the University of Albany, and, as we have seen, came to Madison in January 1856 to occupy the chair of Chemistry and Natural History.

When Dr. Carr arrived there were but two buildings on the campus, the North and the South dormitories, the latter having just been completed and occupied. Both buildings also provided a certain amount of classroom space. In the *Report of the Board of Regents* for 1856 we learn that in the south half of South Hall there are four "public rooms": a lecture room on the first and on the third floor; the cabinet of Natural History on the second; and the embryo library on the fourth floor. "One of the lecture rooms has been seated and furnished for the use of the Professor of Chemistry and Natural History."

In the same report Professor Carr, describing the work he expects to do, states: "Instruction will be rendered in this department mainly by a regular series of lectures with intermediate examinations. The lectures will be attended by ample experiments and demonstrations illustrative of the general reasonings in each science. The course . . . will occupy one year . . . fall term, Geology and Mineralogy; winter term, Chemistry; spring and summer term, Botany and Zoology, etc.," This instruction was given only to members of the senior class. Professor Carr seems to have been interested primarily in chemistry and geology and as a result botany and zoology were given rather scant attention. In 1858 Professor Carr thus describes the content of the botany course offered in the spring semester: "Botany—the Plant being first considered as an individual in reference to the nature and processes of vegetable life; second, its relation to other plants, or the Vegetable Kingdom; third, its uses." As textbooks the following are listed: "Wood's, Grey's Works*, Lindley's *Vegetable Kingdom.*" It may seem surprising that, at a time when instruction in botany in the United States was chiefly a matter of naming and describing plants and in making local herbaria, Carr appears to have given so little attention to this phase of the subject. The answer is probably to be found in the nature of the course that the Board of Regents expected Professor Carr would give. Just prior to his arrival

* This error in spelling Asa Gray's name occurs in several subsequent reports.

at Wisconsin the board stated "he will lecture on Agricultural chemistry and the *applications* of *science* to the *useful arts*. This course of instruction is expressly designed for young farmers and artisans of the State." The emphasis, it will be noted, is upon the *practical aspects* of the sciences taught. Without doubt Professor Carr's "course" was intended to become the nucleus about which an agricultural department could be built.

An interesting sidelight is thrown upon Professor Carr's methods of teaching by the following excerpt taken from the *Report of the Regents* for 1857: "The instruction in this department is given by lectures and demonstrations on the part of the Professor . . . The recitation of the student consists in *his* giving a lecture, illustrated with experiments and demonstrations on the same subject and after the manner of the Professor."

One of the interesting aspects of these early days in the history of the University is to be found in the eager and at times reckless financial support of the Cabinet of Natural History. Starting with the modest collection begun by H. A. Tenney in 1849, to which reference has already been made, the cabinet grew rapidly both in numbers and in types of specimens. In 1851 we learn from the *Report of the Board of Regents* that "The Herbarium furnished to the University by Dr. Lapham is in a state of careful preservation and will be of very great value to the future student as illustrative of the natural production of Wisconsin." In 1856 the Board of Regents made the rather astonishing appropriation of $1200 to purchase a collection of fossils owned by Dr. Carr, and in 1857 reported as folows: "The Cabinet has been greatly enlarged by the purchase of the valuable collection of Professor Carr made at Albany, etc. Containing full suits of New York fossils, it will afford means for the solution of questions which may arise in the prosecution of the geological survey of our State without the necessity of going abroad for the purposes of comparison and classification."

In that same year ex-Governor Farwell presented to University "a collection in Natural History comprising the fauna of Wisconsin and the Northwest, and enriched by specimens from other portions of this Continent and from the Old World."

In 1865 the following inventory of the Cabinet was made by Professor Carr who was responsible for its care:

6450	specimens	of	minerals, fossils, etc.
50	"	"	corals
2000	"	"	marine shells
11	"	"	fish
54	"	"	reptiles
65	"	"	quadrupeds
332	"	"	birds
50	"	"	miscellaneous
3000	"	"	Herbarium
50	"	"	Curiosities
75	"	"	Seeds and Woods

Professor Carr was proud of the Cabinet and declared it to be, with the exception of that at the University of Michigan, the "finest collection in the Northwest." It was valued by him at not less than $15,000."

At the same time Professor Carr lists among the meager items of class equipment and apparatus for which he is responsible—one microscope valued at $100! It must be remembered, however, that Cabinets were among the institutional fads of the day. No first-class college, or university was supposed to be without one. That they were expected to play an important role in state universities is clearly set forth, for example, in the following letter to Chancellor Lathrop from I. A. Lapham of Milwaukee dated November 29, 1851:

"I send you a systematic catalogue of animals, so far as they have been observed, or their existence clearly ascertained, in this State. It is presumed . . . that it will have its use in forming the Cabinet of the University, which, it is understood, is intended to embrace and exhibit, at one view, the natural resources of the State. Such a Cabinet would be of inestimable value not only to the officers and students of the institution but to citizens generally and to strangers, who, in great numbers visit our State to view and examine for themselves her natural productions. It should have for its object the illustration of the principles of science rather than unmeaning display of showy articles."

One may well question whether the Cabinet ever met the high ideals set forth in this letter from Lapham. That all persons were not equally enthusiastic over the Cabinet is apparent from other references which rather decry the "moth eaten" animals and the "dusty specimens."

The Civil War brought added difficulties to an institution which had already been hampered by political conditions in the state, by powerful adverse criticisms concerning the types of instruction offered, and the manner in which university affairs had been handled. By the close of 1862 most of the students had gone to the war, and, although salaries had been slashed, the institution virtually faced bankruptcy.

In this emergency the authorities put into effect a long-considered plan of establishing a Normal Department open to women as well as to men. Co-education, beginning as a war-time emergency, was destined to remain as a fixed policy of the University.

A three-year course was established for the Normal Department, and in the "middle year" zoology was offered in the second term and botany in the third. The students in both courses were taught by Professor Carr.

With the close of the war and the return of men to classes, Wisconsin entered upon a new period ushered in by the reorganization of 1866. In 1862 President Lincoln had signed the Morrill Act, under which the state of Wisconsin would be granted 240,000 acres of public land, "thirty thousand acres for each senator and representative in Congress."

The purpose of the gift was to provide endowment for "at least one college where the leading objective should be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and mechanical arts . . . in order to promote the liberal and practical education of industrial classes in the pursuits and professions of life."

In order to qualify for the benefits of the Morrill Act the State Legislature, in 1866, passed an act reorganizing the University. Some of the provisions of this state law were: (1) that there should be a college of arts; a college of letters; and such professional and other colleges as might from time to time be added; (2) that there should be a President with certain limited powers instead of a Chancellor; (3) that the regents should "make arrangements for securing without expense to the state, or to the funds of the University, suitable lands in the immediate vicinity of the University, not less than two hundred acres, including the University grounds, for an *experimental* farm";

and (4) that Dane County is authorized to issue forty thousand dollars worth of bonds, the proceeds of their sale to be applied to the purchase and improvement of the aforesaid experimental farm.

In a report to Governor Fairchild in 1866 Edward Solomon, President of the Board of Regents, emphasizes the requirement of the reorganization act, namely, "that an *experimental* farm is to be provided." It is to be "an *experimental* rather than a *model* farm." Agriculture is to be studied through *experimentation.* In this manner was laid deep and strong the foundation plan of the College of Agriculture.

In the shakeup that followed this reorganization, Professor Carr resigned in the year 1867; and the regents, on recommendation of the newly chosen President Chadbourne, elected John E. Davies to be Professor of Chemistry and Natural History, and William W. Daniells Professor of Analytical Chemistry and Agriculture.

John E. Davies was born at Llanidloes, Wales, in 1839, and at an early age came with his parents to this country. In 1855 the family removed to Wisconsin, and in 1862 young Davies was graduated from Lawrence College with the A. B. degree. He immediately enlisted in the army and served until the close of the war. Returning to Wisconsin he taught for two years at Lawrence as Professor of Physics and Chemistry, and one year at the Chicago Medical School (now the medical department of Northwestern University) as lecturer in chemistry. In 1868 he received the degree M. D. from the Medical School, and in the summer of that same year returned to Wisconsin to enter upon his duties at the University.

William W. Daniells was born in Michigan in 1840. In 1860 he entered the Michigan Agricultural College and, having graduated with the degree of B. S. in 1864, was immediately appointed as instructor in chemistry in the same institution. Later he spent two years at the Lawrence Scientific School at Harvard, and early in 1868 came to Madison.

The University now had *three* men who were capable of giving instruction in the botany of that day, since the new President Chadbourne had himself held the Chair of Botany and Chemistry at Williams College and later at Bowdoin.

As a matter of fact, Davies was primarily interested in physics and mathematics; while Daniells leaned strongly in the direction of chemistry. It is to the great credit of the latter that on his arrival he at once established a chemical laboratory, in the basement of the south wing of Main Hall, "the first laboratory possessed by the University." (4) Daniells however was not very popular with his colleagues who also had classes in Main Hall. There were some bitter comments on the "horrible smells" and "stinks" that emanated from the basement and pervaded the building!

The establishment of laboratory work in biology did not begin, as we shall see, for another decade. As for President Chadbourne, "he was known to have confessed that he thought he could teach any subject in the curriculum better than it was generally taught." (8) The reorganization of the University brought about a new curriculum in which botany, at first offered in the sophomore year of the College of Arts and in the College of Letters, was later (1873) transferred to the freshman year. That this course was actually given by President Chadbourne in 1869 is indicated by the following excerpt from the regents' Reports for that year: "The following are the regular courses of lectures: . . . To the Sophomore Class on Structural and Systematic Botany, by the President; on Practical Botany and Agriculture, by Prof. Daniells."

On Chadbourne's departure in 1870, Davies is listed as taking over the lectures on structural and systematic botany, which embraced a discussion of "the microscopical examination of tissues and minute structures; germination and growth of plants; general principles of plant classification; limitations of species and varieties; and exercises in botanical analysis." Daniells' lectures in practical botany and agriculture covered the following topics: "Botanical characteristics and geographical distribution of natural orders and their relative importance; the genera and species having agricultural, commercial, medical, or ornamental value; noxious plants . . . weeds or poisonous plants."

Not only did Professor Daniells offer the above course but several electives such as: Horticulture, History of Useful Plants, Forestry, etc., which appear in the list of studies. It seems that these electives were not actually given because of a lack of students and they eventually disappeared from the catalogue.

The course in Agriculture somehow did not strike a responsive chord among the students of the eighteen seventies. Even as late as 1880 the Board of Visitors reported that they could find no students in the agricultural department, nor anyone who had graduated from the course. That this was a slight error has been pointed out by Pyre. (8) It appears that *one* student did graduate as Bachelor of Agriculture in 1878!

The causes for the failure of the course are undoubtedly to be attributed to the general conditions of the time. Daniells himself is said to have been a "loveable, conscientious and diligent" man. His were pioneer labors which helped to pave the way for the success of later workers.

PART II

With the arrival of President Bascom in 1874 the institution began to move slowly into a new period of its existence—the gradual evolution toward a university through specialization in subject matter. In this process John Bascom played a distinguished role. He was himself a superlative teacher; a man of vision who realized that "all important teaching should be in the hands of men of specific learning"; furthermore, he appreciated the necessity of affording staff members time for private study and research in order to vitalize their teaching and activity.

In his last report to the Board of Regents (1885) occurs this significant paragraph: "The smallness of salaries begins to be felt, and the most ready remedy is to reduce the instructional force, increase the recitation work of each professor and enlarge his pay. This policy will, in the end, be found very ruinous to higher attainments as a University. Men of original powers and desirous of fresh resarch in their own departments will not seek an institution of this character and will leave it when a more free field is offered them. Those who are content simply to give instruction in familiar things and take their pay for it will form the governing power of the University and this means the decay of all large incentives in teacher and student alike."

A first step toward specialization in teaching occurred in 1874 when Davies moved from the Chair of Chemistry and Natural History to that of Physics and Astronomy and President Bascom brought to the University in the next year a young man, (destined to play an outstanding role in the history of the institution), Edward A. Birge, to be Instructor in Natural History and Assistant Curator of the Cabinet.

Birge was born at Troy, New York, in 1851. He studied at Williams College, receiving his A. B. degree in 1873. Bascom was one of his teachers and observed at once the keen and penetrating mind of this student. On leaving Williams, Birge began graduate work at Harvard under Agassiz, who unfortunately died a few months later. After completing two years of graduate study he accepted Bascom's offer and came to Wisconsin in 1875.

The new instructor in natural history apparently continued to offer, for a year or two, the same type of botany as that given by his predecessor. But the catalogue for the year 1877–78 contains, for the first time, a brief description of the courses taught in each department. From this account we learn that Mr. Birge was giving all the work in natural history; and that there were two courses being offered in Botany.

"The *preparatory* course is given in the third term (spring) of the year. The subject is studied by the Scientific, and Modern Classical sub-freshmen; and by the Ancient Classical Freshmen. The text-book used is Gray's *Manual with Lessons*. After the appearance of flowers two *recitations* in the week are devoted co careful analysis and description of plants: one plant occupying an hour. The students are required to mount and name an herbarium of 35 specimens.

"The *advanced* course in Botany consists of Lectures given to the Modern Classical, and Scientific Freshmen. The subjects of Vegetable Anatomy and Physiology are treated of in the Lectures, and two days in the week are given to analyses. The students are required to hand in an herbarium of 50 specimens and write descriptions of 12 plants."

Assuming that this excerpt from the catalogue is trustworthy, it becomes evident that instruction in botany at this time was chiefly by means of recitations supplemented by lectures; but the germ of laboratory work appears in the careful analysis of plants in flower.

In the scholastic year 1878–79 an additional and optional course in analyses of plants was offered in the first term (fall) to sophomores. "It begins with the opening of the term and lasts usually about six weeks. Practice in identification of flowers is thus secured and an acquaintance with fall flowers gained."

Meanwhile there had been progress in the physical plant and equipment of the University. In 1877 a desperately needed Science Hall (now remembered as Old Science Hall) had been completed and occupied. The main portion of the building was a massive, four-storied, rectangular structure, 136 feet long and 60 feet in depth. Two wings, each 78 feet long and 42 feet wide, extended from the rear. This building is said to have housed "the laboratories, the lecture rooms and the 'studies' of *all* of the professors of science," a statement not entirely accurate. Proof will be given presently that classes in botany and in agriculture were held elsewhere. Much of the University Cabinet which had been located in South Hall was transferred to and occupied a large portion of the fourth floor of the new building. We learn that the Cabinet had been "greatly enriched" by a legislative act in 1876 authorizing the governor to purchase for $10,000 and turn over to the University the library and Cabinet of I. A. Lapham, recently deceased. In this newly purchased Lapham Cabinet there was said to be an *herbarium* of 20,000 specimens. Fortunately the herbarium of the Cabinet was never stored in the new Science Hall. For seven years that building was the show place and pride of the University. On the night of December 1, 1884 the structure was wrecked by fire and its contents destroyed.

In 1879 President Bascom was able to make further progress toward his ideal of specialization respecting subjects taught. Reporting to the Board of Regents that year he writes, "If a professor is to do really superior work his entire labor must be confined to a single department, or to closely allied departments." Apparently the regents were agreeable, for Daniells gave up his attempts at agriculture and was assigned to chemistry alone; Edward A. Birge, who had just received the degree of Ph. D.

at Harvard, was appointed Professor of Zoology; and J. C. Arthur was named Instructor in Botany.

Arthur was born at Lowville, New York, in 1850. In 1870 he was a student in Prof. C. E. Bessey's first botany class at Ames, Iowa. Emphasis in the course was on anlysis and description of cultivated and native plants. Each member of the class was required to collect, press, mount and accurately name 100 different species of plants. Arthur developed into a keen taxonomist. It is narrated that at examination time he was able to give the Latin names of the 50 required specimens "by the shadow seen through the mounting paper when the sheets of dried plants were held at the window with the backs turned toward the students."

In 1872 Arthur graduated from Ames with the B. S. degree. In the scholastic year 1878–79 he was appointed honorary fellow at Johns Hopkins, working there under Farlow who was on leave of absence from Harvard; and during the summer of that year he studied at Harvard under Dr. Goodale.

Arthur came to Wisconsin at the close of the summer of 1879 well versed in many of the newer aspects of the botany of his day. However he remained only a year. What changes he made, if any, in the courses are not clear.

"In June, 1880, W. A. Henry was appointed Professor of Botany and Agriculture. He was required to give all the botanical instruction offered in the University." The above quotation is taken from the *20th Annual Report of the Agricultural Experiment Station* and was written by Henry himself. He was born in Ohio in 1850; studied at Ohio Wesleyan, 1868–69; taught school for several years, and finally entered Cornell University from which he was graduated in 1880 with the degree of Bachelor of Agriculture.

On coming to Wisconsin, Henry was faced with a heavy task. He was not only responsible for the work of the Experimental Farm but, as previously noted, was required to give all of the botanical instruction then offered in the University. It must have been, therefore, with great pleasure that in the early spring of 1881 he greeted William Trelease who had been appointed Instructor in Botany.

Trelease was born in Mount Vernon, New York, in 1857. As a young man he showed a strong bent for natural history and was graduated from Cornell University with the degree of B. S. in 1880, specializing in entomology as well as botany. In these early years he was particularly interested in the subjects of the secretion of nectar, and in the cross-pollination of flowers by insects.

In 1883 Trelease was promoted to Professor of Botany and Henry's title was changed to Professor of Agriculture. It was in this year, also, that the Agricultural Experiment Station was organized. Henry had succeeded in getting a small appropriation from the State Legislature for the study of sorghum in the making of sugar, and for the construction of silos in the formation of ensilage. This work had been so successful that Governor Rusk recommended in his message to the legislature that an Experimental Station be founded, which was done in 1883, with the following personnel:

W. A. Henry, Professor of Agriculture
Wm. Trelease, Professor of Botany
H. P. Armsby, Professor of Agricultural Chemistry

Professor Henry was clear in his own mind as to the basic work of the Experiment Station. "Its purpose," he states, "is to investigate questions of special interest to the farmers of the state. It is to be expected also that the results will not only have general value but may be real contributions to agricultural science." The people of the state were requested to send to the Experiment Station: specimens of weeds and introduced plants of questionable value; cultivated and other plants attacked by fungi (rusts, smuts, mildews), and noxious insects. Professor Henry further states that, "The names of unknown plants will be furnished if specimens are sent in, and seeds will be examined as to purity and vitality. All work of general interest will be free of charge in so far as facilities of the Station permit."

Henry's ideal of service to the agricultural interests of the state proved to be not only of inestimable value to the farmers of Wisconsin but also to the University itself as it eventually moved into an era of rapid expansion.

The year 1883 also saw the beginning of courses in pharmacy under the newly appointed Frederick B. Power, Professor of Pharmacy and Materia Medica.

Meanwhile, under Trelease and Henry, the inherited courses in botany had been modified and expanded and new courses established. One notable feature was the introduction of *laboratory* work in one or more of the *advanced courses.*

Two short, i. e. single term, courses were offered in the spring: an elementary course for freshmen consisting of *recitations* from Gray's *Lessons* supplemented by *lectures;* the second, a more advanced course for sophomores, embraced *recitations* from Bessey's *Botany* accompanied by *lectures* on physiology and systematic botany, the latter dealing particularly with plants of economic importance. Microscopic *demonstrations* were given as an important feature of this course. Students in both courses were required to form an herbarium of 35 specimens correctly named and properly mounted.

A different course was required of all sophomores in agriculture and covered two terms. In the fall the students began the study of the structure and development of the Cryptogams, especially the fungi injurious to higher plants. The course consisted largely of *laboratory work* using compound microscopes and supplemented by lectures and field excursions. In the winter term the students continued with a study of Phanerogams, particularly grasses, weeds and forage or other useful plants.

In addition to these courses Trelease offered horticulture to juniors, and forestry to seniors, in agriculture. The Course in Horticulture covered two terms. The work of the first term combined "Economic Entomology" and "Cross-Fertilization of Plants" and involved laboratory, lectures and field experiments. The study was continued in the second term "by *recitations* from Lindley's *Horticulture* and Darwin's *Animals and Plants under Domestication* accompanied by lectures on the physiology of plants and laboratory work in their cell structure."

As to forestry we learn from the catalogue that "The class recites from Hough's *Forestry* and lectures are given on fungi and insects which attack forest trees."

The modification and expansion of courses in botany during these years was not peculiar to Wisconsin. In fact, the decade from 1875 to 1885 roughly marks out a turning point in the development of botany in American institutions.

It should be remembered that in 1865 there were only two men in the United States who earned their living as professors of botany—Asa Gray at Harvard and D. C. Eaton at Yale. It is true that Torrey taught botany at Columbia, but he had to spend much of his time in assay work in order to eke out a meager salary.

The study of botany, at least in most college classes of this period, was carried on chiefly as an adjunct to the course in medicine. It will be recalled, for example, that S. P. Lathrop, Carr, and Davies, Professors of Natural History at Wisconsin, all held the degree of M. D. But the times are changing. Already in 1872 Farlow, who was then at work with de Bary at Strassburg, wrote, apparently with some surprise, that he was the only botanical student there at the time who had studied medicine.

By 1885 botany was becoming well established in the United States as a profession in its own right.

Another change within the decade is to be noted in the content of the course of study. Taxonomy had dominated American botany to the practical exclusion of other phases of the subject. On the other hand such was not the case in Europe and particularly in Germany, where, during the 'sixties and 'seventies, the researches and publications of Hofmeister, Sachs, deBary and others had opened great new fields of botanical study.

This new work had, however, received little attention from American botanists because few of them could read German, and further, with the slim budgets available, books and periodicals from that country were not readily available.

A distinct turning point came in 1880 when C. E. Bessey published his epoch-making *Botany for High Schools and Colleges*. The importance of this book is admirably set forth in the following review written by John M. Coulter for the *Botanical Gazette*, September 1880.

"The question may naturally arise in the minds of many teachers, what need is there of another botany? We have Gray's, Wood's, Youman's, etc., almost every publishing house being represented by a botany; surely it is but publishers' rivalry that is throwing this new book upon the market. Even a casual glance will show, however, that we have no stereotyped repetition of books gone before, but a *new departure* in American botanical text books . . . Once the study of a little morphology, the learning of a few terms in the glossary, and the analysis of a few flowers was thought to be all the profitable study that botany could furnish students. But this state of thought has entirely changed and plants are getting to be recognized as living organisms that have life histories, that have digestion, nutrition, assimilation, respiration, reproduction, and other functions just as remarkably performed as in animals . . . It is evident that we can study plant physiology as well as anatomy, and it is this very thing that has so long been neglected in our schools . . . Our great botanists have been systematists, as is perfectly natural in a country just developing its flora, hence all botanical work in the schools has followed the same bent. Such work is not to be decried,—but it is not all of botany."

"Of necessity the book could not be entirely or even mostly original, but rather in Part I a following of that done in German laboratories, and, based chiefly upon Sach's great *Lehrbuch*. In Part II the higher plants, of course, conform to the system of Bentham and Hooker. The classification and treatment of the lower plants seems to be the author's own work and is probably the part of the book that is most original."

A third change within the decade is to be noted in the slowly increasing employment of the laboratory system in connection with the teaching of botany.

Prior to 1870 laboratory work in botany was almost unknown. At Harvard, for example, Dr. Wm. P. Beal who studied there between 1862 and 1865 writes: "During one spring Dr. Gray met three of us for lessons in this text book (Gray's *Botanical Text Book)* freely illustrated by fresh specimens. The botanical department at Harvard did not own a compound microscope but had the use of a thousand-dollar instrument belonging to the Lowell Institute. A little crude work was done, such as viewing the streaming motion of granules of chlorophyll in leaf section of Valisneria, looking at grains of pollen, sections of ovules, etc."

By 1884, according to J. C. Arthur, more than a dozen prominent institutions of learning in this country had established laboratory work in some, if not all, of their courses in botany; and two institutions, Cornell University and Michigan Agricultural College, had progressed to the point that each had erected a building exclusively for botany.

The manner in which textbooks were used in the earlier days apparently varied but little from institution to institution. Too often so many pages of the given text would be assigned for each lesson, and the nearer the recitation of the student corresponded word for word with the text the more highly was his knowledge and grasp of the subject supposed to be.

The slowness in developing laboratory work in botany at Wisconsin is undoubtedly to be attributed in part to a lack of suitable rooms for the course. Dr. L. H. Pammel who began his botanical studies at Wisconsin in 1881 wrote, "I had my first botanical instruction in the old main building on the hill. The lectures were given in what was then the chapel and now (1927) is the office of the President or, at least, was his office at the last time I visited the University. It may be of interest to state that we used Bessey's textbook then just issued by Holt. The following fall the quarters of the department were in Old South Hall. Prof. Trelease had his office on the second floor at the south end, and the lecture room was on the first floor and the laboratory on the second floor. Here we received our first instruction in cryptogamic botany, as it was called, which was followed by courses on flower ecology, systematic botany, etc. . . . Prof. Henry was the agricultural department, and under him we had a variety of courses in agriculture, live stock, and farm crops."

Further valuable information concerning classrooms and equipment in botany is recorded in the report of Professor Trelease, to the Hon. George H. Paul, President, Board of Regents, dated October 1, 1884.

"When I was called to the University to give instruction in Botany in the spring of 1881 I found it the minor part of a composite department—agriculture and botany—with few facilities for instruction and no rooms except those of other departments which could be used only when not required for other purposes.

"At present (1884) the department occupies the greater part of the first and second floors of the renovated south building (South Hall) containing a lecture room, a reagent room, laboratory, museum and herbarium, while there is the possibility of further addition when this shall become necessary.

"The lecture room is capable of seating 100 students and is on the ground floor. The reagent room is furnished with good chemical desks and a set of chemicals needed in the preparation of such reagents as are used in vegetable histology and micro-chemistry. In it all operations attended by the evolution of gases likely to injure the microscopes and other laboratory apparatus can be performed.

"The laboratory is sufficiently large to accommodate 20 tables and is equipped with six dissecting microscopes and ten *good* compound microscopes giving a range of magnifying power from 20–2000 diameters, besides other instruments useful in the microscopic study of plants.

"The museum is a room of equal size adjoining the laboratory. Some of the more interesting fungi of the state, and a collection representing the wood of several hundred species of trees are now being arranged in it. Collections of Wisconsin weeds and grasses and a set of models of the varieties of fruits recommended for growth in the state will shortly be added. These are intended for agricultural students and farmers who visit the University.

"The University herbarium, which is located in the room devoted to my original work, is based on the Lapham herbarium estimated to contain between 10 and 12 thousand *species*, which has been thoroughly poisoned and is being properly mounted as rapidly as possible. Since it came into my charge it has been augmented by donations of several hundred species from the Department of Agriculture at Washington, by a set of exotic forms from Cornell University, and by between 3 to 5 thousand specimens from Professor Henry's herbarium and my own. The specimens donated by Professor Henry include a valuable set of alpine plants from the Rocky Mountains and many California species.

"The lectures are illustrated by a set of 60 Veny's Botanische Wandtafeln representing the minute anatomy and development of plants; and both actual specimens and fresh and mounted preparations under the microscope are employed in demonstrations whenever it is practical to use them.

"A practical familiarity with the common plants of the state is secured by requiring each student to form a small herbarium. In the systematic laboratory courses constant reference is made to the University herbarium which is supplemented by the private collection of the professor containing several thousand species of parasitic fungi, including all that are known to occur in the state of Wisconsin. The collection is constantly being added to from all parts of the world."

In regard to the fungi mentioned in the above paragraph it should be stated that Professor Trelease, during his stay at Wisconsin, devoted much time to a study of bacteria and fungi, and made the first comprehensive survey of the parasitic fungi of the state. In 1884 Trelease received the Ph. D. degree from Harvard, his thesis being on the subject, "Zoogloeae and Related Forms." This paper was published in the studies from the Biological Laboratory of Johns Hopkins University, Vol. 3, 1885, and is notable as being probably the first doctor's thesis written in this country in the field of bacteriology. Under the stimulus of this work the University authorized Professor Trelease to order, in the spring of 1885, special bacteriological equipment from Europe. Shortly afterwards, however, Professor Trelease was offered and accepted an appointment as Englemann Professor of Botany at Washington University, St. Louis. He left Wisconsin at the close of the summer at 1885.

An interesting development centered about this bacteriological equipment. Since Professor Trelease had departed, it fell to Dr. Birge to unpack the apparatus on its arrival. In an address on the beginnings of the pre-medical course in the University delivered in 1935, Dr. Birge stated: "It was quite unthinkable that an equipment so large and valuable should stand idle, so I was told to get busy and teach bacteriology, which accordingly I proceeded to do. My course was regularly given but it was not announced in the catalog for the first two years, for I regarded my part in it as a temporary affair and expected to turn it over to the botanist who would succeed Dr. Trelease. But the first appointments were temporary matters, and then Professor Charles R. Barnes came as botanist in 1887 it turned out that he knew little and cared less about bacteria, so I, who meanwhile learned a little about them, was obliged to continue the course."

Later on we shall note further progress in bacteriology at Wisconsin.

By the summer of 1883 the renovation of South Hall had afforded space not only for classes in botany, but the courses in pharmacy had taken over a part of the fourth floor, while Professor Henry had finally been able to secure a laboratory and office on the third floor. *For more* than a *decade after* this time *South Hall* was *designated* as *Agricultural Hall!* Students were slowly being attracted to Henry's classes. But experimental work on the farm was not progressing well. The reasons are clearly set forth in one of Professor Henry's early reports.

"Many persons seem to regard the farm as a mere pleasure ground. Plots of grain have been trampled down, labels misplaced or destroyed. Fruit is taken from the orchard when scarcely half grown, and this season *all* the grapes were stolen before some of them had time to color . . . Experiments that have cost much time and labor have been brought to naught until thoroughly discouraged we are really doing nothing on the experimental farm to advance horticulture . . . It would require two watchmen, day and night, a part of the season to secure immunity from these depredations. *As our work seems* to be *shut* off in *these directions* we *shall turn toward dairying* and *stock feeding experiments* for *which* we *will soon* be prepared and *which cannot* be *harmed* by *marauders.*" In this manner was Professor Henry literaly driven into a special line of research which later brought him national fame.

With the departure of Trelease in 1885, and upon his recommendation, Arthur B. Seymour came to Wisconsin as Instructor in Botany, but remained only for the academic year 1885–1886.

Seymour was born at Moline, Illinois in 1859; graduated with the B. S. degree from University of Illinois in 1881; served as botanist, Illinois State Laboratory of Natural History 1881–1883; and spent the two years before coming to Wisconsin at the cryptogamic herbarium, Harvard.

He was succeeded during the academic year 1886–87 by Frederick L. Sargent.

Sargent was born at Boston, Massachusetts, in 1863; studied at the College of the City of New York from 1879–82; and at the Lawrence Scientific School, Harvard, 1883–86. He also remained at Wisconsin only a year.

In the winter of 1886 an important development occurred in the opening of the Short Course in Agriculture, which was ordered established by the Board of Regents over the doubts and fears of Professor Henry. The distinctive features of this development were as follows: any person of suitable age with common-school education could enroll; the term should embrace 12 weeks beginning in January when farmers' sons have most leisure; the subject matter should be practical and have a direct bearing upon every day matters on the farm.

Twenty young men enrolled the first year and attended daily lectures in chemistry, botany, and applied agricultural practices, with occasional lectures by the state veterinary officer on the diseases of animals.

The Short Course in Agriculture has undergone, in the 60 years of its existence, a variety of modifications, but it remains today as one of the important contributions of the Agricultural College to farming interests of the state.

In the summer of 1887 Charles R. Barnes was called to Wisconsin as Professor of Botany.

Barnes was born in Indiana in 1858. He attended Hanover College and graduated with the A. B. degree in 1877. While at Hanover he studied botany under John M. Coulter, and from that time dated their life-long friendship and scientific collaboration—first in taxonomic studies, then as joint editors of the *Botanical Gazette,* and, finally, as colleagues at the University of Chicago.

After graduation, Barnes taught high school and during the summers of 1879 and 1880 studied at Harvard under Asa Gray. He was teacher of Biology at Ford High School at Lafayette, Indiana, when Professor Hussey, biologist at Purdue, suffered a sudden stroke. Barnes was called upon to take over the work and in 1882, his ability having been proved, was appointed Professor of Botany. In 1885 he was granted a year's leave of absence to study plant physiology at Harvard under Goodale.

Barnes came to Wisconsin just as the new Science Hall was being occupied. The catalogue of 1887–88 gives a full description of the building and emphasizes the fact of its fire-proof construction—no wood being used except for floors, doors and window frames. The staircases are of iron with slate treads. This building housed at first: the various branches of engineering; physics; geology; mineralogy, botany, and zoology. Botany and zoology shared together an elementary laboratory on the third floor—a large room arranged to accommodate 72 students. The laboratory was fitted with both dissecting and compound microscopes. A smaller adjoining laboratory was used for advanced work. Important pieces of botanical apparatus were listed as: a sliding microtome, and a direct vision auxanometer. For illustrating the lectures there were specimens especially provided in a case in the lecture room. Considerable space on the third floor was occupied by the herbarium which is described as being chiefly composed of the Lapham Herbarium purchased by the state and said to contain about 8,000 *species* of flowering plants.

On coming to Wisconsin Professor Barnes began to broaden the types of courses offered by the department of botany. In the catalogue of 1888–89 he is listed as offering the following:

Morphology of Flowering Plants—an elementary course involving lectures, laboratory and field work. Naming a considerable number of common plants is regarded as an important feature of the course.

General Morphology—a year course for advanced students. The features stressed are: a study of the cell; and the life histories of important types in the plant kingdom.

Histology—a study of the tissues of phanerogams and ferns. Imbedding, section cutting, staining, mounting, etc.

Embryology and Physiology—a year course involving a study of embryo development, but much time given to experimental physiology.

Applied Botany—a course of 30 lectures given to students taking the short course in Agriculture. The lectures deal with the following topics: principles of nutrition and growth; relations of plants to light temperature, moisture, etc.; forests and timber; propagation of plants; wounds and diseases.

In the academic year 1891–92 Professor Barnes discontinued the elementary course in botany and shared with Dr. Birge a year's course in General Biology. We learn from the catalogue that the course required 12 hours a week on the part of the student, and that in the first semester general principles of biology were studied for the first month, the remainder of the semester being devoted to botany. The second semester was given over entirely to zoology. Assisting in this course the catalogue lists Dr. Hodge as Instructor in Biology, and L. S. Cheney and R. H. True as Fellows in Botany. Several years later Cheney was appointed Assistant Professor of Pharmaceutical Botany, and True Assistant Professor of Pharmacognosy.

In 1893 Dean Henry of the Agricultural College took a very important step when he brought back to the University, with the rank of Assistant Professor, Dr. Harry L. Russell to take over the work in Bacteriology. Russell was born at Poynette Wisconsin, in 1866, entered Wisconsin in 1884, and received the B. S. degree in 1888. He majored in biology and, having his interest strongly aroused by Dr. Birge's course in bacteriology, decided to make that subject his life work. From 1888 to 1890 Russell held a fellowship at Wisconsin and continued graduate work, receiving the M. S. degree in 1890. There followed studies abroad at Koch's laboratory in Berlin, L'Institut Pasteur in Paris, and at the Zoological Station in Naples. He then returned to the United States and, completing the work for the Ph. D. degree at Johns Hopkins in 1892, accepted a fellowship in bacteriology at the newly formed University of Chicago. As has already been stated, in 1893 Dean Henry persuaded Dr. Russell to return to Wisconsin and take charge of the new department of bacteriology to be organized in the College of Agriculture, and also to carry on the courses in bacteriology in the College of Letters and Science which some years before had been started by Dr. Birge. In this manner began Dr. Russell's long and distinguished service to the people of Wisconsin and to the scientific world.

Professor Barnes remained at Wisconsin until 1898. In the latter year of his stay he offered an advanced year course, experimental in nature, in plant physiology for which chemistry and physics were listed as prerequisites. In the first semester the subject was "plant physics"; in the second semester, "plant chemics." It was in this field of plant physiology that he was destined later to win distinction at the University of Chicago.

Barnes has been described by those who knew him as a scholar, an oustanding lecturer and teacher, and a man of high principles. Like many of his contemporaries he was broadly trained and one of his hobbies was the taxonomy of the mosses, a field in which he won national recognition. He served for several years as secretary of the faculty at its meetings, and played an important part in the discussions. It was an event at one of the faculty meetings that lead to his decision to leave

Wisconsin.* It seems that President Charles K. Adams was strongly interested in student athletics and a particularly zealous supporter of football. One spring, serious efforts were made by many of the faculty to get rid of an indolent football player whose sole interest was in athletics rather than study. A stringent resolution was passed which, if enforced, would prohibit the playing of any man whose standing was not up to grade. For some reason these resolutions were not presented by the President to the Board of Regents and hence did not have the force of law.

In November of that year a crucial game was to be played with Northwestern. One of the most important Wisconsin players was very delinquent in his studies. At a faculty meeting prior to this game the President explained that the faculty had enacted legislation that would bar the delinquent from playing, but that the resolutions had never been presented to the regents and, consequently, had no legal force; that he had talked with one of the regents who agreed there was no way to keep the man from playing; and that therefore he, the President, would assume all responsibilities and allow the man to play. He then attempted to dismiss the faculty saying, "That is all, gentlemen." But Professor C. R. Barnes, secretary of the faculty, was on his feet in an instant, and, pointing his finger directly at the President said, "Mr. President, did I not take those resolutions to you before the April meeting and ask you to present them to the board of regents? You did not do it. Did I not take them back to you and ask you to present them to the June meeting of the board? I want to know why this matter was not attended to!" The President replied, "Doubtless the superior memory of the Professor of Botany is correct." But the matter did not end there. Professors Turner, Parkinson and others deplored the situation and criticized the President's position. When the meeting finally broke up, it was evident that many members of the faculty had lost confidence in the President.

This incident lead to a permanent break between Adams and Barnes, and years later the latter told Professor Skinner that it was one of the chief reasons why he left Wisconsin. In 1898 Barnes went to the University of Chicago as Professor of Plant

* Condensed from recollection of Prof. E. B. Skinner as related to Charles Forster Smith. (10)

Physiology and was succeeded in the same year by Robert A. Harper.

Harper was born at Leclaire, Iowa, in 1862. He received the B. A. degree from Oberlin in 1886, and was Professor of Greek and Latin at Gates College, Nebraska, 1886–88. He spent the year 1888–89 as a graduate student at Johns Hopkins; and at the close of that year went to Lake Forest Academy, Illinois as Instructor in Science. In 1891 he received an M. A. degree from Oberlin and became Professor of Botany and Geology at Lake Forest College. He continued graduate work at Bonn from 1894 to 1896, and in the latter year received a Ph. D. degree. He returned to his position at Lake Forest College until his call to Wisconsin. On arriving at Wisconsin, Harper carried on much of the work of his predecessor, but added new and important fields, such as cytology, mycology and plant pathology. He was aided by Assistant Professor Cheney who gave courses in anatomy and histology, trees and shrubs, and bryology; and by Instructor Timberlake who gave work on flowering plants. Harper was a scholar, a stimulating lecturer, and an active research worker. Under his leadership graduate students were attracted to Wisconsin, various lines of research were begun, and the department entered upon a period of growth and prosperity.

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SECONDARY SUCCESSIONS ON THE PEAT LANDS OF GLACIAL LAKE WISCONSIN

JOHN CATENHUSEN

INTRODUCTION

The purpose of this paper is to present the results of studies of the effects of drought, drainage, fire, a restored or rising water table, and flooding upon the plant successions on the peat lands in the bed of Glacial Lake Wisconsin (Fig. 1). Approximately 300,000 acres of peat land lie in central Wisconsin within the boundary of this extinct lake.

The field work was done during portions of the summers of 1937, 1938, 1939, and 1940, and was made possible by grants from the Wisconsin Alumni Research Foundation. Grateful acknowledgment is made to Dr. N. C. Fassett for many helpful suggestions made during the study, and to my wife, Carolyn W. Catenhusen, for assistance in the preparation of this paper.

The classifications are those of Weaver and Clements (1938). The term bog community refers to a mature tamarack–spruce bog and is analogous to the tamarack–spruce associes.

GEOLOGY AND PHYSIOGRAPHY

The underlying rocks of the region belong to the Cambrian series of sandstones, which have contributed most of the surface deposits. The northern edge of the Cambrian sandstones forms an escarpment, which has been retreating southward, leaving behind it outliers on the surface of a broad plain. Friendship Mound, Bear Bluff, and Saddle Mound are such outliers. At Necedah, however, is a mound of quartzite, a partly exhumed monadnock of the pre-Cambrian rock which underlies the Cambrian series. The sandstone outliers occur in the form of towers, crags, and buttes, and are scattered about on the flat plain which stretches to the north and east of the escarpment.

GLACIATION

Although most of the bed of Glacial Lake Wisconsin lies within the Driftless Area (Fig. 1) and therefore was not glaci-

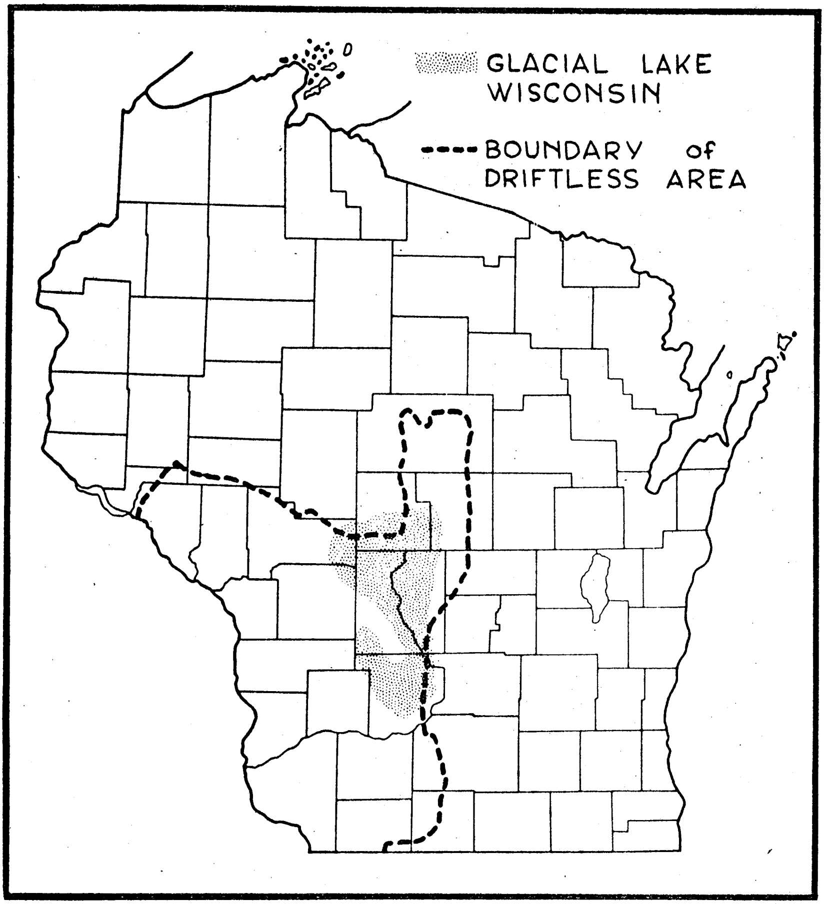

FIGURE 1. Glacial Lake Wisconsin.

ated (Martin, 1932), glaciation nevertheless has had a considerable effect on the region. Glaciation to the east of the glacial lake was accomplished by the Green Bay lobe of the Lake Michigan glacier. The ice moved southward and westward across the central plain as far as the eastern part of Adams County (Fig. 2) and the Baraboo Range, damming the preglacial Wisconsin River, whose backed-up waters formed Glacial Lake Wisconsin. Towers, crags, and buttes, outliers of the Cambrian sandstones that have an escarpment to the southwest, existed as islands in the lake, and many of these now carry beach deposits or other evidences of former shorelines. Deposits of erratic material are found in the valley of the East Fork of the Black River which indicate that it formed the outlet of Glacial Lake Wisconsin during the time that the preglacial Wisconsin River was blocked by glacial ice. After the disappearance of the ice, the Wisconsin River completed the cutting of a new outlet southeastward through what is now the Dells of the Wisconsin, completely draining the lake and leaving an essentially level plain.

Considerable deposits were made by the lake during its existence. In the southern part of the basin are reddish silts and sandy clays, while in the north the principal deposit is white quartz sand. Additional deposits include boulders of gran-

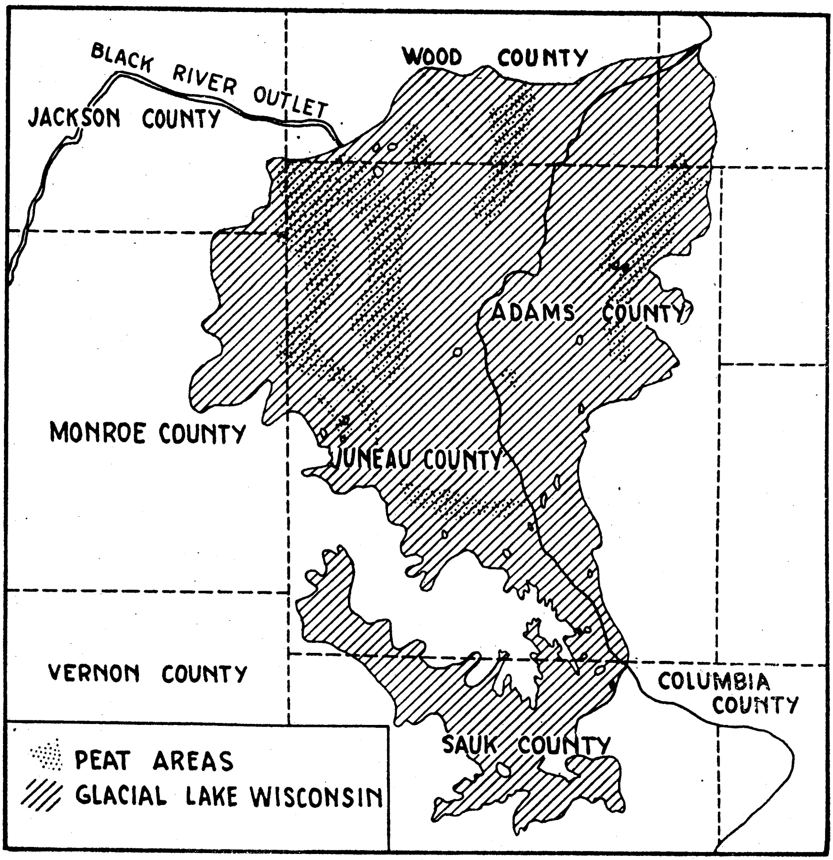

FIGURE 2. Peat areas of Glacial Lake Wisconsin.

ite and other rocks, rafted in by floating ice. The lake deposits are covered in many places by glacial outwash, dune sand, or river-laid silt. In addition, peat and muck have developed over much of the area as a result of the existence of marshes and bogs.

SOILS

The soils of the region (Whitson, 1927; Bordner, 1934) are of two general types: sand and peat. The sandy soils are mainly derived from the Cambrian sandstones. Erosional forces of various types have acted upon this material and redeposited it. The peat occupies low places in the very gently undulating plain, and varies in depth from a few inches to fifteen feet. In many places it is perfectly preserved and unoxidized, but elsewhere

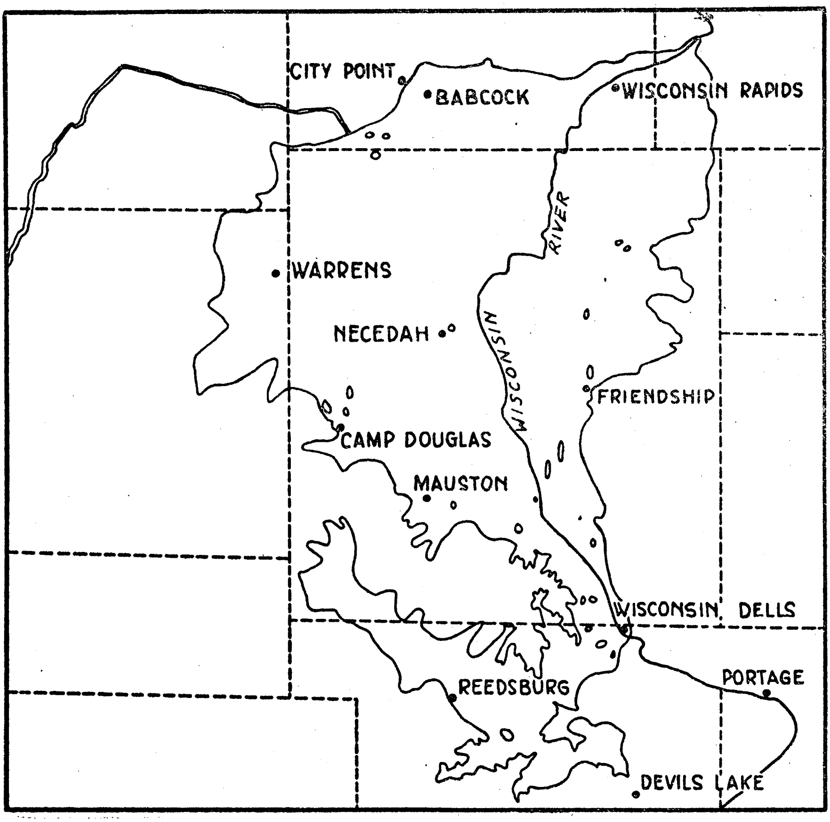

FIGURE 3. Location of principal towns.

various stages of decomposition exist, brought about by drainage, fire, and cultivation. While various plant nutrients are tied up and unavailable in undecomposed peat, nitrogenous and other compounds are made available by bacterial and fungal action when disturbance takes place. High acidity usually hinders such action, but low acidity or slight alkalinity favors it. The peat, therefore, which occurs over a large portion of the lake bed, represents a series of soil types and conditions within itself.

The results of studies made near City Point and Warrens (Fig. 3) by Dachnowski (1925), and near Babcock by Huels (1915) indicate that in these areas there are three types of peat from the standpoint of botanical composition. The surface is composed of a layer of *Sphagnum* peat a foot thick, underlain by a layer of woody material varying in thickness, and this in turn by a layer of fibrous and matted material of sedge origin, which varies in thickness from five to eight feet. At Warrens, roots and stumps of tamarack and spruce exist below the thick layer of sedge peat. Underlying the organic deposits is a mineral soil of gray, siliceous sand. Where deep burns have occurred, the sphagnum and woody peat have been destroyed, and fires have often burned into sedge peat.

The peat underlying relic bogs ranges from six to fifteen feet in depth and is quite acid (pH 4 to 5). Where drainage and fires have taken place, the acidity ranges between pH 5.5 and pH 7. Generally areas of deeper peat were not as successfully drained as were the more shallow ones.

CLIMATE

The average annual precipitation in this region is approximately thirty inches. About half of the total comes during May, June, July, and August. June, with 4.1 inches, has the heaviest rainfall; July has 4 inches, and May 3.2 inches. Precipitation during the winter is light; December, January, and February average 1 to 1.5 inches. Short periods of drought are frequent, but serious droughts have occurred at least four times since 1890 (Fig. 4).

The mean temperature for the growing season is about 66° F. The growing season as determined by temperature readings at Wisconsin Rapids in Wood County (Fig. 3), at an elevation of 1,021 feet, is 126 days, with the first killing frost about

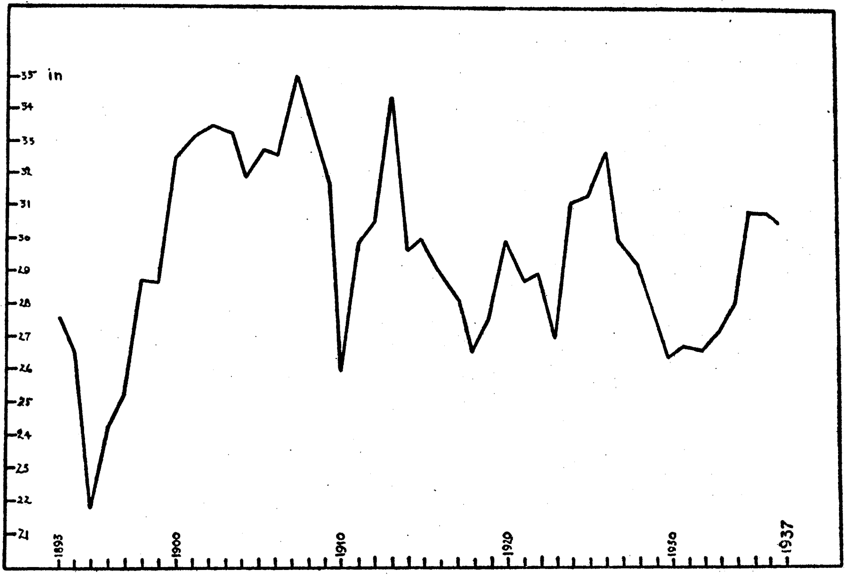

FIGURE 4. Three-year moving average of annual precipitation—Meadow Valley, Wisconsin.

September 26. However, Wisconsin Rapids is not located on the low peat lands, where the temperatures reported have been consistently lower, and where frosts may occur throughout the year.

HISTORY OF THE PEAT LAND

Pre-settlement period. Descriptions of the early vegetation are given in reports of government land surveys of 1839 to 1855 (manuscripts now deposited at the State Capitol in Madison). These reports describe extensive areas of "open marshes" and "moss marshes." Areas similar to these except for scattered individuals or small stands of tamarack, spruce, and white pine were equally extensive. Dense stands of tamarack and spruce were reported less frequently. Occasional wild cranberry bogs were also reported by the surveyors. "White maple" (probably red maple), aspen, white birch, and alder were infrequently associated with the scattered stands of tamarack, spruce, and white pine.

Frequent complaints about the difficulties encountered in surveying are recorded in the surveyors' field notes, and often add valuable information concerning the nature of the country.

Many of the "moss marshes" and "open marshes" as well as those with scattered trees were quite wet or even under water, so that surveying was exceedingly difficult. Section lines and section corners were established with difficulty in the extensive and treeless marshes. In addition the marshes were often underlain by an infirm substrate or were so inundated that it was impossible to dig pits for the purpose of marking section corners.

Drainage period. Previous to 1890, the peat areas were exploited for nothing more than the natural crops which they produced. Cranberries, sphagnum moss, wire-grass, and marsh hay were the chief products. Agricultural expansion, which led many farmers into submarginal regions throughout the country, brought a few settlers to the sand areas associated with the peat lands in the 1880's. When local fires laid bare small areas of peat, farmers immediately cultivated them also, and often harvested good crops. These occasional successes led to the establishment of an elaborate system for draining the peat and allowing it to be cultivated. Construction of the ditches was begun and continued until about 1920. The porosity of the peat soil and sandy subsoil was such that good underdrainage developed when the ditches were from six to nine feet deep with an adequate fall, and were placed from ½ to ¾ mile apart. In sections where drainage was successfully accomplished, the peat became dry enough to be cultivated. Most of the farmers, however, soon met with failure. Early frosts, poor soil soon depleted of nutrients, high drainage expenses, and repeated crop failures compelled most of the farmers to abandon their land. Of those who hung on, some were moved during the nineteen-thirties by the Resettlement Administration. Despite this momentary expansion of agriculture, there still remained thousands of acres of uncultivated peat, some of which had been successfully drained, while the rest remained undamaged.

Fires during the pre-settlement period. Drought, drainage, and fire have been important factors affecting the peat land and the plant successions on it. While drainage did not become a factor until the period of 1902 to 1920, drought and fire have probably always been influential.

Records of fires previous to settlement are inaccurate and inconclusive. Extensive fires occurred in 1864 along the Wisconsin and Black rivers (Grange, 1942), but it is not known how far these fires spread into the peat land. Surveyors in 1851 reported a burned area just north of Babcock. That other fires occurred previous to settlement can be deduced from the vegetation record. Aspen was recorded on peat areas in 1851. Wild cranberry bogs, which were exploited in the early days of settlement, were probably created by hot, rapid fires (Grange, 1942) which burned off the trees, but did not penetrate the peat. It is purely conjectural, but highly probable, that the "open marshes" dotted with scattered individuals or small stands of tamarack, represent superficially burned areas. Many such areas exist today as the result of recent superficial fires.

That the peat lands generally were considerably wetter during the 60-year period preceding drainage is shown by the records of the surveyors. Their complaints about the difficulties encountered because of wetness and flooding have already been mentioned. During the years of settlement previous to ditching, horses used in harvesting wire-grass were shod with large wooden shoes to keep them from becoming mired. Though direct information is lacking, it can probably be safely assumed that when fires occurred in the period before settlement, they came during periods of severe drought.

Fires in the settlement period. Four severe fires have occurred since settlement: in 1893, 1910, 1920, and 1930. Only the first took place prior to drainage. Severe drought (cf. Fig. 4) was evidently primarily responsible. The fires of 1910, 1920, and 1930 occurred after the inauguration of drainage, and like the one of 1893, took place during or after severe drought periods. The cumulative effects of drainage, combined with excessive drought, made possible these widespread fires, the last of which was by far the most extensive and destructive. Indicative of the most recent of these fires are large pure stands of aspen (Fig. 13) which today are encountered along many of the roads in the region. Such destructive burns had not been possible under conditions described by the surveyors, nor do their records show extensive areas of aspen. The scattered admixtures of aspen described by them could have been only the result of superficial fires upon an undrained peat soil. The vegetation of the peat land in the pre-settlement period consisted of various stages of bog succession, with possibly only the final tree associes held in check by fire. It is highly probable that at this time fires

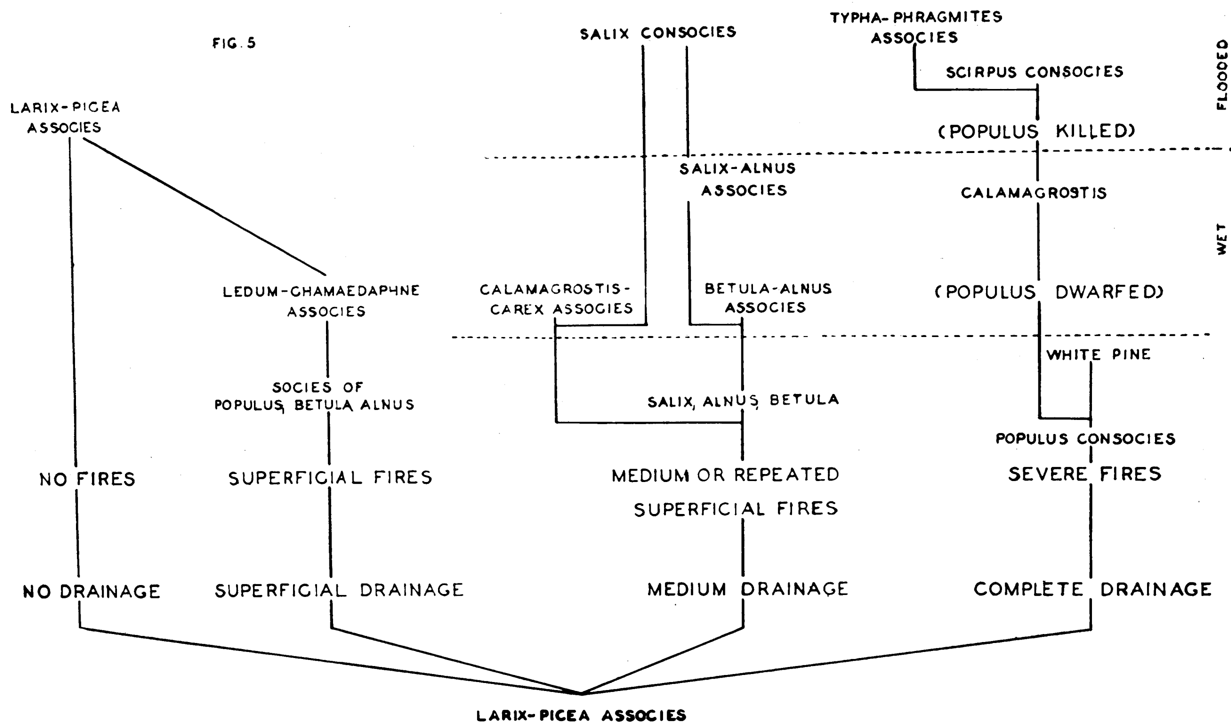
FIG. 5
LARIX-PICEA ASSOCIES
SALIX CONSOCIES
TYPHA-PHRAGMITES ASSOCIES
SCIRPUS CONSOCIES
FLOODED
(POPULUS KILLED)
SALIX-ALNUS ASSOCIES
CALAMAGROSTIS
WET
LEDUM-CHAMAEDAPHNE ASSOCIES
CALAMAGROSTIS-CAREX ASSOCIES
BETULA-ALNUS ASSOCIES
(POPULUS DWARFED)
WHITE PINE
SOCIES OF POPULUS, BETULA ALNUS
SALIX, ALNUS, BETULA
POPULUS CONSOCIES
NO FIRES
SUPERFICIAL FIRES
MEDIUM OR REPEATED SUPERFICIAL FIRES
SEVERE FIRES
NO DRAINAGE
SUPERFICIAL DRAINAGE
MEDIUM DRAINAGE
COMPLETE DRAINAGE
LARIX-PICEA ASSOCIES

FIGURE 5.

