PROCEEDINGS

of the

Ohio State Academy of Science

VOLUME IV, PART 1.

Twelfth Annual Report.

PROCEEDINGS OF THE OHIO STATE ACADEMY OF SCIENCE
Volume IV, Part 1.

Twelfth Annual Report

OF THE

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Report of the Thirteenth Annual Meeting

OF THE

Ohio State Academy of Science.

ANNUAL MEETING.

The thirteenth annual meeting of the Academy was held at Denison University, Granville, November 27, 1903. All but one of the papers on the printed program were read.

Regarding the status of membership, the secretary reported that the executive committee had decided, "the Academy is so small as to make any classification of members unnecessary."

In accordance with a recommendation of the treasurer, the Academy decided that "authority shall be secured from the executive committee before any debt is incurred by any member, officer, or committee."

Hereafter members are not to receive the publications if their dues are in arrears more than one year.

The publication committee reported: "During the year four reports have been published, amounting in all to 435 pages. The greater part of the expense of publication was covered by the McMillin fund."

The trustees reported: "During the year the Academy has published three valuable 'Special Papers,' Nos. 5, 6 and 7. The studies upon which these papers were based were largely carried on by aid from the Emerson McMillin Research fund, and the expense of publication was mainly met by the further aid of the same fund. It is expected that two more 'Special Papers' will be completed and published during the year 1904, and that in addition to this, much research work in other lines will be done. The annual donation of $250.00 by Emerson McMillin for the year 1904 has been received and deposited in the Capital City Bank, Columbus."

The Academy adopted the following resolutions:

FIRST.

"*Resolved,* That the rule be established that no paper shall hereafter be admitted to the program of the annual meeting, unless by special vote of the Academy, which shall not have been submitted either in full or in abstract to the program committee and approved by them. Titles of proposed papers may be sent to the program committee or to the secretary at any time in advance of the meeting in order to aid the committee in planning the program, but this cannot take the place of the absract. Abstracts should not exceed 300 words in length and should be submitted typewritten in the form desired for publication in the proceedings. The full text of all papers designed for publication by the Academy, properly edited for publication and typewritten, should be in the hands of the publication committee not later than the adjournment of the annual meeting."

SECOND.

"*Resolved*, That the Ohio Naturalist be made an official organ of the Ohio State Academy of Science, the Naturalist to print in full papers under 1,500 words in length, and abstracts, not to exceed 300 words in length, of other papers read. All abstracts and other MSS. designed for the Ohio Naturalist, after having been passed upon by the publication committee, shall be submitted in typewritten form to the editor of the Ohio Naturalist within one week after the adjournment of the annual meeting.

"The Ohio Naturalist shall publish announcements of meetings, lists of publications for sale, etc., whenever the Academy may desire, such announcements not to exceed one-half page of advertising matter in any one issue. Copies of all numbers of the Ohio Naturalist shall be sent to all members of the Academy not in arrears for the payment of dues.

"The Academy shall pay to the Ohio Naturalist 50 cents for each subscription of the Naturalist thus sent to its members.

"The annual reports, including lists of members, officers, proceedings, the presidential address and such other matter as the publication committee may determine, shall be issued separately by the publication committee. Papers offered for publication which exceed 1,500 words in length may be published by the Academy, when accepted by the publication committee, in the series of Special Papers now running. The publication committee shall assemble the Annual Reports and Special Papers into volumes of proceedings of convenient size and page them consecutively in each volume. But a part of the edition of each volume of proceedings shall be made up with each Annual Report and Special Papers stitched and covered separately, and offered for sale at the lowest reasonable rate."

PAPERS READ.