FIGURE 6. A relic tamarack-spruce bog.

FIGURE 7. Quasi-mesophytic climax following continued desiccation of a bog.

FIGURE 8. Tamarack and spruce invading a *Ledum–Chamaedaphne* associes.

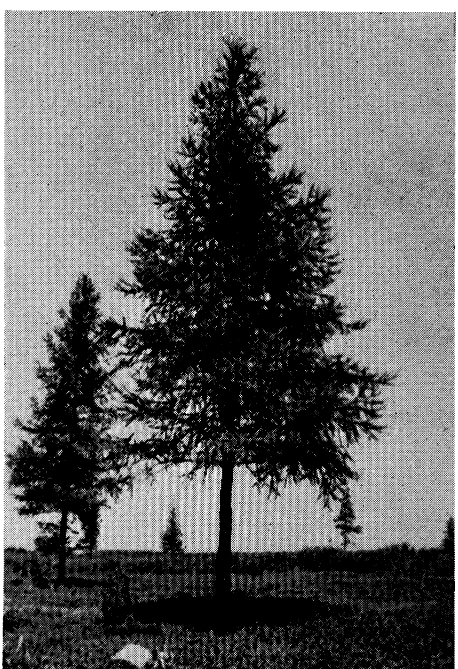

FIGURE 9. Relic tamarack in a *Ledum–Chamaedaphne* associes. The plants near the vasculum are *Ledum* and *Chamaedaphne*. In the background is a pure stand of *Betula*.

FIGURE 10. Tamarack and spruce invading a *Calamagrostis–Carex* meadow.

FIGURE 11. A *Calamagrostis–Carex* meadow following medium or repeated superficial burning. In the background is a relic tamarack-spruce bog.

FIGURE 12. Wool grass meadow *(Scirpus cyperinus* var. *pelius).*

FIGURE 13. A pure stand of aspen on deeply burned peat.

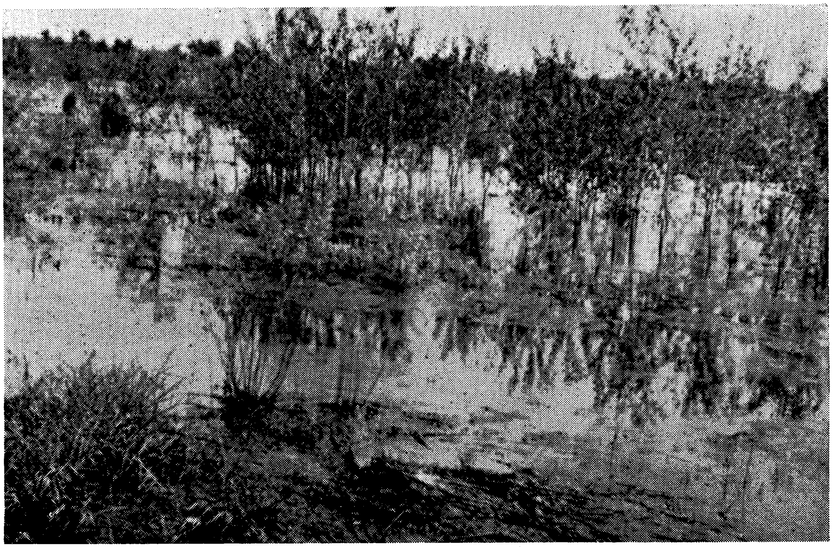

FIGURE 14. Shallow flooding which in some places has followed the installation of dams. Aspen tolerates such flooding if it is not continuous.

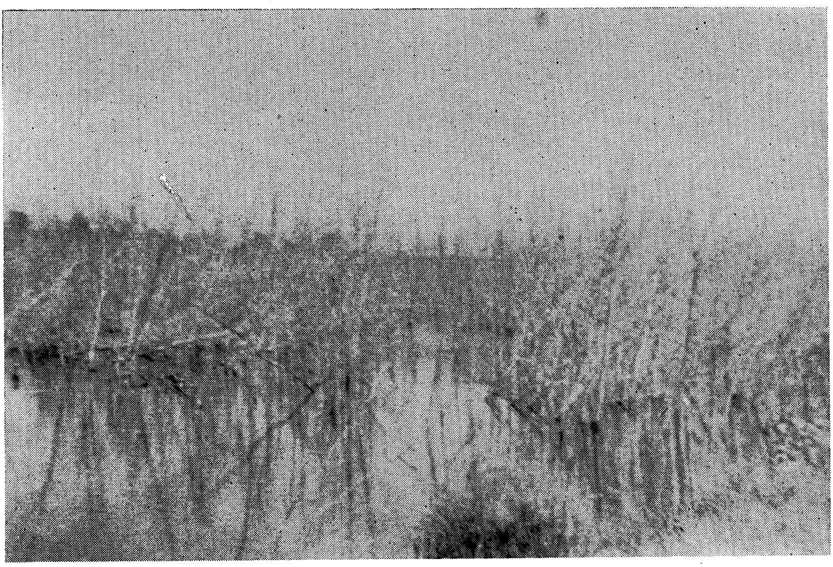

FIGURE 15. Aspen killed by continuous flooding.

FIGURE 16. A flowage created by a dike.

FIGURE 17. A drainage ditch with aquatic and subaquatic plants. Invasion of flooded areas and deep flowages is taking place by plants from ditches like the one above.

FIGURE 18. A drainage ditch. To the right of it is a *Calamagrostis* meadow.

periodically destroyed some of the trees, while the excessive inundation in some places hindered their reestablishment.

By contrast, the cumulative effects of drought, ditching, and fires since drainage have resulted in progressive oxidation of the peat and the destruction of greater and greater amounts of it. In many instances, because of the repetition of fires, most successional stages from the tamarack–spruce stage downward have been returned again and again, or have been forced still lower, while many have been wiped out entirely and have been replaced by aspen stands. However, for reasons which will be discussed later, some areas escaped drainage. These relics have maintained their original vegetation (Fig. 6) and raw peat, and in some instances are now progressing to more advanced stages in the bog succession.

As a result of unequal drainage and fires, all stages of the bog succession, from the lowest to the final tamarack–spruce stage, exist at one place or another, presenting simultaneously all the stages in the developmental procession.

Period of dams and dikes. In 1933 and in several years following, a series of dams was installed, which led to complications in the successional stages. In many instances, dikes were constructed in conjunction with the dams, creating flowages (Fig. 16).

Secondary Successions

The following conclusions regarding secondary successions and the factors which initiated them are based chiefly upon observations made during the period of field study, 1937–1940. Analysis of such successions was greatly aided by information received from cranberry operators, local hunters, and several early settlers, concerning the conditions of certain of the areas before and after drainage and fire.

Relic areas of bog communities consist of tamarack *(Larix laricina)*, black spruce *(Picea mariana)*, and occasional individuals of white pine *(Pinus Strobus)*. Of the two dominant trees, tamarack seems to be much more fire resistant. This is demonstrated where there have been superficial fires. In such cases, black spruce has been killed, while tamarack has persisted (Fig. 9). To a limited extent, spruce has been cut for pulp and for local Christmas-tree markets. A few white pine occur, but they are usually retarded in growth. On shallow peat, however, they have attained considerable size.

The following members of the heath family typically form distinct shrub socies in the above community: bog rosemary *(Andromeda glaucophylla)*, leatherleaf *(Chamaedaphne calyculata)*, Labrador tea *(Ledum groenlandicum)*, blueberries *(Vaccinium canadense* and *V. angustifolium)*, large cranberry *(Vaccinium macrocarpon)*, small cranberry *(Vaccinium Oxycoccos)*, and huckleberry *(Gaylussacia baccata)*. Of primary importance are *Chamaedaphne, Andromeda,* and *Ledum*. *Ledum* is the most shade-tolerant and persists in greater numbers in the mature bog community where a dense canopy has developed. *Andromeda* is the most water-tolerant and dominates the more highly saturated areas. In treeless sphagnum-heath meadows, where a rising water table has brought about an extremely saturated condition, *Andromeda* tends to become the dominant shrub. *Chamaedaphne,* on the other hand, prefers drier peat, and grows in profusion where fires have destroyed much of the vegetation but have not burned into the peat (Fig. 9). Little is known of the pioneering efficiency of these shrubs by means of seeding (Stallard, 1929), but the fact that they are proficient in propagating and spreading by means of rootstocks may explain their abundance on superficially burned areas.

Cranberry, like Labrador tea, tolerates shade, and persists in fairly considerable numbers under a dense tree canopy. Huckleberry and blueberry are secondary shrub species occurring infrequently in the bog community.

Conspicuous areas of pitcher plant *(Sarracenia purpurea)* occur in the sphagnum mat while pink lady's slipper *(Cypripedium acaule)* occurs less frequently. Periodical harvesting of sphagnum by raking results in the fragmentation of plants of *Cypripedium* and their consequent increase by far greater numbers than normal reproduction would bring about. This practice also does not seem to reduce the sphagnum materially. Scattered plants of creeping snowberry *(Chiogenes hispidula)*, Indian pipe *(Monotropa uniflora)* and sundew *(Drosera rotundifolia)* are found in the dense sphagnum mat. Cotton grass *(Eriophorum virginicum)* is restricted to open places, and *Osmunda cinnamomea* often occurs around the edges of such areas.

Those scattered relics of the bog community (Fig. 6) which still persist escaped destruction for various reasons. Some of the ditches were ineffective in draining the peat because they were too shallow, or soon became so through silting. In several instances very large peat areas were more resistant to drainage because of their size, while still others were associated with reservoirs for cranberry bogs. In addition, several tamarack–spruce areas exist today in places where the surveyors recorded open marsh. They are presumably the result of recent development.

Causes of secondary successions:

1. Desiccation of the peat by drought and drainage.
2. Fire after desiccation, the intensity of the fire being dependent on the severity of the desiccating factors.
3. Rise of the water table as a result of damming the ditches, which has killed mesophytic vegetation on destroyed bogs and aided bog communities where they still survived.
4. Flooding of large areas by impounded water inside dikes, which has destroyed existing vegetation and initiated aquatic successions.
5. Cultivation and later abandonment of the peat, resulting in weedy successions, some of which have been obliterated by the 1930 fire and by the rising water table, or by actual flooding.

SECONDARY SUCCESSIONS INITIATED BY DESICCATION: Successions resulting from desiccation after drainage were almost entirely wiped out by the subsequent widespread fires. Where such areas do occur, the following quasi-mesophytic climax (Fig. 7) results: white pine, jack pine, oak, maple, white birch, alder, bracken fern, and dewberry.

SECONDARY SUCCESSIONS INITIATED BY FIRES: Three degrees of burning are distinguishable: (1) superficial burning, in which a rapid hot fire destroys many or all of the trees without seriously affecting the ground-cover plants or the peat; (2) medium burning, in which the ground-cover and surface peat have been destroyed; (3) deep burning, in which the bog vegetation is completely wiped out and the peat is burned to a considerable depth. A summary of the typical secondary successions resulting from drainage, fire, and later flooding are sketched in Figure 5.

(1) *Successions following superficial burning*

(a) The *Larix–Picea* associes. The most favorable places for the establishment of *Picea mariana* and *Larix laricina* are comparatively dry peat areas where the *Ledum–Chamaedaphne* associes occurs. While the latter associes is usually the forerunner of an invasion by tamarack and spruce (Fig. 8), these trees may occasionally invade a *Calamagrostis–Carex* associes (Fig. 10) before or simultaneously with the shrub invasion. Typical situations for the invasion of tamarack and spruce, however, are sites on which a superficial fire has killed most of the trees, but has not seriously affected the peat or the ground cover. Here the heath shrubs quickly recover by means of rootstock propagation, and sphagnum readily invades any burned-out patches. Where seed stock is present (Fig. 8), reestablishment of tamarack and spruce takes place rapidly.

In some cases spruce, because it is more vulnerable to fire, is entirely wiped out, and reestablishment of tamarack alone proceeds, resulting in a *Larix* consocies. However, it is possible for a *Larix–Picea* associes to develop eventually into a *Picea* consocies. Since spruce is more shade-tolerant than tamarack, its seedlings can develop in the shade of the latter. As individuals of tamarack mature and die, establishment of spruce seedlings in spaces left by their death is more likely to occur (Stallard, 1929). This procedure may continue until the final result in a *Picea* consocies. In this region, no bogs occur which are mature enough to present a stage so late in the bog succession.

(b) The *Ledum–Chamaedaphne* associes. The following heath shrubs are members of this associes: *Chamaedaphne calyculata, Ledum groenlandicum, Andromeda glaucophylla, Vaccinium macrocarpon, V. Oxycoccos, V. canadense, V. angustifolium. Gaylussacia baccata* and *Nemopanthes mucronata* occasionally occur as secondary species. A sphagnum mat is the characteristic ground cover.

This associes is the typical stage existing on peat areas where a superficial, hot, rapid fire has wiped out the trees. In such instances the heaths are also affected by the fire, but recover rapidly by rootstock propagation and become more numerous than before. Where such fires have occurred, the surface peat is generally somewhat dry. Under these conditions, *Chamae-*

daphne readily propagates from rootstocks and tends to dominate. If relic plants of bog birch *(Betula pumila* var. *glandulifera)* are present, dense stands of it often develop. Like *Chamaedaphne,* it does not produce thick stands where loose sphagnum or saturated peat are present, but where the peat is dry, dense stands are likely to appear. Alder *(Alnus rugosa)* also develops some stands on the same situations. Scattered stands of aspen *(Populus tremuloides)* often develop on rather dry peat surfaces where superficial fires have occurred, but do not produce hardy individuals where the water table is high. Continued high water level invariably kills the aspen (Fig. 15). Where the peat becomes saturated or slightly flooded after a superficial fire, *Andromeda* reinvades and becomes the dominant shrub.

Where the water table is close to the surface, sphagnum remnants easily regenerate typical hummocks which eventually enlarge and coalesce. Of the herbaceous plants, *Sarracenia purpurea* is the most likely to escape complete destruction, and if the fire has not been too severe, it may regenerate communities in the sphagnum mat. In the open heath stage, it often occurs in depressions between the sphagnum hummocks where there is likely to be more moisture and shade. *Monotropa uniflora, Cypripedium acaule,* and other herbaceous plants of the sphagnum mat are less hardy and are easily destroyed by superficial fires.

Summary: Where a superficial fire has killed most of the tamarack and spruce, but has not seriously affected the ground cover or peat, a rapid invasion of these trees follows. In such instances the heaths are also affected by the fire but recover quickly by means of rootstock propagation.

(2) *Successions following medium burning or repeated superficial fires*

(a) The *Betula–Alnus* associes. This appears on medium burns where the water table is well below the surface, since the seeds of *Betula, Alnus, Cornus,* and *Salix,* which are the predominant members of the associes, germinate above the water. Here *Betula pumila* var. *glandulifera* usually appears first. Vegetative propagation by means of root shoots, as well as the production of large amounts of mobile seeds produced early in the life of the plant, often bring about the formation of pure stands (Fig. 9). *Alnus rugosa,* which produces fairly mobile seeds, may also appear, though usually in less abundance. Where relic plants of *Chamaedaphne* exist, vegetative propagation leads to a fair representation of it. Other plants often occurring as secondary species are red-osier dogwood *(Cornus stolonifera)*, poison sumac *(Rhus Vernix)*, paper birch *(Betula papyrifera)*, willows *(Salix* spp.) and aspen *(Populus tremuloides)*. Sphagnum is usually replaced in varying amounts by *Polytrichum commune.*

Repeated superficial fires on a *Ledum–Chamaedaphne* area may also result in a *Betula–Alnus* associes, or in widespread stands of *Betula* with an admixture of *Chamaedaphne* where the surface peat is fairly dry.

Where open places exist, various herbaceous species or combinations of them may occur. The most prominent include *Scirpus cyperinus* var. *pelius, Calamagrostis canadensis, Solidago gigantea, S. uliginosa, Eupatorium perfoliatum, Cirsium muticum,* and *Helianthus giganteus.* These open areas are eventually invaded by woody species and the herbaceous plants are shaded out.

Considerable variation in the makeup of these associes may be found, depending on the condition of the peat, proximity of parent plants, and particular characteristics of component species, such as tolerance of water, ability to propagate vegetatively, abundance and mobility of seeds produced, and germination requirements of seeds.

(b) The *Salix–Alnus* associes. The members of the *Betula–Alnus* associes develop their best stands where the surface of the peat is dry following burns and the water table is fairly low, though the majority can grow with their bases submerged in water for considerable periods of time. This is especially true of willows, which often are found in considerable depths of water. A *Salix–Alnus* associes develops where high water levels follow the initial stage of dry peat and a low water table. Other water-tolerant shrubs of the *Betula–Alnus* associes may occur as secondary species, or a pure stand of willows may develop, forming a characteristic *Salix* consocies.

(c) The *Calamagrostis–Carex* associes. According to old settlers of the region, many of the "open marshes" were covered with a dense stand of bluejoint and sedge, some of which may have been the original "prairies" described by the surveyors; others probably were the result of medium fires which removed the woody species and allowed an invasion of the *Calamagrostis–Carex* associes. These "open marshes" or "prairies" were the wire-grass meadows which furnished raw materials for a thriving weaving industry at the turn of the century. The dominant sedges of this associes were *Carex oligosperma* and *C. filiformis,* while *Calamagrostis* was considerably less abundant. With the advent of drainage, however, *Calamagrostis* became the dominant species.

Open areas in the *Ledum–Chamaedaphne, Betula–Alnus,* and *Salix–Alnus* associes were often invaded and occupied by *Calamagrostis.* Similarly, large areas of *Calamagrostis* (Fig. 11) may develop where medium fires have burned the peat uniformly and removed the woody species. Where adequate water is supplied at a constant level, relic patches of sphagnum eventually produce a typical mat. In such instances, the *Carex* species increase also, especially where *Calamagrostis* does not form a closed stand very rapidly. Both *Carex* and *Calamagrostis* are aided in spreading and invading by the blowing of seeds. Once established, they solidify the stand by means of root shoots.

The *Calamagrostis–Carex* associes (Fig. 11) also becomes established on areas where repeated superficial burns have progressively reduced stands of *Ledum–Chamaedaphne.* With each successive fire, closing in of stands by the bog heaths becomes more difficult, and where the water table is sufficiently high, the *Calamagrostis–Carex* associes finally replaces them.

After reinvasion by sphagnum, establishment of a *Ledum–Chamaedaphne* associes may begin. Where relics of these heaths exist, the process is considerably hastened. Relatively drier situations where sphagnum does not readily reinvade may be invaded by *Betula, Alnus, Salix,* or similar plants. In such instances, the kind of species and the stage of succession which follow depend on the proximity of parent plants as well as mobility of the seed.

Typical *Calamagrostis–Carex* associes have associated with them a living sphagnum mat. However, sphagnum may be destroyed by drouth or by flooding. Stallard (1929) observes that sphagnum cannot survive or develop in flooded areas or in places where the water table fluctuates. In the latter case an elevation of the water level perches the plants on the culms of grasses and sedges, where they are left when the water recedes, and readily dry out and die. While sphagnum in a saturated condition holds water up to 20 times its own weight (Dachnowski, 1935), it is incapable of drawing up water efficiently by capillarity, so a prolonged and decided drop in the water level results in the death of the sphagnum. Where drought kills the sphagnum, it eliminates many of the sedges of the associes as well.

Wool grass *(Scirpus cyperinus* var. *pelius)* (Fig. 12) is much more tolerant of fluctuating water levels as well as of periods of drought or flooding than are the primary members of the *Calamagrostis–Carex* associes. When such disturbances take place, invasion by *Scirpus* follows (Fig. 12). Where water levels permit, the following secondary species may also be present: *Spiraea tomentosa* var. *rosea, Solidago* spp., *Aster paniculatus, Eupatorium perfoliatum, Helianthus giganteus, Bidens* spp., *Cirsium muticum.* Periods of drought may result in invasion by *Alnus, Betula, Salix,* and other woody species.

Summary: Medium burns result in earlier retrogressive successions than do superficial burns and involve either various woody plants not typical of the bog community or plants of the sedge-meadow stage. Most of these associes, however, are merely preliminary to invasion by the typical bog associes.

(3) *Successions following deep burning*

(a) The *Populus tremuloides* consocies. Where drainage was entirely successful, the fires burned deeply into the peat, often burning down to the underlying substratum. A pure stand of aspen *(Populus tremuloides)* follows deep burning of desiccated peat (Fig. 13).

In many instances the aspen seedlings are arranged in groups around burned-out stumps of tamarack and spruce. Where cracks occur in the peat as a result of drying, the seedlings appear in a reticulate pattern which may still be apparent in mature trees. Probably seed germination is more successful in these cracks because of the moisture which is held there. Burns on established stands of aspen result in the reestablishment of the consocies by sprouts from the burned trees. Repeated burning, however, may eventually destroy the plants completely and wipe out the stand.

Admixtures of aspen often are found with various of the associes resulting from less severe fires. Growth of these aspen is retarded by the less favorable environment, and their ultimate destruction is assured where high water levels exist and they must compete with other more water-tolerant woody plants.

In many instances drainage has been successful, and the consequent fires have severely burned vast areas of peat land, leading to the establishment of solid stands of aspen (Fig. 13). At present no conclusion can be drawn regarding the successions following the aspen monotype. What happens will depend on the level at which the water table becomes stabilized. If they remain dry, it is quite possible that white pine may follow. Many of the aspen areas are already, as a result of rising water levels, too wet to permit further development (Fig. 14), while still others have been flooded for several years, with resulting death of the trees (Fig. 15). Amphibious and aquatic plants are invading such areas.

Summary: Deep burns not only completely destroy the bog plants, but initiate a succession which neither involves bog species nor tends toward the reestablishment of the bog community.

SECONDARY SUCCESSIONS INITIATED BY A RISING WATER TABLE AND BY FLOODING: Damming of the ditches, which was begun in 1933, has brought about a steadily rising water table, with the result that the water is near or at the surface. However, where deeply burned peat basins occur, shallow flooding has been the result (Fig. 14).

A rising water table retards the growth of the aspen, while flooding, if it continues, kills them. Comparatively deep flowages (Fig. 16) were created where the water was impounded behind constructed dikes and allowed to flood natural basins.

Large sources of sub-aquatic plants in the ditches (Figs. 17 and 18) and cranberry reservoirs (Catenhusen 1944) are aiding the invasion of the wet and flooded areas.

(1) *Successions following shallow flooding*

(a) The *Typha–Phragmites* associes. Following shallow flooding, the typical associes consists of cat-tail *(Typha latifolia)* and reed *(Phragmites communis)*. Often socies are formed by several species of *Alisma, Sagittaria,* and *Sparganium. Scirpus validus* occurs infrequently, as do *Polygonum natans* forma *genuinum, P. Careyi,* and *P. coccineum* var. *pratincola.*

Typha and *Phragmites* are the most aggressive because of the speed with which they reproduce vegetatively. While most of the other species propagate similarly, their efficiency is considerably lower; in addition their seeds occur in smaller numbers and are not easily disseminated by wind.

The seeds of *Typha* are produced in abundance and are easily scattered by the wind. Unlike *Phragmites,* it will develop in a variety of situations just as long as there is sufficient moisture to bring about seed germination. *Phragmites* does not produce a large number of viable seeds and it is much more restricted in its requirements for seed germination and successful establishment.

Because of the ease with which *Typha* and *Phragmites* reproduce vegetatively, it is likely that they will eventually replace the secondary species. At present, no conclusion can be drawn regarding successions which might follow. It is likely, however, that enough debris will be deposited by them to raise the surface above the water level and allow an invasion of a *Salix–Alnus* or a *Calamagrostis–Carex* associes.

(2) *Successions following establishment of flowages*

Plants of the *Typha–Phragmites* associes often form a zone along wet shores. Other herbaceous plants occurring on wet shores or in shallow water are *Eleocharis obtusa, Pontederia cordata,* and *Ludwigia palustris* var. *americana.* Several grasses often appear on wet shores as well: *Glyceria canadensis, Echinochloa pungens,* and *Leersia orzyoides.*

Various floating plants growing in the ditches have been washed into these flowages and are becoming established there; the following are usual ones observed in such instances: *Lemna minor, L. trisulca, Utricularia vulgaris* var. *americana,* and *Potamogeton epihydrus* var. *Nuttallii.*

Fairly constant water levels in these flowages have existed for only the past few years, so that natural revegetation of such areas has only just begun. The normal succession of aquatic plants in these flowages has probably been upset by the introduction of numerous aquatic plants, planted there for the purpose of increasing the wildlife potentialities of the flowages.

SUMMARY

U. S. government surveyors in 1839–1855 found extensive treeless areas of "open marshes" and "moss marshes" as well as "marshes" with scattered individuals or small stands of

tamarack, spruce, and white pine, and other less extensive areas of the tamarack–spruce community. Occasional admixtures of maple, aspen, white birch, and alder were also reported.

Because of the extremely wet condition of the peat land previous to drainage, fires were probably of a superficial nature, arresting the stages of the bog succession but never completely destroying them.

The combined effects of several severe drought periods and drainage resulted in more severe fires. During the drainage period, fires of various intensity occurred, depending upon the degree of desiccation.

A superficial burn on a bog results in retrogressive successions. Where no later interference takes place, a progressive recovery occurs, tending toward the reestablishment of the bog community. Tamarack and spruce readily reestablish themselves after superficial fires from any seed stock which has escaped destruction, and the bog heaths recover by means of rootstock propagation of relic plants. Sphagnum, provided the peat is wet, rapidly regenerates a typical mat.

A medium burn or frequent superficial burns result in a lower stage of retrogressive succession than does a superficial burn and make possible an invasion by bog birch, dogwood, willow, and alder, where the surface of the peat is dry. If shallow flooding follows, willow, and to a lesser extent alder, become the dominant plants. Open areas betwen stands of these woody species are often invaded by bluejoint and sedge if the peat is wet and by wool grass where fluctuations of water levels or alternating periods of drought and flooding occur.

A deep burn not only completely destroys the bog species, but initiates a succession which neither involves bog species nor tends toward the reestablishment of the bog community. Such deep burns are followed by a pure stand of aspen. A rising water table retards the growth of aspen, while flooding, if it continues, kills them. It is not known what successions will follow the aspen stands which are established on dry peat, but it is possible that white pine may follow. Where flooding has killed the aspen, wool grass invades.

The aquatic plants which survived the drainage period in protected cranberry reservoirs, natural streams, and in the ditches themselves, are spreading into the flooded areas. The

Typha–Phragmites associes often forms a zone along wet shores. Several grasses often appear on wet shores as well: *Glyceria canadensis, Echinochloa pungens,* and *Leersia oryzoides.* Floating plants, such as *Lemna minor, L. trisulca, Utricularia vulgaris* var. *americana, Potamogeton epihydrus* var. *Nuttallii* form zones in the water.

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SOME MORPHOLOGICAL AND CULTURAL STUDIES ON LAKE STRAINS OF MICROMONOSPORAE*

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INTRODUCTION

The classification of the *Actinomycetaceae,* the parent family of the genus *Micromonospora,* has interested many investigators, Breed and Conn (1919), Drechsler (1919), Jensen (1931), Krainsky (1914), Krassilnikov (1940), Lehmann and Neumann (1912), Lieske (1921), Orskov (1923), Stainer and Van Niel (1941), Waksman and Curtis (1916), Waksman (1940). Two later workers, Waksman and Henrici (1943), have given one of the newer classifications for the family, with a marked revision of new genera for some of the members. It is interesting to note, however, that with all of the altering in position of the other actinomycetes the original genus *Micromonospora* has not been subjected to much change in its placement since Orskov (1923) proposed it. While it is true that the genus itself has not been subject to change, the classification framework for the organisms within the genus has not met with such uniform acceptance by the workers with the group.

Colmer and McCoy (1943) have shown that micromonosporae are found in the waters and muds of some Wisconsin lakes. During the course of the survey of these lakes a pure culture collection of 538 representatives of the group was obtained. In view of the present status of the classification of the genus, it was thought to be of interest to study the correlation of these lake strains of micromonosporae with the speciation as has been proposed in the classifications based on known soil forms. Too, a study of the organisms from both a morphological and cultural approach is desirable because the genus does comprise a little-known group of organisms.

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Probable micromonsporae of thermophilic nature. In some of the early work on thermophilic actinomycetes there is reason to believe that organisms now named *Micromonospora* were involved. Kedzior (1896) found in sewer water a thermophilic organism considered by him a *Cladothrix*. His statement about it ("einige Kurze Fäden mit ganz deutlichen Endanschwellungen versehen sind") and his illustrations indicate that his organism was probably a *Micromonospora*. Tsiklinsky (1899) isolated a thermophilic actinomycete from such varied sources as potatoes, manure, soil, etc. She named it *Thermoactinomyces vulgaris*. Her photomicrographs might well represent work done in 1950 on a member of the *Micromonospora* rather than pictures made in 1899 on *Thermoactinomyces vulgaris*. Her statement is of interest: "Les spores apparaissent au bout des filaments sous forme de renflements ronds ou ovoïdes." The cultural characteristics, as well as the morphological properties, of *Thermoactinomyces vulgaris* agree well with those of *Micromonospora*.

In 1907 Miehe, studying the self-heating of hays, described an organism with the name of *Actinomyces thermophilus* which, when the manner of spore formation is considered, indicates its relation to *Micromonospora*. Additional work on the self-heating of hays, particularly that of clover, was done by Schütze (1908) who isolated another thermophile which he named *Actinomyces monosporus*. His drawings show a typical *Micromonospora*, and his description of spore formation might well apply to those forms to be reported in this work.

Probable micromonosporae of pathologic significance. Williams (1912) must have been working with a *Micromonospora*, although he terms the organism a *Streptothrix*, since his organism had "single oval spores at the end of threads." It was isolated from a case of tuberculous pericarditis. Acton and McGuire (1931) found a *Micromonospora*-like organism concerned with pathologic processes on the feet of rice workers in India when suffering from a disease caused by an organism termed *Actinomyces keralolytica*. Erikson (1935, 1940) made a study of some aerobic and anaerobic pathogenic *Actinomyces*. One of the aerobic cultures, N. C. T. C. #4582, had been isolated from a case of Banti's disease. Although this organism produced a sparse aerial mycelium she regarded it as a micromonospora resembling *M. parva* Jensen. An anaerobic strain, N. C. T. C.

#5779, had been isolated from diseased hair; its characteristics were those of a micromonospora resembling *M. fusca* Jensen.

Other reports of the occurrence of micromonosporae. In 1932 Bredemann and Werner demonstrated a rather common *Actinomyces* species which was a powerful butyrate decomposer. Their illustration indicated that their organism was a micromonospora.

Kriss (1939), a Russian worker, studied eight mesophilic, saprophytic strains of micromonosporae isolated from semi-arid soils. He named his organism *Micromonospora globosa* and termed all his organisms strains of the one species. Waksman, Umbreit, and Cordon (1939) have given the results of their study of soils and composts in relation to thermophilic actinomycetes and fungi, and it is in this late report that reference was made to an aerial mycelium being a morphological attribute of the thermophilic members of this genus. Waksman, Cordon, and Hulpoi (1939) amplified the findings reported in the first paper. Hungate (1946) has reported finding a *Micromonospora* sp. in the alimentary tract of the wood-eating termite, *Amitermes minimus*. It was obligately anaerobic and was of interest due to its possible evolutionary relationship to the propionic bacteria and the actinomycetes.

Suggested Schemes for Classification of Micromonosporae

Although it was Orskov (1923) who, in his scheme for the classification of that group of microorganisms previously known as *Actinomyces*, put the genus *Micromonospora* in Group III and based the definition of the genus upon the characters possessed by the one strain which he had received from a culture collection, it was Jensen (1932) who gave the genus a firm footing with his study of the mesophilic, saprophytic forms. His findings will be used in later discussions; his scheme of classification is given below:

I. Vigorously growing organisms, typically with copious spore formation on dextrose–asparagin agar.
   A. Vegetative mycelium pale pink to deep orange, no typical soluble pigment *Micromonospora chalceae.*
   B. Vegetative mycelium orange changing to brownish-black, brown soluble pigment
   ....*Micromonospora fusca.*

II. Slowly and feebly growing organisms, with scant spore formation on dextrose-asparagin agar, no soluble pigment.
   A. Vegetative mycelium pale pink to pale orange ....*Micromonaspora parva.*
   B. Vegetative mycelium blue ....*Micromonospora coerulea.*

In 1940 Krassilnikov published a short report on the classification of the actinomycetes. He set up two co-ordinate families, the *Actinomycetaceae* and the *Micromonosporaceae*. The latter had but one genus, *Micromonospora.* His description of this genus again gave the outstanding characteristics of the group: "*Micromonospora,* unlike the species of the genus *Actinomyces,* forms conidia on the branches of its aerial mycelium,—one at the end of each conidiophore."

Waksman (1940) gave impetus to the subdivision of the genus into subgroups. This was an outgrowth of the earlier work of Jensen (1932) which had been directed toward such a subdivision. The findings of Waksman and his co-workers in their work with micromonosporae of composts aided in the classification. Because of the discussion that will be undertaken upon the placement of the lake strains of this genus, the Waksman classification of these organisms is given *in toto.*

Family MICROMONOSPORACEAE Krassilnikov

Well developed, fine, non-septated mycelium, 0.3–0.6 μ in diameter. Grows well into the substrate. Not forming at any time a true aerial mycelium. Multiplies by means of conidia, produced singly at end of special conidiophores, on surface of substrate mycelium. Conidiophores short and either simple, branched or produced in clusters. Strongly proteolytic and diastatic. Comprises mostly saprophytic forms. These organisms occur mostly in manure, aerial dust and soil; many are thermophilic and can grow at 65 degrees C.

I. Genus *Micromonospora* Orskov
   Type species—*Micromonospora chalceae* (Foulerton) Orskov

This genus could be subdivided on the basis of the relations of the organisms to temperature, since it includes a number of thermophilic forms which grow readily at 55–65 degrees C, and mesophilic forms having their optimum temperature at 30 degrees C. Each of these groups is divided into three subgroups, based on the structure of the spore-bearing hyphae. Among the thermophilic forms only representatives of the first group have so far been isolated in pure culture although the existence of the other two groups has definitely been demonstrated in microscopic preparations.

Subgroup 1. Simple spore-bearing hyphae.
Type species—*M. vulgaris* (Tsiklinski) Waksman

Subgroup 2. Branching spore-bearing hyphae.
Type species—*M. chalceae* (Foulerton) Orskov

Subgroup 3. Spore-bearing hyphae in clusters.
Type species—*M. fusca* Jensen

The available information does not justify as yet the separation of the thermophilic forms into separate species. However, this may have to be done later when more information has accumulated concerning these organisms.

EXPERIMENTAL

Culture sources and designations. Of the 49 cultures finally selected for more intensive study, 32 came from Lake Mendota. With the exception of culture S 1932–5 and the two cultures, J 301 and J 405, all of the remainder were from the lakes reported on before (Colmer and McCoy 1943). J 301 and J 405 were from the culture collection of Jansky (1936), who secured them from the "Highland lake district of northeastern Wisconsin."

The following cultures were from Lake Mendota:

A4–4	E1–3	H5–4	O3–1
A6–3	E2–2b	J5–7	P1–3
A2–4	E2–2p	J7–15	P1–4
A6–6	E3–7	J3–5	Q2–5
A6–8	F2–2	K2–8	S3–2
E5–6	G4–3	L2–4	T3–4
E5–3	H5–3	M1–6	T5–3
E2–1	H5–9	N3–5	T9–2

Each is designated by a letter followed by two numbers. This scheme permitted a type of bookkeeping which facilitated tracing the date of collection and the location in the lake from which the sample was taken. Culture S 1932–5 came from Lake Mendota also, but singularly, it was isolated from a sample of shallow mud which had been collected in 1932, dried in a 37°C incubator, and then held at room temperature. All of the cultures except N3–5 were from muds at the 15 to 18 meter depth of Lake Mendota. N3–5 came from the sandy bottom of the University Bay area.

The cultures chosen from the other lakes are:

TL 190 (Trout Lake)	J 301 (Jansky, thesis culture)	R 1 (Ripley)
TL 200–1	J 405	R 18
TL 215		
TL 217	LJ 41–2 (Little John)	N 6 (Nebish)
TL 220–2	LJ 51–3	C 91 (Crystal)
W 24 (Weber)	M 2 (Monona)	Bog (Unnamed bog)

Some techniques used for actinomycete study. Waksman (1919) quotes Nadson as indicating that the term colony is incorrect for designating a mass of growth of an actinomyces because "it is not true to nature to call a mass of mycelium developing out of a spore a colony, as in the sense of a bacterial colony." This statement may be applied as well to the mass of mycelium of *Micromonospora* species. However, since in bacteriological terminology the word "colony" carries concomitantly so much other than the idea that it is the resulting progeny of a single cell or spore or small aggregate of these, colony will be used in this report to mean that resulting mass of filaments and spores which might have resulted from the growth of a single spore or closely lying cluster of them or possibly from a small segment of mycelium.

Both Drechsler (1919) with *Actinomyces* species and Kriss (1939) with *Micromonospora* species used impression techniques to study the morphology of their organisms. An adhesive-coated glass cover slip was pressed down upon the organism to be studied, carefully raised, and then stained. The procedure revealed the structure of the surface of the colony. Waksman Umbreit, and Cordon (1939) made use of contact slides in their compost work. Orskov (1923) developed an agar block technique for the study of members of the actinomycetes.

Two tests were devised to study the possibility of using contact slides in this investigation. One test made use of lake deposits known to have about 300,000 micromonosporae per gram. Glass tumblers were filled with the mud and then sterile glass slides were placed upright in them. The glasses were covered to prevent excessive evaporation and were then incubated at room temperature. After times varying from five to 30 days, the slides were carefully removed and stained with phenolic rose bengal for 12–15 minutes over a steam bath. The second test was made on pure cultures of the organisms, since in many instances it had been noticed that they grew attached to the sides of the tubes of broth. To investigate the possibility of using this property as a means of attachment to slides for microscopic work, glass slides were submerged in nutrose broth containing growing cultures.

Use of liquid and solid substrates. The primary liquid medium used was nutrose broth (Henrici and McCoy, 1938). The "milky" sheen of this broth disappeared under the diastatic and proteolytic action of the organisms, and the liquid, as a result, became water clear. Thus any turbidity of the liquid could be regarded with suspicion as having been caused by a contaminant.

Wet mounts made from the broth did not allow proper focusing with the oil immersion lens, and, because of the minute size of the growth, it was obligatory that the magnification furnished by this lens system be used. Care had to be taken, too, in observing the mass of filaments and interpreting the observations since a refraction could be caused by the crossing of filaments to give a minute, dense area of high refractivity which had the appearance of a spore. This condition also could be caused by the turns of the filaments being at such an angle that the refraction of the added protoplasm at the spot gave a dense area resembling that caused by a spore. However, when aqueous methylene blue was permitted to flow under the cover slip, the slide being still mounted under the oil immersion lens, the progressively staining portions of the basal hyphae, branchlets, and spores permitted a more detailed study of these microscopic structures.

The solid media commonly used with actinomycetes by Conn, (1921); Krainsky, (1914); Waksman, (1919); Jensen, (1930); were used in the study of the morphology and cultural characteristics of the micromonosporae. Such work was found to be standardized by the use of the starch casein and dextrose casein media of Jensen (1930). For morphological studies, colonies of different ages were dug from the agar slants and crushed upon slides to free the growth of agar. When such masses were observed, as in a wet mount or by the use of the conventionally stained slide, it was found that the agar debris and the fragmentation of the growth resulting from the preparation of such slides did not permit a satisfactory study of the organisms.

Stained agar slide technique. Because of the deficiencies shown in the other procedures, an agar-slide technique was developed to permit the observation of an undisturbed growth. To prepare for these slides, petri dishes were selected so that two slides could be placed in them abreast. Glass tubing in the bottom of the dishes held the slides level and kept them above the moistened blotting paper in the bottom of the dish. The whole assembly was autoclaved at 15# steam pressure for 30 minutes, and, upon cooling, each slide had a streak of dextrose casein agar layered along each lengthwise edge. This gave, as a result, a central area the length of the slide where the expressed fluid from the hardened agar streaks lay in a film. Growth from the liquid culture to be examined was inoculated upon the agar and this thin nutrient layer. For some cultures a loop carried sufficient growth to serve, but for organisms which grew as fine granules and could not be handled effectively by the loop, a pipette was used. In this case as little of the substrate was carried over as was possible. In some tests the inoculants were five to eight days old, whereas with others, when a spore suspension was desired, they were approximately 30 days old.

The petri plates containing the inoculated slides were incubated at 30°C. in cans saturated with water vapor. Under such conditions of moisture, both within and without the petri dishes, the agar slides did not dry out even when held for a month. Slides were taken from the petri dishes at varying lengths of time to observe the growth, and when it was seen by macroscopic observation that this was satisfactory, the agar was rapidly dried over a steaming water bath. Usually the time of incubation was from five to 10 days with the longer period needed for the slower growing strains. The agar on the slides had but little tendency to crack in drying and when slides were kept in a dried-down, unstained condition for weeks, there was no deterioration in their usefulness.

The staining technique devised by Frost (1921) for the "little plate" culture was tried. With either methylene blue or thionine the agar was too deeply stained to permit good definition of the organisms, and the filaments and spores of the organisms were not dyed intensively enough. Carbol fuchsin and crystal violet stains were used but were not satisfactory. The final staining technique made use of the Hucker Gram stain as given in the Manual for Pure Culture Study (1939).

Sectioned agar colonies. Both starch casein and dextrose casein agars were used as the substrates for the organisms in this portion of the cultural study. Decimal dilutions made possible well isolated colonies and the spore inoculant ensured a colonial growth derived most probably from a single spore. Incubation was at 30°C. and samples of the colonies were taken at ages varying from two to six weeks. Both sub-surface colonies and colonies with a surface exposure were used.

Greene (1938) used an agar-paraffin embedding technique to study colony organization of certain bacteria; Erikson (1941) used a similar method for her study. In the present work a paraffin with a high melting point, approximately 55°C. was used. It supported the agar-colony complex better under the action of the microtome than did the softer paraffins. Formalin-acetic acid-alcohol and the solution of Karpechenko proved most satisfactory as fixing solutions for the agar-embedded colony. The dehydration of the preparations was accomplished by the usual alcohol-cedar oil technique.

The embedded colonies were serially cut by means of a rotary microtome. Sectionings were made so as to give both cross sectional and tangential preparations. Different thicknesses of sections were tried; those of five micra had less tendency to tear than did those of less thickness, and at the same time permitted more observation on colonial structure than the sections of greater thickness. Differential staining was attempted, but the best results were secured by the use of Delafield's hematoxylin or crystal violet.

RESULTS

Morphological findings:

Kriss (1939) did not stress the information gained by his "Klatsch" procedure for the surface study of the colonies of *Micromonospora.* A similar technique used so well by Drechsler (1919) in his *Actinomyces* work failed to give fruitful results in the present study. Only detached, isolated spore-masses resulted from the pressure put on the surface colonies, and little information was gained of the conidiophore structure. No procedure was utilized in this work which was comparable to that of Orskov (1923), since it was found that the use of unstained mycelia posed problems which the stained-slide technique overcame.

The attempts to use glass slides for contact preparations in the lake muds ended in failure. Possibly this was due to too low a number of micromonsporae per unit area of the glass slide exposed, or it might have been that the area exposed by the colloidal mud particles and the nature of the growth of the micromonosporae in such a substrate prevented their attachment to the slides. When pure cultures were used with glass slides submerged in the broth, the attachment of the growth to the slides was very insecure and the type of the growth present made its use inadvisable for detailed morphological study. Henrici and McCoy (1938) reported that filamentous forms were seldom seen in direct staining of mud samples.

It was the stained agar slides which made detailed observations possible upon the composition and arrangement of the growth of the micromonosporae. The mycelial masses which were produced upon the agar strips of the slides were dense, bore few spores, and, because of the lack of sharp definition, were hard to study. Since the center areas of the slides were free of the agar, there was a clear background and observations were facilitated.

When a spore suspension of a fast-growing strain was used for inoculation, germination occurred, the germ tubes elongated, side branchlets appeared, and the conidiophores bore their singly placed spores. With some of the slow-growing strains this complete cycle was not completed before growth stopped.

With organisms which had to be pipetted onto the agar slide due to their granular type of growth, few filamentous strands were seen on the stained slide and the organisms appeared, in the main, in dense colonies. These colonies (clumps) were those which had been in the inoculation and thus had grown but little in proportion to the mass of mycelium introduced. Only the peripheral portions had continued growing as was demonstrated by a deeply stained fringe about the original clump. The center of the clump appeared to have disintegrated; it remained unstained and it seemed to have undergone dissolution leaving but a circular fringe of viable filament ends with deeply staining protoplasm.

Mature spores were round or elliptical in shape varying from 0.7 to 1.0 micron in size. Spores about to germinate were larger, averaging about 1.5 micra in diameter. The germ tubes were smaller in diameter than the spore body from whence they came, and there appeared to be no characteristic number of these tubes which might arise from a spore. Usually one to three tubes were seen coming from the spore body. In some instances side branchlets appeared within three days upon these young hyphae, and with the fast-growing strains a well developed mycelium was evident in five days. Very frequently with the slower-growing strains the growth from the spore failed to develop a dense mycelium; only young hyphae were seen about the spore.

Hyphae of the micromonosporae were small in diameter; most, as measured by a filar micrometer, ranged about the mean of 0.5 micron. With some of the strains there seemed to be a heavier axial strand from which filaments of lesser diameter arose. No dichotomous branching was observed.

The formation of conidiophores or, in the case of some strains, the branchlets which in turn bear conidiophores, began with bud-like swellings on the side of the hyphae. Where this bud was to serve for the reproductive unit, there was an elongation of the conidiophore followed by a terminal swelling which, after assuming a spherical or oval shape, had a final septum formation which subtended the formed spore. The conidiophore, bearing its single conidium, varied in length. In some slide preparations, the conidiophore was so short that the spore appeared to rest on the hypha; in other instances the conidia were at the end of conidiophores varying from 1.0 to 2.0 micra in length. A single microscopic field of some preparations gave all gradations in conidiophore lengths.

Usually the spores appeared back in the mass of the mycelium rather than at the periphery of the colony. No definite portion of the colony could be determined as the area for this reproductive process until the protrusion of the buds on the hyphae became evident. In wet mounts made from broth cultures approximately a month old, ripe spores were easily loosened from the conidiophores. These old spores did not retain the dye well; only the membrane held the stain while the remainder of the spore remained unstained. In like preparations of younger cultures of some strains, spore clusters were seen in which the short branchlets still held the conidiophores and the whole mass strikingly resembled a cluster of grapes or a fruiting head of *Botrytis.*

The fragmentation of the mycelium, so often reported as characteristic of the *Actinomyces,* was never observed in the *Micromonospora.* On old agar slides "ghost" hyphae were often seen which had not retained the stain. In some preparations granules were observed in the hyphae but true cross-walled mycelia were never encountered. The rudimentary serial mycelium reported for some of the thermophilic members of this genus and for some of the other specimens reported in the literature was never seen in this work.

No morphological character or set of characters were found in these lake strains of micromonosporae which could serve for distinguishing the microorganisms.

Cultural findings:

By making use of their growth characteristics as shown in liquid culture, particularly the standard nutrose broth, three arbitrary divisions of these lake strains were made possible. The strains belonging to these divisions are grouped as follows:

Division I		Division II		Division III
A2–4	A4–4	E2–1	E2–2p	A6–3
A6–6	A6–8	Bog	J5–7	C91
E1–3	E2–2b	L2–4	LJ41–2	E3–7
E5–3	E5–6	M1–6	M2	F2–2
G4–3	H5–3	TL190	R18	K2–8
H5–4	H5–9	N3–5	T9–2	S3–2
J3–5	J301	S1932–5	TL200–1	T5–3
J405	J7–15	TL215	W24	
LJ51–3	N6			
O3–1	P1–3			
P1–4	Q2–5			
R1	T3–4			
TL217	TL220–2			

Cultural traits of micromonosporae of Division I. The strains of micromonosporae which composed this division were grouped under the descriptive term "fluffy." In this, the major division of the 49 cultures, the growth of the organisms did not present a uniform and constant set of characters which would permit a hard and fast separation from the other divisions. This was true because the growth traits of some strains of the division varied from the characteristics displayed by the majority of the strains into a gradation of those displayed by the next grouping.

One of the cultural characteristics was rapidity of growth. A fine, filamentous growth in nutrose broth was apparent within two days after the inoculation of either a crushed colony from agar or a bit of mycelium from a liquid culture. If the inoculation of the new liquid was made in such a fashion that portions of the inoculant were placed on the surface of the liquid, a typical growth trait was demonstrated by most members of this division. Floating surface colonies grew upon the liquid. In some instances a circular confluent ring developed around the top of the liquid in the tube. When the growth became so heavy that the adhesive force was unable to support it, the whole mass would settle to the bottom of the tube.

Another common trait was shown when colonies developed on the surface of the liquid. There was then a copious development of fluffy streamers extending down into the liquid from the under surface of these colonies. The appearance was similar to that of a floating jelly-fish. When the weight of this growth overcame the buoyancy of the floating mass it, too, settled to the bottom. A marked difference in appearance was then presented between the surface of either the floating or the ring type with the fluffy growth of the bottom portions. The growth of the surface colonies was dense, compact and more colored than that shown by the fluffy, filamentous growth of the bottom. If the weight of the mass of the floating colonies did not cause the rapid sinking of it, the surface colonies would show marked sporulation. Many times this sport crust was so dense that the colony appeared as a floating mass of black spores.

Cultural traits of micromonosporae of Division II. There was no sharp delineation between the fluffy characteristics of Division I and the "lumpy" growth traits of Division II. There were no surface rings nor surface colonies with streamers observed in this group. The major distinguishing mark of this group was the large lumpy growth of its organisms; the surfaces of the bottom growths were dome-shaped with a hollow appearing center to the mass. The growth in this group was good but the initiation of growth after transfer was slower and the total volume of mycelia produced was less than that of the members of Division I. Usually the mycelium was uncolored and even those possessing color did not have deep shades. It was in this group that the tendency for the colonies to be formed in stellate clumps on the sides of the tubes appeared to be accentuated. When these colonies formed, the growth was flattened, had a dense center and a mass of growth radiated from it. Sporulation was delayed with the majority of the members of the division.

Cultural traits of micromonosporae of Division III. The most distinguishing cultural mark of this group was the pellet or granular method of growing at the bottom of the tubes of liquid. There was no surface ring, no hanging filamentous growths and no tendency to form stellate colonies on the sides of the tubes. Growth was extremely slow and when transfers were to be made, pipettes had to be employed to be sure of adequate inoculation into the new media. Inoculating loops with the usual orifice would not hold the small pellets. With but few exceptions the strains lacked colored growth. Sporulation was very slow; the typical olive-green cast given to the strains of Division I by the surface spore layer was never seen on the cultures of this group.

Cultural Characteristics as Affected by Growth upon Varied Substrates

Amount of growth. The amount of growth produced by the organisms with an agar substrate depended in large measure upon the position of the colony in relation to the agar, i. e., upon the agar surface or embedded. In the original dilution plates made from lake muds, embedded colonies belonging to Division III were very small and their detection was made possible only by careful scrutiny of the plates under the Quebec counting device. Colonies of Division I and II were much larger on all solid media and it was noted that the starch casein agar, which was used for the original isolation of the lake strains, gave increased chromogenesis and size to the colonies of micromonosporae grown upon it.

Types of growth. Strains of Division III did not spread over the surface of the agar slopes. The colonies were small, approximately one millimeter in size, of little color and changed little with age. The strains of Division I produced colonies ranging from three to five millimeters in diameter, and there was a tendency for a confluent growth of the colonies. It was with the members of Division I that there was a trait which caused the older surface colonies to give a "burst-through" picture. Certain portions of the peripheral mycelium grew faster than neighboring areas and, as a result, those sectors were markedly larger in size than the remainder of the colony. Members of both Divisions I and II placed on agar slopes or grown on agar plates grew down into the agar to an appreciable extent; this characteristic growth trait made their removal quite difficult.

When a colony of a strain from either Division I or II was formed just under the surface of an agar, a typical growth trait occurred. The pressure of the growing globular colony upon the surrounding agar would cause the overlying portion to give way and allow an umbonate colony to be produced. Upon the tip of this mycelial protrusion then exposed to air, a spore crust would be formed. The final picture would be a round, sub-surface colony with a short extension which was subtended by a black spore mass.

Consistency of growth. The cartilaginous character of the growth of so many actinomycetes upon agar was not observed with these lake mud micromonosporae, but rather a granular type of growth was typical. With the faster growing strains this property was pronounced, but the members of Division III were not marked in this character. Starch casein agar, rather than the other agars tried, gave this growth property. The shaft-strengthened, spatula-shaped inoculating needle used throughout the study was a necessity because of this hard mycelial growth. Surprising pressure was required at times before the globular growth could be crushed.

Effect of age on growth. All strains, no matter of what group, which possessed color at maturity, showed color in early growth on agar, but the color changed, in many instances, as the colonies grew older. With some of the strains of Division II a growth characteristic, increasing with age, was a rugose, pleated appearance to the surface of the colony. The edges were split and the surface of the whole colony looked like crumpled foil. Kriss (1939) noted a similar surface change in his strains. This phenomenon was never seen in the case of members of Division III, and was not detected in strains of Division I due probably to their rapid sporulation and the tendency of their sport crust to be moist. Thus this character of rugose surface at least goes with some strains of Division II. Where the media were of such nature that the growth of the colony was limited, this split surface was never seen. The starch casein medium was the most productive of this condition.

With sub-surface colonies in nutrose agar there was a characteristic fringe about the colonies; the lighter colored filaments of the growing points of the mycelia were in marked contrast with the sporulated blackened colonies. The strains of Division III were not seen to display this property.

Sporulation of agar colonies. One of the macroscopically distinguishing marks of the strains of Divisions I and II was their early sporulation. The formation of a moist, olive-black spore layer over the top of the colony began to be evident in about five days when starch casein agar was the substrate. Strains E2–2b and J7–15 were outstanding in this respect. Upon transfer of large masses of mycelia from liquid medium to an agar slope the rate of sporulation was enhanced. The strains of Division III were slower in forming spores and they failed to give the macroscopically prominent spore crust.

The effect of the substrate upon sporulation was marked. Nutrient agar did not support rapid or abundant spore formation. The mycelia of the colonies remained in their typical colored form; shades of orange predominated in these, and the surface spore layer was lacking. The use of less rich media changed this situation. The amount of growth, the rapidity of sporulation and the color of the mycelia varied on the different substrates, but none of these media gave results which were so predominately diagnostic that they were capable of being used in species determination of the strains. The citrate, glycerol asparaginate, and malate media were the poorest of the substrates used in supporting growth of the lake strains.

Colonial structure as shown by agar sectioning. Erikson (1941) reported the zonation of hyphae bearing spores in micromonosporae colonies, a finding confirmed in this study. Plate I

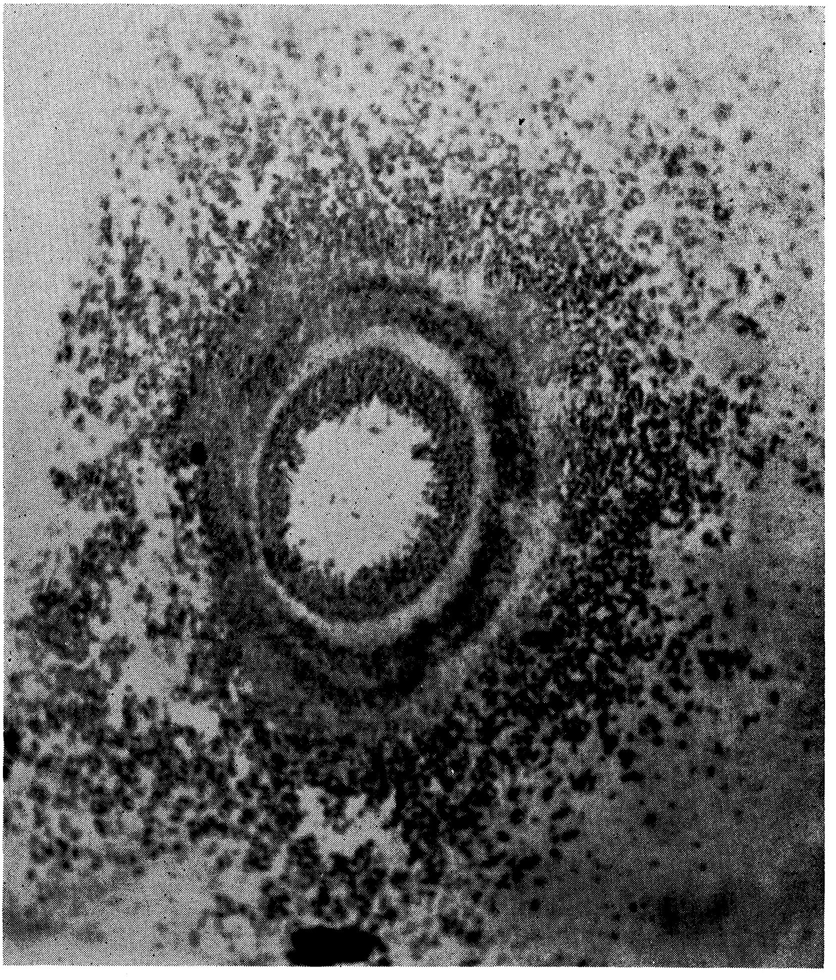

PLATE I. Cross section of agar colony of strain A4–4. Nutrose agar; 8 weeks old colony; Delafield's hematoxylin strain.

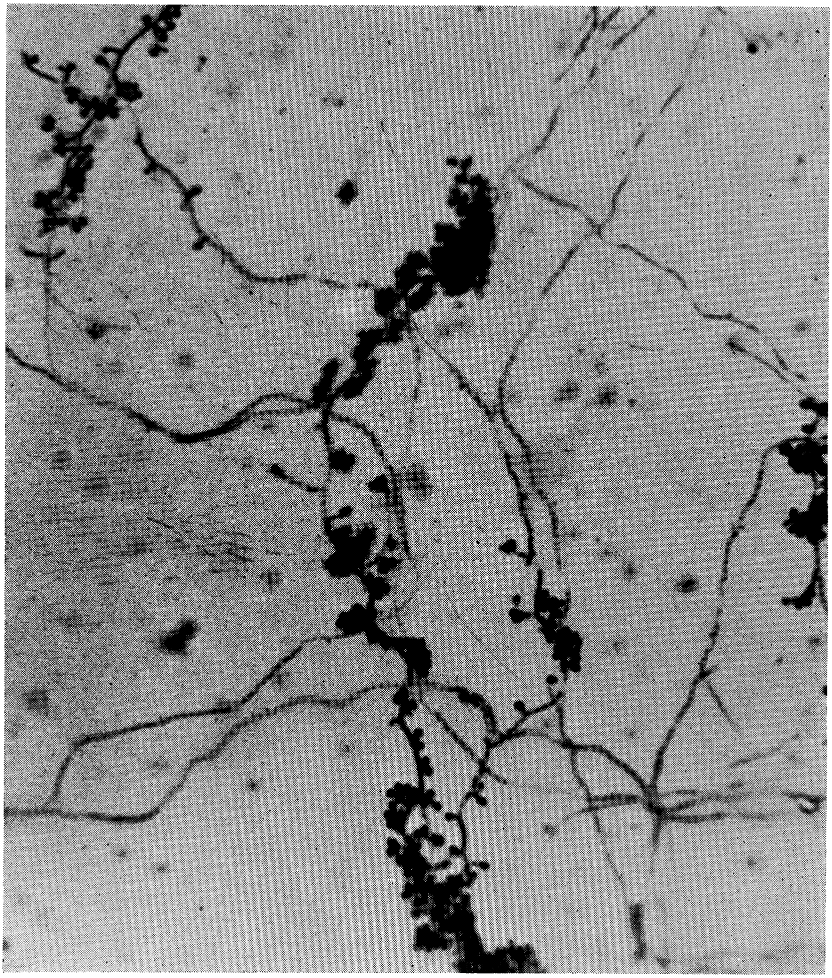

PLATE II. Strain E2–2b showing copious spore formation. Dextrose casein agar slide; growth 7 days old; Gram stain.

gives a cross sectional view of a sub-surface agar colony which shows an "onion slice" semblance that is characteristic of the organisms. In cultures of approximately 30 days of age, the center of the colony seemed to have disappeared. No hyphae were evident in this area, and only scattered spores were present. Bounding this empty space was a dense spore layer; alternating with the spores was another circular sector rather devoid of hyphae. Such an area of hyphal dissolution alternating with a dense spore layer varied with the colonies depending upon their age, the richness of the medium and the position of the colony in the agar. This hollow-center phenomenon also could be observed by lightly crushing a colony upon a slide, adding a drop of water to the mass, covering with a cover slip and lightly staining with methylene blue drawn under the cover slip. The colony resembled the testa of the protozoan *Arcella*.

Discussion

Jensen (1932) stated, after the study of his mesophilic soil strains of *Micromonospora*, that "morphological differences were found to be too slight to allow any real differentiation between the strains." However, Kriss (1939) used morphology, in the main, to identify his new species, *Micromonospora globosa*. His eight strains all belonged to this species and their placement was predicated upon their globular conidia. The type of conidiophore was not emphasized.

It is interesting to note that the classification as proposed by Waksman (1940) made use of a characteristic minimized in importance by the former worker, Jensen. Waksman based his classification on the types of conidiophore present. Only one of the type species of the subgroups listed, *Micromonospora vulgaris* having simple spore-bearing hyphae, had been studied in pure culture. The other two subgroups listed in the classification, the type species *M. chalceae* with its branching spore-bearing hyphae, and *M. fusca* of the clustered spore-bearing hyphae, had not been isolated and studied in pure culture. Attention has been called to the fact that the work which served as the background for this scheme was done on thermophilic representatives of the genus. Erikson (1941) evidently favored the findings of Jensen because she did not find her 10 lake strains eliciting a constant picture of spore formation.

The present study showed that the lake mud strains did not possess a constancy in structure in this important characteristic of the genus. While there were spore structures possessed by some strains which greatly predominated in slide preparations, it was possible to find microscopic fields on the same slide which, if taken as the criterion for the culture, might give an entirely different classification to the strain. Many microscopic fields could be seen where single, branched and cluster type conidiophores were all present. It is doubtful if any strict criterion, such as conidiophore structure or shape of conidium, would serve to separate and classify the lake-mud strains studied. Plate II shows the structure of strain E2–2b after seven days of growth on a dextrose casein agar slide.

The results of the cultural studies showed that substrates markedly affect the manner of growth of the micromonosporae. On a solid substrate of proteinaceous material such as nutrient agar they grew vigorously, but their growth was of such character that very little variation was noted between the strains, and, as a result, such media would not serve for distinguishing between them. The color of the mycelia when growing on nutrient agar was generally a shade of orange. When an inorganic nitrogen source was present, e. g., sodium nitrate or ammonium sulfate, colonial formation and chromogenesis were often striking. With *Actinomyces* this chromogenesis might be found in the aerial hyphae or in the vegetative hyphae or diffused into the substrate; with the *Micromonospora* only the two latter locations might serve for the detection of this property. Jensen used chromogenesis as a means of separating his *Micromonospora*. The chromogenesis of the lake strains studied was not so constantly demonstrated that it was possible to use the characteristic for a separation of the organisms into species. Only one strain gave a pigment which could be constantly detected when diffused into the liquid or solid substrates. This character was possessed by strain M1–6. Later physiological studies showed that this strain also possessed the enzyme tyrosinase.

Conn and Conn (1941) studied the value of color classifying *Actinomyces*. They felt that, although these organisms often show striking color formation, the property had such variability that it could not be used successfully in classification. Their work indicated, however, that pigmentation might be a feature sufficiently constant to be of diagnostic value.

The cultural properties displayed by the lake strains on solid media were dependent upon many factors. The growth of the colony was a resultant of the factors of kind and amount of inoculum used, the composition of the medium; and the appearance of the colony varied in relation to its surface or sub-surface position and the age of the colony at the time of observation. Since many variables rendered solid media less useful for macroscopic cultural study, a liquid medium, nutrose broth, was used to group the strains. While admittedly the cultural properties displayed by these organisms in nutrose broth were not ideally uniform and distinct, features of such constancy were demonstrated that three divisions of the organisms were made possible. These divisions are tentative and based on evidence of the cultures studied. It is felt that members of Division I are similar to the "vigorously growing organisms, typically with copious spore formation on dextrose-asparagin agar" which Jensen (1932) described. The members of Division III are similar to those described as "slowly and feebly growing organisms, with scant spore formation on dextrose-asparagin agar, no soluble pigment" while members of Division II might be considered as intermediates.

Man has an inordinate desire to label and to classify the findings which his curiosity has gained for him. He likes to apply yardsticks of his own choosing and by sundry bendings and turnings adapt the organisms and his yardstick so that some concrete results will be obtained. In bacteriology this bent has had free reign. It is well that such a tendency toward labeling and the putting of labeled parts into a coherent picture exists. To a known mass of facts one can bring his findings for comparison with those which are uncovered by the preceding workers, and in turn, perchance, add to the store so that the sequence of passing knowledge from one worker to another is not hindered by a labeling error. Frequently new bacteria are found and are studied, and one wishes labeled organisms to flow from these studies which will make a picture with such completeness that any scheme of classification of it will be of a nature that all who see it later can be sure of their own starting point for their endeavors should they be interested in the organisms or the genus which contains it.

But Nature, with the prodigal lavishness of its forms, is none too anxious to aid and abet the worker in his labeling. Many are the characteristics borne by organisms, so that although the mosaic, the over-all result, appears clear, a closer observation brings out intergrading characters which then give a blurred picture. So one must make compromises; one must use the yard-sticks most suitable and fit the parts together making use of these guides in such a fashion that an end product is produced. Then, although the results might leave much to be desired, the attempt was made and by making it there was initiated an effort which in the future might yield results to complete the picture.

The placement of the micromonosporae into a classification which would satisfy all workers has not been accomplished. This follows as a result of differences in emphasis that workers assign to properties displayed by the organisms. The moropho-logical structures and the cultural properties are not stable within the group. The literature on *Micromonospora* attests to the fact that variability is the common rather than the uncom-mon occurrence. While some investigators claim that rigidly controlled techniques will occasion reproducible results, other workers of comparable ability present data which indicate that this might be questionable.

SUMMARY

The findings of the morphological and cultural studies made on some lake strains of the genus *Micromonospora* may be sum-marized as follows:

1. A characteristic unicellular, monopodially branched basic mycelium was formed. No evidence of an aerial mycelium was found.

2. A single spore was borne at the end of a single conidio-phore. The length of the conidiophore varied within a given strain; there appeared to be no definite type of conidiophore which could serve as a criterion for a separation of the strains.

3. Evidence has been secured which suggests that the whole mycelial mass of a colony of *Micromonospora* is not viable. The central portion of the colonial ball is often degenerating, while the periphery is still actively growing.

4. The chromogenesis of the organisms studied was not found to be a constant trait. Its strict use in classification is, therefore, of doubtful value.

5. The cultural traits displayed in nutrose broth served to divide the lake strains into three divisions. The divisional boundaries were not rigid and an intergradation was found in the growth characteristics displayed by the strains of a division.

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RECENT ADDITIONS TO THE RECORDS OF THE DISTRIBUTION OF THE REPTILES IN WISCONSIN

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It has been nearly twenty years since the last of T. E. B. Pope's[1] "Wisconsin Herpetological Notes." Among his papers left at the Milwaukee Public Museum on retirement was one entitled "Notes IV" which had been tendered to the Wisconsin Academy for publication in 1936. Due to the curtailment of publications at that time it was not included in the Transactions, so with that manuscript as a basis the writer has appended all subsequent notes and records to bring the state faunal lists up to date.

Mr. Howard Suzuki of Marquette University has assumed the task of writing up the amphibians which will comprise a separate paper.

All species represented in the list are believed to constitute new county distributional records. For the sake of uniformity the arrangement of these notes will follow the pattern of Mr. Pope's papers, listing first the actual preserved specimens, then observations, and finally species listed in publications but where no actual catalog numbers appear.

A. *Specimens in Institutional collections:*

SAURIA

Ophisaurus ventralis (Linné)
Glass-snake

Green Lake County, Green Lake; MPM 2448; July 1933; Coll. A. Johnson

Sauk County, Reedsburg; MPM 2385–86; Sept. 1931; Coll. R. D. Adams

[1] Curator Emeritus, Milwaukee Public Museum.

Eumeces fasciatus (Linné)
Blue-tailed Skink

Shawano County, Shawano Lake; MPM 2424; Sept. 1932; Coll. E. G. Meyer
Washburn County; MPM 2651, 2664–66; June 1948; Coll. C. L. Strelitzer
Juneau County, Necedah; U. Wisconsin; May 1949; Coll. H. Levi
Jackson County, Knapp Twp.; U. Wisconsin; May 1949; Coll. H. Levi

Eumeces septentrionalis septentrionalis (Baird)
Northern Skin

Washburn County; MPM 2618; Coll. A. G. Johnson
Douglas County, Brule; U. Wisconsin coll.; July 1949; Coll. H. Levi

OPHIDIA

Heterodon contortrix contortrix (Linné)
Hog-nosed Snake

Monroe County, Sparta; MPM 2519; September 1935; Coll. R. Herin
Marinette County Goodman; MPM 2606; Coll. W. Pelzer

This is an unusually dark form considering the general sandy conformation of the area.

Opheodrys vernalis vernalis (Harlin)
Smooth Green Snake

Sawyer County, Birchwood; MPM 2449; August 1933; Coll. T. T. Rodgers
Washburn County; MPM 2662; June 1948; Coll. C. L. Strelitzer
Price County; MPM 2582; Coll. E. Voelker
Florence County, Tipler; U. Wisconsin; July 1949

Coluber constrictor flaviventris (Say)
Blue Racer

Sauk County; MPM 2595; Coll. W. Pelzer

Elaphe vulpina vulpina (Baird & Girard)
Fox Snake

Marinette County, Lake Noquebay; MPM 2435–37; Nov. 1932; Coll. R. F. Grow
Marquette County, Montello; MPM 2458; Sept. 1933; Coll. H. B. Flavelling
Monroe County, Tomah; MPM 2509; May 1935; Coll. R. Riechl
Shawano County; MPM 2595; Coll. R. Barnes

Lampropeltis triangulum triangulum (Lacépéde)
Common Milk Snake

Racine County, Brown Lake; MPM 2452; Aug. 1933; Coll. M. Reingang
Walworth County, Delavan; Chicago Academy 526; May 1932; Coll. E. G. Wright

Storeia dekayi (Holbrook)
Dekay's Snake

Walworth County, Lake Benlab; Oct. 1932; Coll. G. Kintz
Grant County, Potosi; U. of Michigan Museum. Zool. 69642

Storeia occipitomaculata (Storer)
Red-bellied Snake

Fond du Lac County, Ripon; MPM 2388; Oct. 1931; Coll. H. P. Gordon
Shawano County, Shawano Lake; MPM 2460; Nov. 1933; Coll. P. F. Dick
Price County, Fifield; MPM 2508; May 1935; Coll. C. F. Johnson
Washburn County; MPM 2663; Coll. C. L. Strelitzer
Taylor County, Medford; U. of Mich. Mus. Zool. 69625

Haldea valeriae valeriae (Baird & Girard)
Brown Snake

La Crosse County, Wisconsin; MPM 2648; Coll. G. Barclay and D. M. Devine

Stejneger & Barbour (1943) reported the western range of this species as Ohio and Tennessee; consequently, this represents quite an extension in its original range.

Dickinson (1949) stated that its introduction did not seem to be accidental because of its secretive habits.

Thamnophis butleri (Cope)
Butler's Garter Snake

Kenosha County, Wheatland; U. Mich. Mus. Zool. 67883

Thamnophis sirtalis sirtalis (Linné)
Common Garter Snake

Milwaukee County; MPM 2600; Coll. Mr. Vierden. (Albino mutant)
Milwaukee County; MPM 2605; Coll. W. Gawrysiak. (Melanistic phase)

Thamnophis sirtalis parietalis (Say)
Red-sided Garter Snake

Marquette County, Neskara; MPM 2530; Oct. 1935; Coll. H. Dettman

Sistrurus catenatus catenatus (Rafinesque)
Massasauga

Sauk County, Prairie du Sac; MPM 2425; September 1932; Coll. E. D. Ochsner
Juneau County, Necedah; Carroll College; September 1933; Coll. H. A. Blank
La Crosse County, La Crosse; MPM 2650; Coll. Wisc. Cons. Comm.

CHELONIA

Chelydra serpentina serpentina (Linné)
Common Snapping Turtle

Burnett County; U. Mich. Mus. Zool. 72510
Fond du Lac County, Mauthe Lake; U. Wisconsin; July 1949; Coll. H. Levi

Clemmys insculpta (Le Conte)
Wood Turtle

Forest County; MPM 5686; Coll. Edw. Johnson

Emys blandingii (Holbrook)
Blanding's Turtle

Marquette County, Westfield; MPM 2511; June 1935; Coll. W. D. Kline

Graptemys geographica (Le Sueur)
Map Turtle

Winnebago County, Oneton Creek; MPM 2377; July 1928; Coll. Geo. Overton

Graptemys pseudogeographica pseudogeographica (Gray)

Le Sueur's Turtle

St. Croix County, Hudson; U. Michigan Mus. Zool. 72505–07

Amyda spinifera spinifera (Le Sueur)
Spiny Soft-shelled Turtle

Jefferson County, Lake Mills; MPM 2414; June 1932; Coll. E. E. McCarthy

Walworth County, Lake Beulah; MPM 2417; July 1932; Coll. Stuart Heath

Winnebago County, Wolfe River; MPM 2441; July 1932; Coll. R. N. Buckstaff

B. *Observations:*

OPHIDIA

Elaphe vulpina vulpina (Baird and Girard)
Fox Snake

Marinette County, Crivitz; August 1949; H. K. Suzuki

Opheodrys vernalis vernalis (Harlan)
Smooth Green Snake

Marinette County, Bass Lake, Sand Lake; Sept. 1949; H. K. Suzuki

Natrix sipedon sipedon (Linné)
Common Water Snake

Marinette County, Sand Lake; August 1949; H. K. Suzuki

Storeia dekayi (Holbrook)
Dekay's Snake

Marinette County, Bass Lake; September 1949; H. K. Suzuki
Washington County, Hubertus; July 1948; H. K. Suzuki

Storeia occipitomaculata (Storer)
Red-bellied Snake

Marinette County, Sand Lake; August 1949; H. K. Suzuki

Thamnophis butleri (Cope)
Butler's Garter Snake

Sheboygan County, Terry Andrae Park; September 1933; W. E. Dickinson

Thamnophis sauritis sauritis (Linné)
Ribbon Snake

Marinette County Bass Lake; September 1949; H. K. Suzuki

Thamnophis sirtalis sirtalis (Linné)
Common Garter Snake

Marinette County, Sand Lake; September 1949; H. K. Suzuki

CHELONIA

Sternotherus odoratus (Latreille)
Common Musk Turtle

Washington County, Hubertus; July 1947; H. K. Suzuki

Chelydra serpentina serpentina (Linné)
Common Snapping Turtle

Marinette County, Sand Lake; August 1949; H. K. Suzuki

Amyda spinifera spinifera (Le Sueur)
Spiny Soft-shelled Turtle

Dane County, Lake Waubesa; July 1944; A. Suckow
Kenosha County, Silver Lake; May 1948; H. K. Suzuki

C. *Species listed in published faunal records not previously mentioned in this series:*

OPHIDIA

Lampropeltis triangulum triangulum (Lacépéde)
Common Milk Snake

Richland County, Sylvan; C. E. Burt (1935)

Natrix sipedon sipedon (Linné)
Common Water Snake

Dane County; A. R. Cahn (1915)

CHELONIA

Chelydra serpentina serpentina (Linné)
Snapping Turtle

Dane County; Cahn (1915)

Chrysemys bellii bellii (Gray)
Bell's Turtle

Winnebago County; O. V. Andrews (1915)

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EFFECT OF GROUND WATER ON THE GROWTH OF RED PINE AND WHITE PINE IN CENTRAL WISCONSIN[1]

R. C. DOSEN, S. F. PETERSON AND D. T. PRONIN[2]

The sandy plain of central Wisconsin represents in its major part the bottom of a shallow glacial lake. Originally this enormous area supported valuable stands of pines, but during the past hundred years its productivity was drastically reduced by the ax, plow, dredging shovel, fire, and grazing livestock. A quarter century ago Nekoosa–Edwards Paper Company initiated the reclamation of depleted sandy soils by artificial reforestation. At present, the combined efforts of state and private agencies have returned much of the unproductive land to timber growth.

As it is well known, highland sandy soils impoverished in humus retain a small amount of moisture which is sufficient to produce only mediocre yields of timber. More rapid forest growth, and hence higher returns on reforestation investments, however, are usually attained on soils underlain at a suitable depth by ground water which supplies the trees with additional moisture. In order to evaluate the effect of this factor in concrete figures, a mensuration analysis was made of red and white pine grown at different levels of ground water.

The investigated stand was established twenty years ago by Mr. F. G. Kilp on the shore of artificial Nepco Lake by planting two-year-old seedlings of red and white pine. In the course of the first twelve years part of the plantation attained an average height of about 20 feet, and produced some trees of merchantable pulpwood size. This was particularly true on the depressed areas.

The topography of the plantation area was carefully surveyed by means of a level. Then, trenches were dug to the groundwater table along the surveyed transects, and samples of soil and ground water were collected for analysis. The height and

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[1] Contribution from the Nekoosa–Edwards Paper Company, Port Edwards, Wisconsin in cooperation with the Soils Department, University, Madison, Wisconsin.

[2] Forester, Nekoosa–Edwards Paper Co., and assistants in Soils, UW, respectively.

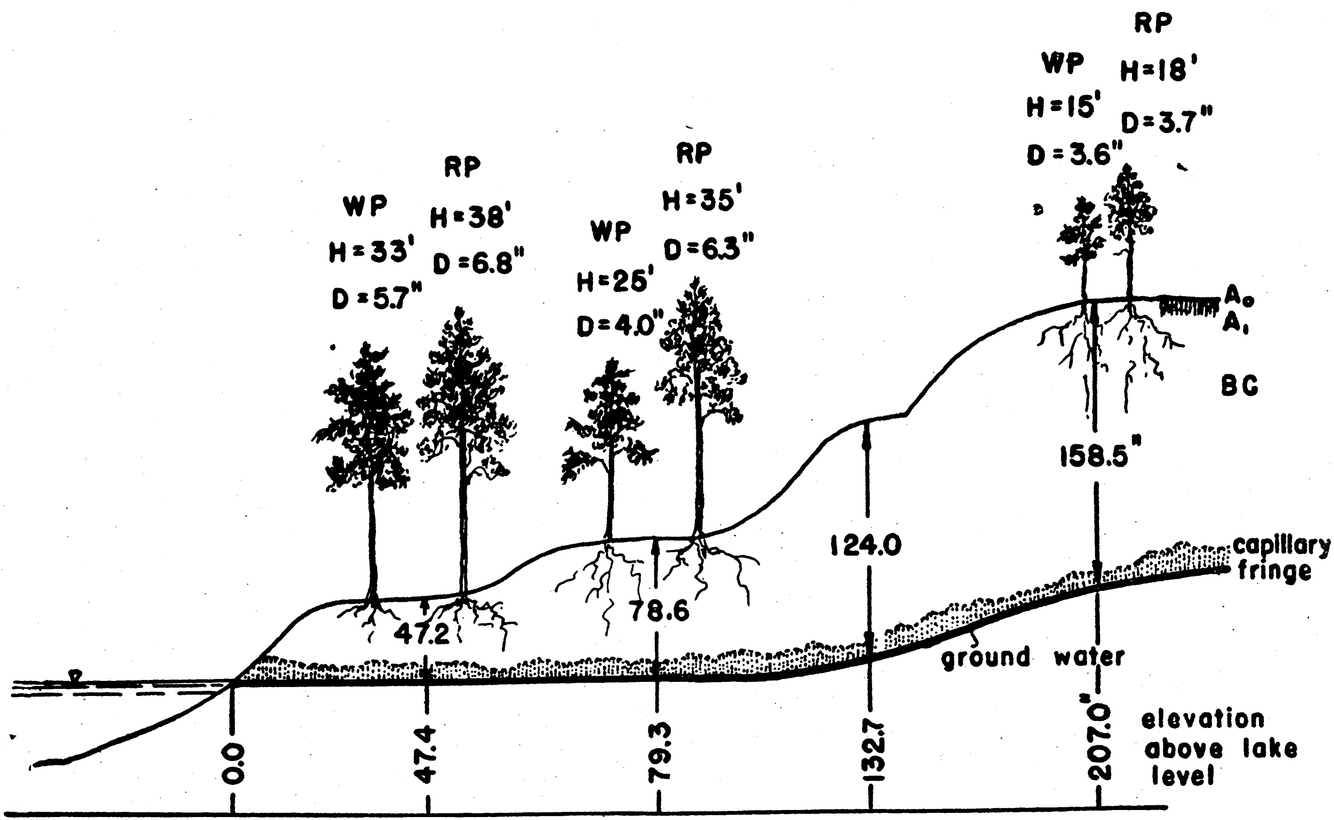


FIGURE 1. Effect of ground water on the growth of 22 year old plantation of red and white pine on sandy shore of Nepco Lake, Wood County, Wisconsin. Position of ground water during the middle of July, 1948.
Legend: WP—white pine; RP—red pine; H—average height; D—average diameter breast height.

diameter of the trees were determined in the plantation and in adjoining second growth stands. The results are graphically presented in Figure 1.

The growth of both red pine and white pine illustrates the greatly beneficial influence of the ground-water table. At the present age of the plantation, the trees underlain by ground water at a suitable depth show more than double-height growth and nearly double-diameter growth as compared with trees on excessively drained uplands. The difference in the yield growth is, of course, much greater and will become especially pronounced when the trees attain economic maturity.

The analyses of soil samples collected on the study area disclosed that surface layers of land contribute little to variation in tree growth (Table 1). The analyses of ground water, however, indicated that the unusually rapid growth of this plantation was due not only to the physical effects of ground water, but also to its chemical composition. Specific conductivity, content of free dissolved oxygen, and oxidation-reduction potential, are at a much higher level than usually found in sandy soils of central Wisconsin (Table 2).

The considerable depth of the ground water and the proximity of a large lake were other beneficial factors which stabilized the ground-water table. As observation throughout the growing season of 1948 showed, the fluctuations of the ground-water table under the plantation did not exceed 17 inches, even though this period included prolonged drought and a considerable lowering of the water table on the plain of central Wisconsin.

This study suggests that ground water at a suitable depth is a factor of far-reaching silvicultural importance. It is a concealed natural resource which in many instances can be utilized most economically by growing trees; i. e., plants endowed with deep-reaching root systems. The small fluctuation of a reasonably deep ground-water table in the proximity of water basins or floating bogs deserves the special attention of foresters.

TABLE 1

STATE OF FERTILITY OF THE SURFACE LAYERS OF SOIL (7 INCHES) SUPPORTING WHITE AND RED PINE PLANTATION AT NEPCO LAKE

LOCATION	REACTION pH	SILT AND CLAY p.ct.	ORGANIC MATTER p.ct.	BASE EX. CAPACITY ME/100 g.	TOTAL N p.ct.	AVAIL. P_2O_5 lbs/A	AVAIL. K_2O lbs/A
Upper slope....	5.22	7.9	1.4	2.9	.032	46	60
Upper slope....	5.28	7.5	1.2	2.7	.028	26	50
Middle slope...	5.10	7.2	1.0	2.4	.023	50	60
Middle slope...	5.15	8.5	1.4	3.2	.030	37	40
Depression....	4.87	9.5	1.4	3.3	.032	60	60
Depression....	4.98	8.2	1.3	3.1	.028	57	60

TABLE 2

COMPARISON OF CHEMICAL PROPERTIES OF WELL WATER AND GROUND WATER UNDERLYING NEPCO LAKE PLANTATION AND ASPEN STANDS IN THE VICINITY OF WISCONSIN RAPIDS

ORIGIN OF WATER	REACTION pH	SPEC. COND. MHOS 10^{-5}	TOTAL ALKALINITY ppm	FREE DISSOLVED O_2 ppm	REDOX POTENTIAL Eh,mv
Well in Cranberry Creek drainage district........................	6.50	11.5	19	3.30	95
Red and white pine plantation at Nepco Lake.................	7.75	15.0	25	8.00	84
Aspen of a fair growth near Big Flats........................	5.75	8.3	11	1.00	—94
Aspen of a poor growth near Walker........................	5.42	6.1	16	0.80	—131

PRELIMINARY REPORTS ON THE FLORA OF WISCONSIN. XXXV

ARALIACEAE

N. C. FASSETT AND H. J. ELSER

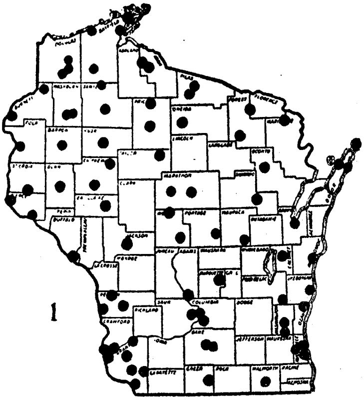
The station records used in this study were taken from the herbaria of the University of Wisconsin and the Milwaukee Public Museum.

Our five species of this family may be keyed as follows:

a. Leaves scattered on the stem or rising singly from a woody rootstalk
  b. Leaves and umbels borne on the same stem; upper pair of leaflets stalked
    c. Plants without bristles; umbels in racemes from the axils of the leaves; leaflets mostly heart-shaped at base, 6 to 10 cm. wide, with a tapered point about 2 cm. long. . . *Aralia racemosa.*
    cc. Plants bristly toward the base; umbels terminating the upper branch; leaflets scarcely heart-shaped at base, 2 to 5 cm. wide, with a short tapering point or none. . . . . *A. hispida.*
  bb. Umbels on naked stems coming from a rootstalk and opening beside a compound leaf; upper pair of leaflets sessile. . . . . . . *A. nudicaulis.*
aa. Leaves whorled near the summit of the stem; rootstocks absent
  d. Plant arising from a spherical tuber; leaflets 3, 6 cm. or less long . . . . *Panax trifolium.*
  dd. Plant arising from a thickened vertical root; leaflets commonly 5 or 7, 7 to 15 cm. long. . . . . *P. quinquifolium.*

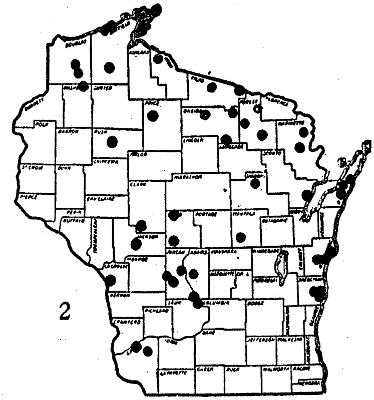
ARALIA SARSAPARILLA

1. A. RACEMOSA L. Spikenard.
   In rich woods throughout the state. Map 1.
2. A. HISPIDA Vent. Bristly Sarasaparilla.
   Mostly northward, southward in the Driftless Area, and along the Lake Michigan shore. Map 2.
3. A. NUDICAULIS L. Wild Sarsaparilla.
   Common in woods, essentially throughout the state. Since it is more common northward, it is less collected than in the southern part of the state, where the collector is apt to recognize it as a little unusual and so take it. Hence, the map probably shows the relative abundance northward and southward as reversed. Map 3.



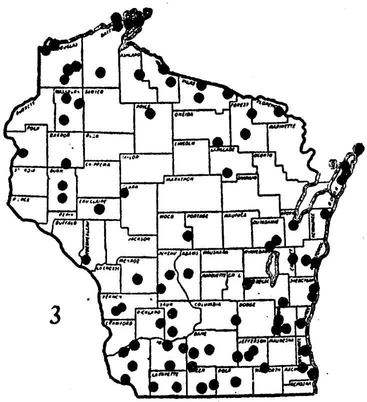
1

Aralia racemosa



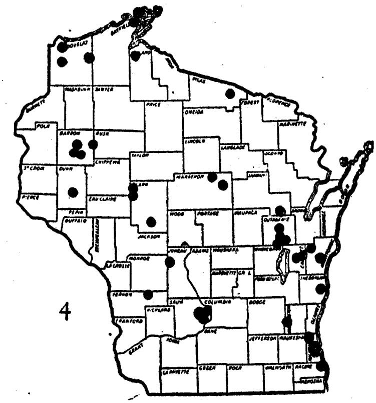
2

Aralia hispida



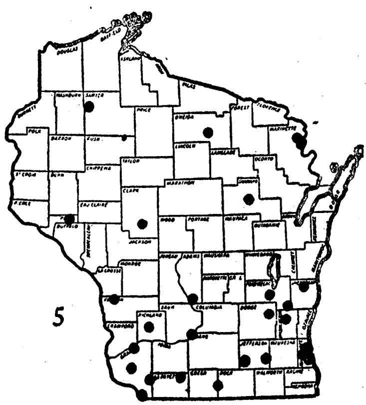
3

Aralia nudicaulis



4

Panax trifolium



5

Panax quinquefolium

PANAX GINSENG

1. P. TRIFOLIUM L. Groundnut.

   Probably fairly abundant northward, and of local occurrence southward in the eastern counties and in the Driftless Area. Map 4.

2. P. QUINQUIFOLIUM L. American Ginseng.

   In rich woods, mostly in southern Wisconsin. Formerly extensively collected for a medicine and now rarely seen except where cultivated in some parts of the Driftless Area. Map 5.

PARASITES OF NORTHWEST WISCONSIN FISHES
II. THE 1945 SURVEY[1]

JACOB H. FISCHTHAL[2]

ABSTRACT

In a survey of fish parasites during 1945 from 27 lakes and streams in northwest Wisconsin, 926 fishes representing 40 different species and subspecies were examined and 808 or approximately 87.2 per cent were infected with at least one species of parasite. The number of fish infected with each parasite from each water as well as the intensity of infection is presented for each species of fish examined. The larval parasites occurred most frequently and in more species of fishes than did the other developmental stages. The bass tapeworm, *Proteocephalus ambloplitis,* was in 9 species of fishes; the black spot parasites, *Neascus* spp., in 25 species; the larval yellow grub, *Clinostomum marginatum,* in 15 species; and the gill flukes (Gyrodactyloidea) in 18 species.

INTRODUCTION

The present paper covering the year 1945 is the second in a series of annual reports by the author on a parasite survey of northwest Wisconsin fishes, and is in continuation of the desire for more knowledge on the distribution, incidence and intensity of parasitism in fishes from the many lakes and streams of Wisconsin. The first report in this series by Fischthal (1947) recorded the parasite survey data for 1944.

The 1945 survey was started March 1 and was terminated November 20. During this period fresh fishes were examined from 27 different lakes and streams as shown in Table 1. These fishes were collected for the most part by the use of fyke nets in lakes and an electric shocking device in streams. Other means

[1] Contribution from the Fish Management Division, Wisconsin Conservation Department.

[2] Department of Biology, Triple Cities College of Syracuse University, Endicott, New York.

used for collecting fishes were a common-sense minnow seine and a dip net in lakes in which a fish mortality was occurring.

A total of 926 fishes, representing 40 different species and subspecies, were examined for parasites and 808 or approximately 87.2 per cent were infected with at least one species of parasite. This percentage of infection is somewhat low when compared to other northern Wisconsin parasite surveys. Perhaps, this lower percentage of infection may be explained in part by the greater proportion of fishes from streams contained in this report, namely, 60.5 per cent of the total number of 926 fishes examined. In a survey of northern Wisconsin, covering mainly the northeastern section of the state, Bangham (1946) found 93.2 per cent of 1,330 fishes infected with parasites. Only 8.7 per cent of these 1,330 fishes were from streams. Fischthal (1947) found parasites in 96.4 per cent of 2,059 fishes surveyed from northwest Wisconsin during 1944. Of these 2,059 fishes, only 32.5 per cent were from streams. If the figures for the 1944 parasite survey by Fischthal (1947) are combined with those contained in this report, both surveys covering the same region, it is seen that 2,985 fishes were examined over a two-year period and that 2,792 of the total number were parasitized. This is a 93.5 per cent infection and, therefore, still shows a relatively high percentage of parasitism in northwest Wisconsin fishes.

Surveys elsewhere in the United States showed either comparable or lower percentages of infections than herein recorded for the 1945 survey. Bangham (1940) found 88 per cent of 1,380 freshwater fishes from southern Florida infected. Fishes from Algonquin Park (Ontario) lakes studied by Bangham (1941) showed 84.3 per cent of 560 parasitized. Hunter (1941) found parasites in 72.5 per cent of 598 Connecticut fishes examined. In a survey of Lake Erie, Bangham and Hunter (1939) found 58.3 per cent of 2,156 fishes infected with parasites. Essex and Hunter (1926) obtained parasites from 39 per cent of 652 fishes from lakes and streams of the Central States.

In Table 1 the locations given for streams are those points at which collections were made. In collecting from lakes fyke nets were set in varying aquatic environments in order to obtain as representative a sample of fishes as possible and under varied ecological conditions. The figures for total alkalinity, also shown in Table 1, were secured from water analyses by Mr. N. H.

Boortz and Mr. D. A. White (unpublished researches); the remaining information on water condition was obtained from lake surveys by Bordner (1942). In Tables 2 to 10, no mark preceding the names of the parasites indicates an adult stage; an inverted T (⊥) before the parasite denotes the presence of both adult and immature stages in the same fish; two asterisks (**) preceding the parasite indicates an immature stage; a single asterisk (*) preceding the parasite indicates a larval stage; the superior figure one (1) following the number of infected fish or a light infection as indicated in the text denotes an infection with one to ten specimens of that species; the superior figure two (2) or a moderate infection indicates the presence of 11–50 specimens; the superior figure three (3) or a heavy infection indicates an infection with 51 or more specimens. The use of sp. after a generic name or a broader classification than genus indicates that the specimens could not be identified more completely. The notations (1) and (2) following Spring creek are used to designate that two different Spring creeks in Washburn County are being considered.

Appreciation is due Dr. Reeve M. Bailey, University of Michigan, for aid in identifying several of the minnow hosts; also, to several of the Fish Management personnel at Spooner for their aid in collecting some of the fishes used in this survey.

Amia calva Linn., Bowfin: Seven fish were examined from Big McKenzie lake and all were infected. Four were lightly parasitized with *Azygia augusticauda*, 6 with immature *Contracaecum* sp., 4 with *Haplobothrium globuliforme*, 2 with *Leptorhynchoides thecatus*, 2 with *Neoechinorhynchus cylindratus*, 1 with *Spinitectus carolini*, and 1 with immature *Triaenophorus nodulosus*. Adult *Proteocephalus perplexus* occurred moderately in 1, immature and adult in 4 others (2 moderately, 2 heavily), and immature only lightly in still 2 others. They were all infected with *Macroderoides parvus*, 6 moderately and 1 heavily.

Salmo trutta fario Linn., Brown trout: Six (40 per cent) of the 15 examined were infected. The 1 Beaver brook fish was negative. Three of the 11 from Crystal brook were parasitized, 1 harboring a light infection of immature *Contracaecum* sp., 2 (1 lightly, 1 moderately) with *Epistylis* sp. on the body surfaces, and 1 lightly with immature *Proteocephalus pinguis*. The 2 Willow river trout harbored larval *Neascus* sp., 1 lightly and 1

TABLE 1

Lakes and Streams Surveyed for Parasites

Lake or Stream	County	Location	Water Conditions	1945 Collection Dates
Bashaw Creek	Burnett	Town 38 North, Range 14 West, Section 16		9/24
Beaver Brook	Washburn	T38N, R12W, S15		6/20
Big McKenzie Lake	Burnett & Washburn	T40N, R14W, S25, 36 T40N, R13W, S30	Total alkalinity 75 p.p.m.—medium hard	7/6
Birch Lake	Washburn & Sawyer	T37N, R10W, S24 T37N, R9W, S19	Total alkalinity 50 p.p.m.—medium hard	5/17
Callahan Lake	Sawyer	T41N, R7W, S33	Medium hard, brown	7/27
Conners Lake	Sawyer	T38N, R3W, S22	Medium hard, clear	8/1
Crystal Brook	Washburn	T39N, R11W, S31	Very hard, clear	3/8
Dahlstrom Brook	Washburn	T38N, R13W, S16		6/8
Dunn Lake	Washburn	T40N, R13W, S23	Total alkalinity 40 p.p.m.—soft	6/22
Fish Lake	Rusk	T33N, R9W, S28, 33	Very soft, clear	6/25
Hay Creek	Washburn	T40N, R11W, S1, 2 T41N, R11W, S25		10/8
Little Sand Lake	Washburn & Douglas	T42N, R13W, S4 T43N, R13W, S33	Total alkalinity 15 p.p.m.—very soft	10/2
Long Lake	Bayfield	T47N, R8W, S2, 3	Medium, clear	11/20
McKenzie Creek	Washburn	T40N, R12W, S6		11/19
Montgomery Creek	Burnett	T38N, R14W, S28		9/24
Pokegama Lake	Washburn	T42N, R12W, S21, 28	Total alkalinity 75 p.p.m.—medium hard	6/27
Prairie Lake	Barron	T33N, R11W, S13	Medium hard	6/25
Rice Lake	Polk	T32N, R18W, S11, 12	Hard	7/18

TABLE 1—(*Continued*)

LAKES AND STREAMS SURVEYED FOR PARASITES

LAKE OR STREAM	COUNTY	LOCATION	WATER CONDITIONS	1945 COLLECTION DATES
Sawyer Creek	Washburn	T38N, R13W, S11	....	6/8
Shell Creek	Washburn	T42N, R12W, S24	....	10/2
Shell Lake	Washburn	T38N, R12W, S29, 30	Total alkalinity 9 p.p.m.—very soft	5/7
Spring Creek (1)	Washburn	T40N, R11W, S31	....	10/4
Spring Creek (2)	Washburn	T40N, R11W, S10	....	10/8
Stuntz Brook (Stance)	Washburn	T41N, R11W, S27 T41N, R12W, S20	....	11/19
Teal Lake	Sawyer	T42N, R6W, S26, 27	Total alkalinity 32.5 p.p.m.—soft	8/1
Willow River	St. Croix	T31N, R15W, S18	....	10/15
Yellow River	Washburn	T39N, R12W, S27, 31	Total alkalinity 72.5 p.p.m.—medium hard	3/1, 3/8, 5/20, 9/26

TABLE 2

Catostomus c. commersonnii (Lacépède)—COMMON WHITE SUCKER

	BASHAW CR.	BEAVER BRK.	BIRCH L.	CONNERS L.	HAY CR.	MCKENZIE CR.	RICE L.	SAWYER CR.	SHELL CR.	SHELL L.	SPRING CR. (1)	SPRING CR. (2)	WILLOW R.	YELLOW R.
Examined 72 Infected 70	7 7	4 4	15 15	1 1	1 1	3 3	1 1	2 2	3 3	13 11	2 2	3 3	13 13	4 4
Acolpenteron catostomi	1^1												2^1	
Allocreadium lobatum												1^1		
Argulus catostomi			1^1											
**Contracaecum* sp.					1^1				1^1					
**Diplostomulum* sp.			11^1				1^1			8^1				
Ergasilus sp.				1^1										
Glaridacris catostomi	3^1		5^1 8^2							4^1	1^1	1^1		
₁*Glaridacris catostomi*									1^1				3^1 1^2	
***Glaridacris catostomi*	2^1												7^1	
*Glochidia														1^1
Hepaticola bakeri	1^1													
Myxosporidia	1^1		2^2					2^1						
**Neascus* sp.				1^1									9^1	1^1
Neoechinorhynchus crassus	3^1 1^2	4^1	3^1 12^2	1^1	1^1	2^1 1^2	1^1	1^1 1^2	2^1		2^2 2^1	3^1	1^2 9^1	1^1
Octomacrum lanceatum										1^1				
Philometra nodulosa								1^1					1^1	
***Philometra nodulosa*											1^1			
Phyllodistomum lysteri	5^1			1^1										

TABLE 2—*(Continued)*

Catostomus c. commersonii (Lacépède)—COMMON WHITE SUCKER

	BASHAW CR.	BEAVER BRK.	BIRCH L.	CONNERS L.	HAY CR.	McKENZIE CR.	RICE L.	SAWYER CR.	SHELL CR.	SHELL L.	SPRING CR. (1)	SPRING CR. (2)	WILLOW R.	YELLOW R.
***Phyllodistomum lysteri*	......	......	......	......	......	......	......	......	......	......	......	......	1¹	......
Pomphorhynchus bulbocolli	3¹	......	......	......	1¹	......	......	......	2¹	1¹	1¹	......	......	2¹
**Pomphorhynchus bulbocolli*	......	......	......	......	......	......	......	......	......	......	......	......	......	1¹
***Rhabdochona cascadilla*	1¹	......	......	......	......	......	......	......	......	......	......	......	1¹	......
**Tetracotyle* sp.	......	......	15²	......	......	......	......	......	......	......	......	......	......	1¹
Triganodistomum attenuatum	......	2¹	......	......	......	......	......	1¹ 1²	1¹	......	1¹	1¹	1¹	......
ɪ*Triganodistomum attenuatum*	......	......	......	......	......	......	......	......	1¹	......	1¹	......	3¹	......
***Triganodistomum attenuatum*	1² 5¹	2¹	......	......	......	1¹	......	......	......	......	......	......	6¹	......

moderately. One fish from the Yellow river was lightly infected with immature *Contracaecum* sp., larval *Diplostomulum scheuringi,* glochidia, and immature *Proteocephalus* sp. which did not have an apical sucker on its scolex. Fischthal (1947) examined 1 brown trout from Crystal brook, but found no parasites.

Salvelinus f. fontinalis (Mitchill), Common brook trout: Only 11 (30.5 per cent) of the 36 examined harbored parasites. The 5 from McKenzie creek, 9 from Montgomery creek, and 10 from Spring creek (2) were negative. These were all fingerling fish. The 2 from Crystal brook were lightly infected with larval *Diplostomulum* sp. in the lens of the eye. The 1 from Stuntz brook was moderately parasitized by immature and adult *Crepidostomum cooperi.* Eight of the 9 Yellow river trout were lightly infected, 1 with immature *Azygia augusticauda,* 4 each with immature *Contracaecum* sp. and *Proteocephalus pinguis,* and with larval glochidia; 2 harbored *Leptorhynchoides thecatus.*

Hypentelium nigricans (LeS.), Hog sucker: Sixteen (88.9 per cent) of the 18 fish were parasitized. The 2 from Spring creek (1) harbored light infections, having larval *Bucephalus elegans* in both, and larval Trematoda in the mesenteries of 1. Only 14 of the 16 from the Yellow river were infected. Five were lightly infected with larval *Clinostomum marginatum,* 1 with glochidia, 1 with larval *Leptorhynchoides thecatus,* and 1 with *Pomphorhynchus bulbocolli.* Ten fish harbored larval *Diplostomulum* sp. in the lens of the eye, 9 lightly and 1 moderately. One was parsitized lightly with adult *Glaridacris catostomi,* 1 moderately with both immature and adult forms, and 2 lightly with only immature worms. Gyrodactyloidea occurred lightly in 3 and moderately in 2. Two fish were heavily infected with *Trichodina* sp. on the gillls.

Catostomus c. commersonnii (Lac.), Common white sucker: Seventy (97.2 per cent) of the 72 suckers were infected (Table 2). The larval *Contracaecum* sp. and *Tetracotyle* sp. occurred in the mesenteries. The larval *Diplostomulum* sp. was recovered from the lens of the eye. The glochidia and Myxosporidia were observed on the gills. The 4 Yellow river fish were taken below the dam at Spooner lake outlet. Bangham (1946) examined 2 suckers from the Yellow river flowage at Spooner, finding both heavily infected with *Pomphorhynchus bulbocolli.* Fischthal (1947) found 10 of 11 fish from the Yellow river below the Spooner power dam infected with similar parasites as herein recorded, with the exceptions of larval *P. bulbocolli* and *Tetracotyle* sp. which he did not find. In addition to those mentioned in common he also recorded larval *Diplostomulum* sp., immature and adult *Glaridacris catostomi*, Myxosporidia, *Phyllodistomum lysteri*, larval *Spiroxys* sp., and immature and adult *Triganodistomum attenuatum*.

Campostoma anomalum pullum (Agassiz), Central stoneroller: Seven (87.5 per cent) of the 8 examined from 2 waters were parasitized. The 4 collected from Beaver brook were all infected. Larval *Clinostomum marginatum* occurred lightly in 1, and *Rhabdochona cascadilla* in the 4. The 4 were also infected with *Neascus* sp., 3 lightly and 1 moderately. Only 3 of the 4 fish from Sawyer creek harbored parasites. *Neascus* sp. was found lightly in 2, and *R. cascadilla* in 2.

Rhinichthys c. cataractae (Val.), Great Lake longnose dace: Only 4 (57.1 per cent) of the 7 examined were infected. The 1 from the Yellow river was negative. Of the 4 from Spring creek (2) only 2 were lightly infected with a single species, *Rhabdochona cascadilla*. The 2 from the Willow river were heavily parasitized with *Neascus* sp.

Rhinichthys atratulus meleagris Agassiz, Western blacknose dace: Only one fish was examined from the Willow river. It was moderately infected with Myxosporidia in the gills, and lightly with *Neascus* sp.

Semotilus a. atromaculatus (Mitchill), Northern creek chub: Of the 48 examined, 42 (91 per cent) were infected (Table 3). The immature *Contracaecum* sp. occurred in the intestine and liver. The larval *Proteocephalus* sp. and Trematoda were taken from the mesenteries. The immature *Proteocephalus* sp. from Spring creek did not possess an apical sucker on its scolex, whereas the species from Bashaw creek did.

Margariscus margarita nachtriebi (Cox), Northern pearl dace: All 13 collected from Bashaw creek harbored parasites. All were infected with *Neascus* sp., 12 lightly and 1 moderately. Immature *Rhabdochona cascadilla* was recovered from 11, 8 being lightly infected and 3 moderately.

Chrosomus eos Cope, Northern redbelly dace: Only 1 of the 10 fish from the Willow river was parasitized, harboring a light infection of *Neascus* sp.

TABLE 3

Semotilus a. atromaculatus (Mitchill)—NORTHERN CREEK CHUB

	BASHAW CR.	BEAVER BRK.	HAY CR.	MCKENZIE CR.	SAWYER CR.	SPRING CR. (1)	SPRING CR. (2)	WILLOW R.
Examined 46	2	6	3	5	6	5	10	9
Infected 42	2	6	1	5	6	3	10	9
Allocreadium lobatum	....	....	....	....	....	....	1^{1}	....
I*Allocreadium lobatum*	....	....	....	1^{1}	....	....	1^{1}	....
***Allocreadium lobatum*	....	....	....	....	....	....	6^{1} 1^{2}	1^{1}
**Clinostomum marginatum*	....	6^{1}	....	....	....	....	....	....
***Contracaecum* sp.	....	1^{1}	....	....	....	....	....	1^{1}
*Glochidia	....	....	....	....	....	....	....	1^{1}
Gyrodactyloidea	....	....	....	....	3^{1}	....	....	....
**Neascus* sp.	1^{1}	....	....	1^{1}	3^{1}	1^{1}	2^{1}	9^{3}
Neoechinorhynchus saginatus	....	....	....	....	....	....	....	2^{1}
Pomphorhynchus bulbocolli	....	....	1^{1}	....	....	....	....	....
**Posthodiplostomum minimum*	....	1^{1}	....	3^{1} 2^{3}	5^{1}	....	4^{1}	6^{1}
***Proteocephalus ambloplitis*	....	1^{1}	....	....	....	....	....	....
***Proteocephalus* sp. (1)	....	....	....	....	....	....	1^{1}	....
***Proteocephalus* sp. (2)	1^{1}	....	....	....	....	....	....	....
**Proteocephalus* sp.	....	....	....	....	....	1^{1}	....	....
Rhabdochona cascadilla	....	....	....	....	....	....	5^{1}	6^{1}
I*Rhabdochona cascadilla*	1^{2}	....	....	....	....	....	....	....
***Rhabdochona cascadilla*	1^{1}	....	....	....	....	....	....	....
*Trematoda	....	....	....	....	....	2^{1}	....	....

Notemigonus crysoleucas auratus (Raf.), Western golden shiner: Four of the 5 examined from Beaver brook were lightly infected. Immature and adult Caryophyllaeidae were taken from 1, immature *Contracaecum* sp. from 1, Gyrodactyloidea from 3, larval *Posthodiplostomum minimum* from 2, and immature *Proteocephalus pearsei* from 2.

Pimephales p. promelas Raf., Northern fathead minnow: The 20 fish examined from 2 waters were all parasitized. The 5 from Beaver brook harbored 8 species of parasites. Immature *Biacetabulum* sp. occurred lightly in 1, immature *Contracaecum* sp. in 1, glochodia in 1, larval *Hymenolepis* sp. in the intestine of 1, Myxosporidia in the liver of 1, *Neascus* sp. in 3, and immature *Proteocephalus pearsei* in 1. Larval *Posthodiplostomum minimum* occurred lightly in 3, moderately in 1. The 15 fish from the Willow river had only 3 species of parasites. Myxosporidia occurred lightly in the liver of 1, and larval *P. minimum* in 9. *Neascus* sp. was observed moderately in 13, heavily in 2. Van Cleave and Mueller (1934), in their survey of Oneida lake (New York) fish, found a larval *Hymenolepis* sp. in the intestine of the largemouth bass *(Huro salmoides)* and stated that "all evidence seems to point to this as an abnormal host and location. It is highly possible that the larva is carried normally by some crustacean through whose agency the tapeworm enters a natural bird host." Fischthal (1947) found a larval *Hymenolepis* sp. in the intestine of the western golden shiner *(Notemigonus crysoleucas auratus)* from Crooked lake, Burnett county, Wisconsin.

Hyborhynchus notatus (Raf.), Bluntnose minnow: Seventeen (89.5 per cent) of the 19 fish examined were infected. The 1 fish from Shell creek was negative. Only 1 of the 2 fish from Dunn lake was parasitized, being lightly infected with larval *Contracaecum* sp. in the mesenteries. All 15 of the fish from Little Sand lake were infected. Immature *Bothriocephalus cuspidatus* occurred lightly in 1, adult Caryophyllaeidae in 3, immature and adult forms in 2 others, *Neascus* sp. in 2, and larval *Tetracotyle* sp. from the mesenteries of 2. Larval *Diplostomulum scheuringi* was lightly present in 14, moderately in 1. The 1 fish from the Yellow river harbored a heavy infection of *Trichodina* sp. on the gills.

Notropis cornutus frontalis (Agassiz), Northern common shiner: Only 51 (88 per cent) of the 58 fish were infected (Table 4). The larval *Bucephalus elegans* were encysted in the mesenteries of a Hay creek fish and in the mesenteries and gills of 2 Spring creek fish. The immature *Contracaecum* sp. occurred in the body cavity of 1 Sawyer creek fish, and in the liver of 2 Yellow river fish. The larval *Diplostomulum* sp. was observed in the lens of the eye. The Microsporidia occurred in the flesh of the body. The Myxosporidia were encountered on the gills. The immature *Proteocephalus* sp. from the Willow river did not possess an apical sucker on its scolex.

Hybognathus hankinsoni Hubbs, Brassy minnow: All 8 fish from the Willow river harbored parasites. *Neascus* sp. was present heavily in the 8, and larval *Posthodiplostomum minimum* lightly in 6, moderately in 2.

TABLE 4

Notropis cornutus frontalis (Agassiz)—NORTHERN COMMON SHINER

	BASHAW CR.	HAY CR.	SAWYER CR.	SPRING CR. (1)	SPRING CR. (2)	WILLOW R.	YELLOW R.
Examined 58	3	15	5	17	1	4	13
Infected 51	3	9	5	16	1	4	13
Allocreadium lobatum							1^1
***Allocreadium lobatum*	1^1			3^1	1^1		
**Bucephalus elegans*		1^1		2^1			
**Clinostomum marginatum*		1^1					
***Contracaecum* sp.			1^1				2^1
**Diplostomulum scheuringi*		1^1					1^1
**Diplostomulum* sp.							4^1
*Glochidia							8^1
Gyrodactyloidea	2^1		1^1 1^2	1^1	1^1	2^1	11^1 1^2
Microsporidia		1^1					3^1
Myxosporidia			2^1 2^2				1^1
**Neascus* sp.	1^1	1^1	4^1	6^1		1^1 2^2 1^3	2^1
Phyllodistomum notropidus				4^1		2^1	3^1
Plagioporus sinitsini		3^1 1^2		5^1			
Pomphorhynchus bulbocolli		1^1		1^1			
**Posthodiplostomum minimum*	1^1	2^1	4^1	4^1			1^1
***Proteocephalus* sp.						1^1	
Rhabdochona cascadilla		1^1	4^1	1^1	1^1	3^1	11^1 1^2
⊥*Rhabdochona cascadilla*	1^2						
***Rhabdochona cascadilla*	1^1		1^1	6^1			

Notropis heterodon (Cope), Blackchin shiner: The 1 fish from Beaver brook harbored a light infection with larval *Contracaecum* sp.

Notropis h. heterolepis Eig. & Eig., Northern blacknose shiner: Nineteen (90.5 per cent) of the 21 fish examined were parasitized. All 6 from Beaver brook were lightly infected, 1 with glochidia, 3 with Gyrodactyloidea, 3 with larval *Posthodiplostomum minimum,* and 2 with immature *Proteocephalus pearsei.* Only 13 of the 15 fish from Little Sand lake harbored a single species of parasite, namely, larval *P. minimum;* 12 were lightly infected, 1 moderately.

Ameiurus n. natalis (LeS.), Northern yellow bullhead: Twenty two (91.7 per cent) of 24 fish were parasitized. The 2 from Hay creek were negative. All 10 from Big McKenzie lake were infected, 2 lightly with *Alloglossidium corti,* 1 with immature *Azygia augusticauda,* 2 with larval *Clinostomum marginatum,* 4 with *Corallobothrium fimbriatum,* 2 with larval *Proteocephalus ambloplitis,* 5 with *Dichelyne robusta,* 1 with larval *Diplosotomulum scheuringi,* 4 with Gyrodactyloidea, 3 with *Phyllodistomum staffordi,* 1 with immature *Proteocephalus pearsei,* 1 with larval *Proteocephalus sp.*, and 2 with *Spinitectus gracilis. Alloglossidium geminus* occurred lightly in 4, moderately in 2; immature *Contracaecum* sp. lightly in 5, moderately in 3; larval *Diplostomulum* sp. in the lens of the eye lightly in 8, moderately in 1; and larval *Spiroxys* sp. lightly in 5, moderately in 2. One was lightly infected with adult *Leptorhynchoides thecatus,* while the larval stage occurred lightly in 4, moderately in 1. Adult *Pomphorhynchus bulbocolli* occurred lightly in 1, while the larval stage was present lightly in 4, moderately in 5. All 12 fish from the Yellow river harbored parasites. Four were lightly infected with *A. corti,* 1 with immature *Contracaecum* sp., 12 with larval *Diplostomulum* sp., 3 with Gyroractyloidea, 2 with adult and 6 with larval *L. thecatus,* 4 with adult and 8 with larval *P. bulbocolli.* 1 with immature *P. pearsei,* and 10 with larval *Spiroxys* sp.

Ameiurus n. nebulosus (LeS.), Northern brown bullhead: All 14 of the fish harbored parasites. The 4 from Beaver brook were infected. Four were lightly infected with larval *Diplostomulum* sp., and 3 with *Phyllodistomum staffordi.* One was parasitized lightly and 1 moderately with *Alloglossidium corti,* 2 lightly and 2 moderately with larval *Clinostomum marginatum,* 2 moderately and 2 heavily with immature *Contracaecum* sp., and 2 lightly and 2 moderately with Gyrodactyloidea. Adult *Alloglossidium geminus* occurred lightly in 1 and moderately in 1, while the immature stage was light in 1. The 8 fish from Big McKenzie lake had 13 species of parasites. Two were lightly parasitized with larval *C. marginatum,* 6 with immature *Contracaecum* sp., 4 with *Corallobothrium fimbriatum,* 5 with *Dichelyne robusta,* 6 with larval *Diplostomulum* sp., 3 with Gyrodactyloidea, 2 with *P. staffordi,* and 2 with larval *Proteocephalus ambloplitis.* Two were infected lightly and 1 moderately with

A. corti, 4 lightly and 2 moderately with *A. geminus,* and 3 lightly and 4 moderately with larval *Spiroxys* sp. Adult *Leptorhynchoides thecatus* occurred lightly in 1, while 3 were lightly and 1 moderately infected with the larval stage. One was lightly parasitized with adult *Pomphorhynchus bulbocolli,* while the larval stage occurred lightly in 4 and moderately in 3. The 2 brown bullheads from Birch lake were heavily infected with larval *P. ambloplitis.* They were lightly infected with immature *A. corti,* larval *Diplostomulum* sp., and *L. thecatus.* Only 1 of the 2 were lightly parasitized with immature *Azygia augusticauda,* immature *Bothriocephalus cuspidatus, D. robusta,* and *Spinitectus gracilis.* Immature and adult *C. fimbriatum* was observed lightly in 1, while the other had only immature forms.

Ameiurus m. melas (Raf.), Northern black bullhead: One fish was examined from Stuntz brook, but was free from parasites.

Noturus flavus (Raf.), Stonecat: Three specimens were examined from Hay creek. Adult *Alloglossidium corti* occurred lightly in 1, while immature forms were taken from the other 2. All 3 were lightly parasitized with larval *Pomphorhynchus bulbocolli.*

Umbra limi (Kirtland), Western mudminnow: Only 23 (79.3 per cent) of the 29 fish examined were parasitized. One from Shell creek and 2 from Spring creek (2) were negative. The 7 from Bashaw creek were lightly infected, 1 with larval *Contracaecum* sp., 4 with *Phyllodistomum brevicecum,* 1 with larval *Spiroxys* sp., and 2 with larval Trematoda in the stomach wall. Five of the 6 fish from Dahlstrom brook were lightly infected, 4 with *Bunoderina eucaliae,* and 2 with *P. brevicecum.* From Hay creek, 4 of the 5 fish harbored parasites, 1 lightly with larval *Contracaecum* sp., 3 with *P. brevicecum,* and 2 with larval *Spiroxys* sp. The 3 McKenzie creek fish were lightly parasitized, 1 with immature *B. eucaliae,* 1 with Gyrodactyloidea, and 3 with *P. brevicecum.* Four of the 5 Willow river fish were lightly infected, 1 with *B. eucaliae,* 2 with *P. brevicecum,* 1 with larval *Proteocephalus* sp., and 2 with larval *Spiroxys* sp.

Esox lucius Linn., Northern pike: The 11 fish examined from 5 waters were all infected. From Big McKenzie lake, 3 fish were parasitized, 2 lightly with *Azygia augusticauda,* and 1 with immature *Triaenophorus nodulosus.* Immature *Proteocephalus* *pinguis* occurred moderately in 1, while both the immature and adult stages were present lightly in 1 and moderately in 1. Two were moderately and 1 heavily infected with both immature and adult *Contracaecum brachyurum*. Gyrodactyloidea occurred moderately in 1, heavily in 2. *Neascus* sp. was present lightly in 2, heavily in 1. Two fish were taken from Birch lake. Both were lightly parasitized by immature *A. augusticauda*, larval *Diplostomulum scheuringi*, and *Neoechinorhynchus tenellus*. Immature *Camallanus oxycephalus* and *Leptorhynchoides thecatus* were present lightly in only 1. Both pike were moderately infected with Gyrodactyloidea and *Neascus* sp., while both immature and adult *P. pinguis* was present heavily. Four fish were examined from Rice lake. One was lightly infected with *A. augusticauda*, while 4 were moderately parasitized with larval *D. schueringi*. Gyrodactyloidea occurred lightly in 1, moderately in 3. *Neascus* sp. was present moderately in 3, heavily in 1. *P. pinguis* was recovered lightly from 3 fish, 1 with adults only, 1 with both adult and immature worms, and 1 with immature worms only. The 1 fish from Stuntz brook was lightly infected with Gyrodactyloidea, and heavily with immature *P. pinguis*. The 1 pike from the Yellow river was parasitized lightly with glochidia, and immature *Macroderoides flavus;* moderately with immature *C. brachyurum*, Gyrodactyloidea, and immature and adult *P. pinguis;* and heavily with *Neascus* sp. Bangham (1946) found all 4 northern pike from the Yellow river flowage at Spooner infected, recording *A. augusticauda*, *Crepidostomum cooperi*, larval *Diplostomulum* sp., Gyrodactyloidea, *Neascus* sp., *P. pinguis*, and *Spinitectus gracilis*. Fischthal (1947) examined 11 fish from the Yellow river, finding similar parasites as herein recorded with the exception of glochidia which he did not find. In addition to those in common he recorded *A. augusticauda*, larval *D. scheuringi*, *L. thecatus*, *N. tenellus*, *Phyllodistomum* sp., and *Trichodina* sp.

Esox m. masquinongy Mitchill, Great Lakes muskellunge: All 7 muskellunge examined harbored parasites. The 1 fish from Teal lake was lightly infected with *Philometra* sp., and immature *Triaenophorus nodulosus*, but moderately with *Macroderoides spiniferus*. The *Philometra* sp. consisted of 2 large specimens recovered from the body cavity, and measuring 185 and 201 mm. in length, respectively. During the summer of 1944 the author had observed Dr. Ralph V. Bangham recover this same parasite

TABLE 5

Perca flavescens (Mitchill)—YELLOW PERCH

	BEAVER BRK.	BIG MCKENZIE L.	BIRCH L.	HAY CR.	LITTLE SAND L.	SHELL L.	SPRING CR. (2)	YELLOW R.
Examined 55	5	1	13	5	5	13	1	12
Infected 55	5	1	13	5	5	13	1	12
Argulus catostomi	....	....	1[1]	....	....	....	....	....
Argulus versicolor	....	....	1[1]	....	....	....	....	....
***Azygia augusticauda*	....	1[1]	5[1]	....	....	....	....	2[1]
Bothriocephalus cuspidatus	....	....	....	....	....	1[3]	....	....
***Bothriocephalus cuspidatus*	....	....	12[1]	....	4[1] 1[2]	3[1] 2[2] 7[3]	1[1]	....
Bunodera sacculata	....	....	5[1]	....	2[1]	5[1] 1[3]	....	11[1]
┴ *Bunodera sacculata*	....	....	....	....	1[1]	....	....	....
***Bunodera sacculata*	....	....	....	4[1] 1[2]	....	....	....	....
***Camallanus oxycephalus*	....	....	10[1] 3[2]	....	....	....	....	....
**Clinostomum marginatum*	3[1]	1[1]	11[1] 2[2]	2[1]	....	1[1]	....	10[1]
***Contracaecum* sp.	1[1]	.... 1[2]	....	....	....	....	....	1[1]
Crepidostomum cooperi	....	....	5[1] 2[2]	....	....	....	....	....
Dichelyne cotylophora	....	....	8[1] 2[2]	....	....	....	....	....
┴ *Dichelyne cotylophora*	....	1[1]	....	....	....	....	....	....
**Diplostomulum scheuringi*	1[1] 3[2]	1[1]	13[1]	5[1]	1[1] 4[2]	13[1]	....	11[1]
**Diplostomulum* sp.	....	.... 1[2]	8[1] 5[2]	4[1]	....	....	1[1]	12[1]
*Glochidia	....	....	1[1]	....	....	....	....	3[1] 9[2]
Gyrodactyloidea	4[1]	1[1]	7[1] 6[2]	3[1]	1[1]	....	1[1]	8[1] 1[2]
Illinobdella sp.	1[1]	....	....	1[1]	....	....	....	....
Leptorhynchoides thecatus	....	....	3[1]	....	....	2[1]	....	....
**Leptorhynchoides thecatus*	....	....	....	2[1]	....	....	....	....
**Neascus* sp.	4[1] 1[2]	.... 1[2]	3[1] 7[2] 3[3]	1[1]	4[1]	12[1] 1[2]	....	.... 7[2] 5[3]
Neoechinorhynchus cylindratus	....	....	5[1]	....	....	....	....	....
**Proteocephalus ambloplitis*	....	....	10[1]	....	....	1[1] 5[2] 6[3]	....	....
Proteocephalus pearsei	....	....	....	....	....	1[1]	....	....
***Proteocephalus pearsei*	2[1] 1[2]	....	5[1] 1[2]	3[1] 1[2]	....	....	.... 1[3]	1[1]
Spinitectus gracilis	....	1[1]	3[1]	....	....	6[1]	....	....
**Tetracotyle* sp.	....	....	....	....	....	2[3]	....	....

from muskellunge from northeast Wisconsin lakes which measured approximately 2 feet in length. The 6 fish from the Yellow river were parasitized, all being lightly infected with immature *Contracaecum brachyurum*, 3 with glochidia, 2 with *Leptorhynchoides thecatus*, 2 with *Neoechinorhynchus tenellus*, 1 with *Phyllodistomum* sp., 1 with *Pomphorhynchus bulbocolli*, and 1 with larval *Spiroxys* sp. One was lightly and 2 moderately infected with both immature and adult *Proteocephalus pinguis*, while 3 were lightly parasitized with immature forms only. *Trichodina* sp. occurred heavily on the gills of 1 fish.

Perca flavescens (Mitchill), Yellow perch: All 55 perch examined were parasitized (Table 5). The fish from Little Sand lake, Hay and Spring creeks, and Yellow river were fingerlings. The 2 species of *Argulus, catostomi* and *versicolor*, were recovered from the body surfaces of Birch lake perch. The larval *Diplostomulum* sp. (probably *D. huronense)* occurred in the humors of the eye. The glochidia were observed in the gills. The larval *Leptorhynchoides thecatus* was encysted in the mesenteries. The larval *Tetracotyle* sp. were encysted around the heart of 2 Shell lake fish. The 12 Yellow river perch were collected from below the dam at Spooner lake. Bangham (1946) in his examination of one perch from the Yellow river flowage at Spooner recorded larval *Clinostomum marginatum, Crepidostomum cooperi*, larval *Diplostomulum* sp. (1), Gyrodactyloidea, *L. thecatus*, larval *Neascus* sp., and *Proteocephalus pearsei*. Fischthal (1947) found all 12 perch from the Yellow river below the Spooner power dam infected with similar parasites as herein recorded, with the exception of *Bunodera sacculata* which he did not find. In addition to those mentioned in common he recorded *Bunodera leuciopercae*, larval *Contracaecum* sp., *C. cooperi*, larval and adult *L. thecatus, Neoechinorhynchus cylindratus, Pomphorhynchus bulbocolli*, larval *Spiroxys* sp., and *Trichodina* sp.

Stizostedion v. vitreum (Mitchill), Walleye: Fourteen fish were examined from 2 waters and all harbored parasites. The 1 fish from Conners lake was lightly infected with *Capillaria catenata, Neascus* sp., immature *Proteocephalus stizostethi*, and *Spinitectus carolini*. It was heavily parasitized with both immature and adult *Bothriocephalus cuspidatus*. The 13 fish from Shell lake were lightly parasitized, 1 with *Bucephalopsis pusilla*, 2 with larval *Clinostomum marginatum*, 6 with larval *Diplosto-*

mulum scheuringi, and 12 with *P. stizostethi.* All 13 had *B. cuspidatus,* 1 moderately and 9 heavily with both immature and adult forms, and 3 heavily with immature forms only. Gyrodactyloidea occurred lightly in 7 and moderately in 2. *Leptorhynchoides thecatus* lightly parasitized 7 and moderately 6. Six fish were lightly infected with *Spinitectus gracilis,* while 4 were moderately infected. Bangham (1946) examined 12 fish from Shell lake, finding similar parasites as herein recorded, with the exceptions of larval *C. marginatum and Gyrodactyloidea* which he did not observe. In addition to those in common he found *Neoechinorhynchus tenellus* and *Uvulifer ambloplites.*

Percina caprodes semifasciata (DeKay), Northern logperch: Three logperch were examined from the Yellow river and found to be infected. One was lightly parasitized with immature *Camallanus oxycephalus,* 1 with immature *Contracaecum* sp., 3 with larval *Diplostomulum scheuringi,* 1 with adult *Leptorhynchoides thecatus* and 2 with the larval stage, 3 with adult *Pomphorhynchus bulbocolli* and 1 of these also with the larval stage, and 2 with larval *Tetracotyle* sp. in the mesenteries. *Neascus* sp. occurred lightly in one and moderately in 2. One was heavily parasitized with *Trichodina* sp. on the gills.

Boleosoma nigrum eulepis Hubbs and Greene, Scaly Johnny darter: Only 25 (86.2 per cent) of the 29 fish examined harbored parasites. Ten of the 13 from Bashaw creek were infected. Adult *Bothriocephalus formosus* occurred lightly in 1, while in another both immature and adult forms were present. Light infections with larval *Clinostomum marginatum* were recovered from 2, immature *Contracaecum* sp. from 8, *Neascus* sp. from 4, and larval *Tetracotyle* sp. from 1. Only 1 of the 2 Little Sand lake fish was parasitized, having a light infection with larval *Diplostomulum scheuringi.* All 14 from the Yellow river contained parasites. Two were lightly infected with larval *C. marginatum,* 9 with immature *Contracaecum* sp., 1 with larval *Contracaecum* sp., 5 with larval *D. scheuringi,* 2 with adult and 1 with larval *Leptorhynchoides thecatus,* 1 with adult and 1 with larval *Pomphorhynchus bulbocolli,* and 1 with larval *Proteocephalus* sp. encysted in the mesenteries. *Epistylis* sp. occurred heavily on the gill rakers and bars of 2 fish. Glochidia were lightly present on the gills and fins of 1 and moderately on another. Six were lightly parasitized with *Neascus* sp., while 5 were moderately infected.

Boleosoma n. nigrum (Raf.), Central Johnny darter: Only 4 (44.4 per cent) of the 9 fish harbored parasites. Three of the 8 Shell creek fish harbored light infections, 1 with larval *Diplostomulum scheuringi*, 2 with *Leptorhynchoides thecatus*, and 1 with *Pomphorhynchus bulbocolli;* 1 was moderately infected with *Neascus* sp. The 1 fish from the Yellow river was lightly infected with larval *Clinostomum marginatum*, immature *Contracaecum* sp., larval *D. scheuringi*, and *Neascus* sp.; 1 was heavily parasitized with *Epistylis* sp. on the gill rakers and bars. Fischthal (1947) recorded similar parasites from 7 Yellow river fish as herein recorded, with the exception of *Epistylis* sp. which he did not observe. In addition to those parasites mentioned he recovered *Bothriocephalus formosus*, larval and adult *L. thecatus*, *Phyllodistomum etheostomae*, *P. bulbocolli*, and larval *Proteocephalus* sp.

Boleosoma n. nigrum x *B. n. eulepis*, Central x Scaly Johnny darter hybrid: Twenty one (84 per cent) of the 25 hybrid darters harbored parasites. The 1 fish from Spring creek (2) and the 2 from Stuntz brook were negative. Two of the 3 fish from Hay creek were lightly infected with immature *Contracaecum* sp., and with larval *Proteocephalus* sp. in the mesenteries. All 8 from Spring creek (1) were parasitized, 1 lightly with *Bothriocephalus formosus*, 1 with larval *Clinostomum marginatum*, 1 with larval *Leptorhynchoides thecatus*, 3 with larval *Tetracotyle* sp., and 2 with *Pomphorhynchus bulbocolli*. Six were lightly and 2 moderately infected with *Neascus* sp. All 11 fish from the Willow river were infected, 1 lightly with adult *B. formosus* and 2 with immature forms, 1 with larval *C. marginatum*, 6 with larval Contracaecum sp., 2 with *Phyllodistomum etheostomae*, and 1 with larval *Tetracotyle* sp. *Neascus* sp. occurred lightly in 3, moderately in 7, and heavily in 1.

Poecilichthys exilis (Girard), Iowa darter: The 9 fish examined were all parasitized. The 1 from Beaver brook was lightly infected with Myxosporidia, and *Neascus* sp. The 1 from the Willow river was lightly parasitized with larval *Contracaecum* sp., and *Neascus* sp. Seven Yellow river fish were parasitized, 2 lightly with immature *Contracaecum* sp., 2 with larval *Diplostomulum scheuringi*, 4 with larval *Leptorhynchoides thecatus*, 3 with *Neascus* sp., 1 with adult and 3 with larval *Pomphorhynchus bulbocolli*, 2 with larval *Proteocephalus* sp., 1 with larval *Spi-*

roxys sp., and 2 with *Trichodina* sp. on the gills. Three were heavily infected with *Epistylis* sp. on the gill rakers and bars, which is similar to those found on the scaly and central Johnny darters. Fischthal (1947) observed similar parsites in 3 of 6 Yellow river fish as herein recorded, with the exception of *Epistylis* sp., larval *L. thecatus* and *P. bulbocolli,* larval *Proteocephalus* sp., and *Trichodina* sp. which he did not observe. In addition to those in common he found adult *L. thecatus.*

Huro salmoides (Lac.), Largemouth bass: Twenty-two fish were examined from 7 waters and all were parasitized (Table 6). The larval *Contracaecum* sp. and *Proteocephalus* sp. occurred in cysts in the mesenteries. *Sanguinicola* sp. was recovered from the mesenteries blood vessels and is similar to the species observed by Fischthal (1947) in the smallmouth and largemouth basses. The Myxosporidia was found in cysts in the mouth region.

Lepomis gibbosus (Linn.), Pumpkinseed: The 33 fish examined from 7 waters were infected. The larval *Diplostomulum* sp. from Big McKenzie lake occurred in the lens of the eye (Table 7). The larval *Contracaecum* sp. and Acanthocephala were encysted in the mesenteries. The Myxosporidia occurred on the heart and mesenteries of two Yellow river fish. The larval *Triaenophorus nodulosus* were encysted in the liver. Bangham (1946) in his examination of 9 pumpkinseeds from the Yellow river flowage at Spooner recorded similar parasites as herein recorded, with the exceptions of immature *Contracaecum* sp., larval *Leptorhynchoides thecatus* and Myxosporidia which he did not observe. In addition to those in common he found a larval nematode, *Azygia augusticauda* and *Crepidostomum cornutum.* Fischthal (1947) also found similar parasites as given in this report for the Yellow river with the exception of Myxosporidia which he did not record. In addition to those found in common he listed immature *Azygia auagusticauda, Bothriocephalus claviceps,* larval *Contracaecum* sp., glochidia, *Phyllodistomum pearsei, Pomphorhynchus bulbocolli* and larval *Spiroxys* sp.

Lepomis m. macrochirus Raf., Common bluegill: All 71 fish examined from 9 waters were infected (Table 8). The larval *Dichelyne* sp. was encysted in the mesenteries. The larval *Diplostomulum* sp. was found in the lens of the eye. The Myxosporidia was on the gills. Bangham (1946) examined 2 Shell

TABLE 6

Huro salmoides **(Lacépède)—LARGEMOUTH BASS**

	BIG MCKENZIE L.	CONNERS L.	FISH L.	HAY CR.	LITTLE SAND L.	RICE L.	SPRING CR. (1)
Examined 22	15	2	1	1	1	1	1
Infected 22	15	2	1	1	1	1	1
Achtheres micropteri	1[1]	......	1[1]	......	......	......	......
Azygia augusticauda	6[1]	......	......	......	......	......	......
⊥ *Azygia augusticauda*	1[1]	1[1]	......	......	......	......	......
***Azygia augusticauda*	1[1]	......	......	......	......	......	......
Caecincola parvulus	1[2] 14[3]	2[2]	......	......	......	1[3]	......
Camallanus oxycephalus	2[1]	......	......	......	......	1[1]	......
***Camallanus oxycephalus*	7[1]	......	......	......	......	......	......
**Clinostomum marginatum*	1[1]	2[1]	......	......	1[1]	......	......
***Contracaecum* sp.	1[1]	......	......	......	......	......	......
**Contracaecum* sp.	......	......	......	......	......	1[2]	......
Crepidostomum cooperi	......	......	......	......	1[1]	......	......
**Diplostomulum scheuringi*	4[1]	......	......	1[1]	...... 1[2]	1[1]	......
Ergasilus caeruleus	8[1] 6[2]	2[2]	......	......	......	......	......
Gyrodactyloidea	3[1] 10[2]	2[2]	......	1[1]	1[2]	......	......
Leptorhynchoides thecatus	6[1] 1[2]	2[1]	......	......	......	......	......
Myxosporidia	5[1] 2[2]	2[1]	......	......	1[1]	......	......
**Neascus* sp.	4[1] 7[2] 4[3]	2[2]	1[2]	......	1[3]	1[2]	1[2]
Neoechinorhynchus cylindratus	9[1] 4[2]	1[1] 1[2]	......	......	......	1[2]	......
Philometra nodulosa	7[1]	1[1]	......	......	......	......	......
Pomphorhynchus bulbocolli	......	......	......	......	......	......	1[1]
Proteocephalus ambloplitis	5[1]	......	......	......	......	1[2]	......
**Proteocephalus ambloplitis*	...... 15[3]	2[2]	1[3]	......	......	1[2]	1[1]
Proteocephalus fluviatilis	3[1]	......	......	......	......	......	......
⊥ *Proteocephalus fluviatilis*	......	......	......	......	......	......	1[1]
**Proteocephalus* sp.	......	......	......	1[1]	......	......	......
Sanguinicola huronis	......	......	......	......	......	......	1[1]
Spinitectus carolini	13[1]	......	1[1]	......	...... 1[2]	......	......

TABLE 7

Lepomis gibbosus (Linnaeus)—PUMPKINSEED

	BEAVER BRK.	BIG MCKENZIE L.	BIRCH L.	CALLAHAN L.	CONNERS L.	FISH L.	YELLOW R.
Examined 33	5	10	3	1	10	1	3
Infected 33	5	10	3	1	10	1	3
***Bothriocephalus claviceps*	3^{1}						
Camallanus oxycephalus		1^{1}			1^{1}		
***Camallanus oxycephalus*		2^{1}					
**Clinostomum marginatum*	4^{1}	6^{1}	3^{1}		4^{1}		2^{1}
***Contracaecum* sp.		3^{1}			1^{1}		1^{1}
**Contracaecum* sp.					1^{1}		
Crepidostomum cooperi		7^{1}	1^{1}				
⊥ *Crepidostomum cooperi*							2^{3} 1^{1}
Crepidostomum cornutum			1^{1} 2^{2}			1^{1}	
**Diplostomulum scheuringi*	3^{1}		3^{1}	1^{1}	2^{1}	1^{1}	2^{1}
**Diplostomulum* sp.		2^{1}					
Ergasilus caeruleus					2^{1}		
Gyrodactyloidea	4^{1} 1^{2}	1^{1} 3^{2} 6^{3}	2^{2} 1^{3}	1^{2}	4^{1} 5^{2} 1^{3}	1^{3}	1^{1} 1^{2}
Illinobdella sp.			1^{1}				
Leptorhynchoides thecatus		4^{1}	2^{1}		9^{1}		2^{1}
**Leptorhynchoides thecatus*							2^{1}
Myxosporidia							1^{2} 1^{3}
**Neascus* sp.	3^{1} 1^{3}	4^{2} 6^{3}	3^{3}	1^{2}	9^{2} 1^{3}	1^{3}	1^{2} 2^{3}
**Pomphorhynchus bulbocolli*					4^{1}		
**Posthodiplostomum minimum*	2^{1} 1^{2} 2^{3}	10^{3}	3^{3}	1^{3}	7^{2} 3^{3}	1^{1}	1^{2} 2^{3}
**Proteocephalus ambloplitis*		2^{1}	1^{1}		2^{1}	1^{1}	
***Proteocephalus pearsei*					1^{1}		1^{1}
Spinitectus carolini		5^{1} 5^{2}	2^{1}		9^{1}	1^{2}	2^{1}
Spinitectus gracilis		4^{1} 1^{2}	1^{1}		2^{1}		
**Triaenophorus nodulosus*				1^{1}	1^{1}		

TABLE 8

Lepomis m. macrochirus Rafinesque—COMMON BLUEGILL

	BIG MCKENZIE L.	BIRCH L.	CONNERS L.	FISH L.	LONG L.	POKEGAMA L.	PRAIRIE L.	SHELL L.	YELLOW R.
Examined 71 Infected 71	10 10	13 13	7 7	11 11	12 12	11 11	5 5	1 1	1 1
Achtheres micropteri	....	1^{1}	....	....	....	....	....	....	....
***Bothriocephalus cuspidatus*	....	....	....	....	4^{1}	....	....	....	....
***Camallanus oxycephalus*	4^{1}	1^{1}	....	....	....	5^{1}	....	....	....
Capillaria catenata	4^{1}	....	....	....	....	....	....	....	....
**Clinostomum marginatum*	1^{1}	....	....	....	6^{1}	....	....	....	....
***Contracaecum* sp.	5^{1}	....	....	....	....	2^{1}	....	....	....
Crepidostomum cooperi	7^{1}	3^{1}	....	....	....	....	....	....	.... 1^{2}
⊥ *Crepidostomum cooperi*	....	1^{2}	....	....	....	....	....	....	....
***Crepidostomum cooperi*	....	....	1^{1}	....	....	....	....	....	....
Crepidostomum cornutum	....	5^{1} 1^{2} 1^{3}	....	3^{1}	....	2^{1}	....	.... 1^{2}	....
⊥ *Crepidostomum cornutum*	....	....	....	....	....	....	1^{2}	....	....
***Crepidostomum cornutum*	....	....	....	1^{1}	....	....	....	....	....
**Dichelyne* sp.	....	....	....	....	....	1^{1}	....	....	....
**Diplostomulum scheuringi*	1^{1}	1^{1}	2^{1}	4^{1}	12^{2}	4^{1}	....	1^{1}	1^{1}
**Diplostomulum* sp.	....	....	....	....	....	....	1^{1}	....	....
Ergasilus caeruleus	....	....	3^{1}	....	....	....	....	....	....
*Glochidia	....	1^{1}	....	....	....	....	....	....	....
Gyrodactyloidea	2^{1} 8^{2}	2^{1} 9^{2} 2^{3}	.... 6^{2} 1^{3}	.... 6^{2} 5^{3}	1^{1} 10^{2} 1^{3}	.... 8^{2} 3^{3}	.... 5^{3}	1^{1}	.... 1^{2}
Illinobdella sp.	....	1^{1}	....	....	....	....	....	....	....
Leptorhynchoides thecatus	7^{1}	6^{1}	1^{1}	....	....	2^{1}	3^{1} 1^{2}	....	1^{1}
Myxosporidia	....	....	....	....	....	....	....	1^{1}	....
**Neascus* sp.	2^{1} 6^{2} 2^{3}	3^{1} 9^{2} 1^{3}	6^{1} 1^{2}	.... 11^{2}	.... 12^{3}	8^{1} 3^{2}	.... 3^{2} 2^{3}	1^{1}	.... 1^{2}
**Posthodiplostomum minimum*	.... 4^{2} 6^{3}	.... 1^{2} 12^{3}	.... 6^{2} 1^{3}	6^{1} 4^{2}	.... 12^{3}	.... 6^{2} 5^{3}	.... 4^{2} 1^{3}	1^{1}	.... 1^{2}
**Proteocephalus ambloplitis*	3^{1}	4^{1}	....	8^{1}	1^{1} 6^{2} 5^{3}	1^{1}	2^{1}	....	....
***Proteocephalus pearsei*	....	....	....	....	3^{1}	....	....	....	....
Spinitectus carolini	5^{1} 4^{2}	10^{1} 1^{2}	1^{1} 6^{2}	4^{1} 7^{2}	7^{1}	8^{1}	3^{1}	....	....
Spinitectus gracilis	4^{1}	....	1^{1}	....	....	2^{1}	....	.... 1^{2}	....

lake bluegills, recording *Crepidostomum cooperi,* larval *Diplostomulum scheuringi,* Gyrodactyloidea, *Neascus* sp., larval *Posthodipostomum minimum,* and *Spinitectus carolini.*

Ambloplites r. rupestris (Raf.), Northern rock bass: The 52 fish examined from 7 waters all harbored parasites (Table 9). The larval *Bucephalus elegans* and *Leptorhynchoides thecatus* were encysted in the mesenteries. The larval *Diplostomulum* sp. occurred in the lens of the eye. The Myxosporidia was observed in the mouth region. Bangham (1946) examined 5 rock bass from Shell lake, recovering similar parasites as herein recorded. In addition he found immature *Bothriocephalus* sp., *Camallanus* sp., and *Proteocephalus pearsei, Crepidostomum cooperi, Cryptogonimus chyli, Dichelyne cotylophora, Ergasilus caeruleus, Leptorhynchoides thecatus, Neoechinorhynchus cylindratus,* larval *Proteocephalus ambloplitis, Spinitectus carolini,* and *Spinitectus* sp. Bangham also examined 6 fish from the Yellow river flowage at Spooner, finding larval *Clinostomum marginatum, Diplostomulum scheuringi, Neascus* sp., and *Posthodiplostomum minimum,* larval and adult *Proteocephalus ambloplitis,* adult *Crepidostomum cooperi, Cryptogonimus chyli,* Gyrodactyloidea, *Illinobdella* sp., *Leptorhynchoides thecatus,* and *Proteocephalus pearsei.* Fischthal (1947) also examined 11 rock bass taken from the Yellow river below the Spooner power dam, observing similar parasites as recorded in this report, with the exceptions of immature *Contracaecum* sp., and larval *Diplostomulum* sp. which he did not observe. In addition to those in common he found *Azygia augusticauda, Crepidostomum cooperi,* Gyrodactyloidea, Myxosporidia, *Neoechinorhynchus cylindratus,* larval *Pomphorhynchus bulbocolli,* and *Trichodina* sp.

Pomoxis nigro-maculatus (LeS.), Black crappie: The 64 fish from 6 waters were all parasitized (Table 10). The Myxosporidia occurred in the gills and intestinal wall of 2 Big McKenzie lake crappies, and in the intestinal wall of Callahan, Conners, and Pokegama lakes fish.

Cottus b. bairdii Girard, Northern muddler: Only 27 (58.7 per cent) of the 46 muddlers harbored parasites. One of the 12 McKenzie creek fish was lightly infected with larval *Contracaecum* sp. encysted in the intestinal wall, and larval *Tetracotyle* sp. in the mesenteries. Seven of the 10 Montgomery creek fish were lightly infected, 4 with Gyrodactyloidea, 2 with immature

TABLE 9

Ambloplites r. rupestris (Rafinesque)—NORTHERN ROCK BASS

	Big McKenzie L.	Birch L.	Conners L.	Hay Cr.	Shell Cr.	Shell L.	Yellow R.
Examined 52	10	5	9	3	1	12	12
Infected 52	10	5	9	3	1	12	12
Achtheres micropteri			1^{1}				
***Azygia augusticauda*		1^{1}					
Bucephalus elegans				2^{1}			
**Bucephalus elegans*				1^{1}			
Camallanus oxycephalus	3^{1}		2^{1}				
***Camallanus oxycephalus*	6^{1}	1^{1}					
Capillaria catenata	5^{1}		1^{1}				
**Clinostomum marginatum*	1^{1}		2^{1}				8^{1}
***Contracaecum brachyurum*	5^{1}		2^{1}				3^{1}
Crepidostomum cooperi		2^{1}		1^{1}			
z*Crepidostomum cooperi*				1^{1}			
***Crepidostomum cooperi*		1^{2} 2^{1}					
Cryptogonimus chyli	3^{1} 5^{2}		1^{1} 4^{2}	2^{1}			1^{1}
***Cryptogonimus chyli*		3^{1}					
Dichelyne cotylophora	2^{1}						
**Diplostomulum scheuringi*	3^{1}	3^{1}	4^{1} 2^{2}			10^{1}	5^{1}
**Diplostomulum* sp.		1^{1}					6^{1}
Ergasilus caeruleus	5^{1} 2^{2}	1^{1} 4^{2}	6^{2} 3^{3}				
*Glochidia							4^{1}
Gyrodactyloidea	1^{1} 4^{2} 5^{3}	4^{2} 1^{3}	4^{1} 3^{2}	1^{1}		3^{1} 8^{2} 1^{3}	
Illinobdella sp.				1^{1}			
Leptorhynchoides thecatus	8^{1}	5^{1}	7^{1} 1^{2}		1^{1}		9^{1}
**Leptorhynchoides thecatus*				1^{1}			1^{1}
Myxosporidia	1^{1}						
**Neascus* sp.	8^{2} 2^{3}	3^{2} 2^{3}	1^{1} 5^{2} 3^{3}	1^{1}	1^{1}	4^{1}	6^{1} 6^{2}
Neoechinorhynchus cylindratus	8^{1}	3^{1}	1^{1}				
Pomphorhynchus bulbocolli	5^{1}	1^{1}					2^{1}
**Posthodiplostomum minimum*	10^{3}	3^{2} 2^{3}	5^{1} 4^{2}			7^{1}	3^{1}
***Proteocephalus ambloplitis*			1^{1}				
**Proteocephalus ambloplitis*	1^{1}	1^{1}					
***Proteocephalus pearsei*	1^{1}			1^{1}			2^{1}
Spinitectus carolini	3^{1}	4^{1} 1^{2}	2^{1}				
Spinitectus gracilis		4^{1} 1^{2}	3^{1}			6^{1} 6^{2}	

Proteocephalus pearsei, and 1 with *Rhabdochona cascadilla.* The 3 Shell creek fish were lightly parasitized, all with *Leptorhynchoides thecatus,* 1 with larval *Pomphorhynchus bulbocolli,* 2 with immature *P. pearsei,* and 1 with *R. cascadilla.* Eleven of the 15 Spring creek (2) fish were infected, 6 lightly and 1 moderately with adult *Crepidostomum cooperi,* 1 moderately with both immature and adult forms, and 1 lightly with immature forms only; 3 were lightly infected with immature *P. pearsei.* Immature *P. pearsei* occurred lightly in the 1 fish from Stuntz brook. Four of the 5 fish from the Willow river were lightly parasitized, 1 with immature *Bothriocephalus sp.;* 2 were lightly infected with *Bucephalus* sp., 1 with both immature and adult forms and 1 with immature forms only.

TABLE 10

Pomoxis nigro-maculatus (LeSueur)—Black Crappie

	Big Mc-Kenzie L.	Birch L.	Calla-han L.	Con-ners L.	Pokeg-ama L.	Rice L
Examined 68	14	13	12	14	11	4
Infected 68	14	13	12	14	11	4
Camallanus oxycephalus	3^1	......	3^1	7^1 2^2	8^1 1^2	......
⊥ *Camallanus oxycephalus*	......	......	......	1^1	......	......
***Camallanus oxycephalus*	......	10^1 3^2	......	......	......	......
**Contracaecum* sp.	......	......	......	......	......	1^1
***Crepidostomum cooperi*	......	4^1 1^2	......	......	......	......
**Diplostomulum scheuringi*	......	......	6^1 1^2	......	5^1	1^1 3^2
Ergasilus caeruleus	......	......	......	1^1	......	......
Gyrodactyloidea	8^1 2^2	7^1 5^2	7^1 2^2	8^1 1^2 1^3	9^1 1^2	1^1
Leptorhynchoides thecatus	......	3^1	2^1	6^1	......	......
**Leptorhynchoides thecatus*	3^1	......	......	......	......	......
Myxosporidia	1^1 1^2	......	2^2 1^3	1^1 2^2	2^1 1^3	......
**Neascus* sp.	......	11^1	9^1 3^2	8^1 1^2	......	......
***Proteocephalus pearsei*	......	......	......	......	1^1	......
***Proteocephalus* sp.	......	......	......	2^1	......	......
Spinitectus carolini	6^1	......	......	......	......	......
Spinitectus gracilis	8^1	7^1 6^2	......	2^1	1^1	......

Eucalia inconstans (Kirtland), Brook stickleback: Only 18 (66.7 per cent) of the 27 fish were parasitized. The 1 Spring creek (2) specimen was negative. Two of the 3 from Bashaw creek were lightly infected, 1 with immature *Contracaecum* sp., and 1 with immature *Rhabdochona cascadilla.* Three of the 4 fish from Sawyer creek were lightly parasitized with immature *Bunoderina eucaliae.* Three of the 4 fish from Dahlstrom brook were lightly infected, 1 with *B. eucaliae,* and 2 with Gyrodactyloidea. Ten of the 15 from the Willow river were lightly infected, 3 with *B. eucaliae,* 1 with Myxosporidia on the gills, 3 with *Neoechinorhynchus rutili,* 3 with larval *Proteocephalus* sp., and 1 with larval *Spiroxys* sp.

Lota lota maculosa (LeS.), Eastern burbot: Eight (88.9 per cent) of the 9 burbot were infected. The 3 from Hay creek were all parasitized, 2 lightly with larval *Diplostomulum* sp. in the humors of the eye, 1 lightly and 1 heavily with Myxosporidia on the gills, 1 lightly with *Neoechinorhynchus cylindratus,* and 2 with immature *Proteocephalus pearsei.* Five of the 6 from Stuntz brook were infected, 2 lightly, 1 moderately, and 2 heavily with glochidia.

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THE MALE GENITALIA OF SYRPHUS, EPISTROPHE AND RELATED GENERA (DIPTERA, SYRPHIDAE)

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During the past thirty-five years there have been several papers dealing with generic and subgeneric concepts in the Syrphini. Matsumura in 1917 split up the genera *Syrphus* Fabr. and *Epistrophe* Wk. and his paper has been followed in part by more recent contributions: Curran (1924), Fluke (1933), Goffe (1943, 44, 46), Frey (1945), and Hull (1949). Most workers agree that these two basic genera need to be divided, but there is some disagreement on just how this should be done.

The study of the male genitalia of these genera began about three years ago, and since then all species in my collection, in which males are represented, from Europe and the Americas, have been dissected and a drawing prepared. These studies have been enlightening and have suggested several changes that appear to show a true relationship among the many species of *Syrphus* Fabr. *Matasyrphus* Mats. *Epistrophe* Wk., *Allograpta* O. S. etc.

METHODS OF PREPARING THE SPECIMENS FOR STUDY

Metcalf (1921) has explained fully the process of relaxing, clearing, and mounting of specimens for study. I have followed in general his methods and have used his terminology. After first relaxing a pinned specimen in a desiccator using ethyl acetate one part, 95% ethyl alcohol one part, and distilled water one part for two days the genitalia were carefully removed with a dissecting needle. They were cleared in 10 per cent caustic potash in small vials for 24 to 48 hours. They were then removed to glycerine in a spot dish where they were manipulated with fine needles into the proper position, spreading the dorsal and ventral parts so that they could all be seen and sketched. In those species belonging to *Allograpta*, it was extremely difficult to spread them without separating the penis sheath from tergite ten.

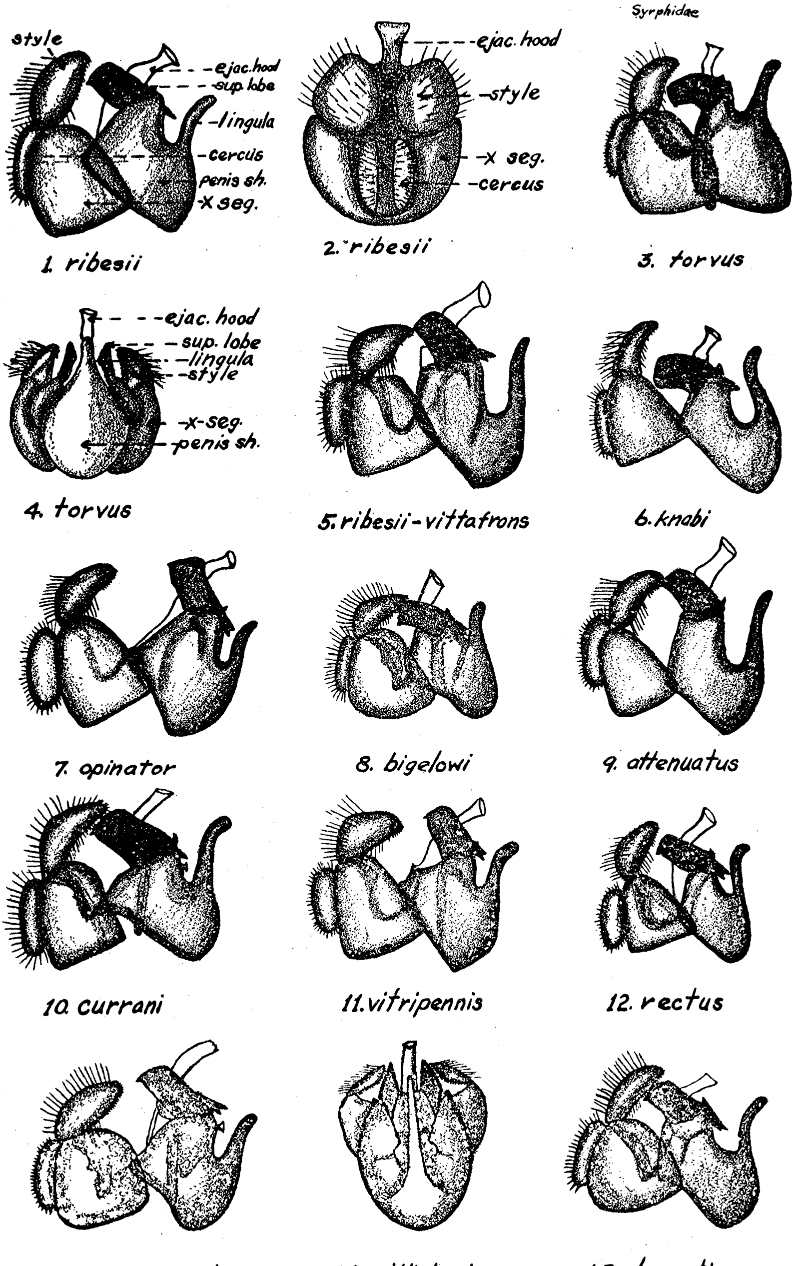
Explanation of Plates

All drawings are genitalia made with the aid of the camera lucida and all are drawn to the same scale. e.h. = ejaculatory hood; s.l. = superior lobes; x = tenth tergite. Except where indicated ventral views are penis sheath only.

Plate I

Figure

1.—Syrphus ribesii, lateral view.
2.—S. ribesii, dorsal view.
3.—S. torvus, lateral view.
4.—S. torvus, entire ventral view.
5.—S. ribesii-vittafrons, lateral view.
6.—S. knabi, lateral view.
7.—S. opinator, lateral view.
8.—S. bigelowi, lateral view.
9.—S. attenuatus, lateral view.
10.—S. currani, lateral view.
11.—S. vitripennis, lateral view.
12.—S. rectus, lateral view.
13.—S. transversalis, lateral view.
14.—S. willistoni, entire ventral view.
15.—S. phaeostigma, lateral view.

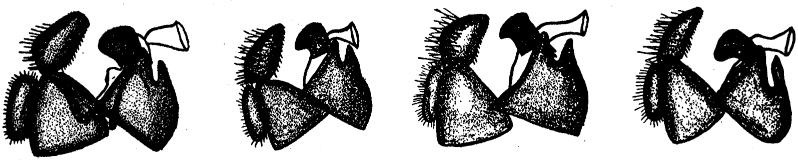


1. ribesii
2. ribesii
3. torvus
4. torvus
5. ribesii-vittafrons
6. knabi
7. opinator
8. bigelowi
9. attenuatus
10. currani
11. vitripennis
12. rectus
13. transversalis
14. willistoni
15. phaeostigma

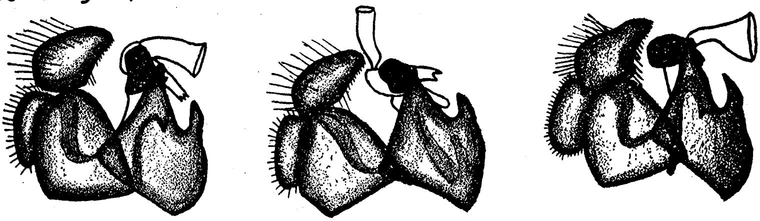
PLATE II

FIGURE

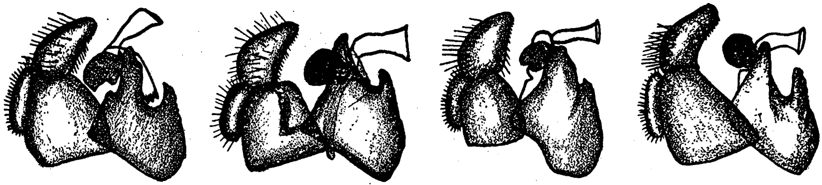
16.—Syrphus (Epistrophe) emarginatus, lateral view.
17.—S. divisus, lateral view.
18.—S. felix, lateral view.
19.—S. invigorus, lateral view.
20.—S. grossulariae, lateral view.
21.—S. xanthostomus, lateral view.
22.—S. nitidicollis, lateral view.
23.—S. hunteri, lateral view.
24.—S. metcalfi, lateral view.
25.—S. melanostomus, lateral view.
26.—S. bifasciatus, lateral view.
27.—S. weborgi, lateral view.
28.—S. bifasciatus, ventral view.
29.—S. grossulariae, ventral view.
30.—S. xanthostomus, ventral view.
31.—S. hunteri, ventral view.
32.—S. metcalfi, ventral view.
33.—S. nitidicollis, ventral view.
34.—S. melanostomus, ventral view.
35.—S. felix, ventral view.
36.—S. divisus, ventral view.
37.—S. invigorus, ventral view.
38.—S. emarginatus, ventral view.
39.—S. weborgi, ventral view.



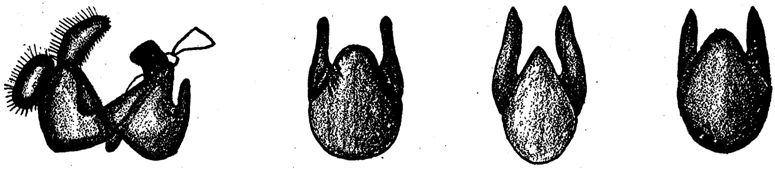
16. emarginatus 17. divisa 18. felix 19. ivigorus



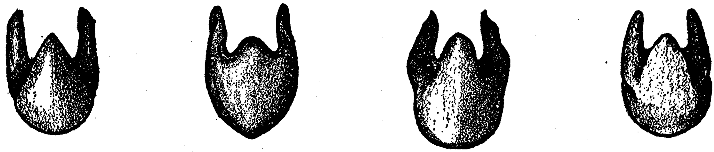
20. grossulariae 21. xanthostomus 22. nitidicollis



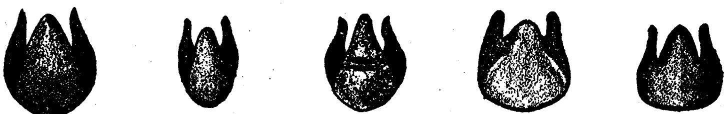
23. hunteri 24. metcalfi 25. melanostomus 26. bifasciata



27. weborgi 28. bifasciata 29. grossulariae 30. xanthostomus



31. hunteri 32. metcalfi 33. nitidicollis 34. melanostomus

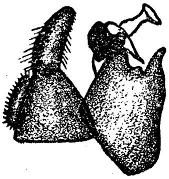
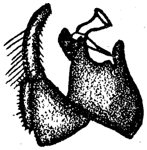
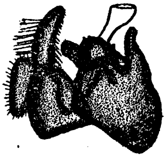
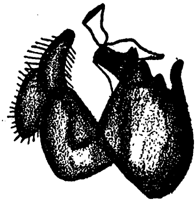


35. felix 36. divisa 37. invigorus 38. emarginatus 39. weborgi

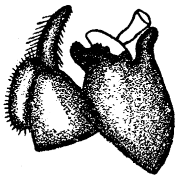
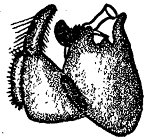
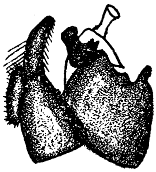
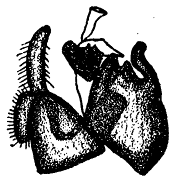
Plate III

Figure

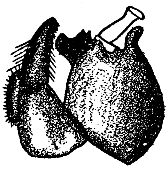
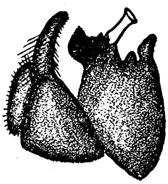
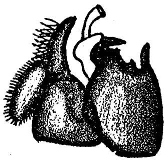
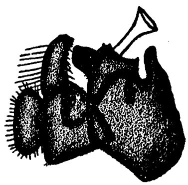
40.—Stenosyrphus albipunctatus, lateral view.
41.—S. barbifrons, lateral view.
42.—S. cherokeenensis, lateral view.
43.—S. columbiae, lateral view.
44.—S. compositarum, lateral view.
45.—S. diversipunctatus, lateral view.
46.—S. fisheri, lateral view.
47.—S. garretti, lateral view.
48.—S. labiatarum, lateral view.
49.—S. lasiophthalmus, lateral view.
50.—S. mentalis, lateral view.
51.—S. pullulus.
52.—S. albipunctatus, ventral view.
53.—S. barbifrons, ventral view.
54.—S. cherokeenensis, ventral view.
55.—S. columbiae, ventral view.
56.—S. diversipunctatus, ventral view.
57.—S. compositarum, ventral view.
58.—S. pullulus, ventral view.
59.—S. mentalis, ventral view.
60.—S. lasiophthalmus, ventral view.
61.—S. labiatarum, ventral view.
62.—S. garretti, ventral view.
63.—S. fisheri, ventral view.

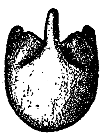
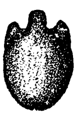
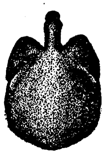
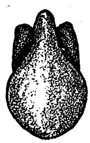
40. albipunctatus 41. barbifrons 42. cherokeenensis 43. columbiae

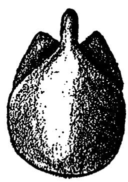





44. compositarum 45. diversipunctatus 46. fisheri 47. garretti

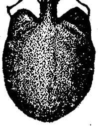
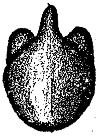
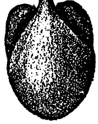
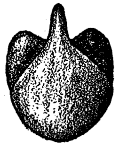
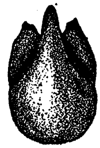
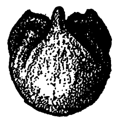





48. labiatarum 49. lasiopthalmus 50. mentalis 51. pullulus



52. albipunctatus 53. barbifrons 54. cherokeenensis 55. columbiae 56. diversipunctatus 57. compositarum

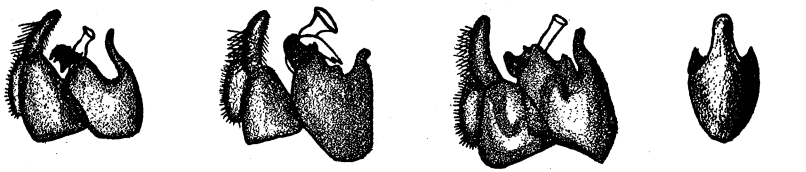







58. pullulus 59. mentalis 60. lasiopthalmus 61. labiatarum 62. garretti 63. fisheri

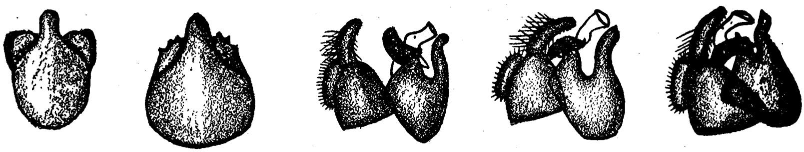
PLATE IV

FIGURE

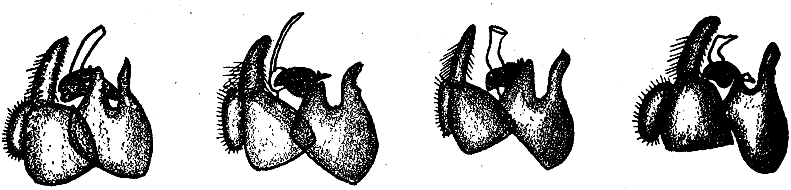
64.—Stenosyrphus punctulatus, lateral view.
65.—S. umbellatarum, lateral view.
66.—S. vittafacies, lateral view.
67.—S. punctulatus, ventral view.
68.—S. umbellatarum, ventral view.
69.—S. vittafacies, ventral view.
70.—S. arcticus, lateral view.
71.—S. genualis, lateral view.
72.—S. insolitus, lateral view.
73.—S. lineola, lateral view.
74.—S. 5-limbatus, lateral view.
75.—S. rectoides, lateral view.
76.—S. semiinterruptus, lateral view.
77.—S. arcticus, ventral view.
78.—S. genualis, ventral view.
79.—S. insolitus, ventral view.
80.—S. lineola, ventral view.
81.—S. 5-limbatus, ventral view.
82.—S. rectoides, ventral view.
83.—S. semiinterruptus, ventral view.
84.—S. cinctus, lateral view.
85.—S. cinctus, ventral view.
86.—S. nigrifacies, lateral view.
87.—S. nigrifacies, ventral view.
88.—S. subfasciatus, lateral view.



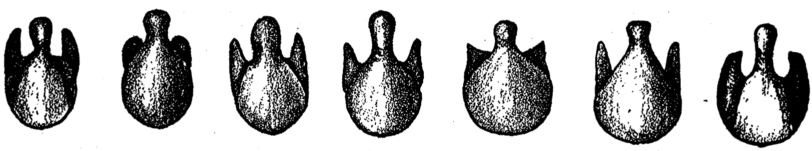
64. punctulatus 65. umbellatarum 66. vittafacies 67. punctulatus



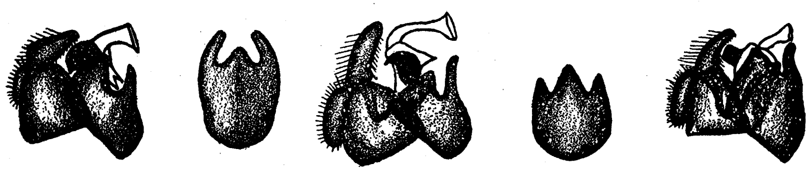
68. umbellatarum 69. vittafacies 70. arcticus 71. genualis 72. insolitus



73. lineola 74. 5-limbatus 75. rectoides 76. semiinterruptus



77. arcticus 78. genualis 79. insolitus 80. lineola 81. 5-limbatus 82. rectoides 83. semiinter.

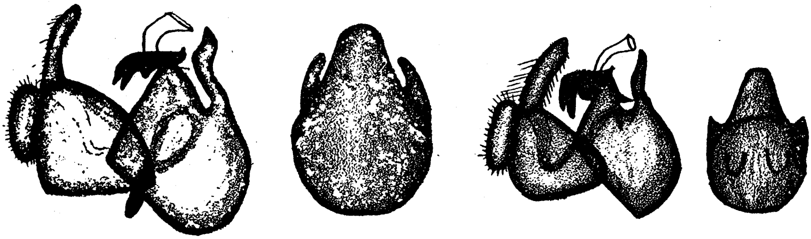


84. cinctus 85. cinctus 86. nigrifacies 87. nigrifacies 88. subfasciatus

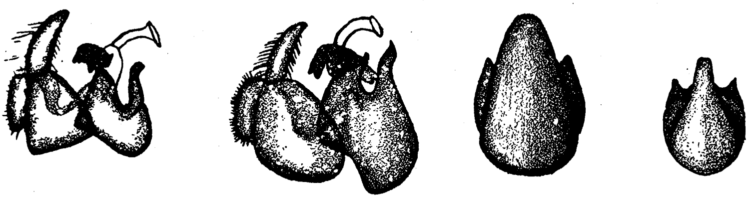
PLATE V

FIGURE

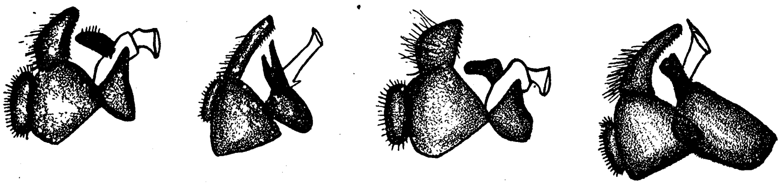
89.—Stenosyrphus tarsatus, lateral view.
90.—S. tarsatus, ventral view.
91.—S. sodalis, lateral view.
92.—S. sodalis, ventral view.
93.—S. macularis, lateral view.
94.—S. mallochi, lateral view.
95.—S. mallochi, ventral view.
96.—S. macularis, ventral view.
97.—Stenosyrphus (Episyrphus) altissimus, lateral view.
98.—S. amplus, lateral view.
99.—S. armillatus, lateral view.
100.—S. cinctellus, lateral view.
101.—S. auricollis, lateral view.
102.—S. auricollis, ventral view.
103.—S. balteatus, lateral view.
104.—S. balteatus, ventral view.
105.—S. diversifasciatus, lateral view.
106.—S. diversifasciatus, ventral view.
107.—S. cinctellus, ventral view.
108.—S. pteronis, lateral view.
109.—S. trabis, lateral view.
110.—S. hermosus, lateral view.



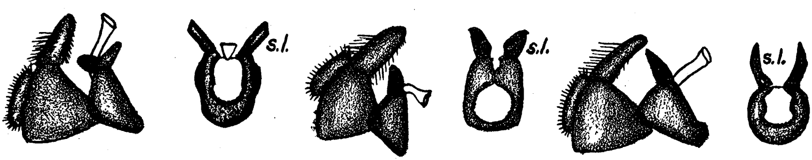
89. tarsatus 90. tarsatus 91 sodalis 92. sodalis



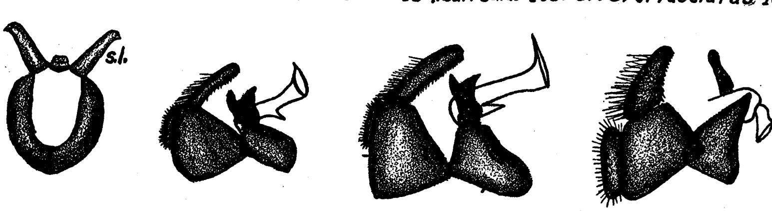
93 macularis 94. mallochi 95. mallochi 96. macularis



97. altissimus 98. amplus 99. armillatus 100. cinctellus



101. auricollis 102. auricollis 103. balteatus 104. balteatus 105. diversifasciatus 106.



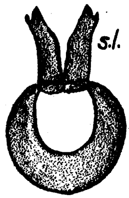
107. cinctellus 108. pteronis 109. trabis 110. hermosus

PLATE VI

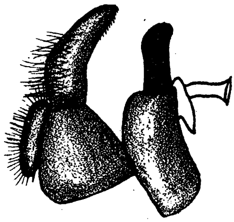
FIGURE

111.—Stenosyrphus (Episyrphus) laxus, lateral view.
112.—S. laxus, ventral view.
113.—S. annulipes, lateral view.
114.—S. nigricornis, lateral view.
115.—S. vittiger, lateral view.
116.—S. vittiger, ventral view.
117.—Stenosyrphus (Meligramma) guttata, lateral view.
118.—S. triangulifer, lateral view.
119.—S. tenuis, lateral view.
120.—S. triangulifer, ventral view.
121.—S. guttata, ventral view.
122.—S. tenuis, ventral view.
123.—Stenosyrphus (Ischyrosyrphus) velutinus, ventral view.
124.—Stenosyrphus (Metepistrophe) remigis, ventral view.
125.—Claraplumula latifacies, ventral view.
126.—Stenosyrphus (Ischyrosyrphus) velutinus, lateral view.
127.—Claraplumula latifacies, lateral view.
128.—Fazia roburoris, lateral view.
129.—F. roburoris, ventral view.
130.—Stenosyrphus (Metepistrophe) remigis, lateral view.
131.—S. argentipila, lateral view.
132.—Stenosyrphus (Mercurymyia) caldus, lateral view.
133.—S. jactator, lateral view.

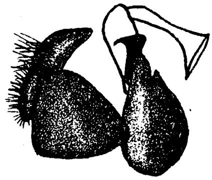
111. laxus



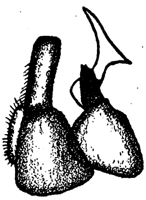
112. laxus



113. annulipes

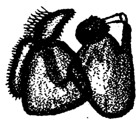


114. nigricornis

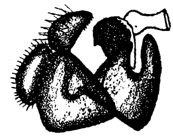


115. vittiger

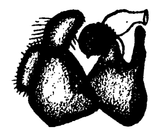
116. vittiger



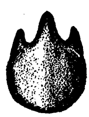
117. guttata



118. triangulifer

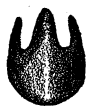


119. tenuis

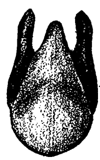


120. triangulifer

121 guttata



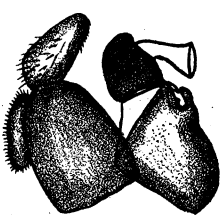
122 tenuis



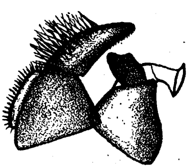
123. velutinus

124 remigis

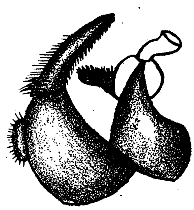
125. latifacies



126. velutinus

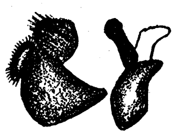


127. latifacies



128. roburoris

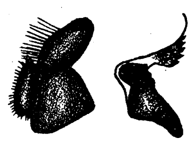
129. roburoris



130. remigis

131. argentipila

132. caldus

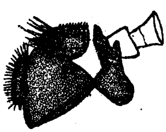


133. jactator.

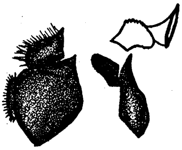
PLATE VII

FIGURE

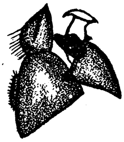
134.—Allograpta alta, lateral view.
135.—A. colombia, lateral view.
136.—A. exotica, lateral view.
137.—A. fasciata, lateral view.
138.—A. obliqua, ventral view.
139.—A. luna, lateral view.
140.—A. micrura, lateral view.
141.—A. neotropica, lateral view.
142.—A. obliqua, lateral view.
143.—A. piurana, lateral view.
144.—A. similis, lateral view.
145.—A. tectiforma, lateral view.
146.—Metasyrphus corollae, ventral view.
147.—M. corollae, lateral view.
148.—Metasyrphus (Posthosyrphus) aberrantis, lateral view.
149.—M. canadensis, lateral view.
150.—M. depressus, lateral view.
151.—M. flukei, lateral view.
152.—M. fumipennis, lateral view.
153.—M. lapponicus, lateral view.
154.—M. latifasciatus, lateral view.



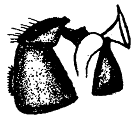
134. alta



135. colombia

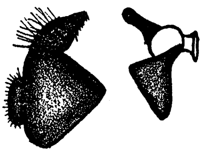


136. exotica



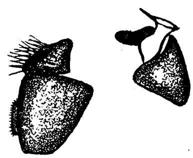
137. fasciata

138 obliqua

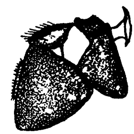


139. luna

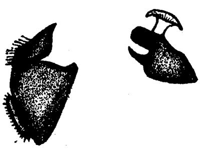
140. micrura



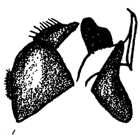
141 neotropica



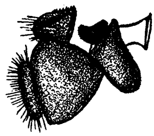
142. obliqua



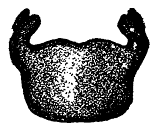
143. piurana



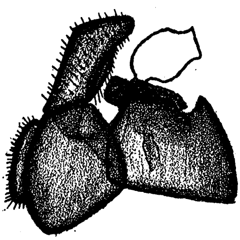
144. similis



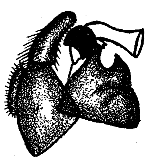
145. tectiforma



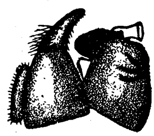
146. corollae



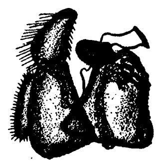
147. corollae



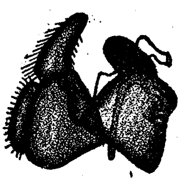
148. aberrantis



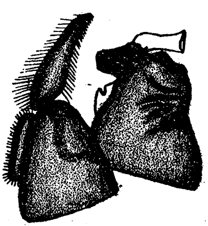
149. canadensis



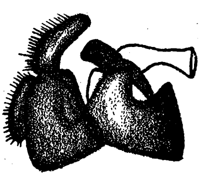
150. depressus



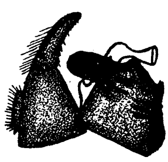
151. flukei



152. fumipennis



153. lapponicus

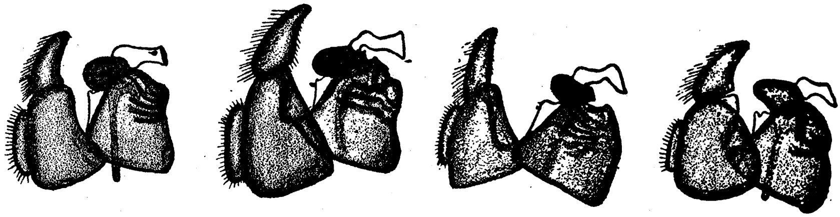


154 latifasciatus

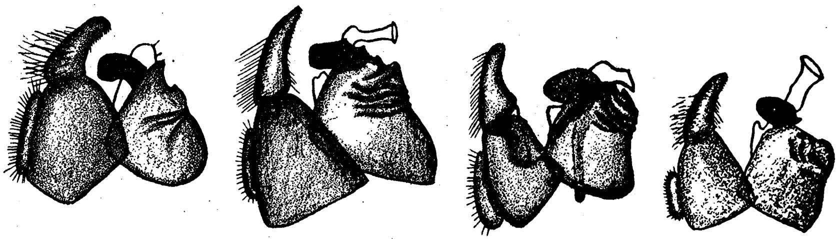
PLATE VIII

FIGURE

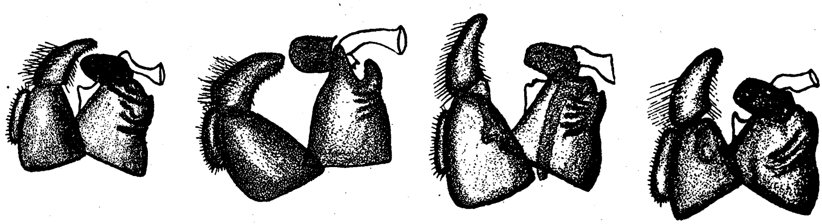
155.—Metasyrphus (Posthosyrphus) lebanoensis, lateral view.
156.—M. lundbecki, lateral view.
157.—M. luniger, lateral view.
158.—M. montanus, lateral view.
159.—M. marginatus, lateral view.
160.—M. meadii, lateral view.
161.—M. montivagus, lateral view.
162.—M. neoperplexus, lateral view.
163.—M. nitens, lateral view.
164.—M. ochrostomus, lateral view.
165.—M. perplexus, lateral view.
166.—M. pingreensis, lateral view.
167.—M. lapponicus, ventral view.
168.—M. aberrantis, ventral view.
169.—M. canadensis, ventral view.
170.—M. depressus, ventral view.
171.—M. flukei, ventral view.
172.—M. lebanoensis, ventral view.
173.—M. latifasciatus, ventral view.
174.—M. lundbecki, ventral view.
175.—M. luniger, ventral view.
176.—M. marginatus, ventral view.
177.—M. meadii, ventral view.
178.—M. montanus, ventral view.



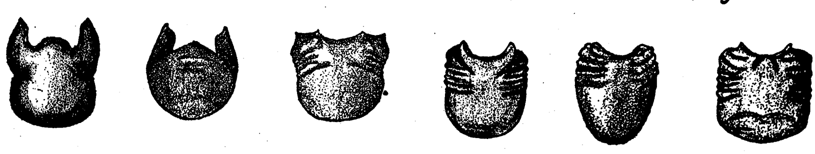
155. lebanoensis 156. lundbecki 157. luniger 158. montanus



159. marginatus 160. meadii 161. montivagus 162. neoperplexus



163. nitens 164. ochrostomus 165. perplexus 166. pingreensis



167. lapponicus 168. aberrantis 169. canadensis 170. depressus 171. flukei 172. lebanoensis

173. latifasciatus 174. lundbecki 175. luniger 176. marginatus 177. meadii 178. montanus

PLATE IX

FIGURE

179.—Metasyrphus (Posthosyrphus) snowi, lateral view.
180.—M. venablesi, lateral view.
181.—M. vinelandi, lateral view.
182.—M. ochrostomus, ventral view.
183.—M. talus, lateral view.
184.—M. wiedemanni, lateral view.
185.—M. wiedemanni, dorsal view.
186.—M. wiedemanni, ventral view.
187.—M. fumipennis, ventral view.
188.—M. montivagus, ventral view.
189.—M. neoperplexus, ventral view.
190.—M. nitens, ventral view.
191.—M. perplexus, ventral view.
192.—M. pingreensis, ventral view.
193.—M. venablesi, ventral view.
194.—M. vinelandi, ventral view.
195.—Dasysyrphus laticaudus, ventral view.
196.—D. pacificus, ventral view.
197.—D. creper, ventral view.
198.—D. amalopis, ventral view.
199.—D. pacificus, dorsal view.
200.—D. pauxillus, ventral view.
201.—D. lotus, ventral view.
202.—D. disgregus, ventral view.
203.—D. lunulatus, ventral view.

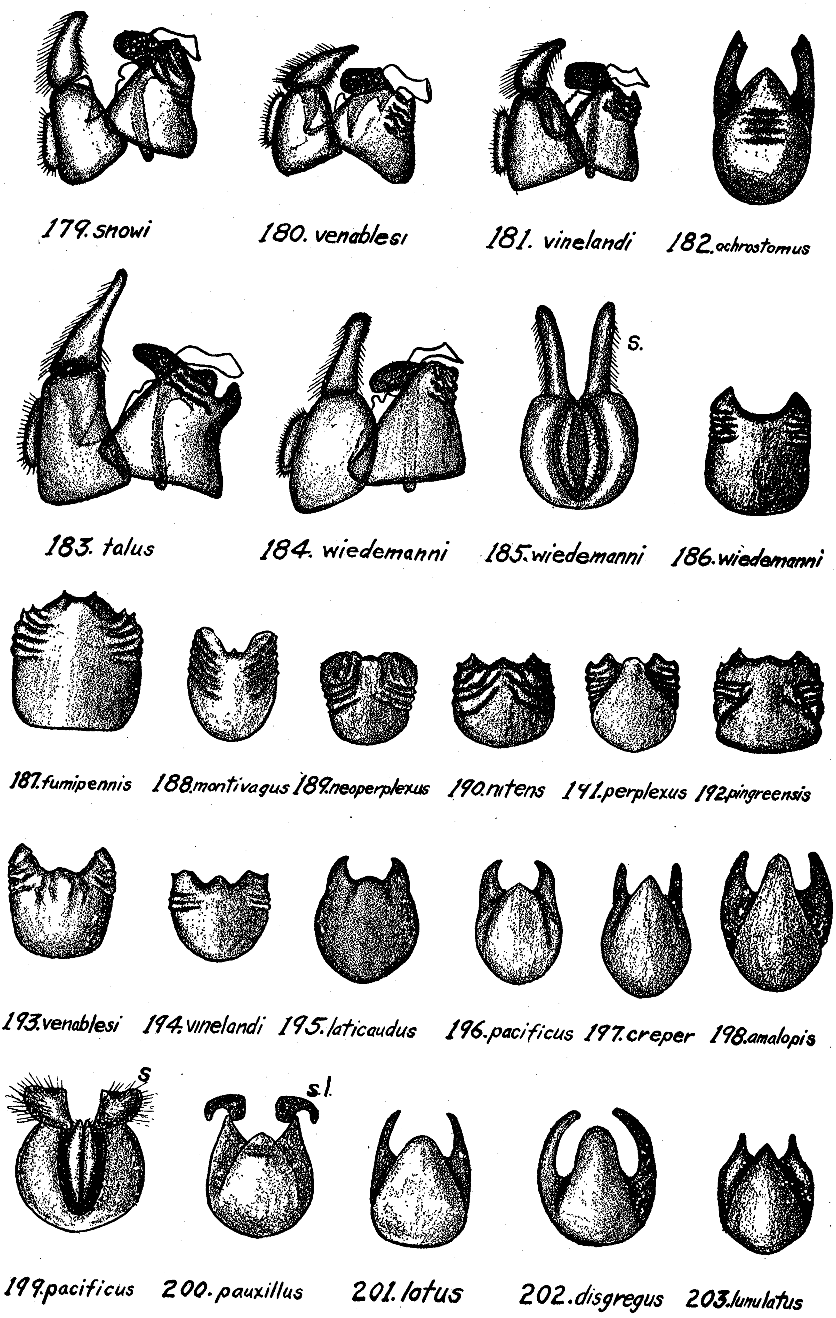
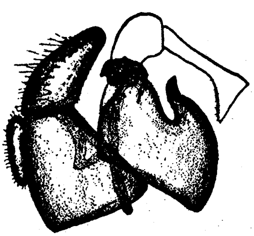

179. snowi
180. venablesi
181. vinelandi
182. ochrostomus
183. talus
184. wiedemanni
185. wiedemanni
s.
186. wiedemanni
187. fumipennis
188. montivagus
189. neoperplexus
190. nitens
191. perplexus
192. pingreensis
193. venablesi
194. vinelandi
195. laticaudus
196. pacificus
197. creper
198. amalopis
s
199. pacificus
s.l.
200. pauxillus
201. lotus
202. disgregus
203. lunulatus

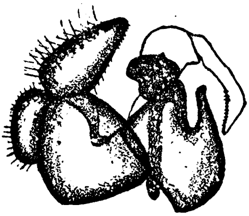
PLATE X

FIGURE

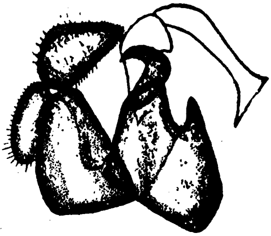
204.—Dasysyrphus amalopis, lateral view.
205.—D. arcuatus (-venustus), lateral view.
206.—D. lotus, lateral view.
207.—D. lunulatus, lateral view.
208.—D. pacificus, lateral view.
209.—D. disgregus, lateral view.
210.—D. albostriatus, lateral view.
211.—D. limatus, lateral view.
212.—D. tricinctus, lateral view.
213.—D. creper, lateral view.
214.—D. pauxillus, lateral view.
215.—D. laticaudus, lateral view.
216.—D. laticaudus, dorsal view.
217.—Metasyrphus (Posthosyrphus) snowi, ventral view.
218.—Dasysyrphus arcuatus, ventral view.
219.—D. albostriatus, ventral view.
220.—D. tricinctus, ventral view.



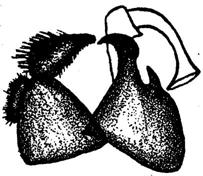
204. amalopis



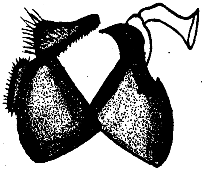
205. arcuatus



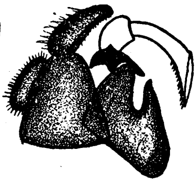
206. lotus



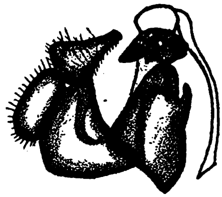
207. lunulatus



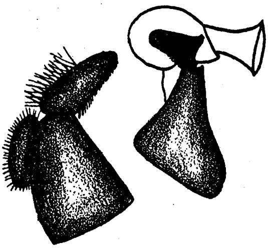
208. pacificus



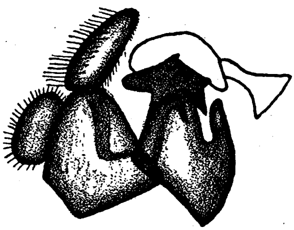
209. digregus



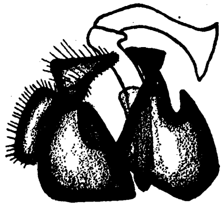
210. albostriatus



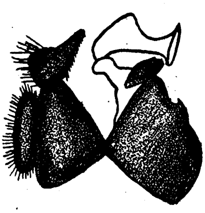
211. limatus



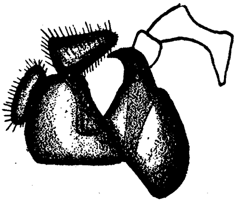
212. tricinctus



213. creper

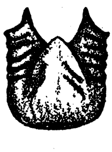


214. pauxillus



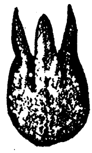
215. laticaudus

216. laticaudus

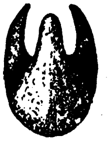


217. snowi

218. arcuatus



219. albostriatus



220 tricinctus

The drawings were made with the aid of the camera lucida and all were made to the same scale. A binocular microscope was used with a number 3 objective and number 15 ocular.

After a sketch was made, the genital parts were placed in a tiny shell vial of glycerine which was in turn pinned to the original specimen for proper association with the adult.

Bean (1949) has made a study of the male genitalia of *Tubifera* Meig. (= *Eristalis* Latr.) in which he describes several methods of handling the specimens. His third method which he used most is not readily applicable for very small parts found in many species of *Allograpta* and smaller specimens of *Stenosyrphus*. Metcalf's techniques have proved satisfactory for the *Syrphini.*

Definitions

Cerci—attached to the tenth tergite (this tergite appears ventral in natural position).

Styli or Styles (S.)—attached apically to the tenth tergite, often called surstyli.

Penis sheath—it surrounds the aedeagus and forms an important character in these studies.

Lingula—an extension, round or flat, and an integral part of the penis sheath, called the ninth sternite by Crampton.

Superior lobes (S. l.)—heavily chitinized structures, paired, that surround the penis, attached to the penis sheath, sometimes with teeth or spine-like setae, but maybe entirely without ornamentation.

Aedeagus—the penis proper, including the ejaculatory hood.

Ejaculatory hood (e. h.)—apical end of the aedeagus, often flared into a thin horn-like opening, may be difficult to observe after clearing in caustic potash.

The reader is referred to Crampton (1942) for a very thorough discussion of the male genitalia of Diptera in which the *Syrphidae* are frequently referred to.

European material was determined by several workers, including the British Museum, Oldenburg and Lindner in Germany, and Von Doesburg in Holland. The American species are my own determinations although many have been confirmed by other North American workers.

There is no intention here to insist on a classification based entirely on genitalia. It is believed however that these studies should help to more properly group the many species belonging to the *Syrphini. Baccha* Fabr., *Sphaerophoria* St. F. & S., *Mesogramma* Lw., *Eupeodes* O. S., *Didea* Macq. s. s., and *Scaeva* Fabr. are not considered in this work.

Some important changes are indicated but before attempting to make final judgment, I am offering the proposals here and inviting correspondence from foreign and American workers with the thought that eventually some agreement may be reached.

The most important changes suggested are: (1) *Epistrophe* Wk. type *grossulariae* Meig. is very little different from *Syrphus* Fabr. type *ribesii* L. and *Epistrophe,* therefore, ranks only at most a subgenus. In this group would go the close relatives of *grossulariae* Meig. and members of the *emarginatus* Say group in *Metasyrphus* Mats. (see Fluke 1933). I would use *Stenosyrphus* Mats. for the large group of slender forms now generally placed in *Epistrophe* Wk. This is in line with Goffe's splendid contribution (1944a) although Curran (1924) was the first to recognize *Stenosyrphus* Mats. (2) *Metasyrphus* Mats. s. s. would be limited to *corollae* Fabr. The rest of the species would be placed in *Posthosyrphus* End. type *wiedemanni* John (= americanus Wd.). Most of the species in this group are recognized by corrugations on the penis sheath. I believe, however, he refers to what we in America know as *wiedemanni* John, one of the commonest of syrphids in Eastern North America. Goffe (1946) has already pointed out the indefiniteness of Enderlein's work.

The development and form of the lingula appears to be an important character. It is cylindrical and always present in *Syrphus* Fabr., also present in N. American *Epistrophe* Wk., but nearly always absent in *Metasyrphus* Mats., *Allograpta* O. S. and many species of *Epistrophe* Wk., especially those from South America. The styles have many variations, from broad oval forms *(Syrphus)* to narrow elongate forms *(Epistrophe* etc.) and some are very triangular or ridged. The superior lobes appear to offer a good character for species differentiation; size, shape, ornamentation. The ejaculatory hood is also quite variable, sometimes very inconspicuous, at other times extremely long and even with spines on the outer flaring envelope, or with prominent teeth-like spines as in *Stenosyrphus caldus* Wk. and *jactator* Lw. In all the drawings the ejaculatory hood has been left unshaded.

In order to show the width of the lingula a ventral drawing of the penis sheath has frequently been included. Care should be taken to interpret these since it was not always possible to place all specimens in exact relative positions for the drawings. A few drawings of the "cercus" side (dorsal) have been made, but relatively few character differences can be noted in this view.

Discussion of the Generic Groupings

Syrphus Fabr. 1776 (= *Syrphidis* Goffe 1934)

Fourteen species or varieties have been examined in this group, and they are all of a similar type: large broad styles, large prominent superior lobes, elongate, cylindrical lingula and a short non-prominent ejaculatory hood. Some of the species have shorter lingula than others (*torvus* O. S. and *bigelowi* Curr.) and in some the superior lobes appear larger in relative proportions (*currani* Fluke, *knabi* Shan., *ribesii* L.). Other differences are very minor and species characterization by genitalia in this group is generally difficult.

The genitalia of *S. similis* Blan. are not illustrated but were examined and found to be indistinguishable from *S. phaeostigma* Wd.

Epistrophe Walker

The genitalia of these differ from *Syrphus* Fabr. s. s. by the shorter, broader lingula and more irregularly shaped superior lobe, but the styles are quite similar to *Syrphus*.

The *Metasyrphus* species in North America belonging to the *emarginatus* group differ very little from *grossulariae* Wk. and while the adults have a beaded abdomen, I still think they belong with *grossulariae* Wk. This beading is often not too definite as has been noted by Curran (1924) when he keyed *invigorus* Curr. as a *Stenosyrphus*.

Stenosyrphus Matsumura 1917

This is one of the larger groups and includes most of the slender forms currently recognized in *Epistrophe* Wk. There are four lines of development when based upon the formation of the lingula and superior lobes. The styles and ejaculatory hood of all groups are quite similar.

The first group *(lasiophthalmus)* has a slender lingula and with prominent, outwardly projecting (dorsally in drawings) spines on the superior lobes. Four species included in this group are not typical, they have a broader lingula: *barbifrons* Fall., *punctulatum* Verr., *umbellatarum* Fabr., and *vittafacies* Curr.

The second group *(lineola)* has a spatulate lingula and usually inwardly projecting spine-like structures on the superior lobes.

The third group *(tarsatus)* has a very large broad lingula and inwardly projecting spine-like structures on the superior lobes. Enderlein (1937) has proposed *Phalacrodira* type *tarsatus* Zett. for this group.

The fourth group contains three species which are somewhat irregular since they are difficult to place.

If group two were to be recognized with a name, Matsumura's proposal of *Mesosyrphus* 1917 (type *constrictus* Mats.) should be the logical choice since *lineola* Zett. was one of the species placed in this genus. He also included *punctulatus* Verr., *annulatus* Zett. and *vittiger* Zett. These studies would indicate that *punctulatus* belongs with Group 1 and *vittiger* with *Episyrphus* Mats.

Stenosyrphus subgenus *Episyrphus* Mats.

Matsumura erected *Episyrphus* for several species and named *balteatus* Zett. as the type. This appears to be a logical group, but I would remove all that he included to other groups except the genotype and *auricollis* Meig.

There is no lingula and a ventral view of the penis sheath shows the complete absence of this structure. The superior lobes have been added to the ventral drawings of this group. There are a few aberrant species included: *armillata* Fl., a species from Ecuador with very broad styles, and altissima Fl., a species also from Ecuador with a row of spine-like setae on the superior lobes—a character I also found on *Fazia roburoris* Fl. Judging by the genitalia, *Syrphus laxus* O. S. and *Syrphus annulipes* Zett. also belong here.

Frey's genus *Meliscaeva* with *cinctella* Zett. as genotype thus becomes a synonym of *Episyrphus* Mats.

Stenosyrphus subgenus *Meligramma* Frey 1945

I would limit this group to the three species studied: *guttatus* Fall., *tenuis* Osburn, and *triangulifer* Zett. The genitalia are small, have round, spiny superior lobes and an elongate narrow lingula, narrower than in typical *Epistrophe* Wk. I strongly suspect that *tenuis* is a synonym of *triangulifer*.

Stenosyrphus subgenus *Metepistrophe* Hull 1949

Hull erected this subgenus for *remigis* Fl. The superior lobes are quite slender and the styles are semi-rectangular with a saw-like outer edge; *argentipila* Fl. has similar genitalia and probably belongs here.

Stenosyrphus subgenus *Ischyrosyrphus* Bigot 1882

The only species I have studied (*velutinus* Will.) has genitalia similar to species in *Stenosyrphus* Mats. as indicated in the drawings. Males of the European species were not available for dissection.

Stenosyrphus subgenus *Mercurymyia* N. subgenus

The very peculiar spinose ejaculatory hood places *caldus* Wk. and *jactator* Lw. in a group by themselves. For these two species I propose the name *Mercurymyia* with *caldus* Wk. the genotype (*Epistrophe biarcuata* Fluke = *caldus* Wk.).

Claraplumula Shannon 1927

Only one species, *C. latifacies* has been described for this genus, and while the adult characters appear quite distinct, the genitalia indicate a close relationship to species in *Episyrphus* Mats., with genitalia most similar to *laxus* O. S. but with broader superior lobes. Hull (1949) recognizes it as a subgenus of *Epistrophe* Wk.

Fazia Shannon 1927

Hull (1949) recognized this as a subgenus of *Epistrophe* Wk., but this study indicates that *Fazia* is a valid genus. However, I have males available for only one species (*roburoris* Fl.) and the spiny superior lobe, long slender styles, and bulbous ejaculatory hood may not appear in the other species.

Allograpta Osten Sacken 1876

The adult characters of this genus are not clearly differentiated from related *Epistrophe* of authors but the genitalia offer, I believe, good characters for separation. The styles are angulated and grooved, the superior lobes and penis sheath quite small; therefore I believe they form a natural and distinct group.

The genitalia of this group were so small and difficult to spread that they were often pulled apart for the drawings. Hull proposes *Metallograpta* for *colombia* Curr., but in this I cannot agree.

Metasyrphus Matsumura 1917

Matsumura erected this genus in 1917 and named *corollae* Fab. as the genotype. The name has since come into rather general use in North America for a very large number of species usually placed in *Syrphus,* see Fluke (1933). *Corollae* Fabr. is so distinctive and different that I think all others studied should be placed in *Posthosyrphus* End. with *wiedemanni* John as the type. At present it seems best to use Enderlein's name as a subgenus only.

Metasyrphus corollae Fab. has large genitalia; unusually large, irregularly shaped styles, small superior lobes, no lingula, bulbous ejaculatory hood and no rough ridges on the penis sheath. Species in *Posthosyrphus* End. have smaller, more slender styles, larger (in proportion) superior lobes, also no lingula (except in four species listed below), smaller hood, and with the exception of *lapponicus* Zett. the penis sheath is rough and corregated.

The majority of the species studied are American and the group is one of the most difficult of the *Syrphini* to separate into species, many almost impossible to determine except by a study of the genitalia.

These studies show four off-type species but I do not believe they are enough different to propose subgeneric names for them; they have definite beginnings of a lingula and one of them (*lapponicus* Zett.) lacks the roughened penis sheath which I believe is so characteristic of the group. The other three are *aberrantis* Curr., *tylus* Fl. and *ochrostomus* Zett., but I'm not at all sure of my identification of the last named. Specimens of *lapponicus* Zett. were examined from many localities, American and European, and I could detect no differences in the genitalia.

Dasysyrphus Enderlein 1937

(= Syrphella Goffe 1944)

This genus, often called the *amalopis* group in North America, has a large ejaculatory hood and a broad lingula which is very short in some and quite long in others. There are two rather distinct lines of development in genitalia, one with large broad styles and spines on the tip of the hood, the other with triangular styles and no spines on the hood. The lingula is usually quite small and broad in this latter group although more elongate in *tricinctus* Fall. In the first group, *pauxillus* Will. has outwardly turning superior lobes as seen in Figure 200.

In group *one* are the following:

> *amalopis* O. S., *arcuatus* Fall., *venustus* Meig., *disgregus* Sn., and *lotus* Will.

In group *two* are the following:

> *lunulatus* Verr., *tricinctus* Fall., *albostriatus* Fall., *creper* Sn., *pacificus* Lov., *pauxillus* Will., *laticaudus* Curr., and *limatus* Hine.

There are several other proposed genera that I am not in a position at present to discuss: *Chasmia* End. 1937, type *hians* End.; *Allograptina* End. 1937, type *octomaculata* End.; and *Miogramma* Frey 1945, type *javana* Wd.

The proposal of any more new names would appear only to add to the confusion. Enough generic and subgeneric categories have probably been proposed to catalogue nearly all the European and American *Syrphini*. The main task is to secure proper associations and groupings. I have therefore prepared the following list of the species studied, placing them in generic or subgeneric groupings based largely on the genitalia.

The species are arranged alphabetically in each genus. It will be noted under *Stenosyrphus* that there are four groups, each group arranged alphabetically. With each species is the locality of the specimens dissected, the original genus with date, and reference to the figures in the drawings.

I—Genus Syrphus Fabricius 1776, genotype ribesii L.

A. Subgenus Syrphus s. s.

Syrphus attenuatus Hine 1922—Wisconsin. Figure 9
Syrphus bigelowi Curran 1924—Canada. Figure 8
Syrphus currani Fluke 1924—California. Figure 10
Syrphus knabi Shannon 1916—Wisconsin. Figure 6
Syrphus opinator Osten Sacken 1877—Oregon. Figure 7
Syrphus phaeostigma Wiedemann 1830—Brazil. Figure 15
Syrphus rectus Osten Sacken 1875—Wisconsin. Figure 12
Musca ribesii Linnaeus 1758—Colorado. Figures 1 and 2
Syrphus ribesii var. vittafrons Shannon 1916 — Wisconsin. Figure 5
Syrphus similis Blanchard 1852—Chili
Syrphus torvus Osten Sacken 1875—Wisconsin. Figures 3 and 4
Syrphus transversalis Curran 1921—Wisconsin. Figure 13
Syrphus vitripennis Meigen 1882—Europe. Figure 11
Syrphus willistoni Fluke 1942—Ecuador. Figure 14

B. Subgenus Epistrophe Walker 1852, subgenotype grossulariae Meigen

Scaeva bifasciata Fabricius 1794—Holland. Figures 25 and 28
Syrphus divisa Williston 1882—Michigan. Figures 17 and 36
Scaeva emarginata Say 1823—Arkansas. Figures 16 and 38
Xanthogramma felix Osten Sacken 1875—Wisconsin. Figures 18 and 35
Syrphus grossulariae Meigen 1822—Vermont. Figures 20 and 29
Stenosyrphus hunteri Curran 1924—Alaska. Figures 23 and 31
Syrphus invigorus Curran 1921—Wisconsin. Figures 19 and 37
Scaeva melanostoma Zetterstedt 1843—Lappland. Figures 25 and 34
Metasyrphus metcalfi Fluke 1933—Wisconsin. Figures 24 and 32
Syrphus nitidicollis Meigen 1822—France. Figures 22 and 33
Syrphus weborgi Fluke 1931—Michigan. Figures 27 and 39
Syrphus xanthostomus Williston 1886 — Wisconsin. Figures 21 and 30

II—Genus Stenosyrphus Matsumura 1917, genotype lasiophthalmus Zetterstedt

A. Subgenus Stenosyrphus s. s.

Group 1

Stenosyrphus albipunctatus Curran 1924—Utah. Figures 40 and 52
Scaeva barbifrons Fallen 1817—Germany. Figures 41 and 53
Melanostoma cherokeenensis Jones 1917—Colorado. Figures 42 and 54
Stenosyrphus columbiae Curran 1924—Washington. Figures 43 and 55
Syrphus compositarum Verrall 1873—Scotland. Figures 44 and 57
Stenosyrphus diversipunctatus Curran 1924—New Hampshire. Figures 45 and 56
Syrphus fisheri Walton 1911—Wisconsin. Figures 46 and 63
Stenosyrphus garretti Curran 1924—Oregon. Figures 47 and 62
Syrphus labiatarum Verrall 1901—England. Figures 48 and 61
Scaeva lasiophthalma Zetterstedt 1843—England. Figures 49 and 60
Syrphus mentalis Williston 1886—New Hampshire. Figures 50 and 59
Syrphus pullulus Snow 1895—Colorado. Figures 51 and 58
Syrphus punctulatus Verrall 1873—Holland. Figures 64 and 67
Syrphus umbellatarum Fabricius 1776—Germany. Figures 65 and 68
Stenosyrphus vittafacies Curran 1923—Pennsylvania. Figures 66 and 69

Group 2

Scaeva arctica Zetterstedt 1838—Alaska. Figures 70 and 77
Syrphus genualis Williston 1886—Wisconsin. Figures 71 and 78
Syrphus insolitus Osburn 1908—Oregon. Figures 72 and 79
Scaeva lineola Zetterstedt 1847—Holland. Figures 73 and 80
Syrphus quinquelimbatus Bigot 1884—Washington. Figures 74 and 81
Syrphus rectoides Curran 1921—Washington. Figures 75 and 82
Epistrophe semiinterruptus Fluke 1935—New Hampshire. Figures 76 and 83

Group 3

Scaeva cincta Fallen 1817—Holland. Figures 84 and 85
Stenosyrphus nigrifacies Curran 1923 — British Columbia. Figures 86 and 87
Stenosyrphus subfasciatus Curran 1924—Washington. Figure 88

Group 4

Scaeva macularis Zetterstedt 1843—Germany. Figures 93 and 96
Syrphus mallochi Curran 1923—Washington. Figures 94 and 95
Syrphus sodalis Williston 1886—Colorado. Figures 91 and 92
Scaeva tarsata Zetterstedt 1838—Alaska. Figures 89 and 90

B. Subgenus Meligramma Frey 1945, subgenotype guttata Fallen

Scaeva guttata Fallen 1817—Colorado. Figures 117 and 121
Xanthogramma tenuis Osburn 1908—Colorado. Figures 119 and 122
Scaeva triangulifer Zetterstedt 1843—Minnesota. Figures 118 and 120

C. Subgenus Episyrphus Matsumura 1917, subgenotype balteatus DeGeer

Epistrophe altissimus Fluke 1942—Ecuador. Figure 97
Epistrophe amplus Fluke 1942—Brazil. Figure 98
Scaeva annulipes Zetterstedt 1838—Europe. Figure 113
Epistrophe armillatus Fluke 1942—Ecuador. Figure 99
Syrphus auricollis Meigen 1822—Holland. Figures 101 and 102
Musca balteata DeGeer 1776—Holland. Figures 103 and 104
Scaeva cinctella Zetterstedt 1843—Tennessee. Figures 100 and 107
Syrphus diversifasciatus Knab 1914—Oregon. Figures 105 and 106
Epistrophe hermosa Hull 1941—Brazil. Figure 110
Didea laxa Osten Sacken 1875—Washington. Figures 111 and 112
Syrphus nigricornis Verrall 1898—Europe. Figure 114
Epistrophe pteronis Fluke 1942—Ecuador. Figure 108
Epistrophe trabis Fluke 1942—Ecuador. Figure 109
Scaeva vittiger Zetterstedt 1843—England. Figures 115 and 116

D. Subgenus Metepistrophe Hull 1949, subgenotype remigis Fluke

Epistrophe argentipila Fluke 1942—Ecuador. Figure 131
Epistrophe remigis Fluke 1942—Ecuador. Figures 124 and 130

E. Subgenus Ischyrosyrphus Bigot 1882, subgenotype glaucius Linnaeus

Syrphus velutinus Williston 1882—Washington. Figures 123 and 126

F. Subgenus Mercurymyia new subgenus, type caldus Walker

Epistrophe caldus Walker 1852—Brazil. Figure 132
Syrphus jactator Loew 1861—Cuba. Figure 133

III—Claraplumula Shannon 1927, genotype latifascies Shannon

Claraplumula latifascies Shannon 1927—Ecuador. Figures 125 and 127

IV—Fazia Shannon 1927, genotype bullaeophora Shannon

Fazia roburoris Fluke 1942—Ecuador. Figures 128 and 129

V—Allograpta Osten Sacken 1876, genotype obliqua Say

Allograpta alta Curran 1936—Ecuador. Figure 134
Allograpta colombia Curran 1925—Ecuador. Figure 135
Syrphus exoticus Wiedemann 1830—Ecuador. Figure 136
Allograpta fasciata Curran 1932—Ecuador. Figure 137
Epistrophe luna Fluke 1942—Ecuador. Figure 139
Sphaerophoria micrura Osten Sacken 1877—California. Figure 140
Allograpta neotropica Curran 1936—Brazil. Figure 141
Scaeva obliqua Say 1823—Missouri. Figures 138 and 142
Allograpta piurana Shannon 1927—Peru. Figure 143
Allograpta similis Curran 1925—Brazil. Figure 144
Allograpta tectiforma Fluke 1942—Ecuador. Figure 145

VI—Metasyrphus Matsumura 1917, genotype corollae Fabricius

A. Subgenus Metasyrphus s. s.

Syrphus corollae Fabricius 1776—Holland. Figures 146 and 147

B. Subgenus Posthosyrphus Enderlein 1937, genotype wiedemanni Johnson

Syrphus aberrantis Curran 1924—Colorado. Figures 148 and 168
Syrphus canadensis Curran 1926—Wisconsin. Figures 149 and 169

Metasyrphus depressus Fluke 1933—Oregon. Figures 150 and 170
Syrphus flukei Curran 1917—Colorado. Figures 151 and 171
Syrphus fumipennis Thompson 1868—California. Figures 152 and 187
Scaeva lapponica Zetterstedt 1838—Colorado. Figures 153 and 167
Syrphus latifasciatus Macquart 1827—Wisconsin. Figures 154 and 173
Syrphus lebanoensis Fluke 1930—Colorado. Figures 155 and 172
Syrphus lundbecki Soot-Ryen 1946—Oregon. Figures 156 and 174
Syrphus luniger Meigen 1822—Germany. Figures 157 and 175
Syrphus marginatus Jones 1917—Oregon. Figures 159 and 176
Syrphus meadii Jones 1917—Colorado. Figures 160 and 177
Syrphus montanus Curran 1924—Colorado. Figures 158 and 178
Syrphus montivagus Snow 1895—Utah. Figures 161 and 188
Syrphus neoperplexus Curran 1924—Alaska. Figures 162 and 189
Scaeva nitens Zetterstedt 1843—Holland. Figures 163 and 190
Scaeva ochrostoma Zetterstedt 1849—New York. Figures 164 and 182
Scaeva perplexus Osburn—1910—Colorado. Figures 165 and 191
Syrphus pingreensis Fluke 1930—Colorado. Figures 166 and 192
Syrphus snowi Wehr 1922—Colorado. Figures 179 and 217
Metasyrphus talus Fluke 1933—Oregon. Figure 183
Syrphus venablesi Curran 1929—Oregon. Figures 180 and 193
Syrphus vinelandi Curran 1921—Wisconsin. Figures 181 and 194
Syrphus wiedemanni Johnson 1919—Wisconsin. Figures 184, 185 and 186

VII—Genus Dasysyrphus Enderlein 1937, genotype albostriatus Fallen

(= Syrphella Goffe 1944, genotype tricincta Fallen)

Scaeva albostriata Fallen 1817—Holland. Figures 210 and 219
Syrphus amalopis Osten Sacken 1875—Alaska. Figures 198 and 204

Scaeva arcuatus Fallen 1817—Holland. Figures 205 and 218
Syrphus creper Snow 1895—Colorado. Figures 197 and 213
Syrphus disgregus Snow 1895—New Mexico. Figures 202 and 209
Syrphus laticaudus Curran 1924—New Hampshire. Figures 195, 215 and 216
Syrphus limatus Hine 1922—Utah. Figure 211
Syrphus lotus Williston 1886—California. Figures 201 and 206
Syrphus lunulatus Meigen 1822—Germany. Figures 203 and 207
Syrphus pacificus Lovett 1919—Idaho. Figures 196, 199 and 208
Syrphus pauxillus Williston 1886—Colorado. Figures 200 and 214
Scaeva tricincta Fallen 1817—Holland. Figures 212 and 220

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THE RIDGES WILD FLOWER SANCTUARY AT BAILEYS HARBOR, WISCONSIN

ALBERT M. FULLER
Curator of Botany, Milwaukee Public Museum

Wild flower sanctuaries are areas where wild flowers and their habitats are given protection. Refuge areas, natural areas, and nature reserves are other names which have been used to designate such areas. In modern conservation practices it is recognized that in order to conserve plant and animal life it is absolutely necessary to conserve the conditions necessary for their survival. The only way to give permanent protection to the wild flowers of Wisconsin is through the establishment of sanctuaries in all parts of the state.

In 1937, a wild flower sanctuary was established at Baileys Harbor, Door County, Wisconsin. It is the outstanding wild flower sanctuary in Wisconsin at present, so it seems worth while to make a written record of this sanctuary and its growth.

The village of Baileys Harbor is situated on Lake Michigan, 172 miles north of Milwaukee. Northeast of the village is a series of sand ridges alternating with low and often water-filled hollows or sloughs, collectively known as the Bailey Harbor Bog or The Ridges. Plate I shows one of the ridges. Because of the climate, the wide range of types of habitats, and geological history, more rare and local plants occur here than in any other locality in Wisconsin.

Many years ago the Federal Government had established a range light reserve, consisting of forty acres, on the southwest portion of the area known as The Ridges. A considerable number of private individuals owned the remaining forties which comprised The Ridges area. Most of the private owners were holding their "forties" for woodlots. Several of the owners had clean-cut their forties. Only a few inhabitants of Baileys Harbor realized the value of their wild flowers. They had grown up with them, so they did not consider them anything rare or unusual.

In 1936 the Federal Government gave its land to Door County to be used as a park. Some of the inhabitants of Baileys Harbor requested the Door County Park Commission to build a rather extensive campsite for tourists. The campsite project had been approved and work on the project had actually commenced in 1936. The land was being cleared of trees and sloughs were being filled.

In early February, 1937, Mr. H. R. Holand of Ephraim, Wisconsin, Chairman of the Door County Park Commission, visited the writer in Milwaukee. As a result of Mr. Holand's visit, the writer addressed the following letter to the Door County Advocate.

FEBRUARY 10, 1937

EDITOR,
DOOR COUNTY ADVOCATE
STURGEON BAY, WISCONSIN

Dear Sir:

My friend, H. R. Holand of Ephraim, was in this morning to have a short visit. He knows that I am a Door County enthusiast. In the course of our visit, I asked as to just how the Door County Park Commission was going to use that land just north of Baileys Harbor that was given to Door County by the Federal Government.

Mr. Holand replied that they were planning to have it set aside for a tourist camp. Immediately I set up a strong protest, as this area is one of the most interesting locations in Wisconsin from a botanical angle.

After I got through voicing my protests, Mr. Holand said that he sympathized with my viewpoint, but as Chairman of the Door County Park Commission, he would be more or less obligated to do what the majority of people in Door County wanted done with this piece of land. He suggested that I write an article about the area under discussion and send it to you for publication in the Door County Advocate.

I have studied the plants of Door County for twelve years. I know all other parts of Wisconsin and have also been on the Pacific Coast, as well as in the Rocky Mountains and in the eastern states. Without any exaggeration, I honestly believe that there is no part of this country which I have seen which is more interesting than Door County, especially the region just north of Baileys Harbor. The County Park Commission should set it aside as a permanent wildlife sanctuary so it can be preserved for posterity.

The following article was published in the Door County Advocate, February 19, 1937:

PLATE I. Sandy Ridge. White pine is the most conspicuous tree on this portion of Sandy Ridge. The ground cover consists of extensive, dense mats of prostrate juniper, bearberry, and clumps of the common juniper. On the moist, partially shaded shoulders of this ridge, such plants as the dwarf Canadian primrose, the dwarf lake iris, gay-wings, large yellow lady's-slipper, and wood lily grow in abundance.

PLATE II. The large yellow lady's-slipper, one of the best known of our native orchids, rare or extinct in many parts of Wisconsin, is frequent in The Ridges Sanctuary.

PLATE III. The showy lady's-slipper, queen of our native plants, is frequent in the bogs and on the wooded portions of the various ridges. Late June and early July is the flowering time of this orchid.

PLATE IV. Ram's-head lady's-slipper. Late May and early June finds this rare orchid in flower. It grows in moist, raw humus under the arborvitae, and balsam fir, and the spruces.

PLATE V. Calypso. This beautiful and rare orchid grows under balsam fir, arborvitae, and hemlock in the vicinity of The Ridges Sanctuary.

PLATE VI. Bog plants. The plants shown in the illustration are the pitcher plant, Labrador tea, creeping snowberry, and cotton grass. These plants grow in peat moss in bogs or under bog-like conditions on the margins of the sloughs.

PLATE VII. Bunchberry. This dwarf relative of the flowering dogwood always attracts attention. It is plentiful in The Ridges.

"It would be a sacrilege that the people of Door County would always regret if The Ridges area at Baileys Harbor were permitted to be made into a campsite, because campers and rare plants are incompatible," states A. M. Fuller, curator of botany of the Milwaukee Public Museum, in a letter to The Advocate, asking the Door County citizens urge the county park commission to make the place a refuge. The land consists of the 40 acres north of Baileys Harbor given to Door County by the government.

"This area consists of boggy sloughs running more or less parallel with the lake shore, alternating with sandy ridges, finally ending at the present like shore," Mr. Fuller explains. "The sandy ridges and sloughs provide habitats for more species of plants than any other one locality in Wisconsin.

"Forty-five species of orchids are found in Wisconsin. Of this number, at least thirty species are found in Door County. Twenty-five native species are found in the region of Baileys Harbor, particularly in the area under discussion.

"It is almost spectacular that twenty-five species of orchids should be found in a space of less than forty acres. This makes it a veritable outdoor museum. The orchids alone should be a strong enough reason for preserving this area. A year ago an amateur botanist from Berlin, Germany, made a trip to Door County to see some the native orchids at home.

"The people of Door County should take great civic pride in localities that are rich in orchids, and other rare plants, and see that they are adequately protected. Every school child in Door County should be taught to love and protect all the plants and trees of the county.

"It seems as if Mother Nature was not satisfied with giving Door County the largest number of native orchids, but also she gave this peninsula county the greatest number of other rare plants that are to be found in Wisconsin. Around Decoration Day, the area resembles a gigantic flower garden with a riot of color.

"Mother Nature did just as well with the trees as she did with the herbaceous plants. All of the conifers to be found in Wisconsin grow here with the exception of the red cedar and jack pine.

"Many of our large cities have spent millions of dollars to reproduce what Mother Nature has given Door County free of charge. It would probably cost at least a million dollars to reproduce the area at Baileys Harbor elsewhere. This area not only belongs to Door County but it also belongs to the people of Wisconsin, and above all it belongs to future generations. The past generations have nearly wrecked the natural beauty that the state once possessed.

"Every civic-minded, loyal resident of Door County should urge the county park commission to set the forty acres at Baileys Harbor aside as a permanent wildlife sanctuary and leave the trees, shrubs, and all other vegetation in their natural condition. Surely an area suitable for campsites can be found in the vicinity of Baileys Harbor without encroaching on the rights of the choicest flowers that we have in Wisconsin.

"Door County is famous throughout the Midwest for its matchless scenery and climate, and for the kindly folk that inhabit this peninsula county. Surely Door County will not allow any of its natural shrines to be desecrated."

On March 5, 1937, the writer gave a talk, "Preserving The Ridges at Baileys Harbor" before the Woman's Club of Sturgeon Bay. Members of the Door County Park Commission were present as well as a few residents of Baileys Harbor. The Park Commission, not long after this meeting, decided to have the Baileys Harbor area set aside as a wild flower sanctuary.

It was realized that, in order to give the Range Light Forty permanent protection, adjacent forties should be added to the area. On October 4th, a group of people from Baileys Harbor, Ephraim, and Ellison Bay, interested in a permanent wildlife conservation program for Door County, met at Baileys Harbor for the purpose of forming a corporation under the name The Ridges Sanctuary. The purposes of The Ridges Sanctuary were stated as follows:

1. To acquire by gift, purchase or otherwise, part or all of the real estate in the area in the town of Baileys Harbor, Wisconsin, known as "The Ridges" or "The Bog" and to protect the native plant and animal life on the same and to preserve the same in its natural or aboriginal state; to erect fences, place signs and make other improvements necessary to protect the property of or deemed desirable to advance the purposes of the corporation.

2. To acquire and hold other pieces of real estate in Wisconsin and elsewhere, and to protect and preserve the native plant and animal life found thereon.

3. To carry on educational and scientific activities which will promote the cause of the conservation and preservation of wild plant and animal life and natural scenery, and to use and transfer its moneys and properties for these purposes.

The Articles of Incorporation were signed by the following persons:

Jens Jensen, Ellison Bay, Wisconsin
Frank Oldenburg, Baileys Harbor, Wisconsin
John Matter, Ephraim, Wisconsin
Emma Toft, Baileys Harbor, Wisconsin
Mrs. James J. McArdle, Baileys Harbor, Wisconsin
William E. Sieker, Baileys Harbor, Wisconsin
Mrs. W. C. Sieker, Baileys Harbor, Wisconsin
Martha Fulkerson, Ellison Bay, Wisconsin
Olivia Traven, Baileys Harbor, Wisconsin
A. B. Gochenour, Baileys Harbor, Wisconsin

The organization of The Ridges Sanctuary, a corporation whose sole purpose is to preserve the habitats of plants, received wide publicity. The Milwaukee *Journal* published the following editorial about The Ridges Sanctuary in its issue of October 18, 1937:

Forty Acres in Door County

There isn't much limit to what people can do if they have enthusiasm and care enough. Witness the movement now growing to make a park in Door county that will preserve a living, growing record of geologic ages.

The peninsula that is Door county, with the rugged and beautiful islands around it, is so attractive and so "different" that yearly it attracts more and more visitors. The casual visitor would say that it is good enough as it is. And that is true. But things don't stay as they are—not in these days of gasoline.

Near Baileys Harbor is a region of lowland and highland which has plant and flower and tree varieties seldom found together—a natural museum, a natural botanical garden, a natural arboretum. The federal government relinquished 40 acres of this; the county kept it going a few years as a park. And then it was proposed to make a tourists' campsite of it.

Whereupon a few persons who knew about it began to tell what they knew. A. M. Fuller, botanical expert of the Milwaukee Public Museum, said that in this region are 30 of Wisconsin's 45 kinds of native orchids. Here are the birdseye primrose and the fringed gentian that has so nearly disappeared from this state. Here are all except two of Wisconsin's varieties of evergreen trees.

"Some counties in the nation," Mr. Fuller said, "would spend millions of dollars to reproduce artificially what nature has formed at Baileys Harbor."

Others listened and helped, among them Jens Jensen, famous creator of natural landscapes in Chicago's west parks and in many other cities of the country. "Here is something we have," they said. "Let's save it, instead of leaving it to future generations to spend 50 years trying to re-create it." So there is a corporation known as "Ridges Sanctuary, Inc." Its members are giving their time and effort and some of their dollars.

Not wealthy, not "influential," but lovers of the beautiful, wanting those who come after them to find such beauty to enrich their lives, these "people who care" have not waited for wealth to make their start. And others who care will help them. Once this project becomes known, we cannot imagine that any garden club or nature-lover group will fail to help. And some who have the means and would like to give something intelligently must be attracted. We spend hundreds of millions trying to "restore" what could have been saved for very little, as this Door county park can be saved, if it is done now.

The Ridges Sanctuary has had from its beginning the generous support of people and organizations throughout Wisconsin and from other states. The garden clubs, especially, have been interested in The Ridges. Mrs. Alfred J. Kieckhefer of Milwaukee, past president of the Green Tree Garden Club of Milwaukee, was extremely active on behalf of The Ridges. She gave numerous illustrated lectures on The Ridges Sanctuary before garden groups in various parts of the Country. Mrs. Kieckhefer, in 1940 and 1941, submitted The Ridges Sanctuary as a conservation project to the Garden Club of America. At the annual meeting of the Garden Club of America in New York, in March, 1942, The Ridges Sanctuary was voted the founders' fund award of twelve hundred dollars.

The land acquisition program of The Ridges Sanctuary began in January, 1938, when the late Ferdinand Hotz of Chicago, Illinois, gave forty acres. In 1944 Mr. Hotz gave an additional two hundred acres to The Ridges Sanctuary. Money raised by the local Baileys Harbor folk, in addition to donations from individuals and clubs outside Door County, have made possible the purchase of over three hundred acres of land. At the present time The Ridges consists of six hundred acres. It is hoped that eventually the acreage will be increased to a thousand acres.

One of the purposes of The Ridges Sanctuary organization is to promote conservation education. For the last ten years The Ridges Sanctuary has sponsored a series of summer conservation lectures. These lectures have been well attended and have been very effective in stimulating interest in conservation. Conservation essay contests have been sponsored by the group in the schools of Baileys Harbor. Conservation books and periodicals have been placed in the local library and in the schools of the township.

During the summers of 1932 and 1933, George F. Sieker of Milwaukee, a student at the University of Wisconsin, collected extensively in the Baileys Harbor area, and in 1934 wrote his bachelor's thesis, "The Flora of the Baileys Harbor Bog." Mr. Sieker has been very active in the work of The Ridges Sanctuary. The following list of the more interesting plants which grow in the general region of The Ridges is based partially on Mr. Sieker's unpublished thesis.

Of the trees which occur on The Ridges, the conifers are the most interesting. The following native species occur on The Ridges:

Balsam Fir *(Abies balsamea)*
Common Juniper *(Juniperus communis* var. *depressa)*
Prostrate Juniper *(Juniperus horizontalis)*
Tamarack *(Larix laricina)*
White Spruce *(Picea glauca)*
Black Spruce *(Picea mariana)*
Red Pine *(Pinus resinosa)*
White Pine *(Pinus Strobus)*
American Yew *(Taxus canadensis)*
Arborvitae *(Thuja occidentalis)*
Hemlock *(Tsuga canadensis)*

The following orchids grow in the vicinity of Baileys Harbor:

Arethusa *(Arethusa bulbosa)*
Grass Pink *(Calopogon pulchellus)*
Calypso *(Calypso bulbosa)*. Plate 5.
Spotted Coralroot *(Corallorhiza maculata)*
Striped Coralroot *(Corallorhiza striata)*
Early Coralroot *(Corallorhiza trifida* var. *verna)*
Pink Moccasin Flower *(Cypripedium acaule)*
Ram's-head Lady's-slipper *(Cypripedium arietinum)*. Plate 4.
Large Yellow Lady's-slipper *(Cypripedium Calceolus* var. *pubescens)*. Plate 2.
Showy Lady's-slipper *(Cypripedium reginae)*. Plate 3.
Giant Rattlesnake Plantain *(Goodyera oblongifolia)*
Dwarf Rattlesnake Plantain *(Goodyear repens* var. *ophioides)*

Intermediate Rattlesnake Plantain *(Goodyera tesselata)*
Tall White Bog Orchid *(Habenaria dilatata)*
Tall Leafy Green Orchid *(Habenaria hyperborea)*
Blunt-leaved Orchid *(Habenaria obtusata)*
Large Round-leaved Orchid *(Habenaria orbiculata)*
Smaller Purple Fringed Orchid *(Habenaria psycodes)*
Long-bracted Orchid *(Habenaria viridis* var. *bracteata)*
Heart-leaved Twayblade *(Listera cordata)*
White Adder's-mouth Orchid *(Malaxis brachypoda)*
Rose Pogonia *(Pogonia ophioglossoides)*
Nodding Lady's-tresses *(Spiranthes cernua)*
Slender Lady's-tresses *(Spiranthes lacera)*
Hooded Lady's-tresses *(Spiranthes Romanzoffiana)*

The following plants, members of the Heath Family, occur rather abundantly in The Ridges:

Bog-Rosemary *(Andromeda glaucophylla)*
Bearberry *(Arctostaphylos Uva-ursi* var. *coactilis)*
Leather-leaf *(Chamaedaphne calyculata* var. *angustifolia)*
Pipsissewa *(Chimaphila umbellata* var. *cisatlantica)*
Creeping Snowberry *(Gaultheria hispidula)*
Trailing Arbutus *(Epigaea repens* var. *glabrifolia)*
Wintergreen *(Gaultheria procumbens)*
Huckleberry *(Gaylussacia baccata)*
Pale Laurel *(Kalmia polifolia)*
Labrador Tea *(Ledum groenlandicum)*
Indian Pipe *(Monotropa uniflora)*
Pine Drops *(Pterospora andromedea)*. Collected at North Bay.
Pink-flowered Shinleaf *(Pyrola asarifolia)*
Shinleaf *(Pyrola elliptica)*
One-sided Shinleaf *(Pyrola secunda* var. *obtusata)*
Green-flowered Shinleaf *(Pyrola virens)*
Velvet-leaved Blueberry *(Vaccinium canadense)*
Small Cranberry *(Vaccinium Oxycoccos)*

Other plants that are rare or local in many parts of Wisconsin but frequent here are listed below:

Dwarf Mistletoe *(Arceuthobium pusillum)*. Parasitic on black spruce.
Clintonia *(Clintonia borealis)*
Bastard Toad-flax *(Comandra umbellata)*
Goldthread *(Coptis groenlandica)*
Bunchberry *(Cornus canadensis)*. Plate 7.
Round-leaved Sundew *(Drosera rotundifolia)*
Smaller Fringed Gentian *(Gentiana procera)*
Spurred Gentian *(Halenia deflexa)*

Shrubby St. John's-wort *(Hypericum Kalmianum)*
Dwarf Lake Iris *(Iris lacustris)*
Beach Pea *(Lathyrus japonicus* var. *glaber)*
Midland Lily *(Lilium michiganense)*
Wood Lily *(Lilium philadelphicum)*
Twinflower *(Linnaea borealis* var. *americana)*
Brook Lobelia *(Lobelia Kalmii)*
Buckbean *(Menyanthes trifoliata* var. *minor)*
Partridge-berry *(Mitchella repens)*
Yellow Pond Lily *(Nuphar variegatum)*
One-flowered Broomrape *(Orobanche uniflora)*
Gay-wings *(Polygala paucifolia)*
Silverweed *(Potentilla Anserina)*
Marsh Five-finger *(Potentilla palustris)*
Dwarf Canadian Primrose *(Primula mistassinica)*
Pitcher Plant *(Sarracenia purpurea)*. Plate 6.
Meadow Spikemoss *(Selaginella apoda)*
Northern Spikemoss *(Selaginella selaginoides)*
Canadian Buffalo-berry *(Sheperdia canadensis)*

The Ridges Sanctuary is especially noteworthy because it is the result of a community's endeavor to protect a part of its natural heritage.

ECOLOGICAL COMPOSITION OF HIGH PRAIRIE RELICS IN ROCK COUNTY, WISCONSIN

PHOEBE ANN GREEN

The eastern tongue of the tall-grass prairie association of North America extends from western and southern Minnesota through central Missouri and Illinois into Indiana and Ohio. Southern Wisconsin has a number of outliers of the prairie peninsula forming more or less isolated communities with a typical prairie flora. An attempt has been made to determine the composition of the prairies in the ecotone region of southern Wisconsin as exemplified by Rock County.

The prairie formation as it appears west of the Mississippi River has been investigated quite thoroughly, but relatively little study has been made of prairies to the east with the exception of some in Illinois and Ohio. East of the Mississippi the prairie has been largely eliminated by white man. In Wisconsin, agricultural operations and pasturing have either destroyed or greatly altered the original vegetation of all prairie locations, thus making very difficult a reconstruction of the prairie as it appeared at the time of arrival of early settlers. There are some remnants of prairie vegetation along roadsides and railroad rights-of-way, in abandoned cemeteries and in similar non-agricultural situations. An analysis of these areas as they exist today should give some indication of the original composition of the prairies.

The U. S. Government Land Surveys of 1833–34 (12) and early reports of settlers, such as those compiled by Guernsey and Willard for a "History of Rock County," 1856 (1), show that the original vegetation of Rock County was about 15% in timber, 20% in oak openings and 60% in prairies, with marshes found along the streams. The true prairie formations merged into oak-opening regions along the borders.

A close correlation is found between the distribution of the original prairies as mapped by the Land Survey of 1833–34 and the large level outwash plains from the Third Wisconsin and earlier glaciers, Martin, (3). The distribution of certain soil types, especially of the Carrington and Waukesha series as mapped by Whitson *et al.,* for the Soil Survey of Rock County, 1922 (10) are also closely correlated with the geologic and vegetational history of the county.

Originally the main prairies of the county were the Rock Prairie extending almost through the county from east to west, varying in width from six to 18 miles; the Jefferson, in the town of Clinton; the Turtle, extending into Rock township; Du Lac mostly in Milton; Ramsey's and Morse's in Fulton; and the Catfish lying in the towns of Fulton, Porter and Union. In addition there were a number of smaller prairies scattered throughout the county.

METHODS

In studying the composition of the high prairies in Rock County a series of five stations was selected. These relics were located along railroad rights-of-way. Four of the stations were located on the Rock Prairie which was developed on the deep outwash deposits of the late Wisconsin glaciers. Three of these were in La Prairie township which, as the name implies, was originally an unbroken prairie. One was in Janesville township on an extension of the main Rock Prairie. The soil underlying the Rock Prairie is primarily the deep phase of the Waukesha silt loam with adjoining soils of the Carrington series. One of the stations was in Milton township in the oak-opening region just south of Milton Junction. This is a gently rolling region, with typical prairies developed on outwash from the Milton Moraine, a section of the terminal moraine of the Third Wisconsin substage of glaciation.

The field work was done in the latter part of June and July, 1947, so many of the early spring-blooming species found on the prairies do not appear in the data. Thirty quadrats, each one meter square, were studied in Station I. This was located along the Chicago & Northwestern railroad about one half mile west of Tiffany, (Section 34, Town 2 North, Range 13 East). The soil type was Waukesha silt loam with a pH of 7.0. Station II was near the South Janesville yards of the Chicago & Northwestern railroad, (S. 18, T. 2 N., R. 13 E.). Twenty-nine quadrats were laid out here. The underlying Waukesha silt loam had a pH of 6.9. Station III was a mile north of Janesville along the Chicago, Milwaukee, & St. Paul railroad, (S. 13, T. 3 N., R. 12 E.). Thirty-two quadrats were studied. The soil, with a pH of 7.5, was the deep phase of the Waukesha silt loam. Station IV, with twenty-five quadrats, was located along the Chicago & Northwestern railroad about a mile and a half northwest of Tiffany, (S. 28, T. 2 N., R. 13 E.). The soil type was Waukesha silt loam with a pH of 7.0. Station V was in the oak-opening region where the deep phase of the Waukesha silt loam showed a pH of 6.5. This station was along the Chicago & Northwestern railroad about two miles south of Milton Junction, (S. 32, T. 4 N., R. 13 E.).

A total of 141 one-meter quadrats was studied. The species found therein were noted and the number of individuals counted, except for the grasses. From the data gathered, the frequency, the density, and the abundance of each species were determined.

Frequency is the number of quadrats in which a species is found, expressed as a percentage of the total number of quadrats examined. Abundance, as it has been used in this paper, refers to the average number of plants in the quadrats in which the species occurred. Density refers to the average number of plants per quadrat based on the total number of quadrats studied.

Results

From the data obtained an attempt has been made to deter mine the composition of the Rock County prairies and to compare these prairies with the associations found in other areas in the eastward extension of the true prairie, the Prairie Peninsula as described by Transeau (7).

A total of 108 species in 36 families was found. A list with total frequency, abundance and density of the native species occurring in the quadrats studied can be found at the end of this paper, (Table 6). Species of Compositae were the most numerous with 34 species in 21 genera. Leguminosae came second among the forbs with 10 species. The Gramineae had 10 species. Thirty-three other families were represented.

Table 1 shows the ranking of the prairie grasses in the various stations and in the total stations studied. *Stipa spartea* is the most prevalent prairie grass. It has a frequency of 48.37% in the total stations and as high as 73.33% in one. Species of *Panicum*, including *P. virgatum*, *P. Leibergii*, and *P. Scribnerianum*, rank next with a total frequency of 40.4%. These species have

TABLE 1

FREQUENCY PERCENTAGES FOR SPECIES OF GRAMINEAE

Total and Individual Stations

Species	Total Stations	Individual Stations				
		I	II	III	IV	V
Andropogon furcatus } *scoparius* }	19.8	10.00	17.24	40.60	20.00	8.00
Elymus canadensis	9.92	13.33	0.00	21.80	8.00	4.00
Koeleria cristata	2.80	0.00	10.34	0.00	4.00	0.00
Panicum Leibergii } *Scribnerianum* } *virgatum* }	40.40	60.00	62.07	46.90	8.00	12.00
Sorghastrum nutans	2.12	3.33	0.00	6.40	0.00	0.00
Sporobolus heterolepis	24.82	33.33	17.24	43.70	4.00	20.00
Stipa spartea	48.37	73.33	62.07	34.30	40.00	28.00
Total	81.56	90.00	96.55	90.60	68.00	56.00

been grouped in the summaries. *Sporobolus heterolepsis* follows with a total of 24.82% occurrance. The *Andropogons,* both *A. furcatus* and *A. scoparius,* assume positions of somewhat lesser importance, 19.8%. *A. scoparius* is a little more prevalent than *A. furcatus.* The occurrence of *Elymus canadensis* varies considerably, but on the whole, is of rather minor importance. *Sorghastrum nutans* and *Koeleria cristata* are of minor importance in this region, with frequencies of only 2.12% and 2.8%, respectively. In three stations, I, II, and III, all of which were located on the Rock Prairie, the total frequency of the prairie grasses was above 90% in all cases and reached a value of 96.55% in one.

The frequency percentage for all species appearing in the quadrats was calculated and has been used to determine the relative importance of the species in the prairie association. The species with a frequency percentage of 20% or more in any station or in the total of all stations are considered to be most typical of the Rock County prairies as a whole. These species are

TABLE 2

FREQUENCY PERCENTAGES FOR TYPICAL SPECIES OF HIGH PRAIRIE RELICS

Total and Individual Stations

Species	Total Stations	Individual Stations				
		I	II	III	IV	V
Amorpha canescens	18.4	10.0	13.8	12.5	0.0	60.0
Andropogon species	19.8	10.0	17.2	40.6	20.0	8.0
Apocynum androsaemifolium	9.2	0.0	3.5	0.0	0.0	48.0
Asclepias syriaca	16.3	10.0	0.0	18.7	52.0	4.0
Aster ericoides	43.3	53.3	34.5	46.8	44.0	36.0
Aster laevis	43.9	60.0	17.2	50.0	80.0	12.0
Baptisia leucantha	7.8	0.0	10.3	25.0	0.0	0.0
Brauneria pallida	26.2	50.0	55.2	18.7	0.0	0.0
Carex species	14.9	13.3	0.0	37.5	20.0	0.0
Cirsium discolor	17.0	10.0	3.5	18.7	56.0	0.0
Comandra umbellata	18.4	26.7	10.3	25.0	12.0	16.0
Convolvulus sepium	14.2	33.3	0.0	3.1	24.0	12.0
Coreopsis palmata	30.5	6.7	30.0	34.3	0.0	84.0
Desmodium illinoense	14.9	16.7	30.0	18.7	16.0	4.0
Elymus canadensis	9.9	13.3	0.0	21.8	8.0	4.0
Equisetum arvense	7.1	0.0	0.0	31.2	0.0	0.0
Erigeron ramosus	5.7	23.3	3.5	0.0	0.0	0.0
Eryngium yuccaefolium	20.0	13.3	13.8	37.5	0.0	32.0
Euphorbia corollata	63.8	60.0	65.5	59.6	84.0	52.0
Fragaria virginiana	17.7	20.0	0.0	40.6	24.0	0.0
Geranium maculatum	3.5	0.0	6.9	0.0	0.0	20.0
Helianthus rigidus	29.1	23.3	24.1	56.3	4.0	60.0
H. occidentalis	14.9	26.7	27.6	0.0	20.0	0.0
Heliopsis scabra	13.5	16.7	0.0	3.1	52.0	0.0
Lespedeza capitata	4.3	0.0	0.0	3.1	0.0	20.0
Liatris scariosa	9.2	13.3	20.7	6.4	0.0	12.0
Monarda fistulosa	14.9	13.3	0.0	28.1	0.0	32.0
Panicum species	40.4	60.0	62.1	46.8	8.0	12.0
Petalostemum candidum	8.5	10.0	30.0	0.0	0.0	0.0
Phlox pilosa	14.2	50.0	10.3	6.4	0.0	0.0
Physalis virginiana	7.8	3.3	24.1	3.1	4.0	12.0
Polytaenia Nuttallii	7.8	0.0	0.0	0.0	0.0	44.0
Potentilla arguta	10.6	23.3	20.7	6.4	0.0	0.0
Ratibida pinnata	31.9	46.7	20.7	25.0	60.0	8.0
Rosa species	29.8	53.3	27.6	9.3	36.0	24.0
Salix species	9.2	0.0	0.0	0.0	0.0	52.0
Silene stellata	8.5	10.0	0.0	0.0	36.0	0.0
Silphium laciniatum	12.8	10.0	3.5	40.6	0.0	4.0
S. terebinthinaceum	4.3	0.0	0.0	0.0	0.0	24.0
Solidago rigida	13.5	6.7	20.7	3.1	0.0	40.0
S. missouriensis	7.8	0.0	6.9	0.0	0.0	36.0
S. speciosa	3.5	0.0	17.2	0.0	0.0	32.0
Sporobolus heterolepsis	24.8	33.3	17.2	43.7	4.0	20.0
Stipa spartea	48.4	70.3	62.1	34.3	40.0	28.0
Tradescantia canaliculata	38.3	33.3	6.9	12.5	64.0	88.0
Vicia americana	9.2	0.0	0.0	0.0	0.0	52.0
Zizia aptera	11.3	10.0	10.3	12.5	24.0	0.0

shown in Table 2. Many of the species with 20% frequency or above in one station have a high-frequency percentage in other stations. Of the 47 typical species, 25 occurred in at least four of the five stations, although the frequency of occurrence varied. Eight species were absent from two stations but had a high frequency in each of the other three. Nine species were present in only two stations, and five were in only one.

The importance of species in individual stations varied from station to station as would be expected considering the rather extreme variations normally found in any prairie area. The greatest deviation occurred in the relic in the oak-opening region, (Station V). The composition of this relic was markedly different from those on the Rock Prairie. *Stipa* was still the dominant grass, but *Sporobolus* surpassed the *Panicum* species in frequency of occurrence. There was a definite invasion of the site by woody species such as *Corylus americanus, Quercus macrocarpa* and *Salix species.* A number of typical prairie species were missing, among them *Cirsium discolor, Brauneria pallida, Fragaria virginiana, Helianthus occidentalis, Heliopsis scabra, Phlox pilosa* and *Zizia aptera.*

Some of the species with high frequency in the Rock Prairie stations were as high or higher in the oak-opening station, e.g., *Aster ericoides, Coreopsis palmata, Eryngium yuccaefolium, Euphorbia corollata, Rosa species,* and *Helianthus rigidus.* A number of species with rather high frequency in the oak-opening station were very low or absent in the open prairie areas. These species included *Amorpha canescens, Apocynum androsaemifolium, Galium boreale, Geranium maculatum, Lespedeza capitata, Solidago rigida, Tradescantia canaliculata, Polytaenia Nuttallii, Salix sp., Silphium terebinthinaceum,* and *Vicia americana.* The latter four of these were found in only this station.

The variations here are mainly due to the development in an oak-opening region where succession is toward the formation of oak woods. Since all Rock County prairies are bordered by oak openings the occurrence and distribution of the flora in relics of oak-opening regions must be considered as part of the typical high-prairie flora in southern Wisconsin.

VARIABILITY OF FLORAL COMPOSITION IN THE HIGH PRAIRIE STATIONS

Variability in the floral composition in any localized area is one of the prime features of prairie associations. An indication of this can be found among the grasses and is noticeable among the minor grasses where some species are found in some stations and not in others. Variability is especially pronounced among the forbs. Examination of frequency, abundance and density figures clearly demonstrate this. Forbs are widely but not necessarily continuously distributed throughout the prairie. Flowers are abundant and there is a profusion of individuals rather than species. Some species are often found in rather dense local societies scattered here and there through the association. Some of these are found in the low frequency-high abundance table, Table 3. *Solidago missouriensis* is included in this group

TABLE 3

SPECIES WITH LOW FREQUENCY PERCENTAGES (UNDER 10%) AND HIGH ABUNDANCE FIGURES (OVER 10)

Total Stations

SPECIES	FREQUENCY	ABUNDANCE	DENSITY
Antennaria species	2.8	20.25	.574
Galium boreale	1.4	11.50	.163
Solidago missouriensis	7.8	13.90	1.085
Solidago speciosa	3.5	16.40	.581

although the frequency percentage and density are noticeably higher than the other species listed. Some species, although few in number of individuals, occur frequently in the quadrats. These would have high frequency and low abundance, and are listed in Table 4. Three of these, *Brauneria pallida, Euphorbia corollata,* and *Tradescantia canaliculata,* show significantly high density figures and could be grouped with the species having high frequency and high abundance figures. A few species (seven of the 108 species in the total stations) have both relatively high frequency and high abundance figures. These also have very high density figures. Table 5 shows the frequency, abundance, and density figures for these seven species. A few species are rare and have both low frequency and low abundance

TABLE 4

SPECIES WITH HIGH FREQUENCY PERCENTAGES (OVER 10%) AND LOW ABUNDANCE FIGURES (UNDER 6)

Total Stations

SPECIES	FREQUENCY	ABUNDANCE	DENSITY
Amorpha canescens	18.4	2.0	.369
Asclepias syriaco	16.3	1.8	.298
Cirsium discolor	17.0	1.5	.255
Comandra umbellata	18.4	4.9	.908
Convolvulus sepium	14.2	3.9	.553
Brauneria pallida	26.2	5.6	1.468
Desmodium illinoense	14.9	2.3	.199
Eryngium yuccaefolium	20.0	1.4	.283
Euphorbia corollata	63.8	3.7	2.362
Fragaria virginiana	17.7	3.4	.596
Potentilla arguta	10.6	2.3	.241
Ratibida pinnata	31.9	3.0	.965
Rosa species	29.8	3.0	.908
Silphium laciniatum	12.8	1.6	.199
Solidago rigida	13.5	4.0	.532
Tradescantia canaliculata	38.3	5.6	2.163
Zizia aptera	11.3	3.9	.440

TABLE 5

SPECIES WITH HIGH FREQUENCY PERCENTAGES (OVER 10%) AND HIGH ABUNDANCE FIGURES (OVER 10)

Total Stations

SPECIES	FREQUENCY	ABUNDANCE	DENSITY
Aster ericoides	43.3	15.1	6.525
Aster laevis	43.9	17.1	7.539
Coreopsis palmata	30.5	17.1	5.411
Helianthus occidentalis	14.9	26.0	3.774
Helianthus rigidus	29.1	10.2	2.977
Heliopsis scabra	13.5	17.4	2.348
Phlox pilosa	14.2	12.2	1.730

figures. These are not considered to be important prairie species. Sometimes a single plant occupies as much area as a whole society. Here low abundance and high abundance figures must be compared with variations in size of plants before conclusions regarding the importance of certain species can be made.

Of the 95 forbs found in the stations studied, a number showed relatively constant high frequency percentages and these appeared among the important species in all stations. Ranking of any species based on frequency percentages varied but the most important species in most of the stations were found to be important in the other stations. Only nine of the forbs showed a frequency percentage of 25% or above. These species were *Aster ericoides, Aster laevis, Brauneria pallida, Coreopsis palmata, Euphorbia corollata, Helianthus rigidus, Ratibida pinnata, Rosa species,* and *Tradescantia canaliculata.* Of the seven forbs with both high frequency and high abundance in the total stations, most have both high frequency and high abundance in the individual stations. Constancy of the figures varies from station to station and some species show both high frequency and high abundance figures in one or two stations but not in others. Although some species do show high frequency percentages, when all species are considered, frequency figures are rather low and abundance figures rather high for about 46 of the most outstanding species. This is about 43% of the total species found.

Variation in prairie-flora lists from different locations are to be expected, due to variations in ranges of plants, seed sources, and the like, yet the major part of the flora of all tall-grass prairie types is similar. This uniformity constitutes one of the most distinctive characteristics of the prairie. No single prairie would be expected to contain all the species listed among typical prairie plants for any state, but a number of important variations occur when Rock County prairies are compared with some of those found in Ohio and Illinois. Many of the species found in these states are typical of Rock County also, but some of the most characteristic species of Ohio and Illinois prairies are not found in the relics studied in Wisconsin.

The dominants of both Ohio and Illinois prairies as listed by Jones (2) and Sears (6) in Ohio; and Vestal (8), Sampson (5), and Paintin (4) in Illinois include *Andropogon furcatus, A. scoparius, Sorghastrum nutans* and *Spartina michauxiana.* In

TABLE 6

LIST OF NATIVE FORBS FOUND IN 141 QUADRATS STUDIED IN ROCK COUNTY

SPECIES*	DENSITY	FREQUENCY	ABUNDANCE
Acerates viridiflora	.014	0.7	2.0
Achillea millefolium	.085	2.1	4.0
Amorpha canescens	.369	18.4	2.0
Anemone cylindrica	.064	2.8	2.3
Antennaria species	.567	2.8	20.3
Apocynum androsaemifolium	.128	9.2	1.4
Apocynum cannabinum	.156	7.8	2.0
Asclepias amplexicaulis	.049	2.8	1.8
Asclepias syriaca	.298	16.3	1.8
Asclepias verticillata	.021	1.4	1.5
Aster ericoides	6.525	43.3	15.1
Aster laevis	7.539	43.9	17.1
Aster sericeus	.035	0.7	5.0
Baptisia leucantha	.156	7.8	2.0
Baptisia leucophaea	.021	2.1	1.0
Brauneria pallida	1.468	26.2	5.6
Cacalia atriplicifolia	.049	2.1	2.3
Ceanothus americanus	.078	6.4	1.2
Circium discolor	.255	17.0	1.5
Comandra umbellata	.908	18.4	4.9
Convolvulus sepium	.553	14.2	3.9
Coreopsis palmata	5.411	30.5	17.7
Corylus americanus	.028	2.8	1.0
Desmodium illinoense	.340	14.9	2.3
Dodecatheon Meadia	.199	4.3	4.7
Equisetum arvense	.489	7.1	6.9
Erigeron ramosus	.106	5.7	1.9
Eryngium yuccaefolium	.283	20.0	1.4
Eupatorium altissimum	.021	1.4	1.5
Euphorbia corollata	2.362	63.8	3.7
Fragaria virginiana	.596	17.7	3.4
Galium boreale	.163	1.4	11.5
Gentiana Andrewsii	.057	3.5	1.6
Gentiana puberula	.241	5.7	4.3
Geranium maculatum	.064	3.5	1.8
Helianthus grosseserratus	.014	0.7	2.0
Helianthus occidentalis	3.774	14.9	26.0
Helianthus rigidus	2.977	29.1	10.2
Helianthus strumosus	.014	0.7	2.0
Heliopsis scabra	2.348	13.5	17.4
Heuchera Richardsonii	.418	7.8	5.4
Kuhnia eupatorioides	.043	0.7	6.0
Lathyrus palustris	.007	0.7	1.0
Lathyrus venosus	.064	2.8	2.2
Lespedeza capitata	.092	4.3	2.2
Liatris scariosa	.475	9.2	5.2
Liatris pycnostachya	.085	1.4	6.0
Lilium michiganense	.028	2.1	1.3
Lithospermum canescens	.057	1.4	4.0
Lobelia spicata	.014	0.7	2.0
Lysimachia ciliata	.178	2.8	6.4
Monarda fistulosa	1.057	14.9	7.1
Oxalis violacea	.014	0.7	2.0
Petalostemum candidum	.830	8.5	9.8
Petalostemum purpureum	.113	3.5	3.2

TABLE 6 *(Continued)*

LIST OF NATIVE FORBS FOUND IN 141 QUADRATS STUDIED IN ROCK COUNTY

SPECIES*	DENSITY	FREQUENCY	ABUNDANCE
Phlox pilosa	1.730	14.2	12.2
Physalis heterophylla	.071	3.5	2.0
Physalis virginiana	.206	7.8	2.6
Polytaenia Nuttallii	.106	7.8	1.4
Potentilla arguta	.241	10.6	2.3
Potentilla simplex	.120	2.8	4.3
Prenanthes racemosa	.014	1.4	1.0
Ratibida pinnata	.965	31.9	3.0
Rosa species	.908	29.8	3.0
Rudbeckia hirta	.057	0.7	8.0
Salix species	.113	9.2	1.2
Scrophularia marilandica	.085	3.5	2.4
Silene stellata	.816	8.5	9.6
Silphium integrifolium	.156	2.8	5.5
Silphium laciniatum	.187	12.8	1.6
Silphium terebinthinaceum	.057	4.3	1.3
Sisyrinchium species	.142	2.1	6.7
Smilacina stellata	.106	2.8	3.8
Solidago juncea	.035	1.4	2.5
Solidago missouriensis	1.085	7.8	13.9
Solidago nemoralis	.036	0.7	5.0
Solidago rigida	.532	13.5	3.9
Solidago speciosa	.581	3.5	16.4
Thalictrum dasycarpum	.071	1.4	5.0
Tradescantia canaliculata	2.163	38.3	5.6
Vicia americana	.284	9.2	3.1
Viola pedatifida	.149	7.8	1.9
Zizia aptera	.440	11.3	3.9
Zizia aurea	.021	0.7	3.0

*Plant names have been standardized, for the most part using FLORA OF INDIANA, C. C. Deam. 1940.

the Rock County prairies *Sorghastrum* occupies a position of only minor importance; *Spartina* is not found in high-prairie associations; and the *Andropogons* are overshadowed by the dominance of *Stipa* and *Panicum* species. Of the 20 most common species in Rock County prairies 14 are found in Ohio prairies. On the whole the Ohio prairies do not seem to be as comparable in floral composition with those of Rock County as do some of those in Illinois.

In Illinois, the prairie association that is most nearly like the type found in Rock County is the "xerophytic prairie grass," the *Andropogan scoparius* association, as studied by Vestal. Vestal states that this association is not extensively developed in the upper Wisconsin glaciation of northeastern Illinois, but can be found locally. Good comparisons of this type and the Rock County types cannot be made as comparable data are lacking.

One of the biggest factors preventing closer relationships with Illinois and Ohio prairies in general probably lies in the poor drainage of prairie sites in those regions. The gray or gray-brown silt loam is underlain with an impervious clay subsoil, according to Woodard (11), which efficiently prevents drainage of the sites. In Rock County the drainage is good since the area is underlain by beds of sand and gravel outwash.

In their studies of the prairies west of the Mississippi River, Weaver and Fitzpatrick (9) analyzed the types of prairie in six states. The areas included grasslands in the western ⅓ of Iowa and the eastern 1.3 of Nebraska. They extended southward into Missouri and Kansas to the Kansas River, and northward into southwestern Minnesota and southeastern South Dakota. These investigators found that the *Stipa spartea* consociation is of practically no importance in the Kansas and Missouri section and is of minor importance in the southeastern portion of the prairie area, where environmental conditions approximate those found in Illinois. The *Stipa* consociation gradually increases northward and becomes well developed. Although comparable data were not given, it is sufficiently evident that the high-prairie relics in Rock County approximate more closely the *Stipa spartea* consociation of southeastern South Dakota and south-western Minnesota than they do the prairie associations to the south and east in Illinois and Ohio.

In all the high prairies west of the Mississippi River, drainage of the soil is of little consequence in determining the species growing there as lack of adequate precipitation is one of the most important environmental factors. Soil reaction is nearly neutral or slightly alkaline. The drainage and soil pH factors of western prairies approximate those of the high prairies of Rock County, and although ranges of many of the western prairie species do not extend into Wisconsin, which limits closer correlation of prairie types, these two factors help to explain the closer relationship of Rock County prairies with the western *Stipa spartea* consociation than with the prairies to the south and east in Illinois and Ohio.

SUMMARY

A study of high-prairie relics on deep soil in Rock County, Wisconsin, has been made. Five stations were studied; four occurring in the Rock Prairie area and one in an oak-opening region south of Milton Junction. A total of 141 one-meter-square quadrats were studied. The 108 species with frequency of occurrence, abundance and density have been listed. The plants typical of high prairies in this region have been determined. *Stipa spartea* is the dominant prairie grass and occurs in 48% of the quadrats studied. *Panicum species* are the most important associates found and occur in 40.4% of the quadrats. *Sporobolus heterolepiis* occurs in 24.8% of the quadrats, and *Andropogon furcatus* and *A. scoparius* in only 19.8%. A few forbs show high frequency percentages (25% or more), but for most outstanding species frequency of occurrence is rather low and abundance figures are rather high.

Soil types on which most of the Rock County prairies have developed are the Waukesha silt loam and its deep phase showing almost neutral reaction under the prairie vegetation.

Floral composition of the high prairies of Rock County is more similar to that of prairie formations in southwestern Minnesota and southeastern South Dakota than that of prairies in the adjacent state of Illinois.

The list of species from these small relic areas is not meant to be complete or to represent absolutely the composition of the more extensive prairie associations before advent of civilization, but will give some idea of the composition of prairie formations in the ecotone region of southern Wisconsin.

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OF
LOUIS KAHLENBERG AND ASSOCIATES*
1903–41[1]

NORRIS F. HALL
University of Wisconsin, Madison

SCIENTIFIC PAPERS

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* The completion of this bibliography, as well as the part previously published, is due entirely to the initiative and interest of Professor Henry L. Shuette.

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Cantwell Printing Company, Madison, Wisconsin.

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The Macmillan Company, New York, 1909. 548 pp.

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Qualitative chemical analysis. A manual for college students.
Cantwell Printing Company, Madison, Wisconsin.

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    J. Phys. Chem., *7*, 302–303.

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    History of chemistry.
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    Progressive problems in general chemistry.
    J. Am. Chem. Soc., *33*, 85–86.

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    J. Am. Chem. Soc., *34*, 1113–1114.

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J. Am. Chem. Soc., *39*, 529.

NOTES ON THE DISTRIBUTION OF WISCONSIN TICKS*

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The following collections of ticks listed below were made from several counties throughout the State of Wisconsin from June 1948 to June 1949. The list also includes the occurrence of Wisconsin ticks previously mentioned in the literature by other workers. Since there is very little published information regarding the distribution of Wisconsin ticks this survey appears worthy of record.

Hosts were trapped or shot during the course of this study and taken to the laboratory for examination. The distributions of the various ticks are indicated by Figures 1 and 2.

Banks (1908) apparently reported the first tick identification from Wisconsin. *Dermacentor nigrolineatus* = *D. albipictus* was collected by Mr. H. S. Barber from a deer at Crab Lake, Vilas County. No further reports were located until 1930 when Gross recorded *Haemaphysalis leporis-palustrus* from prairie chickens, short-tailed grouse and ruffed grouse. This tick was reported on Wisconsin cottontail rabbits, jackrabbits and snowshoe hares by the Minnesota Wildlife Disease Investigations (1933–1936).

The first occurrence of *Ornithodorus kelleyi (O. talajae)* in Wisconsin was noted by Herrick (1935). A complete monograph on the soft ticks including *O. kelleyi* was published by Cooley and Kohls (1944). Peters (1936) listed *D. albipictus* from the American woodcock from Wisconsin in his collection of external parasites of birds.

Bishopp and Smith (1938), Cooley (1938) and Smith *et al.* (1946) presented the distribution of the American dog tick *(D. variabilis)* in North America. Collections from Wisconsin

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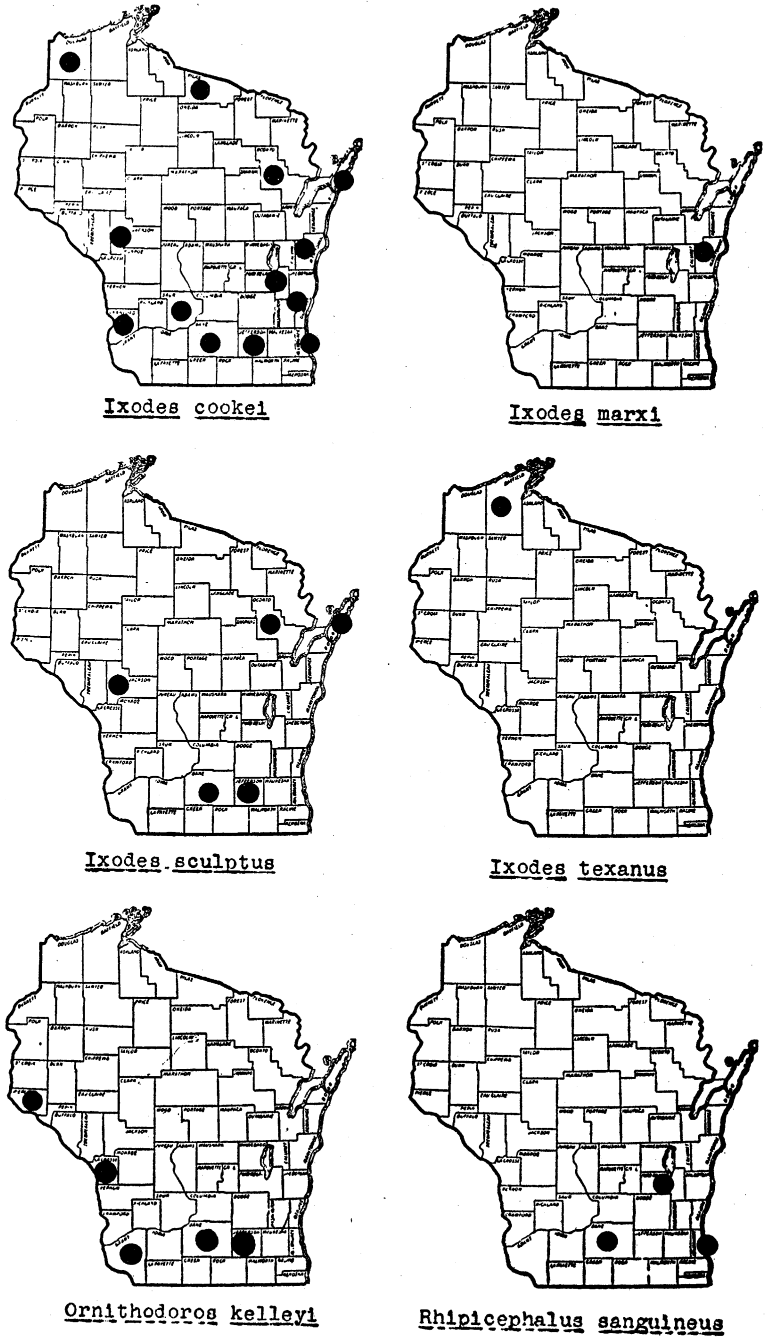
Ixodes cookei
Ixodes marxi
Ixodes sculptus
Ixodes texanus
Ornithodoros kelleyi
Rhipicephalus sanguineus

FIGURE 1.

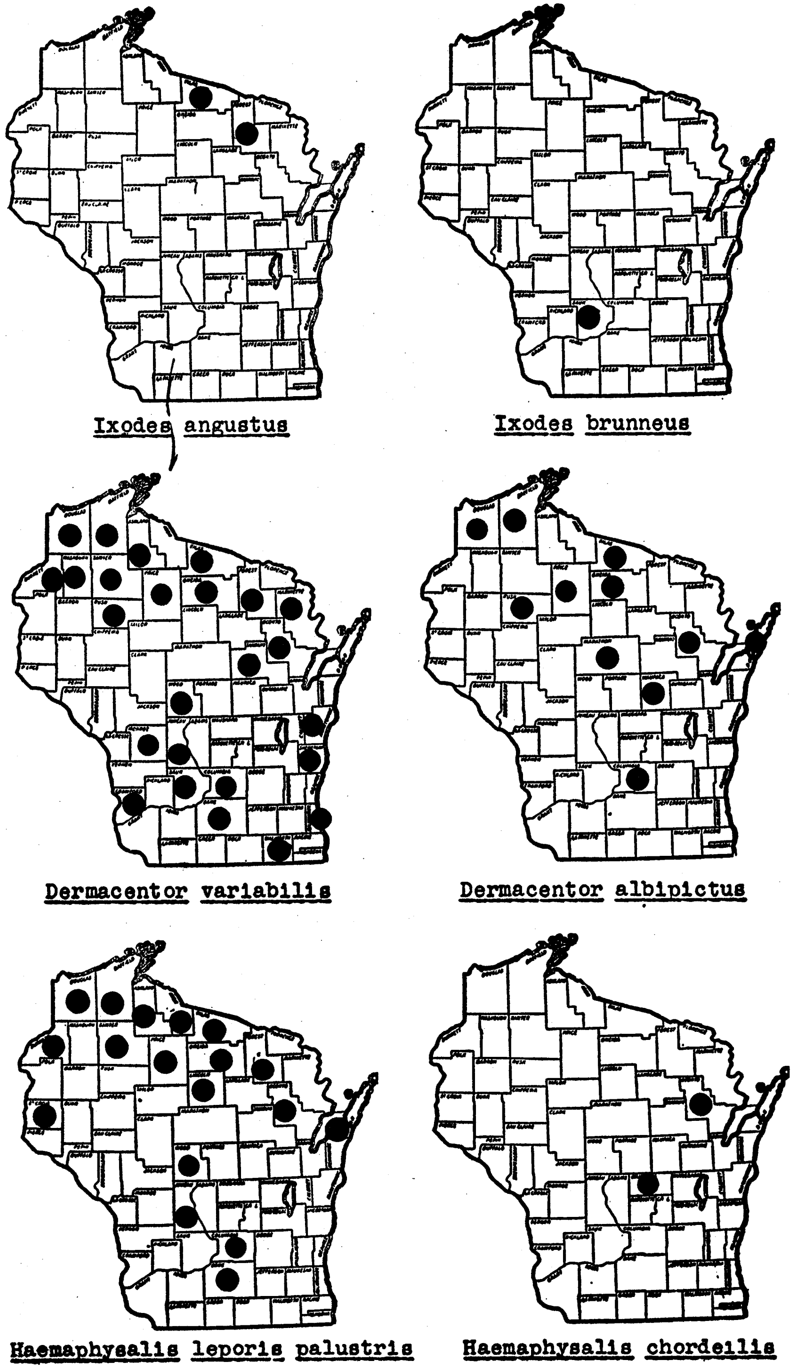
Ixodes angustus
Ixodes brunneus
Dermacentor variabilis
Dermacentor albipictus
Haemaphysalis leporis palustris
Haemaphysalis chordeilis

FIGURE 2.

were included. Later, Cole (1947) and King (1948) reported further collections of this tick in northern Wisconsin.

In a comprehensive review of the distribution and hosts of certain North American ticks Bishopp and Trembley (1945) listed *D. albipictus, D. variabilis, H. leporis-palustris, Ixodes cookei, I. texanus* and *Rhipicephalus sanguineus* as occurring in Wisconsin. Later, Cooley and Kohls (1945) in their monograph on the genus *Ixodes* recorded *I. cookei* from Wisconsin. *Rhipicephalus sanguineus* and *H. chordeilis* were recorded from Wisconsin hosts by Cooley (1946).

Host List of Wisconsin Ticks

**Dermacentor albipictus* (Packard, 1869)

(Moose or winter tick)

1. American woodcock *(Philohela minor)* location in Wisconsin not given (Peters, 1936). Door County, 8/4/34 (Collected by P. W. Hoppman).

2. Porcupine *(Erethizon d. dorsatum)* 4 collected, 1 infested, Oneida County, 6/27/48, 1 engorged female.

3. White tailed deer *(Odocoileus virginianus borealis)* 1 collected, 1 infested. Bayfield County, 10/17/48, 1 nymph; Oconto County, 11/28/45, 1 male (Collected by K. MacArthur); deer, Vilas County, collected by H. S. Barber (Banks, 1908); Columbia County, 11/12/43 (Collected by E. M. Searls); deer bed, Lodi, Columbia County, 11/12/43, 4 engorged females.

4. Cow *(Bos taurus)* Oneida County, 11/2/48, 12 engorged females, 1 male; Marathon County, 9/27/43, 1 female, 1 male; Waupaca County, 11/24/48, 6 engorged females (Collected by G. Sevan); Bayfield County, 12/2/47, 1 engorged female; Rusk County, 10/20/42 (Collected by R. A. Omalden).

5. Horse *(Equus caballus)* Price County, 12/14/25 (Collected by A. Prather).

Dermacentor variabilis (Say, 1821)

(American dog tick, wood tick)

1. Dog *(Canis familaris)* 6 examined, 2 infested. Douglas County, 7/15/48 (Collected by George Halazon), 1 male; Dane County, no date record, 1 male, 1 female; 6/1/41; 7/6/41;

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* *D. nigrolineatus* is considered a synonym of *D. albipictus*.

6/28/41 (Collected by O. Andregg); Monroe County, 7/20/30 (Collected by C. L. Fluke); Rock County, 6/13/49, 2 females; Price County, 5/8/49, 1 male.

2. Raccoon *(Procyon lotor)* Juneau County, 6/21/49, 1 female.

3. Black bear *(Euarctos a. americanus)* Lakewood, Oconto County, 7/1/47, 331 males, 515 females; 7/16/47, 139 males, 105 females (Cole, 1947).

4. Cow *(Bos taurus)* Price County, 7/20/25 (Collected by A. Prather).

5. Red squirrel *(Tamiasciurus hudsonicus)* 16 collected, 3 infested. Manitowoc County, 6/17/48, 1 male, 1 female; Forest County, 7/20/48, 1 nymph, 2 nymphs.

6. Woodchuck *(Marmota monax)* Eagle River, Oconto County, 6/12/47, 1 male, 3 females (Cole, 1947).

7. White footed mouse *(Peromyscus* sp.) 156 collected, 1 infested. Sheboygan County, 7/14/48, 1 nymph; Oconto County, 7/6/47, 3 larvae; 7/12/47, 6 larvae, 1 nymph (Cole, 1947).

8. Meadow vole *(Microtus* spp.) Lakewood, Oconto County, 6/18/47, 2 larvae, 3 nymphs; 7/9/47; 6/18/47; 6/25/47; 7/9/47, 9 larvae, 38 nymphs; 7/6/47, 3 nymphs; 7/6/47, 2 larvae, 16 nymphs (Cole, 1947).

9. Porcupine *(Erethizon d. dorsatum)* 5 collected, 2 infested. Oneida County, 6/27/48, 8 females, 3 males; Forest County, 5/1/49; Oconto County, 6/12/47, 1 male, 2 females; 6/12/47, 1 male, 9 females; 6/24/47, 9 males, 8 females; 6/24/47, 2 males, 1 female; 7/9/47, 1 male, 4 females; 3 males, 3 females; 7/12/47, 1 male, 1 female; 7/14/47, 1 female; 7/14/47, 5 males, 8 females (Cole, 1947); Sawyer County, 6/20/34 (Collected by T. M. Frison); Columbia County, 5/9/39.

10. Snowshoe hare *(Lepus americanus)* 2 collected, 1 infested. Vilas County, 7/23/48, 4 engorged nymphs; Lakewood, Oconto County, 6/23/47, 19 larvae, 1 nymph (Cole, 1947).

11. Cottontail rabbit *(Sylvilagus floridanis mearnsi)* Lakewood, Oconto County, 7/15/47, 2 nymphs (Cole, 1947); Dane County, 6/30/49, 1 female (Collected by C. Hawkinson).

12. Man *(Homo sapiens)* Sauk County, 5/23/48, 1 male (Collected by Frank Grether); Vilas County, 6/12/48, 19 adults; 6/14/48, 7 females, 8 males (Collected by James Hamilton); 5/31/48, 2 females, (Collected by K. MacArthur); 6/10/48, 3

males; 6/12/48, 2 males, 2 females; Shawano County, 6/5/48, 2 females; Bayfield County, 6/15/48, 1 female; 6/1/49 (Collected by H. Bergseng); Rusk County, 7/13/48, 26 adults (Collected by Elmer Herman); Marinette County, 7/19/48, 1 male; Forest County, 7/20/48, 3 males; Price County, 7/20/25 (Collected by A. Prather); 5/12/49; Douglas County, 5/26/37 (Collected by E. Stringham); Dane County, 5/1/49; 5/17/49; 5/22/48 (Collected by H. Levi); Washburn County, 7/8/47, 3 males; 7/3/47, 1 female; Ashland County, 5/1/49; 6/1/49; Burnett County, 6/6/49; Wood County, 6/21/49; Sawyer County, 6/20/34 (Collected by C. D. Mohr); Walworth County, 6/18/49, 1 female (Collected by J. A. Carroll); Crawford County, 6/1/49 (Collected by L. Smethurst); Grant County, 6/17/49 (Collected by H. Levi).

Hosts not recorded, location in Wisconsin not given (Cooley, 1938; Smith, Cole and Gouck, 1946).

Dermacentor sp. (Larva)

1. Short-tailed shrew *(Blarina brevicauda)* 71 collected, 1 infested. Dane County (near Madison), 8/7/49, 1 larva.

Haemaphysalis chordeilis (Packard, 1869)
(Bird tick)

1. Prairie chicken *(Tympamuchus cupido americanus)* Waushara County, 5/15/40, location in Wisconsin not given (Cooley, 1946).

Haemaphysalis leporis-palustris (Packard, 1869)
(Rabbit tick)

1. Sharp-tailed grouse *(Pediaecetes phasianellus campestris)* Wood County, 9/23/29 (Collected by A. D. Grass), location in Wisconsin not given (Peters, 1936); 9/23/29; 9/24/29 (Gross, 1930).

2. Prairie chicken *(Tympamuchus cupido americanus)* Wood County, 4/25/31 (Collected by F. W. Schmidt); Marathon County, 7/14/29 (Gross, 1930).

3. Ruffed grouse *(Bonasa umbellus)* Lakewood, Oconto County, 7/16/47, 76 larvae, 9 nymphs (Cole, 1947).

4. Snowshoe hare *(Lepus americanus)* 3 collected, 3 infested. Vilas County, 7/23/48, 141 nymphs, 22 larvae, 2 males, 3 engorged females; 7/23/48, 7 larvae, 62 nymphs, 1 male, 1 female; 8/21/40; Iron County, Oct. 1933, 903 ticks (Collected by Rheave); Douglas County (Brule State Forest), May 1934, 59 hares, 3 to 453 ticks (Collected by W. Grange); Forest County, June 1934, 2102 ticks, 4920 ticks, 366 ticks; July 1934, 973 ticks; Burnett County, June 1934, 3268 ticks, 1722 ticks, 1013 ticks, 833 ticks, 962 ticks, 707 ticks; Douglas County, Oct., Nov. and Dec. 1935, 200 ticks, 102 ticks, 421 ticks, 37 ticks, 405 ticks, 156 ticks, 73 ticks, 111 ticks (Collected by W. Grange), 419 ticks, 141 ticks, 52 ticks, 198 ticks, 44 ticks, 116 ticks, 134 ticks, 412 ticks, 27 ticks, 98 ticks, 29 ticks, 47 ticks, 69 ticks, 52 ticks, 44 ticks, 258 ticks, 249 ticks, 249 ticks, 443 ticks (Collected by Greig, Nov. 1935); 256 ticks, 19 ticks, 102 ticks, 15 ticks, 18 ticks (Collected by Swanson, Nov. 1935); Oneida County, 33 ticks (Collected by W. Grange) (Minnesota Wildlife Disease Investigation); Lakewood, Oconto County, 6/23/47, 653 larvae, 64 nymphs, 94 males, 57 females (Cole, 1947); Door County, 8/14/40 (Collected by F. C. Bishopp).

5. Cottontail rabbit *(Sylvilagus floridanus mearnsi)* 103 examined, 21 infested. Dane County (University of Wisconsin Arboretum), 4/1/39, 20 larvae; 4/3/49, 3 larvae; 4/8/39, 2 larvae, 6 larvae; 4/13/39, 6 larvae, 16 larvae, 2 larvae; 5/4/39, 1 larva; 4/3/40, 6 larvae; 4/20/40, 8 larvae; 5/3/40, 408 larvae; 6/1/40, 1 male; 6/2/40, 8 females; 6/8/40, 2 females; 6/13/40, 7 females, 1 male; 6/18/40, 2 females, 1 female, 3 females; 5/21/49; 6/1/49; Juneau County, 6/23/49; Lakewood, Oconto County, 7/15/47, 1 larva, 9 nymphs, 1 male, 3 females (Cole, 1947); Burnett County, June 1934, 3 ticks, 1 tick, 2 ticks (Minnesota Wildlife Disease Investigation); Door County, June 1934, 218 ticks (Collected by W. Grange) (Minnesota Wildlife Disease Investigation).

6. Meadow vole *(Microtus* sp.) Lakewood, Oconto County, 6/25/47, 6 larvae, 1 male (Cole, 1947).

Haemaphysalis sp.

1. Ruffed grouse *(Bonasa umbellus)* Iron County, Oct. 1933, 264 ticks, 234 ticks (Collected by Rheave); Oneida County, Oct. 1933, 7 ticks (Collected by Oshesky); Sawyer County, Oct. 1933,

174 ticks, 96 ticks, 306 ticks, 110 ticks, 106 ticks (Collected by Schmidt); 200 ticks, 218 ticks (Collected by Moreland); Price County, Oct. 1933, 78 ticks (Collected by Schmidt); Ashland County, Oct. 1933, 698 ticks (Collected by Schmidt); Bayfield County, Oct. 1933, 656 ticks, 982 ticks (Collected by Minor); 23 ticks, 66 ticks (Collected by Jones); 123 ticks (Collected by Schmidt); Lincoln County, Oct. 1933, 403 ticks (Collected by Fosnot); Douglas County, Oct. 1933, 40 ticks (Collected by McNaughton); Oct., Nov. and Dec. 1935, 847 ticks (Collected by Greig); 704 ticks (Collected by Simmons); 222 ticks, 172 ticks, 12 ticks, 35 ticks, 14 ticks (Collected by Grange); 13 ticks (Collected by Swanson); Sept. 1934, 611 ticks; Forest County, Nov. 1935, 15 ticks (Collected by Sanders); July 1934, 60 ticks, 949 ticks, 1894 ticks.

2. Pheasant *(Phasianus colchicus)* St. Croix County, Oct. 1934, 1 tick.

3. Sharp-tailed grouse *(Pediaecetes phasianellus campestris)* Douglas County, 10/1/34; 11/1/34; 12/1/34, 71 ticks (Collected by Swanson).

Ixodes angustus Neumann, 1899

1. Red squirrel *(Tamiasciurus hudsonicus)* 16 collected, 1 infested. Forest County, 7/20/48, 1 nymph.

2. White footed mouse *(Peromyscus* sp.) 156 collected, 1 infested. Vilas County, 7/23/48, 1 engorged female.

Ixodes brunneus Koch, 1844

1. Sparrow *(Passerella i. iliaca)* Sauk County, 4/17/47, 1 engorged female (Collected by Robert Rausch).

Ixodes cookei Packard, 1869

(American castor bean tick)

1. Common opossum *(Didelphis virginiana)* Milwaukee County, 4/16/40; Dane County, 5/14/49.

2. Common shrew *(Sorex cinereus)* 215 collected, 1 infested. Dane County (near Madison), 8/17/48, 1 nymph.

3. Mink *(Mustela vison)* 2 collected, 2 infested. Dane County (near Madison), 1947, 1 female; 3/14/47, 7 engorged nymphs (Collected by Robert Rausch); Door County, 11/16/40 (Collected by H. F. Johnson).

4. Weasel, Douglas County, 11/30/45, 1 female (Collected by W. Pelzer); Jefferson County, 5/4/49.

5. Badger *(Taxidae t. taxus)* 3 collected, 3 infested. Crawford County, 11/30/48, 2 nymphs, 3 larvae; Sauk County, 4/29/48, 1 nymph (Collected by Robert Rausch); Dane County, 11/2/47, 1 engorged female.

6. Skunk *(Mephitis* sp.) Ozaukee County, 8/12/38, 11 females, many nymphs, collected by C. L. Larson (Cooley and Kohls, 1945).

7. Dog *(Canis familaris)* Dane County, 6/28/41 (Collected by O. Andregg).

8. Grey fox *(Urocyon cinervargenteus)* Dane County, 7/1/41 (Collected by O. Andregg).

9. Cat *(Felis domestica)* Fond du Lac County, 4/29/48, 1 female.

10. Woodchuck *(Marmota monax)* 1 collected, 1 infested. Crawford County, 4/2/48, 1 engorged female, 1 nymph (Collected by Robert Rausch); Vilas County, 8/8/40; Dane County, 5/26/49.

11. White footed mouse *(Peromyscus* sp.) 156 collected, 1 infested. Manitowoc County, 7/16/48, 1 nymph.

12. Meadow jumping mouse *(Zapus hudsonius)* 46 collected, 1 infested. Dane County, 8/24/48, 1 nymph.

13. Porcupine *(Erethizon d. dorsatum)* Lakewood, Oconto County, 7/14/47, 1 female (Cole, 1947).

Ixodes marxi Banks, 1908

(Squirrel tick)

1. Red squirrel *(Tamiasciurus hudsonicus)* 16 collected, 1 infested. Manitowoc County, 7/17/48, 4 females.

Ixodes sculptus Neuman, 1904

1. Weasel, Door County, 8/25/31 (Collected by H. F. Johnson).

2. Long tail weasel *(Mustela longicauda)* Jefferson County, 5/4/49.

3. Thirteen lined ground squirrel *(Citellus t. tridecemlineatus)* 9 collected, 1 infested. Dane County (near Madison), 8/7/48, engorged female.

4. White footed mouse *(Peromyscus* sp.) Lakewood, Oconto County, 7/12/47, 1 nymph (Cole, 1947).

5. Dog *(Canis familiaris)* Dane County, 4/1/48 (Collected by H. Levi).

No host recorded, Jackson County, 7/14/31 (Collected by C. L. Fluke).

Ixodes texanus Banks, 1908

1. Weasel, 1 collected, 1 infested. Bayfield County, 11/28/--, 1 engorged female.

No host recorded, location in Wisconsin not given (Bishopp and Trembly, 1945).

Ixodes sp. (Larvae)

1. Common shrew *(Sorex cinereus)* 215 collected, 39 infested. Dane County (near Madison), 8/5/48, 3 larvae; 8/6/48, 3 larvae; 8/7/48, 2 larvae; 8/12/48, 4 larvae; 5/17/48, 1 larvae; 8/18/48, 3 larvae; 8/19/48, 2 larvae, 1 larva, 6 larvae, 1 larva; 8/20/48, 1 larva, 1 larva, 2 larvae, 3 larvae; 8/24/48, 1 larva, 1 larva, 5 larvae; 8/25/48, 3 larvae, 1 larvae, 2 larvae; 8/26/48, 1 larva, 1 larva; 8/27/48, 5 larvae; 4 larvae, 3 larvae, 2 larvae, 2 larvae, 1 larva, 1 larva; 9/3/48, 1 larva; 9/4/48, 1 larva, 2 larvae, 2 larvae; 9/9/48, 4 larvae, 1 larva, 1 larva, 2 larvae; 9/17/48, 1 larva; 9/18/48, 4 larvae.

2. Short-tailed shrew *(Blarina brevicauda)* 71 collected, 4 infested. Dane County (near Madison), 8/7/48, 1 larva; 8/12/48, 1 larva; 8/17/48, 1 larva; 9/1/48, 1 larva.

3. Meadow vole *(Microtus p. pennsylvanicus)* 208 collected, 6 infested. Dane County (near Madison), 8/11/48, 1 larva; 8/13/48, 2 larvae, 1 larva; 8/17/48, 1 larva; 8/28/48, 4 larvae; 9/1/48, 1 larva.

4. Meadow jumping mouse *(Zapus hudsonius)* 46 collected, 3 infested. Dane County (near Madison), 8/25/48, 2 larvae, 2 larvae; 8/26/48, 1 larva.

Ornithodoros kelleyi Cooley and Kohls, 1941

1. Little brown bat *(Myotis lucifugus)* Grant County, 6/8/49; Grant County, rooming house, 5/4/49; Dane County, residence (bathtub of rooming house), 10/21/48, 1 nymph, 1 female (Collected by W. O. Haberman); 2 females (Collected by Otto Manthey); private home, 4/1/49; Jefferson County, 3/3/49,

2 ticks from walls of private home (Collected by Mr. Kiesling); La Crosse County, no date, 1 nymph (Collected by E. Young); Pierce County, residence, 10/17/45 (Collected by Steiner and E. L. Chambers); old hotel, men's club, private house, 4 rooming houses (Herrick, 1935; Cooley and Kohls, 1944; Cooley, 194--).

Rhipicephalus sanguineus (Latreille, 1806)

1. Dog *(Canis familaris)* 6 examined, 1 infested. Dane County, no date record, 108 larvae, 2 males, 1 female; Milwaukee County, 1/1/46, 2 males, 1 female (Collected by K. MacArthur); 1/24/40; 8/10/43; Fond du Lac County, 10/25/40 (Collected by W. P. Hammond).

No host recorded, location in Wisconsin not given (Cooley, 1946).

Summary

A preliminary survey revealed the occurrence of the following species of ticks in Wisconsin: (1) *Ixodes* sp. (larvae) from common shrew, short tailed shrew, meadow vole and jumping mouse. (2) *I. angustus* from red squirrel and white footed mouse. (3) *I. brunneus* from sparrow. (4) *I. cookei* from common shrew, mink, badger, skunk, woodchuck, porcupine, white footed mouse and jumping mouse. (5) *I. marxi* from red squirrel. (6) *I. sculptus* from ground squirrel and white footed mouse. (7) *I. texanus* from weasel. (8) *Dermacentor albipictus* (moose or winter tick) from American woodcock, porcupine, white tailed deer, cow and horse. (9) *D. variabilis* (American dog tick) from dog, cat, black bear, red squirrel, woodchuck, white footed mouse, meadow vole, porcupine, snowshoe hare, cottontail rabbit and man. (10) *Haemaphysalis chordeilis* from prairie chicken. (11) *H. leporis-palustrus* (rabbit tick) from cottontail rabbit, snowshoe hare, sharp-tailed grouse and ruffed grouse. (12) *Ornithodorus kelleyi* from little brown bat, walls, ceilings of private homes, rooming houses. (13) *Rhipicephalus sanguinius* (brown dog tick) from dog.

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PRELIMINARY LIST OF SOME FLEAS FROM WISCONSIN*

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In the course of investigations on the distribution of ticks in Wisconsin a large number of fleas was collected and identified. Prior to this compilation on examination of the literature indicated a paucity of information available to Wisconsin scientists. The purpose of this paper is to stimulate interest in certain economically important groups and to demonstrate the potentialities of the field for future students. Since there is a lack of information on Wisconsin fleas, a compilation of our records with those of the literature seemed desirable.

The following list includes all of the collections made during the years 1948–1949. Supplementary collections are also included. Reports taken from the literature on fleas occurring in Wisconsin are preceded by an asterisk (*).

The writers are indebted to Dr. G. M. Kohls and Dr. W. L. Jellison, Rocky Mountain Laboratory, U. S. Public Health Service, Hamilton, Montana, who kindly checked and verified all specific identifications.

PARASITE HOST LIST OF WISCONSIN FLEAS

FAMILY: PULICIDAE

Cediopsylla simplex (Baker, 1895)

1. Dog *(Canis familaris)* Dane County, 11/10/48, 1 male.

2. Red fox *(Vulpes regalis)* Adams County, 11/7/41, 2 females, 2 males.

3. Cat *(Felis domestica)* Dane County, 4/4/49, 1 male; 6/27/49, 5 females.

4. Cottontail rabbit *(Sylvilagus floridanus)* Dane County, 1/10/41, 3 males, 2 females; 12/12/48, 3 males, 6 females;

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12/15/48, 2 males; 12/16/48, 1 male, 9 females; 12/20/48, 1 male, 4 females; 12/24/48, 5 males, 10 females; 1/3/49, 2 males, 1 female; 5/21/49, 1 male; 11/30/48, 3 males, 2 females; Pierce County, 7/1/41, 1 male.

*5. Coyote *(Canis latrans)* Wood County, 10/10/32 (Collected by J. W. Schmidt); Fox, 1940.

6. Raccoon *(Procyon lotor)* Juneau County, 2/22/48, 1 male.

Hoplopsyllus affinis (Baker, 1904)

1. Jack rabbit *(Lepus americanus)* Pierce County, 7/1/41, 4 males, 4 females.

Xenopsylla cheopis (Rothschild, 1903)

1. House rat *(Rattus norvegicus)* Dane County, 4/25/47, 2 females; 4/20/41, 1 male, 1 female.

2. House mouse *(Mus musculus)* Dane County, 9/9/48, 1 male, 2 females; 9/15/48, 3 males, 5 females; 5/1/49, 9 females, 5 males.

3. Golden hamster *(Cricetus auratus)* Dane County, 9/11/48, 1 male (accidental laboratory infestation).

Ctenocephalides felis (Bouche, 1835)

1. Cat *(Felis domestica)* Dane County, 7/1/49, 1 male, 4 females.

Ctenocephalides canis (Curtis, 1826)

*1. Dog *(Canis familiaris)* Dane County, 8/5/49, 4 males, 12 females; Rock County, 9/20/49. Listed by Trembley and Bishopp, 1940; host not given, Milwaukee.

FAMILY: DOLICHOPSYLLIDAE

Ctenopthalmus pseudagyrtes Baker, 1904

1. Masked shrew *(Sorex cinereus)* Dane County, 8/13/48, 1 female.

2. Short-tailed shrew *(Blarina brevicauda)* Dane County, 8/17/48, 1 female; 8/28/48, 1 female; 9/1/48, 1 female; 9/4/48, 1 female; 10/5/48, 1 male; 10/5/48, 3 males, 1 female; 10/6/48, 2 females; 12/21/48, 2 females.

3. Least chipmunk *(Eutamias minimus)* Bayfield County, 10/17/48, 1 female.

4. White-footed mouse *(Peromyscus* sp.) Dane County, 10/9/48, 1 female.

5. Meadow mouse *(Microtus p. pennsylvanicus)* Dane County, 8/18/48, 1 male; 8/19/48, 1 male, 1 female; 10/27/48, 1 female; 11/17/48, 1 male; 11/23/48, 1 male; 4/2/49, 1 male.

6. Long-tailed weasel *(Mustela frenata)* Jefferson County, 5/21/49, 1 female.

Ceratophyllus garei Rothschild, 1902

1. Marsh hawk *(Circus hudsonius)* Dane County, 8/18/43, 1 male, 4 females.

Ceratophyllus gallinae (Schrank, 1803)

1. Host not recorded, Manitowoc County, 4/1/48, 1 male, 1 female (Collected by T. Torgerson).

Ceratophyllus riparius Jordan and Rothschild, 1920

*1. Bank swallow *(Riparia riparia)* Milwaukee County. Fox, 1940.

Megabothris acerbus (Jordan, 1925)

1. Red squirrel *(Tamiasciurus hudsonicus)* Vilas County, 9/7/48, 2 females.

Megabothris asio (Baker, 1904)

1. Meadow mouse *(Microtus p. pennsylvanicus)* Dane County, 7/8/48, 1 male, 1 female; 8/12/48, 1 male, 1 female; 8/17/48, 1 male; 8/28/48, 1 female; 10/9/48, 1 female; 10/27/48,1 female; 10/29/48, 1 male; 11/17/48, 2 females, 1 male; 11/23/48, 2 males; 4/2/49, 1 male.

2. Mink *(Mustela vison)* Dane County, 5/1/41, 1 female.

Megabothris quirini (Rothschild, 1905)

1. Meadow mouse *(Microtus p. pennsylvanicus)* Bayfield County, 10/16/48, 2 males.

Megabothris wagneri (Baker, 1904)

1. Short-tailed shrew *(Blarina brevicauda)* Dane County, 8/24/48, 1 female; 10/5/48, 1 female; 10/48, 1 female.

2. White-footed mouse *(Peromyscus* sp.) Dane County, 9/4/48, 1 female; 5/26/49, 1 male, 1 female; Juneau County, 6/21/47, 1 female; Sheboygan County, 7/14/48, 1 female.

Nosopsylla fasciata (Bosc, 1801)

*1. Fox, 1940; listed this flea from Wisconsin.

Odontopsyllus multispinosus (Baker, 1898)

1. Cottontail rabbit *(Sylvilagus floridanus)* Dane County, 11/30/48, 2 females; 5/21/49, 1 male, 1 female.

Opisocrostis brunneri (Baker, 1895)

1. Striped ground squirrel *(Citellus tridecemlineatus)* Dane County, 4/21/27, 2 males; Waukesha County, 7/28/48, 1 male, 1 female; Juneau County, 6/23/49, 3 females; *Kenosha County, 10/8/36 (Collected by R. Komarek). Fox, 1940.

2. Franklin ground squirrel *(Citellus franklini)* Dane County, 4/20/41, 2 males, 1 female.

Orchopeas cadens (Jordan, 1925)

1. Red squirrel *(Tamiasciurus hudsonicus)* Dane County, 12/1/48, 1 female; Manitowoc County, 7/20/48, 1 female.

2. Gray squirrel *(Sciurus carolinensis)* Dane County, 10/1/46, 1 female.

3. White-footed mouse *(Peromyscus* sp.) Sheboygan County, 7/14/48, 1 male.

Orchopeas leucopus (Baker, 1904)

1. White-footed mouse *(Peromyscus* sp.) Sheboygan County, 7/14/48, 2 females; Dane County, 8/7/48, 1 female; 8/26/48, 1 male; 9/4/48, 3 females; 10/1/48, 1 female, 1 male; 10/20/48, 1 male; 10/27/48, 1 female, 2 males; 3/27/49, 1 female; 3/27/49, 1 female; 4/2/49, 1 female.

*2. White-footed mouse *(Peromyscus leucopus noveboracensis)* Door County, 9/14/30 (Collected by F. J. Schmidt). Fox, 1940.

3. Meadow mouse *(Microtus p. pennsylvanicus)* Bayfield County, 10/16/48, 1 female.

4. Jumping mouse *(Zapus hudsonius)* Dane County, 8/25/48, 1 female.

5. Cottontail rabbit *(Sylvilagus floridanus)* Dane County, 8/1/48, 1 female.

6. Weasel *(Mustela frenata)* Jefferson County, 5/21/49, 1 male.

7. Muskrat *(Ondatra zibethica)* Dodge County, 5/26/49, 1 male.

Orchopeas wickhami (Baker, 1895)

1. Opossum *(Didelphis virginiana)* Dane County, 5/14/49, 1 male, 1 female.

2. Golden hamster *(Cricetus auratus)* Dane County, 4/1/48, 2 females (accidental laboratory infestation).

3. Grey squirrel *(Scuirus carolinensis)* Dane County, 10/1/46, 1 male.

Orchopeas howardi (Baker, 1895)

1. Northern flying squirrel *(Glaucomys volans)* Jackson County, 2/3/45, 2 females.

Orchopeas sp.

1. Weasel *(Mustela frenata)* Jefferson County, 5/21/49, 4 females.

2. White-footed mouse *(Peromyscus* sp.) Sheboygan County, 7/14/48, 1 male.

Oropsylla arcotomys (Baker, 1904)

1. Woodchuck *(Marmota monax)* Dane County, 1947, 1 female.

2. Badger *(Taxidea t. taxus)* Crawford County, 11/30/48, 4 males.

3. Opossum *(Didelphis virginiana)* Dane County, 5/14/49, 1 male.

Rectofrontia fraterna (Baker, 1895)

1. Masked shrew *(Sorex cinereus)* Dane County, 8/9/48, 1 female; 8/24/48, 1 male; 8/25/48, 1 female; 8/27/48, 1 male.

2. Short-tailed shrew *(Blarina brevicauda)* Dane County, 8/11/48, 1 male; 8/12/48, 1 male; 8/17/48, 1 male; 8/18/48, 2 males; 8/20/48, 2 males; 8/24/48, 1 male; 10/6/48, 1 female; 10/9/48, 1 male; 12/7/48, 1 male.

Monosopsyllus wagneri (Baker, 1904)

1. White-footed mouse *(Peromyscus* sp.) Dane County, 9/1/48, 1 male; 8/26/48, 1 male.

Monosopsyllus vison (Baker, 1904)

1. White-footed mouse *(Peromyscus* sp.) Sheboygan County, 7/14/48, 1 male.
2. Franklin ground squirrel *(Citellus franklini)* Dane County, 1947, 1 female.
3. Red squirrel *(Tamiasciurus* sp.) Dane County, 12/1/48, 1 male.

Monosopsyllus eumolpi (Rothschild, 1905)

1. Least chipmunk *(Eutamias minimus)* Bayfield County, 10/17/48, 6 females, 4 males.

Thrassis sp.

1. Mink *(Mustela vison)* Dane County, 3/14/47, 2 females.
2. Striped-ground squirrel *(Citellus tridecemlineatus)* Dane County, 4/22/47, 1 female.

FAMILY: HYSTRICHOPSYLLIDAE

Epitedia wenmani (Rothschild, 1904)

1. Short-tailed shrew *(Blarina brevicauda)* Dane County, 12/21/48, 1 male.
2. White-footed mouse *(Peromyscus* sp.) Dane County, 12/7/48, 1 male; 4/8/49, 1 female.
3. Meadow mouse *(Microtus p. pennsylvanicus)* Dane County, 12/26/47, 1 male; 8/17/48, 1 male; 11/23/48, 1 male; 12/7/48, 1 male; 12/7/48, 1 male.

Nearctopsylla genalis (Baker, 1904)

1. Masked shrew *(Sorex cinereus)* Bayfield County, 10/16/48, 2 females.
2. Short-tailed shrew *(Blarina brevicauda)* Bayfield County, 10/16/48, 1 male, 1 female.

Peromyscopsylla catatina (Jordan, 1928)

1. Meadow mouse *(Microtus p. pennsylvanicus)* Bayfield County, 10/16/48, 1 female; 10/16/48, 3 females.

Doratopsylla curvata Rothschild, 1915

1. Masked shrew *(Sorex cinereus)* Dane County, 8/19/48, 1 male.
2. Short-tailed shrew *(Blarina brevicauda)* Dane County, 8/28/48, 1 male; 11/9/48, 1 male.

FAMILY: ISCHNOPSYLLIDAE

Myodopsylla insignis (Rothschild, 1903)

1. Little brown bat *(Myotis lucifugus)* Dane County, 11/25/40, 1 female, 1 male; 11/1/41, 14 females, 9 males.

HOST PARASITE LIST OF WISCONSIN FLEAS

OPOSSUM
Orchopeas wickhami
Oropsylla arcotomys

MASKED SHREW
Ctenopthalmus pseudagyrtes
Rectofrontia fraterna
Nearctopsylla genalis
Doratopsylla curvata

SHORT-TAILED SHREW
Ctenopthalmus pseudagyrtes
Megabothris wagneri
Rectofrontia fraterna
Epitedia wenmani
Nearctopsylla genalis
Doratopsylla curvata

LITTLE BROWN BAT
Myodopsylla insignis

EASTERN RACCOON
Cediopsylla simplex

BADGER
Oropsylla arcotomys

WEASEL
Orchopeas leucopus
Ctenopthalmus pseudagyrtes

COMMON MINK
Megabothris asio
Thrassis sp.

RED FOX
Cediopsylla simplex

COYOTE
Cediopsylla simplex

DOG
Cediopsylla simplex
Ctenocephalides canis

CAT
Ctenocephalides felis
Cediopsylla simplex

WOODCHUCK
Oropsylla arcotomys

THIRTEEN-STRIPED GROUND SQUIRREL
Opisocrostis brunneri
Thrassis sp.

FRANKLIN GROUND SQUIRREL
Opisocrostis brunneri
Monosopsylla vison

LEAST CHIPMUNK
Ctenopthalmus pseudagyrtes
Monosopsyllus eumolpi

NORTHERN FLYING SQUIRREL
Orchopeas howardi

RED SQUIRREL
Megabothris acerbus
Orchopeas cadens
Monosopsylla vison

GRAY SQUIRREL
Orchopeas cadens
Orchopeas wickhami

MUSKRAT
Orchopeas leucopus

JUMPING MOUSE
Orchopeas leucopus

WHITE-FOOTED MOUSE
Ctenopthalmus pseudagyrtes
Megabothris wagneri
Orchopeas cadens
Orchopeas leucopus
Monosopsyllus wagneri
Epitedia wenmani

MEADOW MOUSE
Ctenopthalmus pseudagyrtes
Megabothris asio
Megabothris quirini
Orchopeas leucopus
Epitedia wenmani
Peromyscopsylla catatina

HOUSE MOUSE
Xenopsylla cheopis

HOUSE RAT
Xenopsylla cheopis

GOLDEN HAMSTER
Xenopsylla cheopis
Orchopeas wickhami

COTTONTAIL RABBIT
Cediopsylla simplex
Odontopsylla multispinosus
Orchopeas leucopus

JACK RABBIT
Hoplopsyllus affinis

MARSH HAWK
Ceratophyllus garei

BANK SWALLOW
Ceratophyllus riparius

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MORPHOLOGY AND SPECIFIC CONDUCTANCE OF FOREST HUMUS AND THEIR RELATION TO THE RATE OF FOREST GROWTH IN WISCONSIN[1]

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One of the vital functions of the forest is to serve as a transformer of energy of radiation. Every day, the sun transmits more than four hundred million of millions of horse power to the earth. A portion of this vast quantity of energy is trapped by the photosynthetic processes, and is stored away in the form of forest litter. Aside from being a storehouse of energy materials, forest humus is the chief carrier of mineral nutrients in forest soils and has a high fertilizing value. Humus is a gift of Nature, and man fails to appreciate its monetary equivalent. It has been estimated that organic debris on a single acre, supporting a mature forest in northern Wisconsin, is worth more than one hundred dollars, if evaluated in terms of commercial fertilizers.

Under the influence of environmental factors, forest litter attains a peculiar morphology which is often indicative of both microbiological and chemical properties of the humus layers. The principal morphological groups of humus which are found in the State of Wisconsin are as follows:

EARTH MULL GROUP. This group is characterized by rapid decomposition of litter under the influence of actinomycetes, other microorganisms, insects, millipods, and often earthworms, particularly *Lumbricus terrestris*. As a result, the soil profile exhibits organic matter thoroughly incorporated with the mineral soil. Morphologically, this group is related to prairie soils which accumulate humus due to the retarded decomposition of grass roots.

TRUE MOR GROUP. This group is distinguished by an accumulation of raw organic remains whose decomposition is retarded by cold climate, strong acidity, impeded drainage or other conditions unfavorable for microbiological activity. The soil profile

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of this group includes a thick layer of raw organic matter, but no incorporated humus. This is because the humified fraction is nearly instantly removed by percolating water.

DUFF MULL GROUP. This group is a transitional form between earth mull and true mor. It is characterized by the presence of a layer of free organic matter, not exceeding 3 inches, and a horizon with incorporated humus. The principal agents employed in the decomposition of organic matter are fungi and insects.

INFILTRATED MOR GROUP. This group is morphologically similar to the true mor, except the raw humus layer is underlain by a dark horizon with infiltrated humus. The latter develops due to influence of ground water or a high content of free carbonates.

The results of this study indicate, that in many instances, the morphology of humus serves as an expression of the suitability of soil to support different species and its potential productivity. Table 1 presents a brief description of the more important morphological types of forest humus occurring in the state of Wisconsin and their relation to floristic cover and rate of forest growth. The terminology of humus is after Wilde (5).

The present investigation was concerned primarily with the specific conductance of different humus types. The ability of a suspension to conduct electric current is directly related to the content of dissociated electrolytes; hence, specific conductance may serve as an index of soil fertility. Moreover, it is known that specific conductance is lowered by the resistive substances present in the suspension. Therefore, the determination of specific conductance on samples subjected to centrifuging provides a measure of readily dispersible colloids.

The following analytical procedure was employed. Air-dried samples of humus were passed through a 2 mm. mesh sieve, and a 50 ml. sample was measured, using a standard scoop. A suspension was prepared by shaking humus on a rotary agitator for 1 hour with 200 ml. of distilled water. The suspension was allowed to settle for 10 minutes and 50 ml. were decanted into a 1 x 6 inch test tube. The temperature of the sample was brought to about 77° F. and the conductivity determined by platinum electrodes connected with a Solu bridge, i.e., a type of Wheatstone bridge provided with a cathode-ray tube (magic eye). The reading was taken instantly (2, 4).

For the determination of the non-conductives, the suspension was centrifuged for 30 minutes at a speed of 2,500 r.p.m., and

TABLE 1

MORPHOLOGICAL FEATURES OF IMPORTANT TYPES OF WISCONSIN FOREST HUMUS AND THEIR RELATION TO FLORISTIC COVER AND RATE OF FOREST GROWTH

(Estimated Yields per Acre are Given Either in Board Feet, Scribner Rule, at 100 Years, or in Standard Cords at 40 Years)

TYPE OF HUMUS	TYPE OF SOIL	FLORISTIC TYPE	APPROX. YIELD PER ACRE
EARTH MULL TYPES			
Prairie humus........	Sparta sand	*Bouteloua hirsuta*	....
Prairie humus........	Parr silt loam	*Andropogon-Sorghastrum*	....
Oak grain mull.......	Miami loam	*Parthenocissus-Circaea*	8.5 Mbf
Oak granular mull....	Miami silt loam	*Parthenocissus-Circaea*	5.0 Mbf
Hardwood crumb mull	Almena silt loam	*Hydrophyllum-Arisaema*	7.0 Mbf
Hardwood lean mull..	Bellefontaine loam	Undetermined	8.5 Mbf
DUFF MULL TYPES			
Hardwood duff mull..	Milaca loam	*Adiantum-Thalictrum*	10.0 Mbf
Hardwood duff mull..	Dubuque silt loam	*Polygonatum-Mitella*	12.0 Mbf
Red pine duff mull....	Vilas sandy loam	*Gaultheria-Maianthemum*	18.0 Mbf
Ba. fir-Birch duff mull	Omega sandy loam	*Vaccinium-Rubus*	12 cords
Heml.-Birch duff mull	Kennan f. s. loam	*Clintonia-Lycopodium*	12.0 Mbf
TRUE MOR TYPES			
Pine matted mor.....	Ontonagon clay	*Clintonia-Lycopodium*	7.0 Mbf
Aspen-Birch root mor.	Nekoosa sandy loam	*Vaccinium-Rubus*	10 cords
Ba. fir fibrous mor....	Rubicon sand	*Hylocomium*	18 cords
Bl. spruce matted mor	Rubicon sand	*Hypnum-Cornus*	8 cords
INFILTRATED MOR TYPES			
Wh. cedar alk. mor...	Longrie loam	*Nudum*	12 cords
Wh. cedar alk. mor...	Longrie loam	*Nudum*	12 cords
Swamp hardw. sedge mor...............	Auburndale silt loam	*Thalictrum-Galium*	7.0 Mbf
Hardw. infiltrated mor	Adolph silt loam	*Carex-Equisetum*	4.0 Mbf
Hardw. conif. greasy mor..............	Adolph silt loam	*Carex-Equisetum*	14 cords

TABLE 2

REACTION, LOSS ON IGNITION, SPECIFIC CONDUCTANCE (Mhos x 10^{-5}), AND CONTENT OF DISPERSIBLE RESISTIVE COLLOIDS IN IMPORTANT TYPES OF WISCONSIN FOREST HUMUS

TYPE OF HUMUS	REACTION pH	VOLUME WEIGHT	LOSS ON IGNITION p.ct.	SPEC. CONDUCTANCE Before Centrifuging Mhos	SPEC. CONDUCTANCE After Centrifuging Mhos	INCREASE DUE TO CENTRI-FUGING MHOS	CONTENT OF NON-CONDUCTIVES
EARTH MULL TYPES							
Prairie humus, sand	5.15	1.02	2.5	4.5	4.8	0.3	Low
Prairie humus, silt loam	6.50	0.71	4.2	8.5	9.7	1.2	Low
Oak grain mull	6.40	0.68	5.0	9.5	10.3	0.8	Low
Oak granular mull	6.60	0.67	8.6	13.0	14.0	1.0	Low
Hardwood crumb mull	5.30	0.75	17.1	13.0	14.0	1.0	Low
Hardwood lean mull	6.65	0.64	2.2	18.5	20.0	1.5	Medium
DUFF MULL TYPES							
Hardwood duff mull	6.00	0.66	24.2	11.5	14.5	3.0	High
Hardwood duff mull	6.68	0.58	27.5	20.5	23.0	2.5	Medium
Red pine duff mull	4.75	0.28	62.7	17.0	20.5	3.5	High
Ba. fir- Birch duff mull	5.50	0.18	59.0	14.5	16.5	2.0	High
Heml.-hardw. duff mull	5.55	0.19	46.5	17.5	18.0	1.5	Medium
TRUE MOR TYPES							
Pine matted mor	4.00	0.18	36.2	13.0	14.0	1.0	Low
Aspen-Birch root mor	4.85	0.26	21.3	13.5	14.0	0.5	Low
Ba. fir. fibrous mor	3.45	0.16	91.1	12.0	13.0	1.0	Low
Bl. spruce matted mor	3.20	0.25	97.3	11.0	11.0	0	Low
INFILTRATED MOR TYPES							
Wh. cedar alk. mor	7.05	0.25	53.2	24.0	27.5	3.5	High
Wh. cedar alk. mor	7.05	0.23	44.9	19.5	21.5	2.0	Medium
Swamp hardw.-sedge mor	5.10	0.27	73.0	39.0	44.5	5.0	High
Hardw. infiltrated mor	4.60	0.13	48.0	14.0	16.0	2.0	Medium
Hardw. conif. greasy mor	4.50	0.21	40.4	14.0	16.0	2.0	Medium

conductance determined as previously described. The analyses were supplemented by determinations of reaction, volume weight, and loss on ignition (1).

The results, presented in Table 2, indicate that earth mull types and true mor types have a low specific conductance and a low content of dispersible resistive colloids. On the other hand, duff mull types, as well as infiltrated mor types, have a high specific conductance and show a greater fraction of dispersible colloids. The differences in electro-kinetic properties of these types would be much more pronounced if analysis were carried on a weight, rather than a volume basis. It was felt, however, that treatment of humus on a volume basis has a much greater importance in regard to the establishment of natural reproduction and the early growth of young seedlings.

True mor types are notorious for their low state of fertility and ill effects on both soils and forest growth (3). This is in agreement with the low mhos-value of this type. The latter, moreover, is largely due to hydrogen ions, rather than nutrient elements. Earth mull is usually considered to be an indicator of high soil fertility. Actually, this type of humus shows a moderate content of electrolytes. The highest conductance, as well as the highest content of dispersible colloids was found in duff mull types. The occurrence of these types coincides with the highest rate of forest growth in Wisconsin, which sometimes exceeded a level of 600 board feet per acre, per year. The group of infiltrated mor is also characterized by a high specific conductance. However, the high potential fertility of this group is often offset by the hydrolytic and reducing effects of non-capillary water.

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AVAILABILITY TO HUMAN SUBJECTS OF PURE RIBOFLAVIN INGESTED WITH LIVE YEAST

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Riboflavin from fresh unfortified compressed yeasts has previously been found to be essentially unavailable for human subjects. Destruction of viability of the yeast cells by heating or by certain drying processes prior to ingestion released the vitamin for absorption. Live yeasts, however, did not interfere with the utilization of riboflavin contained in food mixtures as they did with food thiamine.

The effect of live yeast upon the availability of riboflavin in pure solution is here reported. The human bioassay technic of Melnick's laboratory for availability of vitamins was used. Fifty-five grams of yeast were ingested in one dose between meals followed immediately by the test vitamins in pure solution. Fifteen grams of yeast with each meal covered the riboflavin of the basal foods.[3]

Viable fresh yeast did not interfere with the absorption of riboflavin in pure solution; urinary returns were not lower than those which were obtained when the pure vitamin alone was added. Comparable results were obtained when yeasts killed by drying in alcohol were given with the pure riboflavin. A comparison of these results with the effects of live and dead yeasts upon the availability of thiamine in pure solution will be discussed.

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[3] Pineapple was generously supplied by the Pineapple Research Institute of Hawaii.

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PRELIMINARY REPORTS ON THE FLORA OF WISCONSIN. XXXIV LILIALES

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The following report is based on a study of herbarium specimens in the University of Wisconsin and the Milwaukee Public Museum. The author is most appreciative of the information and suggestions given by Professor Norman C. Fassett, and of loans of material from the Milwaukee Public Museum by Mr. A. M. Fuller. This paper is incidental to the work of the writer as a research assistant under a grant from the Wisconsin Alumni Research Foundation.

KEY TO THE FAMILIES

A. Plants mostly rush-like; perianth small (2–5 mm.), greenish or brown, often bristle-like.................................*Juncaceae.*

AA. Plants not rush-like

B. Plant a trailing vine with small axillary panicles or racemes. ....*Dioscoreaceae.*

BB. Plant not as above

C. Perianth borne at the base of the ovary...............*Liliaceae.*

CC. Perianth borne at the summit of the ovary

D. Stamens 6 ....*Amaryllidaceae.*

DD. Stamens 3 ....*Iridaceae.*

LILIACEAE

A. Leaves basal or nearly so

B. Flowers in umbels

C. Rootstock creeping; umbel 3–6-flowered; leaves 2–5, 4–10 cm. wide, 14–25 cm. long, oblong or oval, ciliate..*Clintonia borealis.*

CC. Base of plant bulbous; flowers usually many in an umbel and sometimes replaced by bulblets; leaves mostly linear; strong onion-scented herbs

D. Leaves flat, elliptic, usually 3–10 cm. wide, 15–20 cm. long, not present at flowering time...............*Allium tricoccum.*

DD. Leaves linear, present at flowering time
 E. Umbel erect, usually bulblet-bearing; capsule not crested.................................*Allium canadense.*
 EE. Umbel not bulblet-bearing
  F. Umbel drooping; capsule 6-crested; leaves flattened and sharply keeled......................*Allium cernuum.*
  FF. Umbel erect
   G. Leaves nearly flat; umbel open with pedicels exceeding perianth; capsule prominently 6-crested. ....*Allium stellatum.*
   GG. Leaves awl-shaped and hollow; umbel subcapitate with pedicels shorter than or barely exceeding perianth; capsule not crested.....*Allium Schoenoprasum.*

BB. Flowers not in umbels
 C. Plants with solitary flowers
  D. Flowers light yellow; style club-shaped with united stigmas; leaves mottled with purplish or whitish. ....*Erythronium americanum.*
  DD. Flowers white or pinkish; style elongate with 3 short, spreading stigmas; leaves less mottled or not at all. ....*Erythronium albidum.*
 CC. Flowers several in a spike or a raceme
  D. Stems and pedicels glandular; leaves grasslike. ....*Tofieldia glutinosa.*
  DD. Stems and pedicels not glandular
   E. Plant without bulbous base; raceme spike-like; flowers many, yellowish-white, tubular; leaves noticeably yellowish-green, spreading and flat..........*Aletris farinosa.*
   EE. Plant with bulbous base; inflorescence a raceme or slightly panicled; leaves not yellowish-green
    F. Flowers blue to white; raceme compact with pedicels never more than 1 cm. long, and 10–17 cm. in length with 35–50 flowers....................*Camassia scilliodes.*
    FF. Flowers greenish-yellow to greenish-white; raceme loose, with pedicels often more than a cm. long, sometimes compound toward the base
     G. Middle and upper bracts of inflorescence herbaceous, tapering to firm subulate tips; sepals and petals strongly suffused on the back with green, bronze, or purple; capsule ovoid-conic, 1–1.4 cm. long, 5–8 mm. in diameter, barely exceeding the finally connivent perianth; leaves coriaceous, mostly blunt or subacute; inflorescence a few-forked, elongate-lanceolate to open-ovoid panicle, (rarely a simple raceme).......................*Zigadenus glaucus.*
     GG. Middle and upper bracts of the inflorescence with scarious margins and summits; sepals and petals paler, with or without a darkened area at base or

middle on the outside; capsule lance-conic, 1.3–2.2 cm. long, 4–6 mm. in diameter, twice as long as the perianth; leaves thinner, usually sharply pointed; inflorescence a slender, loosely cylindric raceme, (rarely a panicle) .... *Zigadenus elegans.*

AA. Leaves cauline

B. Flowers large and showy, 4–10 cm. in diameter, orange to reddish-orange with purple spots; sepals colored like the petals; fruit a large, cylindric capsule, 2–5 cm. long

C. Flowers open bell-shaped with perianth segments not recurved; segments of perianth clawed; bulbs not rhizomatous

D. Leaves chiefly whorled .... *Lilium philadelphicum.*

DD. Leaves chiefly scattered except for one whorl at summit. .... *Lilium philadelphicum* var. *andidum.*

CC. Flowers with perianth segments strongly recurved; segments of perianth not clawed; bulbs rhizomatous

D. Leaves chiefly whorled, not bulblet-bearing in upper axils .... *Lilium michiganense.*

DD. Leaves scattered and bulblet-bearing in upper axils. .... *Lilium tigrinum.*

BB. Flowers smaller or if large with green sepals; fruit a short, elliptic to globose capsule, 1–2 cm. long, or a berry

C. Leaves in one or two whorls

D. Flowers not more than 1.5 cm. in diameter and in a sessile umbel; leaves in two (rarely 3) whorls, a whorl of 7–9 leaves at the middle of stem and a smaller whorl of 3–5 leaves at the top .... *Medeola virginiana.*

DD. Flowers 2 to several cm. in diameter, showy with green sepals, solitary and terminal; leaves 3, in one whorl

E. Flower sessile; petals dark purple and narrowed to a claw at the base .... *Trillium recurvatum.*

EE. Flower peduncled

F. Leaves short-petioled, (petiole 4–8 mm. long). .... *Trillium nivale.*

FF. Leaves sessile, or rarely one short-petioled one, (petiole 2 mm. long)

G. Anthers exceeding the stigmas; petals large (4–8 cm. long) and white, turning rose color when old; peduncle erect or nearly so .... *Trillium grandiflorum.*

GG. Anthers not exceeding the stigmas; peduncle horizontal, recurved or reflexed

H. Filaments very short, about a third as long as the anthers or less; anthers 6–15 mm. long, usually yellow .... *Trillium flexipes.*

HH. Filaments nearly as long or equalling anthers

I. Anthers 2.5–4.5 mm. long; petals 5–10 mm. broad .... *Trillium cernuum.*

II. Anthers 4–6.5 mm. long; petals 9–17 mm. broad. .... *Trillium cernuum* var. *macranthum.*

CC. Leaves alternate

D. Plant feathery in appearance with leaves reduced to scales and the filiform branches in alternate clusters; flowers axillary.......................... *Asparagus officinalis.*

DD. Plant with flat leaves

E. Flowers axillary or terminal, solitary or several, or in umbels, not racemose

F. Flowers one to several in each axil, or terminal, not umbellate

G. Peduncles fused partway up the internodes and appearing under the leaf above

H. Nodes fringed; leaves sessile, not clasping, with strongly ciliate margins (20–30 cilia per cm.); perianth segments not recurved except at tip; flowers pink.......... *Streptopus roseus* var. *longipes.*

HH. Nodes glabrous; leaves cordate-clasping with weakly to strongly ciliate margins; perianth segments widely spreading or recurved; flowers yellow

I. Leaf margins entire or with up to about 6 teeth per cm..... *Streptopus amplexifolius* var. *americanus.*

II. Leaf margins with 10–25 minute teeth per cm. .... *Streptopus amplexifolius* var. *denticulatus.*

GG. Peduncles not fused with internodes, directly above leaves from whose axils they come.

H. Flowers small and greenish (10–20 cm. long); pedicel jointed near flower; fruit a berry

I. Leaves puberulent beneath at least on minor nerves, glaucous, usually with 3–9 prominent nerves...................... *Polygonatum pubescens.*

II. Leaves glabrous beneath but glaucous, with 1–7 prominent nerves......... *Polygonatum commutatum.*

HH. Flowers mostly larger and yellowish (12–45 mm. long); pedicel not jointed; fruit a capsule

I. Leaves perfoliate; capsule 3-lobed, truncate. .... *Uvularia grandiflora.*

II. Leaves sessile, not perfoliate; capsule sharply 3-angled....................... *Uvularia sessilifolia.*

FF. Flowers in umbels in axils of leaves; dioecious

G. Stem with long, blackish bristles, woody. .*Smilax hispida.*

GG. Stem without bristles, herbaceous

H. Mature leaves pale and glabrous beneath; umbels of both staminate and pistillate plants with 25–80 flowers...................... *Smilax herbacea.*

HH. Leaves pale and pubescent beneath
I. Plant tendril-bearing; umbels of both staminate and pistillate flowers with 30–110 flowers. ....*Smilax herbacea* var. *lasioneura.*
II. Plant not tendril-bearing or only upper petioles; staminate plants with fewer than 25 flowers and pistillate with fewer than 20....*Smilax ecirrhata.*

EE. Flowers racemose
F. Stem leaves 2–3 in number and less than 9 cm. long, cordate at the base, the lower one usually short-petioled; perianth 4-parted
G. Lower leaf surface glabrous, margins merely papillate or crenulate..............*Maianthemum canadense.*
GG. Lower leaf surface pubescent at least on the veins, margins abundantly ciliate. ....*Maianthemum canadense* var. *interius.*
FF. Stem leaves usually more than 3 and usually longer than 9 cm., not cordate, generally all sessile; perianth 6-parted
G. Leaves 2–4; inflorescence a peduncled raceme. ....*Smilacina trifolia.*
GG. Leaves more than 6
H. Inflorescence a raceme, sessile or nearly so; plant 2–5 dm. high; leaves oblong-lanceolate and slightly clasping, 7–12 in number...*Smilacina stellata.*
HH. Inflorescence a peduncled panicle, (rarely sessile); plant 4–10 dm. high; leaves oblong or oval-lanceolate, short petioled, 7-many in number..........................*Smilacina racemosa.*

CLINTONIA Raf.

CLINTONIA BOREALIS (Ait.) Raf. Map 1.

Following cool, moist rich woods, cedar swamps, spruce woods, and tamarack bogs; abundant northward and locally southward in bogs, at Wisconsin Dells and along Lake Michigan.

ALLIUM L. Onion

ALLIUM TRICOCCUM Ait. Wild Leek. Map 2.

A good indicator of rich, moist woods, often being found in maple-basswood associations throughout the state.

Both races of *A. tricoccum* recognized by Hanes and Ownbey, Rhodora 48:61–63. 1946, appear in Wisconsin. There is no geographical distinction however; both are scattered across the state.

ALLIUM CANADENSE L. Wild Garlic. Map 3.

Confined largely to glacial drift in the southeastern part of the state from Brown and Waupaca counties down through Lafayette and Racine counties. Also in the northwest in Polk County. Rich woods, wet or dry prairie, and river bottoms.

ALLIUM CERNUUM Roth. Wild Onion. Map 4.

Four southeastern counties of this state, Kenosha, Racine, Milwaukee, and Walworth with one specimen from Lafayette County. The habitat is prairie, sunny with sandy loam. *Poa, Silphium,* and *Tradescantia* spp. are common associates of this plant.

ALLIUM STELLATUM Ker. Map 5.

Occurs in northwestern Wisconsin from Douglas to St. Croix and Dunn counties. Found along railroads, on sand barrens, on rocky ground.

ALLIUM SCHOENOPRASUM L. Chives. Map 6.

Introduced from Europe. Not common.

ERYTHRONIUM L. Dog's Tooth Violet

ERYTHRONIUM AMERICANUM Ker. Yellow Adder's Tongue. Map 7.

Rich maple-basswood woods, damp thickets, and wooded banks. Local and apparently absent from much of southern Wisconsin. Forma BACHII (Farwell) Dole is found at Two Rivers, Manitowoc County. It is a color form based on the fact that the lower half of the perianth segments and the stamens are purplish-brown or magenta.

ERYTHRONIUM ALBIDUM Nutt. White Dog's Tooth Violet. Map 8.

Common southward, local northward, in rich damp woods. It appears to avoid the large area of granite in northeastern Wisconsin which is part of the Laurentian Shield.

TOFIELDIA Huds. False Asphodel

TOFIELDIA GLUTINOSA (Michx.) Pers. Map 9.

Recorded from only five counties in Wisconsin: Milwaukee, Waukesha, Green Lake, Manitowoc, and Door. Wisconsin specimens are all subsp. TYPICA, Hitchcock, C. L., Am. Mid. Nat. 31:487–498. 1944.

ALETRIS L.

ALETRIS FARINOSA L. Map 10.

Local in Wisconsin, being found in sandy places in the central part of the state or southward. Wet or moist prairies or open woods with prairie habitats.

CAMASSIA Lindl.

CAMASSIA SCILLOIDES (Raf.) Cory. Map 11.

On relic prairies along railroads on the southern border of the state. Not very common.

ZIGADENUS Michx.

The characters used in the key to distinguish the eastern Z. GLAUCUS Nutt. from the western Z. ELEGANS are quoted from that of Fernald, Rhodora 37:256–258. 1935.

Our material appears to consist of both species with many intermediates. *Zigadenus* occurs in a variety of habitats in Wisconsin from rocky and sandy hillsides to dunes, fields, swamps, and lake shore. Map 12.

LILIUM L. Lily

LILIUM PHILADELPHICUM L. Wood Lily. Map 13, crosses.

The typical form of this species is found only in Door County, probably coming in from the northeast on the Niagara limestone that follows down the Lake Michigan shore.

LILIUM PHILADELPHICUM L. var. ANDIDUM (Nutt.) Ker. Map 13, dots.

Found on sand flats, low prairies and in bogs. It appears to be granite-avoiding in this state.

LILIUM MICHIGANENSE Farwell. Turk's Cap Lily. Map 14.

Low prairie, marsh, or low woods, preferring heavy, mucky soils. Abundant throughout the state.

LILIUM TIGRINUM Ker. Tiger Lily.

Introduced from eastern Asia. A garden escape.

MEDEOLA L.

MEDEOLA VIRGINIANA L. Indian Cucumber Root. Map 15.

Found in rich, damp woods along the Lake Michigan shore and up into Oconto County. Deam mentions its preference for deep, wooded ravines or beech woods. This is of significance in Wisconsin since beech woods are found in the same range as *Medeola*—the broken line on the map indicates the western limit of beech.

TRILLIUM L.

TRILLIUM RECURVATUM Beck. Map 16.

Found in southern Wisconsin in rich, moist woods. It appears to have entered the state by two routes, one following Lake Michigan and the other up the Pecatonica River.

TRILLIUM NIVALE Riddell. Map 17.

Rather rare on limestone slopes and cliffs on the two main regions of limestone in the state, along the eastern border of the state and in the northwest around Pierce and St. Croix counties.

TRILLIUM GRANDIFLORUM (Michx.) Salis. Map 18.

Found in rich, moist woods throughout the state. Many freak forms of this species have been found with odd numbers of leaves, petals, and sepals.

TRILLIUM FLEXIPES Raf. *T. Gleasoni* Fern., *T. declinatum* (Gray) Gleason. Map 19.

Anderson, W. A., Rhodora 36:121. 1934; Fernald, M. L., Rhodora 46:16–17. 1944; Fernald, M. L., Rhodora 34:21–22, 1932.

Rich woods in southern Wisconsin. There are two specimens of doubtful identification from Pierce and Outagamie counties. They are probably *T. cernuum* rather than *T. flexipes* since they are definitely out of the latter's range.

TRILLIUM CERNUUM L. Map 20.

Eames, A. J., and Wiegand, K. M., Rhodora 25:191. 1923.

Uncommon in this state, found mostly in eastern Wisconsin down to Sheboygan County and in the northern part of Wisconsin in Douglas, Washburn, Ashland and Price counties. Eames and Wiegand say this species is only east of the Alleghanies but several Wisconsin species resemble the var. *typicum* exactly. It is quite rare, however as, compared with var. *macranthum*.

TRILLIUM CERNUUM var. MACRANTHUM Eames & Wiegand. Map 21.

In wet woods throughout Wisconsin; local southward.

ASPARAGUS (Tourn.) L.

ASPARAGUS OFFICINALIS L. Garden Asparagus. Map 22.

Introduced from Europe; common.

STREPTOPUS Michx. Twisted Stalk

STREPTOPUS ROSEUS var. LONGIPES (Fernald) Fassett. Map 23.

Fassett, N. C., Rhodora 37:110. 1935.

Abundant northward and eastward in rich woods; local in the Driftless Area in sphagnum bogs and woods.

STREPTOPUS AMPLEXIFOLIUS var. DENTICULATUS Fassett. Map 24.

Ibid., 98.

Local in wet woods in the Lake Superior region. Intermediates between it and var. *americanus* sometimes are found.

POLYGONATUM [Tourn.] Hill. Solomon's Seal

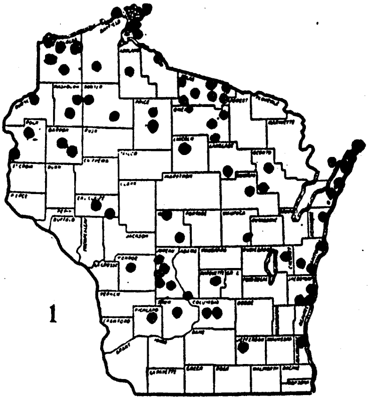
Bush, B. F., Am. Mid. Nat. 10:385–400. 1927; Farwell, O. A., Bull. Torrey Bot. Cl. 42:247–257. 1915; Fernald, M. L., Rhodora 46:9–11. 1944; Gates, R. R., Bull. Torrey Bot. Cl. 44:117–125. 1917; Ownbey, Ruth Peck, Ann. Mo. Bot. Gard. 31:373–413. 1944.

POLYGONATUM PUBESCENS (Willd.) Pursh. Map 25.

Distributed nearly throughout Wisconsin in low, rich woods; local southward.

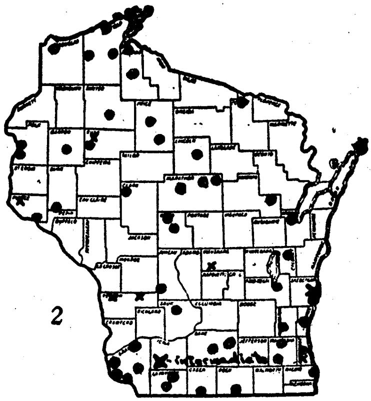
POLYGONATUM COMMUTATUM (R. & S.) Dietr. Map 26.

Quite common in Wisconsin in a variety of habitats from oak woods to dry sand banks and river bottoms. In the latest work done on *P. commutatum* it was found to be a tetraploid, small individuals to be separated from the diploid *P. biflorum* only by the chromosome number. Chromosome counts of the following specimens, many of them small and *biflorum*-like, were made by Mr. J. G. Ross; all were found to be tetraploid ($n = 20$). Vernon Co.: Bakelein Church, Coon Valley, May 11, 1946, *Fassett 26100;* oak woods 3 mi. southeast of Coon Valley, Sec. 22, T. 14 N., R. 5 W., May 12, 1946, *Fassett 26100; ibid., Fassett 26112;* Sec. 4, T. 14 N., R. 5 W., May 12, 1946, *Fassett 26115; ibid., Fassett 26116*. Sauk Co.: Ableman Gap, May 12, 1946, *Fassett 26124; ibid., Fassett 26127*. Dodge Co.: oak woods near Clyman, Sec. 30, T. 10 N., R. 15 E., May 25, 1946, *Fassett 26189*.



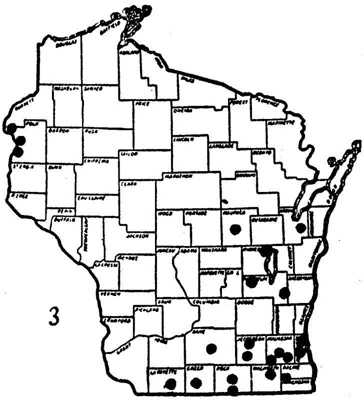
1

Clintonia borealis



2

● Allium tricoccum
✕ reddish race



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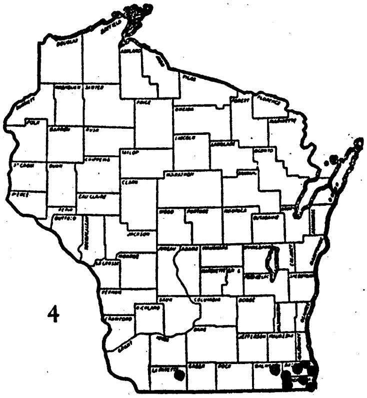
Allium canadense



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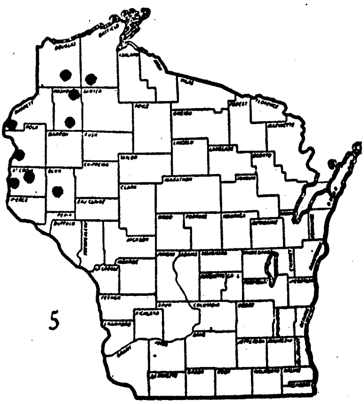
Allium cernuum



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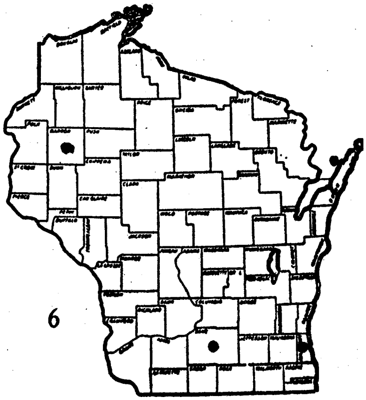
Allium stellatum



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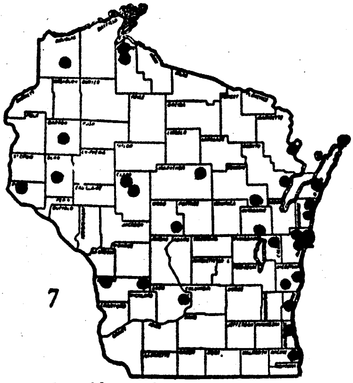
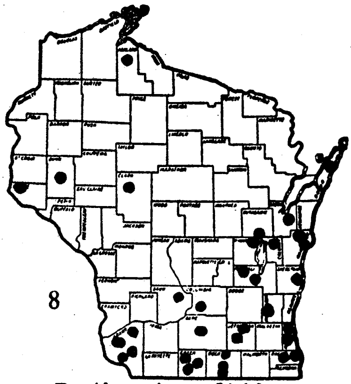
Allium Schoenoprasum



7

Erythronium americanum



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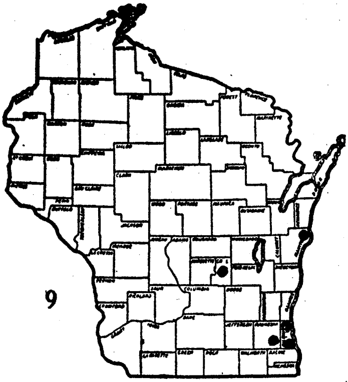
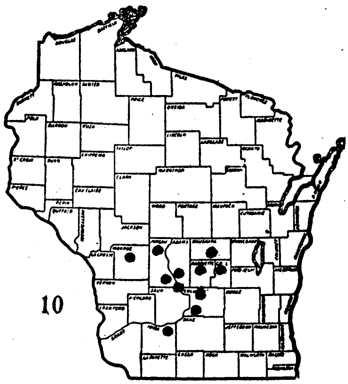
Erythronium albidum



9

Tofieldia glutinosa



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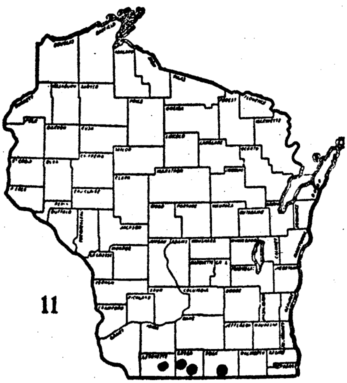
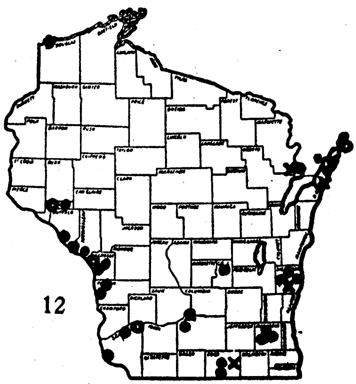
Aletris farinosa



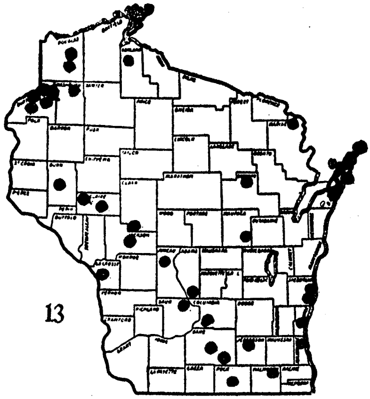
11

Camassia scilliodes



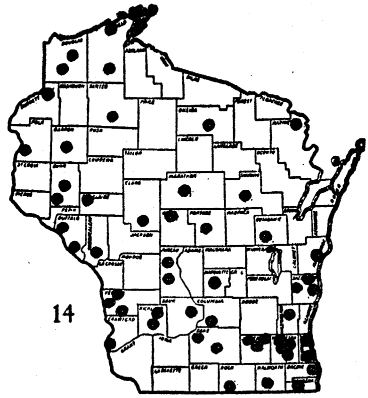
12

● Zigadenus elegans
◉ Intermediate
✖ Zigadenus glaucus



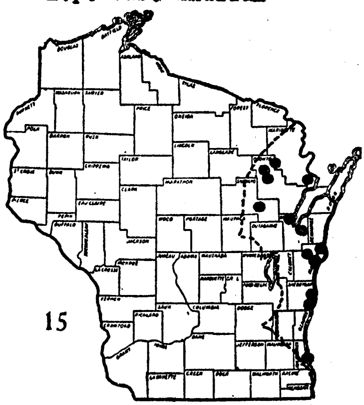
13

X Lilium philadelphicum
● L.p. var. andidum



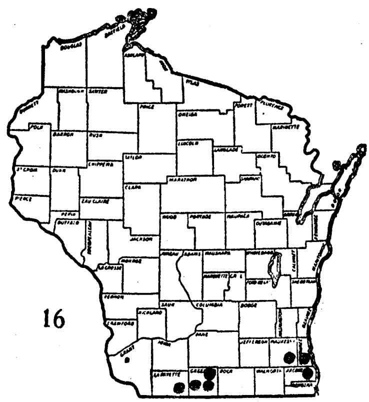
14

Lilium michiganense



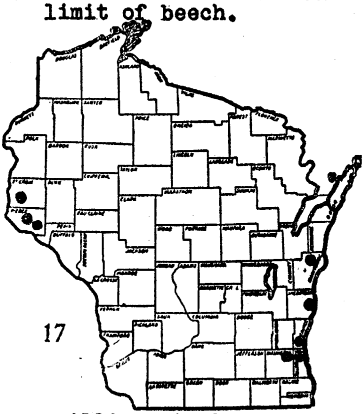
15

Medeola virginiana
Dotted line is western limit of beech.



16

Trillium recurvatum



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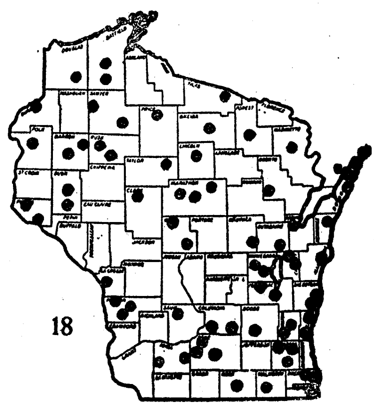
Trillium nivale



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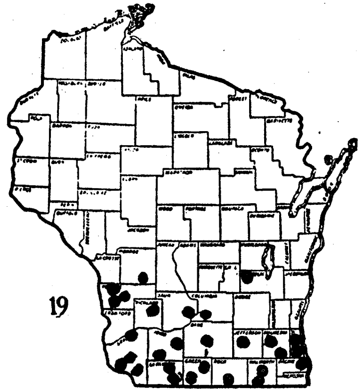
Trillium grandiflorum



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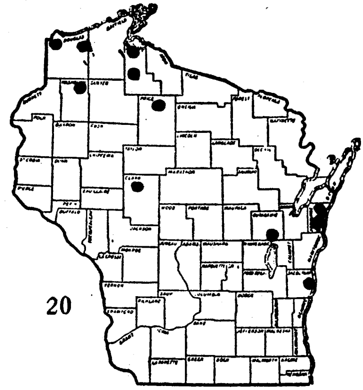
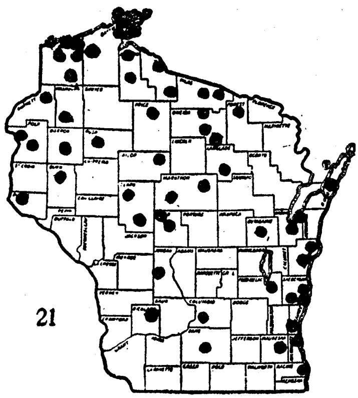
Trillium flexipes



20

Trillium cernuum



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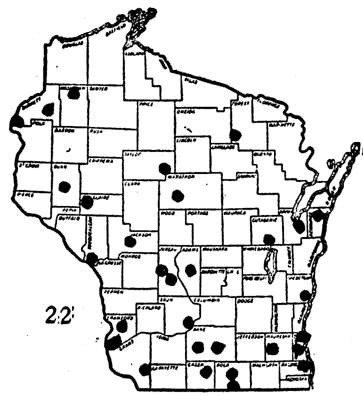
T. cernuum var. macranthum



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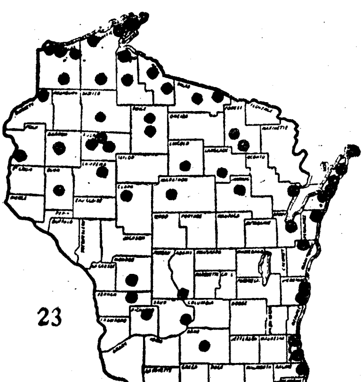
Asparagus officinalis



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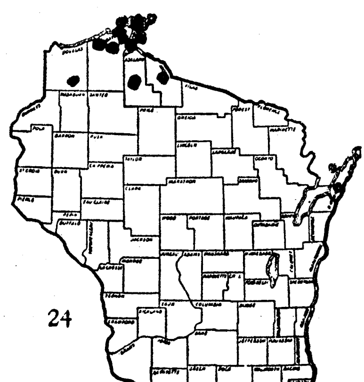
Streptopus roseus var. longipes



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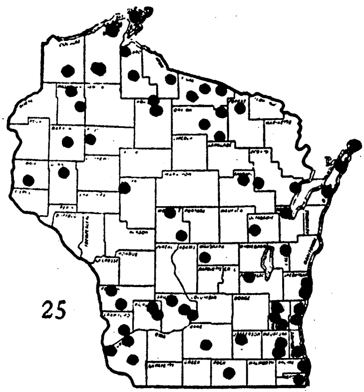
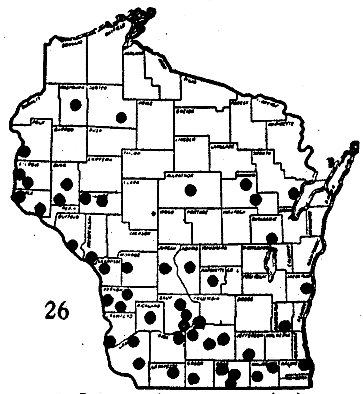
Streptopus amplexifolius var. denticulatus



25

Polygonatum pubescens



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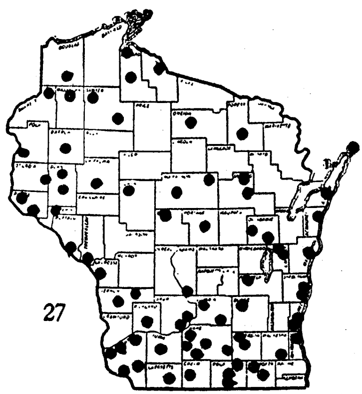
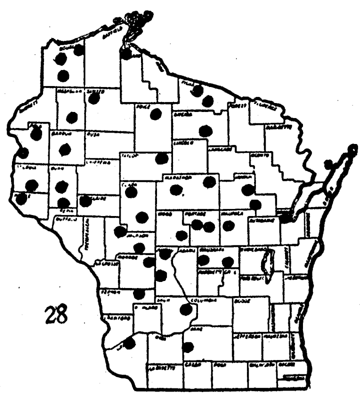
Polygonatum commutatum



27

Uvularia grandiflora



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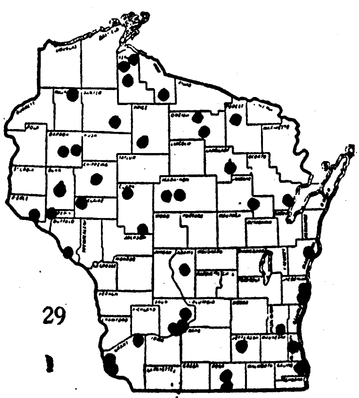
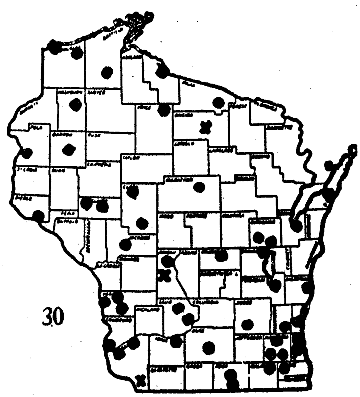
Uvularia sessilifolia



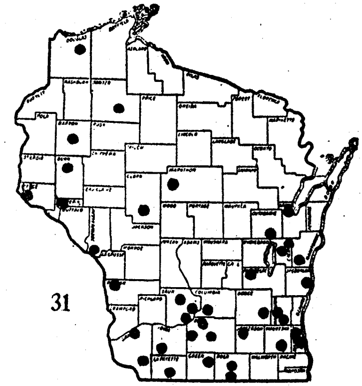
29

Smilax hispida



30

✖Smilax herbacea
●var. lasioneura



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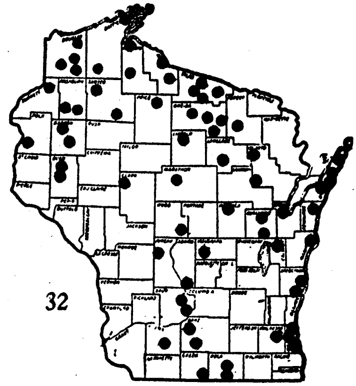
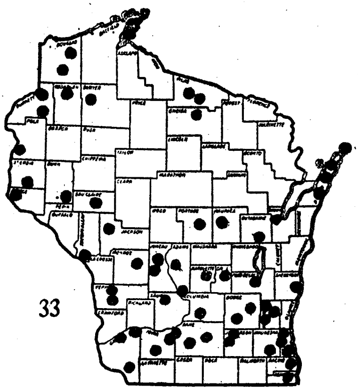
Smilax ecirrhata



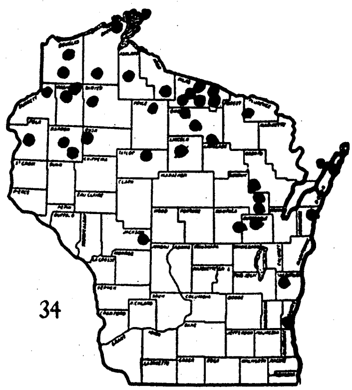
32

Maianthemum canadense



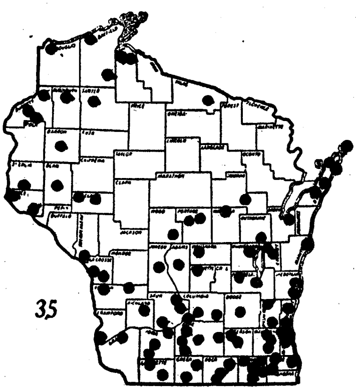
33

Maianthemum canadense
var. interius



34

Smilacina trifolia



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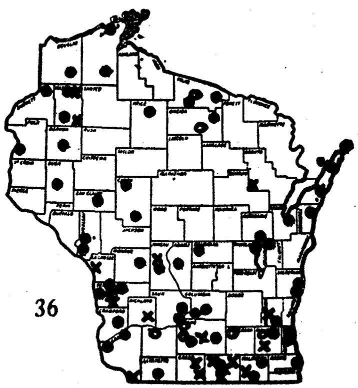
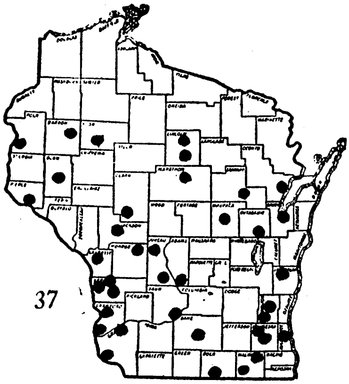
Smilacina stellata



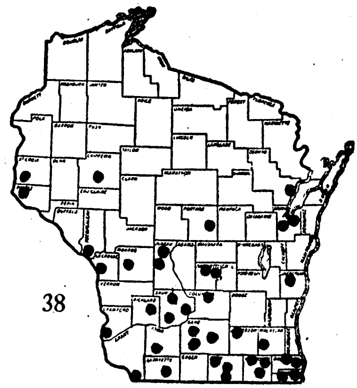
36

● Smilacina racemosa var. typica
✕ var. cylindrata
◐ intermediate



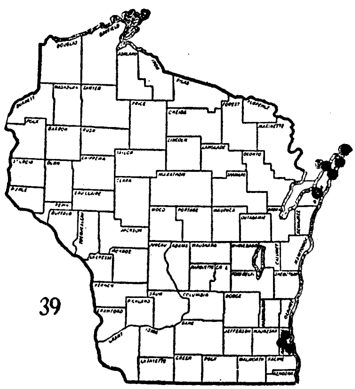
37

Dioscorea villosa



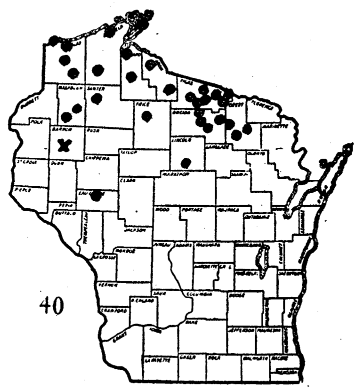
38

Hypoxis hirsuta



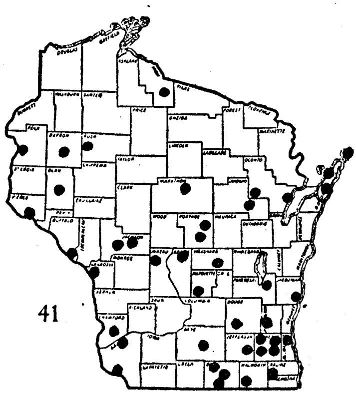
39

Iris lacustris



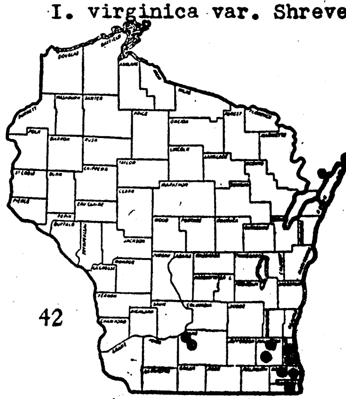
40

●Iris versicolor
✖Intermediate between it and I. virginica var. Shrevei



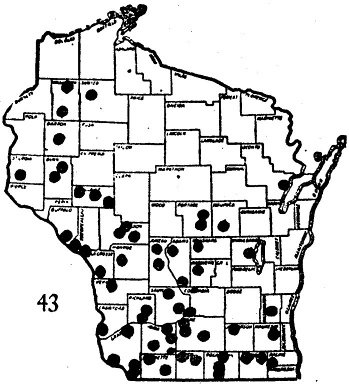
41

Iris virginica var. Shrevei



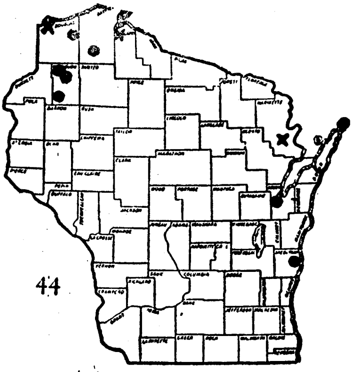
42

Sisyrinchium albidum



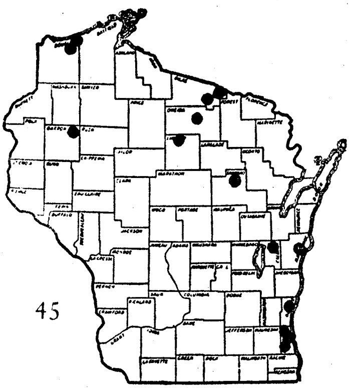
43

Sisyrinchium campestre



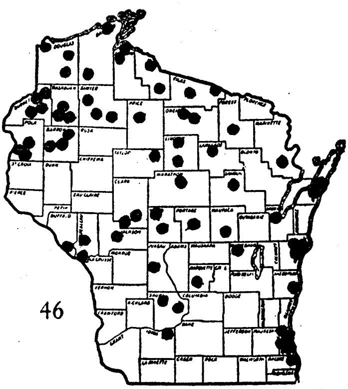
44

● Sisyrinchium montanum
✕ S. montanum var. crebrum



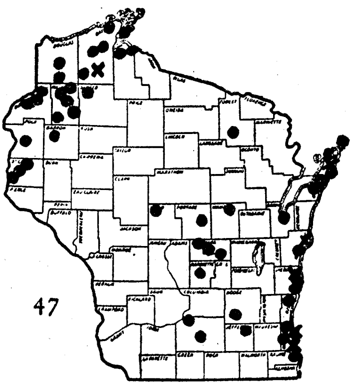
45

Sisyrinchium angustifolium



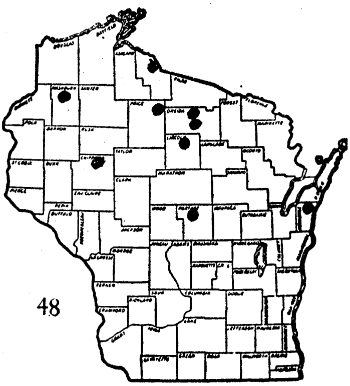
46

● Juncus effusus



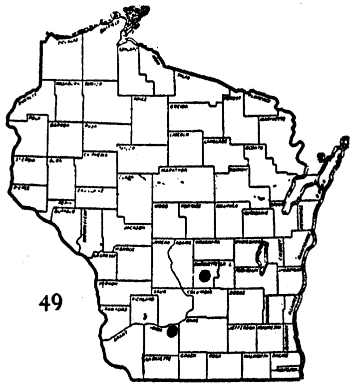
47

● Juncus balticus var. littoralis
✕ f. dissitiflorus



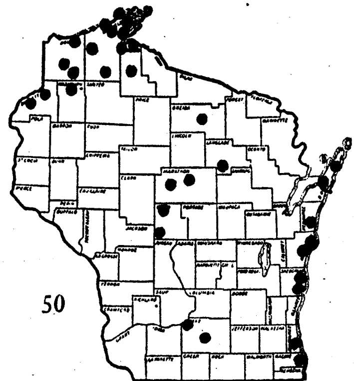
48

Juncus filiformis



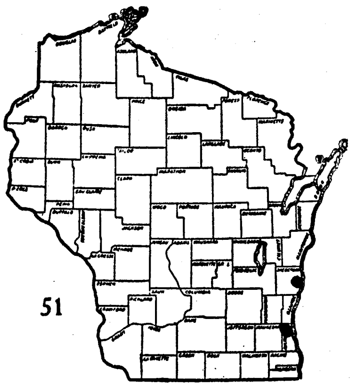
49

Juncus marginatus



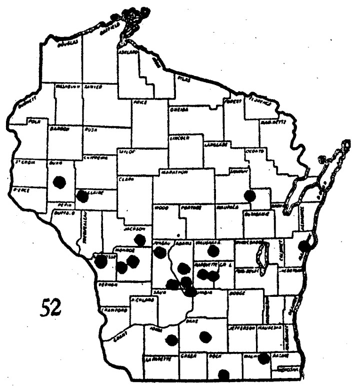
50

Juncus bufonius



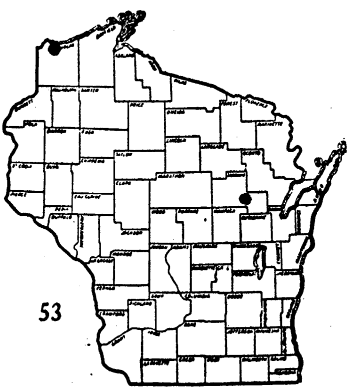
51

Juncus Gerardi



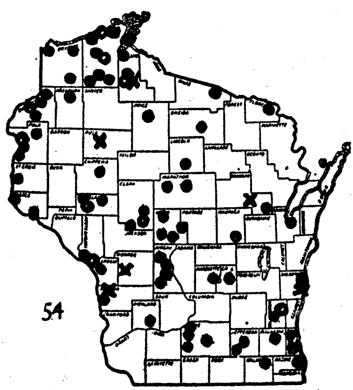
52

Juncus Greenei



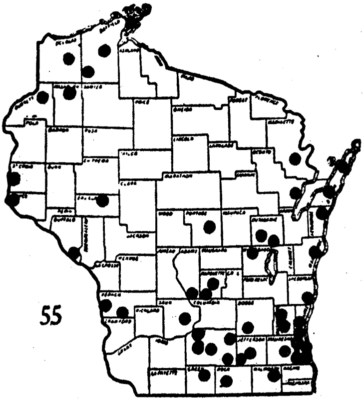
53

Juncus Vaseyi



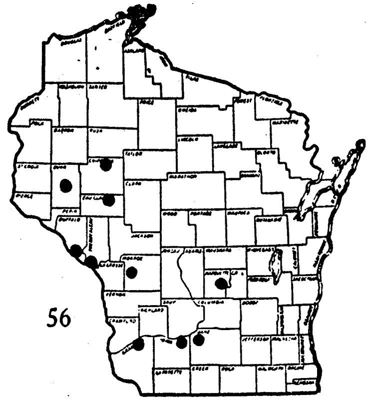
54

● Juncus tenuis
✕ f. anthelatus
○ f. Williamsii



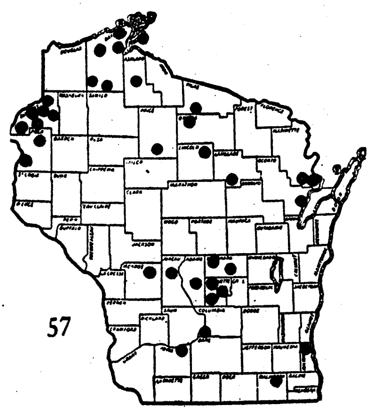
55

Juncus Dudleyi



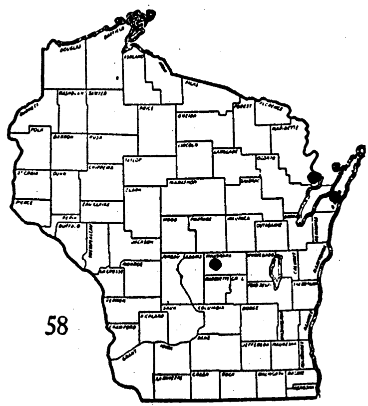
56

Juncus interior



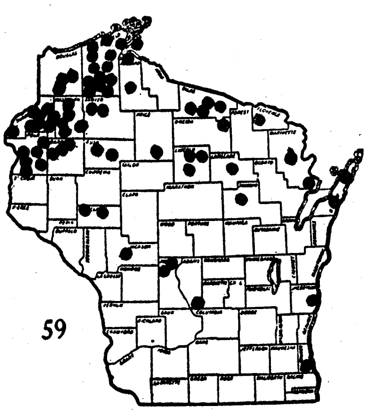
57

Juncus canadensis



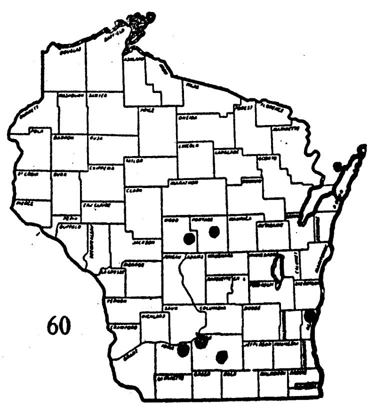
58

Juncus brachycephalus



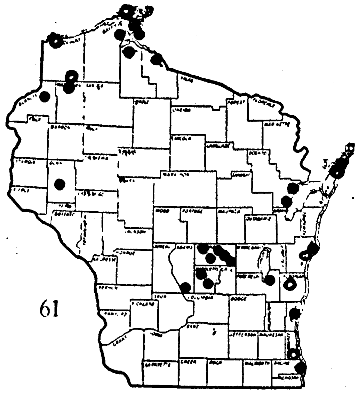
59

Juncus brevicaudatus



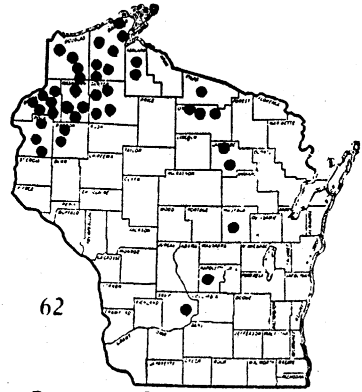
60

Juncus acuminatus



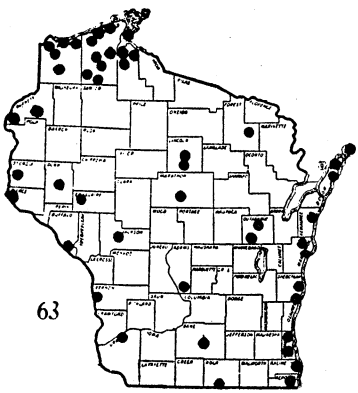
61

● Juncus alpinus
○ var. rariflorus



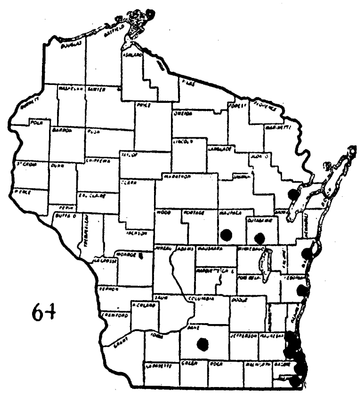
62

Juncus pelocarpus



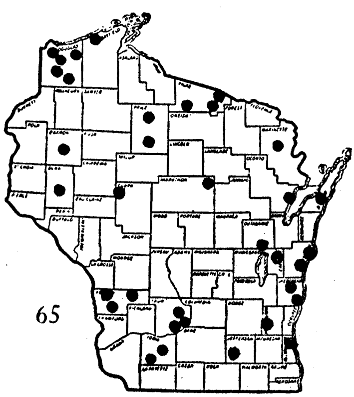
63

Juncus nodosus



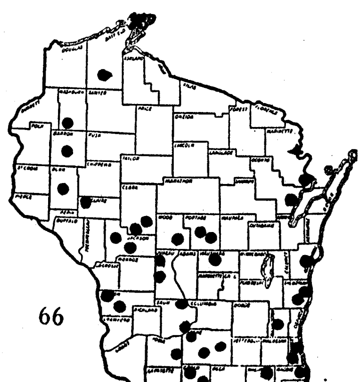
64

Juncus Torreyi



65

Luzula acuminata



66

● Luzula multiflora
✗ var. bulbosa

SMILAX [Tourn.] L. Green Briar

Pennell, F. W., Bull. Torrey Bot. Cl. 43:409–421. 1916.

SMILAX HISPIDA Muhl. Map 29.

Generally distributed in the north, rare southward.

SMILAX HERBACEA L. Map 30, crosses.

Only found in Juneau and Oneida counties.

SMILAX HERBACEA var. LASIONEURA (Hook) A. DC. Map 30, dots.

Scattered throughout Wisconsin on dry ground, although the habitat may vary from meadow or open woods to limestone cliff or steep sand slope.

SMILAX ECIRRHATA (Engelm.) Wats. Map 31.

Woods, usually low woods. Mostly in the southern half of the state although a few plants have been found in Barron, Pepin, and Pierce counties.

UVULARIA L. Bellwort

UVULARIA GRANDIFLORA J. E. Smith. Map 27.

Common in woods throughout Wisconsin.

UVULARIA SESSILIFOLIA (L.) Wats. Map 28.

Woods south to Dane County and rarely Grant County in Wisconsin.

MAIANTHEMUM Wiggers

Butters, F. K., Minn. Studies in Pl. Sc. 5:429–444. 1927; Fernald, M. L., Rhodora 16:210–211, 1914.

MAIANTHEMUM CANADENSE Desf. Map 32.

Most common in northern Wisconsin, although found in Rock County, along the Wisconsin River valley, and Lake Michigan shore. It is found chiefly in moist places but some specimens have been collected from dry cliffs and wooded talus slopes.

MAIANTHEMUM CANADENSE (L.) Desf. var. INTERIUS Fernald. Map 33.

A similar range as the typical phase of the species and also in moist woods and bogs. Its most abundant distribution seems to be in southern Wisconsin but it is scattered all through the state.

SMILACINA Desf.

SMILACINA TRIFOLIA (L.) Desf. Map 34.

In northern Wisconsin south to Jackson County, and east in Sheboygan, Ozaukee, and Milwaukee counties.

SMILACINA STELLATA (L.) Desf. Map 35.

A fairly common species, particularly in the southern part of the state. Found in both dry and moist habitats.

SMILACINA RACEMOSA (L.) Desf. False Solomon's Seal. Map 36.

Fernald, M. L., Rhodora 40:404–407. 1938; Galway, Desma H., Am. Mid. Nat. 33:644–666. 1945.

Common in woods. Fernald separated this into var. *typica* and var. *cylindrata* which he considered a southern variety. Both may be found in almost any colony of *S. racemosa* in Wisconsin.

DIOSCORACEAE

DIOSCOREA VILLOSA L. Wild Yam Root. Map 37.

Found in rich woods throughout Wisconsin as far north as Lincoln and Polk counties.

AMARYLLIDACEAE

HYPOXIS HIRSUTA (L.) Coville. Yellow Star Grass. Map 38.

Open woods and prairies throughout southern Wisconsin and as far north as Brown, Chippewa, and Pierce counties.

IRIDACEAE

A. Leaves usually over 1 cm. wide; flowers several cm. long; stigmas petal-like
  B. Plant short with stem 0.5–1.5 dm. high; perianth tube 1 cm. or more in length. . . . . *Iris lacustris.*
  BB. Plant taller with stem 1.5–5 dm. high; perianth tube 5 mm. or less in length
    C. Petals shorter than the styles; ovary less than 2 cm. in length; outermost bracts of inflorescence darker and somewhat vernicose along the margins; sepals with a dull greenish-yellow spot at base of blade. . . . . *Iris versicolor.*
    CC. Petals slightly longer than styles; ovary 2 cm. or more in length; outermost bracts of the inflorescence with undifferentiated margins; sepals with a bright yellow spot at base of blade. . . . . *Iris virginica* var. *Shrevei.*

AA. Leaves less than 1 cm. wide; flowers about 1 cm. long; stigmas thread-like

B. Spathes 2, with a single outer leaf-like bract. .*Sisyrinchium albidum.*

BB. Spathes solitary, enclosed by two green bracts

C. Outer, longer bract with margins free to base. ....*Sisyrinchium campestre.*

CC. Outer bract with margins united for a short distance above the base.

D. Spathe terminating the culm (rarely a peduncled spathe present)

E. Leaves and stems whitish-green with whitish-brown or straw colored capsules.............*Sisyrinchium montanum.*

EE. Leaves and stems dark green with green or purple-suffused capsules which become almost black when ripe..................*Sisyrinchium montanum* var. *crebrum.*

DD. Spathes peduncled from the axils of a leaf-like bract. ....*Sisyrinchium angustifolium.*

IRIS [Tourn.] L. Fleur-de-lis

IRIS LACUSTRIS Nutt. Lake Dwarf Iris. Map 39.

Found along shore in Door and Milwaukee counties in this state. Those inland in Milwaukee County are on the abandoned beaches of Lake Michigan, relics of a time when the lake was higher. (Shinners, L. H., Vegetation of the Milwaukee Region, B. A. thesis, U. of Wis., 1940.)

IRIS VERSICOLOR L. Map 40.

Wet places in northern Wisconsin. A few individuals are intermediate with the next.

IRIS VIRGINICA var. SHREVEI (Small) Anderson. Map 41.

Anderson, Edgar, Ann. Mo. Bot. Garden 23:459–469. 1936.
Scattered in wet places throughout Wisconsin.

SISYRINCHIUM L. Blue-eyed Grass

SISYRINCHIUM ALBIDUM Raf. Map 42.

Sunny fields in southern Wisconsin. Not common.

SISYRINCHIUM CAMPESTRE Bick. Map 43.

Common in sunny fields as far north as Washburn and Sawyer counties. Particularly abundant in southwestern Wisconsin.

SISYRINCHIUM MONTANUM Greene. Map 44, dots.

S. angustifolium sensu Bicknell in Bull. Torrey Club 26:336. 1889, in part only.

Found in northwestern Wisconsin and northeastern Wisconsin along the lake shore.

SISYRINCHIUM MONTANUM var. CREBRUM Fernald. Map 44, crosses.

This variety is considered as a more eastern plant by Fernald, *Rhodora* 48:159. 1946, but there are several specimens from Wisconsin that resemble this darker variety of *S. montanum.*

SISYRINCHIUM ANGUSTIFOLIUM Mill. Map 45.

S. gramineum Curtis, 7th ed. Gray; *S. anceps* Man. ed. 6; *S. graminoides* Bick.

Wet meadows and damp woods, New Hampshire to Minnesota and southward. Not frequent in Wisconsin.

JUNCACEAE

A. Capsule 3-celled, many seeded; plant not hairy
  B. Inflorescence apparently borne on the side of the stem
    C. Rootstocks short-creeping with inconspicuous internodes; culms caespitose; stamens 3 .... *Juncus effusus.*
    CC. Rootstocks long-creeping with conspicuous internodes; culms usually well separated, arising in a single row; stamens 6
      D. Flowers brown, 3.5–5.0 mm. long; involucral leaf much shorter than the stem
        E. Inflorescence not diffuse, 1.5–3.5 cm. long; flowers approximate or subapproximate. . *Juncus balticus* var. *littoralis.*
        EE. Inflorescence diffuse, 4–12 cm. long; flowers widely separated .... *J. balticus* var. *littoralis* f. *dissitiflorus.*
      DD. Flowers green, 2–3 mm. long; involucral leaf nearly or quite as long as the stem below the inflorescence. .... *Juncus filiformis.*
  BB. Inflorescence obviously terminating the stem
    C. Leaves flat, or in age involute, not septate (terete in *J. Greenei*)
      D. Flowers in heads .... *Juncus marginatus.*
      DD. Flowers borne singly on the branches of the inflorescence
        E. Inflorescence more than half the height of the plant; flowers scattered along the loose, forking branches; annual .... *Juncus bufonius.*
        EE. Inflorescence much less than half the height of the plant; perennial
          F. Leaf sheaths covering half of the stem or more. .... *Juncus Gerardi.*
          FF. Leaf sheaths covering ¼ of stem or less
            G. Leaves terete; capsule much exceeding perianth, reddish or castaneous .... *Juncus Greenei.*

GG. Leaves involute or flat.

H. Leaves nearly involute, channeled on one side; seeds with long caudate appendages....*Juncus Vaseyi.*

HH. Leaves mostly flat or involute in age; seeds short-pointed or blunt

I. Auricles at summit of sheath very thin, white, and scarious, conspicuously produced beyond the point of insertion (1.0–3.5 mm. long)

J. Flowers clustered mostly at the tips of the branches..........................*Juncus tenuis.*

JJ. Flowers scattered or somewhat secund along the branches

K. Ultimate floriferous branches elongate and ascending up to 4 cm. long. ....*J. tenuis* f. *anthelatus.*

KK. Ultimate floriferous branches widely spreading, 0.5–2.0 cm. long. ....*J. tenuis* f. *Williamsii.*

II. Auricles at summit of sheath firm

J. Bracteoles blunt to acute; auricles cartilaginous, yellow, becoming brown with age, very rigid and glossy, especially the short produced portion; inflorescence generally compact; perianth widely spreading...*Juncus Dudleyi.*

JJ. Bracteoles acuminate to aristate; auricles with the very slightly produced portion membranaceous, not rigid (easily broken), stramineous, often tinged with brown or light red, occasionally somewhat cartilaginous along the sides below the summit; inflorescence generally loose; perianth from appressed to slightly spreading.......*Juncus interior.*

CC. Leaves hollow, septate

D. Seeds with tails

E. Seeds with conspicuous tails, their total length 1–1.8 mm.; capsule equalling or moderately exceeding calyx; heads few to many with 5–50 flowers in a head...*Juncus canadensis.*

EE. Seeds with total length of 1 mm. or less; capsule usually much exceeding calyx; heads numerous with 3–7 flowers in a head

F. Mature fruit about 2.5 mm. long; seeds very short-tailed, total length usually less than 1 mm.; heads numerous in diffuse panicle, 3–5 flowers in a head. ....*Juncus brachycephalus.*

FF. Mature fruit about 4 mm. long; seeds with longer tails, total length about 1 mm.; heads numerous on a fairly erect cyme, 3–7 flowers in a head. ....*Juncus brevicaudatus.*

DD. Seeds without tails
E. Stamens 3, one behind each sepal........*Juncus acuminatus.*
EE. Stamens 6, behind each sepal and petal
F. Flowers solitary or in pairs, often reduced to fascicles of small leaves..................*Juncus pelocarpus.*
FF. Flowers more numerous, in glomerules
G. Flowers in hemispherical heads; involucral bract much shorter than the inflorescence
H. None of the flowers stalked within the heads. ....*Juncus alpinus.*
HH. One or more flowers within each head stalked. ....*Juncus alpinus* var. *rariflorus.*
GG. Flowers in spherical heads; involucral bract usually exceeding inflorescence
H. Plant 1–4 dm. high; flowers 3–4 mm. long; petals equalling or exceeding sepals...*Juncus nodosus.*
HH. Plant 4–10 dm. high; flowers 4–5 mm. long; petals shorter than sepals............*Juncus Torreyi.*
AA. Capsule 1-celled, 3-seeded; plant often hairy
B. Flowers solitary at tips of branches of inflorescence. ....*Luzula acuminata.*
BB. Flowers crowded in spikes or glomerules
C. Cauline leaves large, (7–)9–14 cm. long, (4–6)–9 mm. wide; filaments equalling the anthers; perianth averaging 3 mm. long, usually slightly exceeding the capsule; base of plant rarely producing bulbs........................*Luzula multiflora.*
CC. Cauline leaves small, 3–5.5 cm. long, 2–3 mm. wide; filaments shorter than the anthers; perianth averaging 2.5 mm. long, shorter than the capsule; base of plant commonly producing bulbs....................*Luzula multiflora* var. *bulbosa.*

JUNCUS [Tourn.] L.

JUNCUS EFFUSUS L. Map 46.

Juncus effusus is very variable in Wisconsin. Var. *Pylaei* seems to be common in the north, while several sheets from Arena in Iowa County are clearly var. *solutus*. But many collections cannot be placed by use of the revision of Fernald and Wiegand, Rhodora 12:90–92. 1910. Some plants of the north approach var. *solutus* in their robust culms, but have smaller flowers with more spreading sepals. Several other combinations of characters suggest that a revision of this species in the Middle West would be in order.

JUNCUS BALTICUS Willd. var. LITTORALIS Engelm. Map 47, dots.

J. balticus has come into Wisconsin along the Lake Michigan shore and the shores of three former glacial lakes, namely, Lake

Wisconsin, L. Oshkosh, and Barrens Lake. Distribution in the state is centered around those four areas.

JUNCUS BALTICUS var. LITTORALIS f. DISSITIFLORUS Engelm. Map 47, crosses.
Rhodora 25:208, 1923.
Same range as variety but less frequent.

JUNCUS FILIFORMIS L. Map 48.
Wet places along lakes and rivers, south to Portage County.

JUNCUS MARGINATUS Rostk. Map 49.
Moist sandy places. Not common.

JUNCUS BUFONIUS L. Map 50.
Moist sandy shores, ditches. Centered around northwestern Wisconsin, along the Wisconsin River, and along the Lake Michigan shore.

JUNCUS GERARDI Loisel. Map 51.
Only in Milwaukee and Sheboygan counties on low ground and beach, respectively, near railroad yards.

JUNCUS GREENEI Oakes & Tuckerm. Map 52.
On dry sandy hills, fields, and in dry oak woods.

JUNCUS VASEYI Engelm. Map 53.
Damp thickets and shores. Not common.

JUNCUS TENUIS Willd. Map 54, dots.
Common throughout the state, particularly in bare places, roadsides, ditches, rather than lake shores or marshes.

JUNCUS TENUIS f. ANTHELATUS (Wieg.) Hermann. Map 54, crosses.
Rhodora 40:81, 1938.
Same distribution as *J. tenuis* but not as frequent.

JUNCUS TENUIS f. WILLIAMSII (Fern.) Hermann. Map 54, circles.
Rhodora 40:82, 1938.
Also with a similar distribution to the typical but not as frequent.

JUNCUS DUDLEYI Wieg. Map 55.
Wet fields, shores, marshes, low woods. Quite common. (The key to this and the next species is taken from Hermann in Deam's Flora of Indiana, 1940.)

JUNCUS INTERIOR Wieg. Map 56.
Sandy bluffs, fields.

JUNCUS CANADENSIS J. Gay. Map 57.

Central and northwestern Wisconsin. Marshes, bogs, and ditches. The f. *conglobatus* Fern. does not appear distinct enough in Wisconsin material to warrant use of the name.

JUNCUS BRACHYCEPHALUS (Engelm.) Buch. Map 58.

Shores, marshes. Infrequent in Wisconsin.

JUNCUS BREVICAUDATUS (Engelm.) Fern. Map 59.

Mostly in northwestern Wisconsin coming as far south as Adams and Sheboygan counties.

JUNCUS ACUMINATUS Michx. Map 60.

Sandy places, central Wisconsin and Ozaukee County.

JUNCUS ALPINUS Vill. Map 61, dots.

J. alpinus var. *fuscescens* Fern.

Moist sand, Lake Michigan shore and following old glacial lake shores in central and northwestern Wisconsin.

JUNCUS ALPINUS var. RARIFLORUS (Fries.) Hartm. Map 61, circles.

Same habitat and distribution as the typical.

JUNCUS PELOCARPUS Mey. Map 62.

Sandy shores, northwestern Wisconsin and scattered southward to Sauk County. F. SUBMERSUS Fassett, a sterile submersed form with the cross-markings of the leaves scattered and incomplete, has the same range.

JUNCUS NODOSUS L. Map 63.

Sandy or muddy banks. Common.

JUNCUS TORREYI Coville. Map 64.

Marly shores, mostly along Lake Michigan.

LUZULA DC. Wood Rush

LUZULA ACUMINATA Ref. Fernald, Rhodora 46:4. 1944. Map 65.

Damp woods throughout the state.

LUZULA MULTIFLORA (Ehrh.) Lejeune. Map 66, dots.

Hermann, F. J., Rhodora 40:83–84, 1938. *Luzula campestris* var. *multiflora* (Ehrh.) Celak.; *Luzula intermedia* (Thuill.) A. Nels.; *Juncoides campestre* of Britton and Brown, Illus. Flora, ed. 2, in part; *Juncoides intermedia* (Thuill.) Rydb.

Found in both woods and prairies.

LUZULA MULTIFLORA var. BULBOSA Wood. Map 66, crosses.

Only one specimen has been found that appears to be this variety. It was collected in the Apostle Islands in extreme northern Wisconsin.

PINE STANDS IN SOUTHWESTERN WISCONSIN

ROBERT P. MCINTOSH

I. INTRODUCTION

Scattered about in southwestern Wisconsin and in the adjacent sectors of northwestern Illinois and northeastern Iowa are numerous areas, usually small in extent, in which pine trees comprise a conspicuous, if not predominant, element of the vegetation. A study was undertaken, primarily as a survey, to determine the species present in as many of these stations in Wisconsin as time and distance would permit. This was done with a view to clarifying their ecological status and suggesting some of the factors involved in the presence and maintenance of pine stands well south of the normal range of pine.

The stations to be studied were chosen by the presence of pine trees,[1] the margins being delimited by the extent of the pines or in some instances of pine stumps. Such stations are not difficult to locate as the conifers are quite distinct among the open fields and deciduous woods covering most of this area of the state. (Plates I and II)

As the photographs show, the stations are not precisely identical in so far as their successional status is concerned. Several of the stations are nearly pure stands of pine trees while others are mixed pine-hardwood stands with the pines appearing as the largest and tallest trees in the stand.

The distribution of coniferous forest in Wisconsin is distinctly northern. This fact is well illustrated by maps of the distribution of the pines and of other species commonly found with them. (Fig. 1) The presence of the pines and other northern species in southwestern Wisconsin, where they are not widespread, is an indication of some ecological peculiarity of the areas which they occupy. It is with the basis, extent, and possible implications of this peculiarity that this paper is concerned.

[1] One exception, number 11, was selected and is included although no living pines are present. The occurrence of species normally associated with pines and information from the owner of the property that pines had been cut from this station form the basis on which it is included.

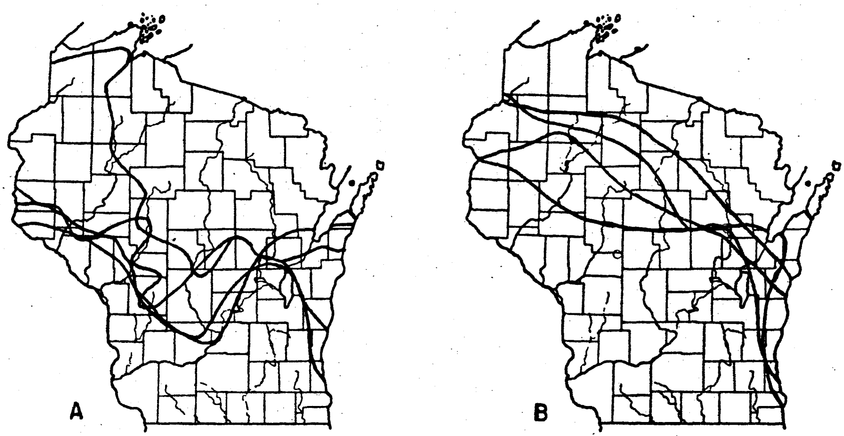


FIGURE 1. Ranges of several species found on the stands studied, showing northern distribution in Wisconsin. *A* includes Pinus resinosa, Pinus strobus, Betula lutea, and Tsuga canadensis. *B* includes Chimaphila umbellata, Corylus cornuta, Pyrola rotundifolia var. americana and Vaccinium canadense. Based on Preliminary Reports on Wisconsin Flora, *Trans. Wis. Acad. Sci., Arts and Letters.*

II. SUMMARY OF LITERATURE

The occurrence of pine stands and northern species south of their normal range has been the subject of a number of studies. Potzger and Freisner ('39) studied plant migration in the area of Wisconsin glaciation in Indiana. They regarded the coniferous stands as relics maintained by microclimates and proceeding toward extinction. These same authors ('36) found that in Indiana the soil moisture content in summer is less in *Tsuga* and *Pinus* stands than in adjacent beech-maple stands. In addition they found that the number of weeks during which the soil moisture was below the wilting coefficient was greater in *Tsuga* and *Pinus* stands than in adjacent areas. The same authors ('34) summarized the ecological status of *Pinus, Tsuga,* and *Taxus* relics in Indiana.

Daubenmire ('30), in a study of the factors inhibiting the advent of forest herbs under hemlock, assigned major importance to the lack of water in July and late summer and ascribed lesser importance to the highly acid soil maintained by the needles falling from the hemlocks.

Welch ('35), studying peculiar plant distributions in Indiana, found certain plants restricted to acid sandstone outcrops. She

PLATE I.

PLATE II.

noted that the presence of limestone inhibited these plants unless the limestone was leached and eroded.

Shimek ('04), in Iowa, found northern species on steep bluffs of St. Peters sandstone. They were mixed with prairie species, particularly at the crests and bases of the slopes.

An aspect of considerable interest as regards the distribution of northern species is brought out in papers by Hansen ('39) in Wisconsin, Waterman ('23) in Illinois and Lindsey ('32) in Indiana. In each case these papers involved studies of bogs. The bog flora evidenced considerable similarity with that of the bluff relics. Significantly mentioned as factors in maintaining the bogs as pine stands are acidity, lack of aeration and low soil temperature.

III. Methods

Each station selected for study was thoroughly surveyed and a list made of all species found. The terminology follows Deam's *Flora of Indiana* in most cases. In the case of some species Fassett's *Spring Flora of Wisconsin* or Gray's *Manual of Botany, Seventh Edition* is followed. It would have been desirable to visit each station more than once to insure the inclusion of those species appearing early and late in the season. Distances involved and limitations of time and money did not permit of this, however, and in all likelihood some species were omitted from any one station. Since each station has been surveyed with comparable intensity the data on each may be compared with reasonable accuracy. A point-quadrat study was made of one of the stands to study the composition of an individual stand.

In addition to the above, measurements were made of the soil and air temperatures both within and on the margin of most stations. The soil temperature measurements were made at the depth of 4–6 inches where the soil was that deep, or if less, at the underlying rock surface.

Measurements of pH were made by the Truog colorimetric method, in each instance in the region of maximum coniferous growth in the station.

IV. Location and Description

The twenty-two stations included in the study are located in the following counties: Sauk (2), Columbia (2), Iowa (13),

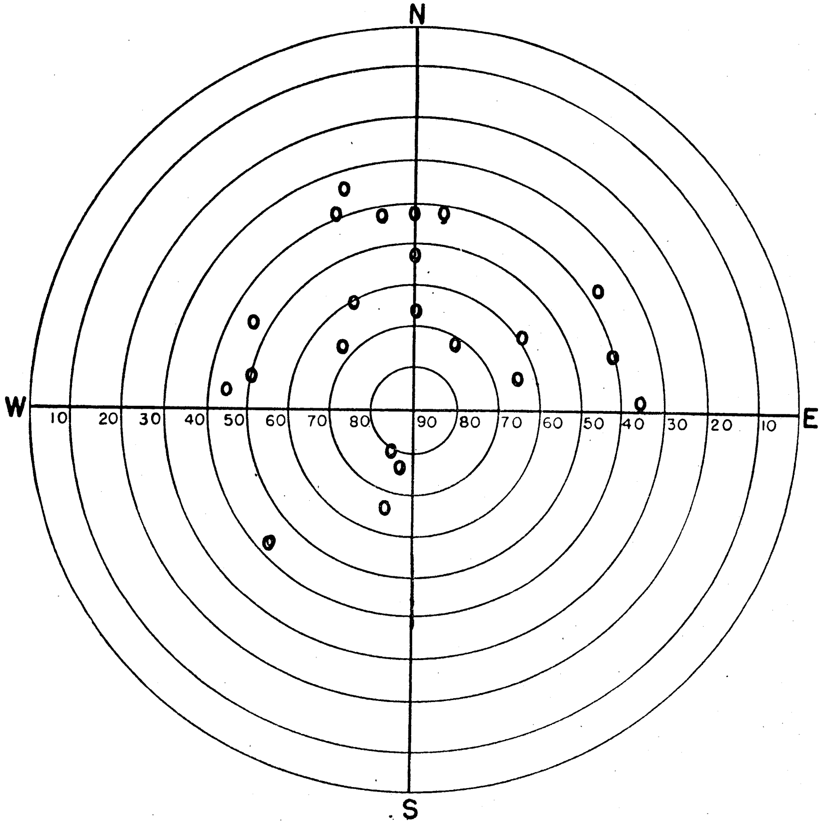


FIGURE 2. A graphic distribution of each station according to the direction which it faces, plotted on a series of concentric circles which represent the approximate angle of the slope. Thus the station indicated by an asterisk faces southwest and has a slope of between 40 and 45 degrees. This method was adopted from a paper by Dr. Hugo Boyko which is discussed by Dr. Paul B. Sears in *Ecology* 28, 1947. It is particularly valuable in showing concisely the relation of slope and direction to the presence of a particular cover.

Dane (3), Lafayette (1), and Green (1). With three exceptions all of these stations lie within the Driftless Area. By far the greatest group is located in the valley of the Pecatonica River, in the southeastern corner of Iowa County. All but two of the stations border streams.

The stations evidence considerable similarity as to topography and geology. The pine stands are found upon steep slopes having a considerable amount of rock exposure. In each case the exposure is St. Peters sandstone except in stations 4, 8, and 16 in which it is Franconia sandstone. The stations found on Franconia are those north of the Wisconsin River where the erosion of the uppermost layers has exposed the Cambrian (Potsdam) rock of which the Franconian is a part.

The St. Peters sandstone is of the Ordovician period overlying the earlier Cambrian sandstones and separated from them by the Lower Magnesian limestones. The St. Peters is covered, in this area, by a layer of Galena–Black River limestone and is exposed only in areas where this is eroded deeply enough to expose the underlying St. Peters. These rock layers dip slightly southward and the St. Peters is buried more deeply under Galena–Black River limestone as one proceeds southward.

One station is found on an island of St. Peters in an otherwise Cambrian sandstone outcrop. This St. Peters rises as a bluff, capped by limestone, well above the surrounding country. Presumably the resistant limestone cap retarded the erosion of the bluff to the level of the surrounding area.

The St. Peters sandstone is largely silica with a slight iron content. It is extremely friable and porous, thus permitting extreme run-off and leaching. In a few instances there are minute clay particles cementing the silica grains. The Franconia is coarse-grained, loosely cemented together, and usually shaley.

The soils are thin and poorly developed varying from virtually none, except for that formed in niches in the rock, to shallow, sandy coverings, 3–10 inches deep, over the sandstone outcrop. The pH of the soils ranged from 5.5–6.8. In most instances it was around 6.0.

The distribution varies from station to station but in general the conifers center upon the steep outcrops, merging with hardwoods, cleared fields, pastureland, or a combination of these. In many stations bordering small streams the crest may be occupied by an open field, the slopes on either side of the conifer center giving way to deciduous woods and the base merging with lowland hardwoods or meadow. Typically, in this area, the crests of hills are prairie; woods are found in the sheltered valleys and stream beds.

Usually the bluff is an open face overlooking a rather broad valley, although in two instances it may be better described as a small gorge on either side of which are steep slopes. In these latter instances pines are found on both slopes although more prevalent on one. Many of the trees are large and ring counts indicating ages up to 110 years were obtained. Several of the better stations show a wide range of tree sizes with younger trees and seedlings well represented. In these instances, the pines promise to hold their own indefinitely and possibly accomplish local extension of the area occupied.

Although each station is marked by the presence of conifers, the same species are not common to all of the stations studied. Generally the white pine *(Pinus Strobus)* is the species present. In several instances hemlock *(Tsuga canadensis)* is found as a considerable admixture with the white pine and may occupy rather extensive areas exclusively. Usually the hemlock is found on the most extreme slopes. One station is largely red cedar *(Juniperus virginiana)* with some white pine. In still other instances the white pine is absent, as in two stations where the coniferous element is red pine *(Pinus resinosa)*, while one station contains jack pine *(Pinus Banksiana)*.

V. Results

In collating the results of the study a very diverse floristic list was accumulated, comprising species usually considered to be representative of different plant communities. Prairie species were prevalent (e.g., *Dodecatheon Meadia, Amorpha canescens, Coreopsis palmata,* and *Erigeron ramosus* were present in more than 25% of the stands studied) as were representative species of the deciduous forest community (e.g., *Tilia americana, Ostrya virginiana, Sanguinaria canadensis,* and *Arisaema triphyllum* were present in more than 25% of the stands studied). Representative pine woods species were more frequently found, however, than representative species of the prairie or deciduous forest.

For purposes of comparison with northern conifer stands a list of species was established by examining the literature for papers which give lists of species found in pine stands. Those species which were present in 25% or more of the twenty lists used are shown in Table 1 in comparison with their percent presence in the twenty-two stations studied.

TABLE 1

Species	Presence	
	Literature	Stations
Pinus Strobus	100%	82
Betula papyrifera	85	95
Pinus resinosa	80	9
Gaultheria procumbens	70	27
Maianthemum canadense	65	95
Clintonia borealis	60	0
Trientalis borealis	60	36
Diervilla lonicera	55	72
Vaccinium canadense	55	14
Cornus canadensis	50	18
Abies balsamea	40	0
Epigaea repens	40	9
Mitchella repens	40	14
Chimaphila umbellata	35	14
Acer spicatum	30	18
Arctostaphylos uva-ursi	30	5
Coptis trifolia	30	0
Corylus cornuta	30	14
Populus tremuloides	30	45
Prunus pennsylvanicum	30	14
Vaccinium canadense	25	68
Aster macrophyllus	25	14
Linnaea borealis	25	0
Lonicera canadensis	25	0
Lycopodium obscurum	25	23
Myrica asplenifolia	25	0
Prunus virginiana	25	63
Pyrola rotundifolia	25	18

It can be seen in Table 1 that only six of twenty-eight species or less than 25 percent are absent from the stations studied. Thus 75 percent of the characteristic species appear on one or more of the stations studied. If the small area of most of the stands is considered it is not surprising that many characteristic species are absent from any one. The total area of all 22 stands probably represents no more acreage than one of the stands cited in the literature. Actually if this total were taken as a composite stand it would compare favorably with most of the stands cited as regards the number of species present.

A detailed study was made of one stand using the point-quadrat method (Cottam and Curtis '49). Forty-six points and 46 one-meter square quadrats were established. Table 2 shows the results of this study.

TABLE 2

A. TREES	PER CENT FREQ.	PER CENT DENS.	PER CENT BASAL AREA	PER CENT FREQ. OF SEED-LINGS
Amelanchier sp.	2	1.1	.06	10
Betula papyrifera	14	7.6	.82	0
Pinus Strobus	98	76.2	94.1	10
Prunus virginiana	10	5.4	.34	8
Quercus alba	4	3.2	2.9	2
Quercus rubra	2	1.1	0.04	2
Quercus velutina	8	4.3	1.7	2
Sorbus decora	2	1.1	0.04	2

B. HERBS (over 20 per cent freq.)	PER CENT FREQ.
Cystopteris fragilis	24
Diervilla lonicera	20
Fragaria sp.	20
Gaylussacia baccatta	28
Maianthemum canadense	60
Polypodium vulgare	35
Rubus sp.	40

Representative species of pine stands were also present in lesser frequencies: *Cornus candensis*—6, *Epigaea repens*—2, *Gaultheria procumbens*—6, *Mitchella repens*—2, *Pyrola rotundifolia*—4, and *Vaccinium canadense*—16.

TABLE 3

AIR AND SOIL TEMPERATURE MEASUREMENTS

Air Temperature		Soil Temperature	
Crest-slope	Base-slope	Crest-slope	Base-slope
.5°	3.0°	.5°	1.3°
—.5	0.0	1.0	2.0
1.0	.8	2.6	2.5
1.5	1.0	4.5	5.0
0.0	0.0	2.0	2.5
0.0	.5	2.0	1.2
—4.0	—4.0	2.2	.5
.5	1.0	.4	2.2
.2	.2	3.2	3.0
1.0	1.0	4.0	—1.0
0.0	0.0	—1.0	1.0
.5	0.0	1.5	1.0
0.0	—.2	.5	1.0
0.0	0.0	1.5	—2.0
0.0	—2.0	2.0	1.0
—1.0	0.0	3.0	4.0
0.3	1.3	29.9	25.2
Ave. = .018°	Ave. = .08°	Ave. = 1.8°	Ave. = 1.57°

Table 3 is a tabulation of the soil and air temperature measurements. Column 1 gives the differences of the air temperature between crest and slope, column 2 the differences between base and slope. Column 3 shows the differences in soil temperature between crest and slope, column 4 the differences between base and slope. In each case the mean is calculated. The air temperature shows little difference, being negligibly cooler on the slopes. The soil temperatures on the slopes are markedly cooler than on either crest or base.

VI. Discussion

The presence of coniferous stands and of plants representative of coniferous stands south of the area in which they are normally found presents something of a problem to ecologists. These stands may be regarded in two ways: (1) as recent (postglacial) extensions of the range of coniferous stands by migration southward of individual species which become established upon restricted habitats; (2) as relics of a more general southward extension of northern coniferous forests in past history which at present may be either a) proceeding towards extinction, b) holding their own, or c) spreading locally from these relic centers. The first possibility is difficult to maintain for several reasons. Many of the species found on the stations in southwestern Wisconsin are separated from their normal ranges by considerable expanses of other plant communities, mostly deciduous forest. It is improbable that these northern species migrated through this intervening area recently by gradual extension of their range when the habitat distinctly favors another type of vegetation. It is equally unlikely to presume that seeds were carried by wind, birds, animals, etc. and dropped upon the small areas in which the habitat factors do allow them to exist. This assumption in many cases would involve transportation of seeds many miles and their deposition upon areas small in surface extent as they are almost vertical in most instances. To presume chance movement of seeds of such plants as *Corylus cornuta* or *Trientalis borealis* is stretching probability.

Considerable evidence is at hand to support the second possibility. The pollen analysis studies of bogs in this area (Hansen '39) indicate that during the glacial period southward migrations of northern species covered this area with a northern coniferous type, and that recession of the glaciers was accompanied by the influx of a more temperate vegetation from refuges south of the glacier or within the Driftless Area. This influx has reduced the northern forest to isolated relics.

Similar stations in Indiana, Illinois, and Iowa (Welch '23) (Pepoon '16) (Pammel '23) indicate that the migration extended south of Wisconsin. These stations, although in general aspect similar to those in southwestern Wisconsin, do not show as many of the species representative of the pine community. They were perhaps never as well established or have been more rapidly supplanted by other flora. The presence of occasional northern species in oak-hickory woods in southwestern Wisconsin also indicates the likelihood of a more widespread coniferous forest area at one time as characteristic herbaceous species usually appear only where the dominant species are present, although they may persist after the dominants disappear.

It seems that the pine stations studied were more extensive even recently than they are today. In two instances the owners of the property indicated that cutting since settlement has reduced the area in coniferous woods. Current demand for timber and the resultant high prices threaten to reduce them even more drastically, and in at least one area the pines are being virtually extinguished by cutting.

The survey of many of these stations in southwestern Wisconsin indicates certain of the factors involved in the maintenance of these northern relics. The stations are restricted to steep sandstone bluffs which are comparatively dry due to runoff and rapid percolation of water through the porous sandstone. This is consistent with the results of Friesner and Potzger ('36) and of Daubenmire ('30).

The marked acidity seems to favor coniferous stands and Welch ('23) indicates that certain species found here are what she terms acid indicators. Daubenmire ('30) ascribes only secondary importance to acidity, regarding soil moisture of greater import.

The steepness of these slopes prevents accumulation of humus or building up of the soil. Falling trees frequently lay bare the rock face. This destroys any soil development which may have been accomplished and tends further to retard any change in the environment which would permit succession. The steepness of the slopes allows greater amounts of light to penetrate the cover enhancing the possibility of the conifers seeding and maintaining themselves. Falling trees open up the canopy favoring the coniferous seedlings.

Other factors likely involved are direction of exposure and temperature. Figure 4 shows the direction of the exposure of each station and indicates that most face north and west. However, the presence of several facing southwest and northeast precludes assigning major importance to exposure. The complete absence of any stations from the southeast quarter of Figure 4 is interesting. In this region northern slopes are usually cooler and westerly slopes drier, both of which conditions would favor the coniferous cover. However, as some stands are found facing northeast and others southwest apparently neither factor is indispensable. The lack of stations in the southeast quarter would indicate that at least one of the advantageous exposure factors is necessary and that other factors cannot compensate and maintain coniferous stands lacking either the colder north slope or the drier west slope.

Table 3 indicates little difference in air temperature between the coniferous stands and surrounding areas but shows some difference in soil temperature. The soil temperature on conifer covered slopes was 1.7°–1.8° cooler on an average than the base or crest. This may well be a result of the coniferous cover rather than a cause, but its effect on the ground vegetation may be none the less important.

Temperature may be a more important factor in the maintenance of pine stands than the data on the stations studied would indicate. The region in which most of the stations are found possesses a markedly lower mean summer temperature than surrounding areas. Whitson and Baker ('12) show most of Iowa County, northeastern Lafayette County, southwestern Dane and northwestern Green County to be in a cool spot as compared with the surrounding area. The growing season in this area is three to five weeks shorter than the rest of southwestern Wisconsin, the steep-sided valleys having the shortest growing season. This cooler area, particularly in the summer when the stress on the conifers is greatest, would favor the maintenance of conifers. Coupled with this, the deep valleys of the much-branched Pecatonica River exposing sandstone cliffs in an otherwise limestone outcrop may serve to explain the clustering of pine stands in this vicinity.

The stations studied are, as suggested previously, in one of three possible conditions: shrinking, holding their own, or expanding. In many of the areas observed the absence of coniferous seedlings and younger conifers and the prevalence of seedlings and young hardwood trees clearly indicates the trend toward extinction. In a few instances, however, the conifers seem to be at least holding their own if not making local extensions as indicated by large numbers of seedlings and the presence of younger trees which in some instances lie outside the canopy of the larger conifers.

The vegetation of these stations is comprised of varying proportions of species which are commonly regarded as representative of distinctly different plant communities. The reason for this admixture must be sought in the location and history of this region. This area of Wisconsin lies in an ecotone in which several major plant communities are now competing and have been competing over a long period of time. Nowhere is this competition more intense than on the stations under discussion which are located near the margins of the prairie, conifer forest and hardwood forest. The probable history of this region involves glaciation and climatic changes which permitted the northern coniferous forest to encroach southward into the deciduous forest. The deciduous forest retreated south and perhaps itself was maintained in the Driftless Area as relics surrounded by coniferous forests. Climatic changes and eventual recession of the glaciers reversed this trend. A warm, dry period subsequent to these occurrences permitted the spread eastward of the prairie at the expense of the more mesophytic deciduous forest and presumably a reversal of this situation brought about its recession leaving relics behind.

The occurrence of a considerable number of species representing a plant community distinctively northern in character in the face of the improbability of separate migration of individual species indicates that the entire community migrated together and must at one time have occupied most of southwestern Wisconsin. The dissection of this northern cover by inroads of the deciduous forest and prairie resulted in a group of relics all containing some of the representative species of the northern flora but none containing all of them. All of the representative species of pine are not present in the sum total of all stations. *Clintonia borealis* is missing from all stands. It may be that this species is less vigorous and disappears quickly in a period of stress. Lacking any data to that effect it seems as reasonable to assume that this species just was not present in the few spots where conditions enabled the coniferous vegetation to hang on, or was present in such low concentrations that it quickly disappeared. The type of coniferous elements does not seem to affect the pattern of succession markedly, as mixed white pine-hemlock stands, white pine, red pine or jack pine stands all appear susceptible to invasion by the deciduous forest species. The white pine stands, however, seem most successful in competition with invading species.

One possibility suggested but not explored is the existence of a physiological difference in the white pine occurring in this area. The white pine seems vigorous in its growth and reproduction and is the most widespread of any of the northern species.

VII. ACKNOWLEDGMENTS

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NUTRITION OF RAINBOW TROUT; FURTHER STUDIES WITH PRACTICAL RATIONS*

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INTRODUCTION

Large scale nutrition experiments with a practical ration (4) carried out in several trout hatcheries in the state, indicated that the meatless ration, though adequate for yearling or older trout, was unable to maintain growth in fingerlings. Fair growth and low mortality rates could be obtained by supplementing it with 20% fresh liver or with 50% of a spleen-carp mixture. Laboratory experiments were planned, therefore, in which trout fry (newly hatched) were to be used for the development of a meatless ration.

EXPERIMENTAL

During two successive years 44,000 newly hatched rainbow trout *(Salmo gairdnerii irideus)* were used to study the value of the practical diets listed in Table 1. Two groups of 12,000 fish were used during the first year. One group was fed fresh liver; the other received a meatless ration. During the second year 20,000 were divided into two groups and handled in the same way. In order to prevent overcrowding as the fish grew older, the larger fish were removed and placed in separate tanks and fed a modification of the dry ration. In this way it was thought possible to determine the age at which trout could be transferred from fresh liver to a dry diet.

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TABLE 1

COMPOSITION OF RATIONS

CONSTITUENT %	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124
Skim milk powder	50	35	35	35	35	35	35	30	50	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Liver A[a]	25	10	10	10	10	10	10	9	9	10	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Gelatin[b]	10	10	10	10	10	10	10	9	9	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Brewers yeast	5	5	5	5	5	5	5	5	4	5	5	5	5	5	...	...	...	...	...	...	...	...	...	...	...
Soybean oil meal	3.3	12	12	12	12	12	12	10	10	29.5	...	...	19.5	19.5	18.5	18.5	24.5	18.5	18.5	18.5	24.5	18.5	18.5	18.5	18.5
Alfalfa leaf meal	3.3	12	12	12	12	12	12	10	9	...	...	...	10	10	10	10	10	10	10	10	10	10	10	10	10
Ground rolled oats	3.3	12	12	12	14	14	14	12	9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Linseed oil meal	...	...	...	...	...	...	...	...	...	...	29.5	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Corn gluten	...	...	...	...	...	...	...	...	...	...	...	29.5	...	...	...	...	...	...	...	...	...	...	...	...	...
Corn oil	...	...	...	...	...	2[c]	...	15	...	10	13	13	13	13	13	13	13	13	13	13	13	13	13	13	13
B-G plus	...	4	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Cod liver oil	...	...	...	...	2	...	...	...	...	...	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Kelp	...	...	4	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
$CaCO_3$	...	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...	6	...	...	...	3	3	...	...
NaCl (Iodized)	...	...	...	...	...	...	...	...	...	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Salts IV (6)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6	...	...	...	...	...	...	...	...	...	...
Major elements—Salts IV	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6	...	...	...	...	...	3	...	3	...
Trace elements—Salts IV	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+[d]	...	...	...	...	...	...	...	...
Bone meal	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6	...	...	...	...	...	...
Crab meal	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	6	...	...	3	3	3
Sodium iodide	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	+[e]	...	...	...	...
Ascorbic acid	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

[a]Products of Wilson and Company, Chicago, Illinois.
[b]Gelatin used at a binder.
[c]With vitamin D added (1 I.U. per fish per day).
[d]Trace elements added equivalent to 6% Salts IV.
[e]Sodium iodide added equivalent to 6% Salts IV.

Results

Two months after the first series was started an epidemic of Octomitiasis occurred. The losses were heavy in both groups but more so in those receiving the meatless ration (Diet 100). At the same time, however, fry of the same age in the hatchery stock were badly affected by the parasite. Both groups were then maintained on liver and treated with Carbarsone (1).

The failure of Diet 100 and the heavy losses due to disease left only the group which had started on the liver diet and a comparatively few "retarded" fish which had received the meatless ration. The latter fish were divided into two groups, one of which was fed fresh liver and the other Diet 101 and 20% fresh liver.

TABLE 2

Effect of Feeding B–G Plus and Kelp in Practical Ration to Rainbow Fry

Diet No.	Variable	Gain	Mortality
		%	%
101	B-G plus	122	10.5
102	Kelp	118	8.5
103	B-G plus kelp	121	6.5
Liver		160	2.2
Liver*		215	5.3
101*	20% liver	148	7.2

*Fry started on dry diet—"retarded fish."

The faster growing liver-fed fish were divided into four groups, three of which were given Diets 101, 102 and 103 and the fourth received liver. The experiment lasted for two months. In Table 2 the results for the slower growing fish and the groups described above, as measured by percentage gain and mortality, are summarized.

These fish were then sorted into three sizes: "small," "medium" and "large." The size distribution is indicated in Table 3. It is evident that the liver diet produced the greatest number of "large" fish.

Since Diet 103 appeared to be the best of this series, all the large fish from each of the groups were maintained in separate tanks and were fed this diet. All the "medium" fish were maintained on their respective diets. Despite the wide differences in the diets, another epidemic of Octomitiasis involving heavy losses occurred in all the experimental groups as well as in the hatchery stock fish. Rather than change all the fish over to a meat diet, since there were appreciable losses also among those receiving liver, attempts were made to improve the practical ration.

TABLE 3

SIZE DISTRIBUTION IN RAINBOW FRY

DIET NO.	SMALL	MEDIUM	LARGE
	%	%	%
101	4.0	62	34
102	1.5	59	39.5
103	1.0	58	43.0
Liver	2.0	37	61.0
Liver	1.5	51	47.5
101+20% liver*	5.5	74	21.5

*Retarded fish.

Diets 104, 105, 106, 107 and 108 were devised, and of these only Diet 107 which contained 15% corn oil and Diet 108 which contained increased amounts of skim milk powder reduced the losses. A further decrease of the losses occurred with Diet 109 which contained the favorable factors of Diets 107 and 108. Because the fish were still infected with the parasite, each of three groups in which the losses were heavy were fed Phemerol (0.006 gm./100 gm. ration) or S. T. 37 (Hexylresorcinol) (0.1 cc./100 gm. ration) or Carbarsone (0.25 gm./100 gm. ration). Only Phemerol was effective in eliminating the parasite with a consequent sharp drop in the losses. Five tanks were available at this time to continue the experiment so the fish were placed in five groups, one of which received liver, one, Diet 109 supplemented with 20% fresh liver, and the other three, Diets 109, 110, 111.

The results of this short term experiment (6 weeks) are given in Table 4. It is apparent that, although the dry diets were still inferior to a diet of fresh liver, this series showed some promise as compared with the earlier attempts. Supplementing the dry diet with 20% fresh liver produced growth that almost equaled that of the fish on the whole liver diet.

TABLE 4

EFFECT OF VARYING THE PROTEIN IN PRACTICAL RATIONS

DIET NO.	GAIN	MORTALITY
	%	%
109	17	6.6
110	13.5	1.4
111	14	3.4
109+20% liver	23	1.8
Liver	26	0.7

In the second year experiments, it was thought advisable to start feeding one group 100% fresh liver and the other the dry ration (Diet 110) supplemented with 20% fresh liver. During the first two months, the usual epidemic of Octomitiasis occurred which was quickly eliminated with Phemerol. At the end of two months, the group receiving fresh liver gained 300% (by weight) and the other group on the dry ration supplemented with 20% fresh liver gained 231%. The losses were 13% and 19% respectively. When the groups were hand sorted into "small" and "large" sized fish, the results as shown in Table 5 indicate that the difference between the two groups was less marked than in the previous year's work.

TABLE 5

SIZE DISTRIBUTION OF RAINBOW FRY

DIET NO.	LARGE	SMALL
	%	%
100% fresh liver	43.2	53.8
110+20% liver	62.2	37.8

The "medium" sized fish were maintained on their respective diets. The "large" fish from both groups were given Diet 110 and Diet 111. After one month the group receiving Diet 111 developed edema and the mortality rate increased. The presence of parasites in the intestinal tract could not be demonstrated in microscopic preparations.

Although the mineral content of the dietary constituents, especially the skim milk powder, was fairly high, the effect of the addition of 6% Salts IV (6) was investigated by Diet 114. In a few days, improvement (i.e., loss of edema and lessened mortality rate) was observed. The effects of the minerals were studied further by the use of Diet 114 and its modifications 115–120 inclusive. The results are presented in Table 6. Of the mineral sources $CaCO_3$ (Diet 117), crab meal (Diet 118) and Salts IV with the trace elements omitted, gave the best results.

TABLE 6

EFFECT OF MINERALS IN PRACTICAL RATIONS

DIET NO.	SUPPLEMENT	GAIN	MORTALITY
		%	%
114	Salts IV	30	10
115	M.E. Salts IV*	46	9.7
116	T.E. Salts IV**	28	9.1
117	$CaCO_3$	50	7.6
118	Bone meal	11	26
119	Crab meal	41	13.5
120	Sodium Iodide	68	32
Control	Liver	32	10

*M.E. = Major elements of salts.
**T.E. = Trace elements of salts.

During the last two months the four remaining groups were fed Diets 121, 122, 123 and 124, in which various combinations of the minerals were tried. The results of this series are presented in Table 7. It was noted that crab meal and the major elements of Salts IV (Diet 124) and crab meal plus $CaCO_3$ (Diet 122) gave very promising results. The fish receiving these diets grew as well as those receiving the fresh liver supplemented diet.

DISCUSSION

For a number of years, meat has been considered essential as a food for young trout—a fact emphasized by the work of McCay and Dilley (2). Recently Tunison, et al. (8) and others (7) have demonstrated the lack of scientific basis for this belief. This knowledge, the meat shortage during the food rationing period and the subsequent high prices of the commodity have made it

TABLE 7

EFFECT OF MINERALS ON PRACTICAL RATIONS

DIET NO.	SUPPLEMENT	GAIN	LOSS
		%	%
121	3% $CaCO_3$ 3% M.E.* Salts IV	42	8.6
122	3% $CaCO_3$ 3% Crab meal	65	2.6
123	3% M.E.* Salts IV 3% Crab meal	53	11.0
124	3% Salts IV 3% Crab meal	77	6.7
Control	Liver	69	6.2

*M.E. = Major elements of Salts IV.

important to investigate the possibility of developing an adequate meatless ration.

These goals were approximated in the experiments reported in this paper. The results obtained are comparable to those of Tunison et al. (8) who found average gains of 30–40% in fingerling trout using a diet of 50% meat and 50% dry mixture. It is questionable whether very young fry could grow on this practical ration but it appears to be adequate for fingerlings four months or older.

SUMMARY

1. Nutrition experiments concerned with the development of a practical ration for rainbow trout fry have been discussed.

2. An epidemic of Octomitiasis was brought under control by the use of Phemerol in the diet.

3. The most successful ration contained the following ingredients: skim milk powder, 35; liver A, 5; gelatin, 10; soybean oil meal, 20.5; alfalfa leaf meal, 10; corn oil, 13; crab meal, 3; the major elements of Salts IV, 3; iodized NaCl, 0.5; and ascorbic acid, 1 part per thousand.

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THE AVAILABILITY OF THIAMINE IN DRIED YEASTS*

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The vitamins, thiamine and riboflavin, which are important essential constituents of a good nutritious diet have been shown in this and other laboratories to be only partially available from certain food products. Fresh compressed yeast is one of these foods and is not so good a source of thiamine and riboflavin as has been widely believed.

It has been shown in this laboratory that fresh bakers' yeast as it is usually obtained contains live yeast cells which are capable of holding these two B-vitamins so the body can not use them. The fresh yeast does not yield its thiamine and riboflavin for absorption and, in addition, there is a positive interference with the absorption of some thiamine from other foods eaten. There is reason to think that this interference may be due to the live yeast cell taking some of the thiamine released from the other foods into its own live cell. Thus it would be possible for a person to consume enough raw compressed yeast with meals to measurably lower thiamine storage in the body. If the yeast cells are killed by boiling, the thiamine and riboflavin escape from the cell and are absorbed by the body.

The killing of the yeast cell may be done not only by boiling but also by a commercial process in the preparation of dried yeast; this particular type of dried yeast is called nutritional dried yeast because the dead yeast is truly a source of thiamine and riboflavin as well as other factors.

In contrast to the nutritional yeast, we have fed to human diet squads three especially prepared samples of dried yeasts. In these yeasts the drying had not measurably injured their effectiveness for breadmaking as the cells were still living. None of these three samples furnished any thiamine for absorption, although their interference with thiamine from other food sources was not so evident as with compressed yeast.

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