1. Preliminary Report on the Development of the Gill in Mytilus .... EDWARD L. RICE
2. Comparative Chart of the Vertebrate Skull....... CHARLES S. MEAD
3. The Protozoa of Sandusky Bay .... F. L. LANDACRE
4. A New Peritrichous Infusorian .... F. L. LANDACRE
5. Report on the Reptiles and Batrachians of Ohio........ MAX MORSE
6. The Protozoa of Brush Lake .... LUMINA C. RIDDLE
7. Cataloguing Museum Collections .... L. B. WALTON
8. A Practical Dissecting Tray .... L. B. WALTON
9. A Further Contribution to the Hemipterous Fauna of Ohio.. .... HERBERT OSBORN
10. Report on the Scale Insects of Ohio .... J. G. SANDERS
11. Report on the Orthoptera of Ohio .... CHAS. S. MEAD
12. A Supplement to the Odonata of Ohio .... JAMES S. HINE
13. Notes on the Introduction of the Chinese Ladybird, Chilocorus similis, in Ohio .... A. F. BURGESS
14. Notes on a Macropterous Phylloscelis atra........ HERBERT OSBORN
15. The Breeding Habits of the Myriopod, Fontaria Indianae Boll .... MAX MORSE
16. A Statistical Plea for Nature Study .... EDWARD L. RICE
17. Shore Line Topography between Toledo and Huron, Ohio—Lantern Slides .... LEWIS G. WESTGATE
18. Some Rare Forms of Aboriginal Implements .... J. H. TODD
19. List of the Mosses of Cuyahoga and Other Counties of Northern Ohio .... EDO CLAASSEN
20. Extra-Floral Nectaries and Other Glands........ JOHN H. SCHAFFNER
21. Notes on Nutating Plants .... JOHN H. SCHAFFNER
22. Notes on Some Rare and Interesting Ohio Plants.. OTTO E. JENNINGS
23. The Keeping Qualities of Apples .... WM. R. LAZENBY
24. Seeds of Celastraceæ .... WM. R. LAZENBY
25. Variation and Environment .... L. B. WALTON
26. Further Floristic Studies in West Virginia ...... W. A. KELLERMAN
27. Additional Infection Experiments with Species of Rusts...... .... W. A. KELLERMAN
28. Mycological Flora of Cedar Point, Sandusky, Ohio—Abstract .... W. A. KELLERMAN
29. Group Names in Natural History .... W. A. KELLERMAN
30. Historical Account of Uredineous Culture Experiments, with List of Species—Abstract .... W. A. KELLERMAN
31. Annual Report on the State Herbarium .... W. A. KELLERMAN and O. E. JENNINGS
32. On the Occurrence of Fossombronia cristula in Ohio.. EDO CLAASSEN
33. The Agar-agar Method of Imbedding Plant Tissues.......... .... HARLAN H. YORK
34. Report on the Flowering Plants and Ferns of Cedar Point.... .... OTTO JENNINGS
35. Preliminary Report on the Geology and Ecology of Clifton Gorge .... W. E. WELLS
36. Notes on the Aradidæ of Ohio.................... HERBERT OSBORN
37. A Root-Infesting Fulgorid .... HERBERT OSBORN

E. L. MOSELEY, Secretary.

NOTICE IN REGARD TO PUBLICATIONS.

Since by a special resolution of the Academy, the Annual Reports and Special Papers are in the future to be collected into definite volumes consecutively paged, it becomes necessary to make some disposition of the reports already issued. It is very unfortunate that a definite and suitable plan of publication was not adopted by the Academy from the very beginning. But although there will be some inconvenience in having volumes consisting of reports specially paged, there seemed to be but one feasible plan, which is to collect the old reports into a number of volumes, each consisting of a number of parts. The reports are therefore collected into three volumes and the new plan with consecutive pagination thus begins with Volume IV. The disposition of the past reports is as follows:

Proceedings of the Ohio State Academy of Science, Vol. I, consists of the following Reports:

Part 1. Constitution, By-Laws, Officers, List of Members, and Historical Sketch; 1891. (Date of publicatlon, 1892.)

Part 2. First Annual Report of the Ohio State Academy of Science; 1892. (No date of publication.)

Part 3. Second Annual Report of the Ohio State Academy of Science; 1893. (No date of publication.)

Part 4. Third Annual Report of the Ohio State Academy of Science; 1894. (No. date of publication.)

Part 5. Fourth Annual Report of the Ohio State Academy of Science; 1895. (No date of publication.)

Part 6. Fifth Annual Report of the Ohio State Academy of Science; 1896. (Date of publication; 1897.)

Part 7. Sixth Annual Report of the Ohio State Academy of Science; 1897. (Date of pubilcation, 1898.)

Proceedings of the Ohio State Academy of Science, Vol. II, consists of the following Reports:

Part 1. Seventh Annual Report of the Ohio State Academy of Science; 1898. (Date of publication, 1899.)

Part 2. Special Papers No. 1, "Sandusky Flora." (Date of publication, May, 1899.)

Part 3. Special Papers No. 2, "The Odonata of Ohio." (Date of publication, March, 1899.)

Part 4. Eighth Annual Report of the Ohio State Academy of Science; 1899. (Date of publication, 1900.)

Part 5. Special Papers No. 3, "The Preglacial Drainage of Ohio." (Date of publication, December, 1900.)

Proceedings of the Ohio State Academy of Science, Vol. III, consists of the following Reports:

Part 1. Ninth Annual Report of the Ohio State Academy of Science; 1900. (Date of publication, 1901.)

Part 2. Special Papers No. 4, "The Fishes of Ohio." (Date of publication, May, 1901.)

Part 3. Tenth Annual Report of the Ohio State Academy of Science; 1901. (Date of publication, 1902.)

Part 4. Eleventh Annual Report of the Ohio State Academy of Science, 1902. (Date of publication, May 1, 1903.)

Part 5. Special Papers No. 5, "Tabanidæ of Ohio." (Date of publication, May 1, 1903.)

Part 6. Special Papers No. 6, "The Birds of Ohio." (Date of publication, October 15, 1903.)

Part 7. Special Papers No. 7, "Ecological Study of Big Spring Prairie." (Date of publication, 1903.)

It is the intention of the publication committee to publish title pages and indexes to the volumes as opportunity and funds will permit. As stated, Vol. IV will be paged consecutively; and hereafter there will be no difficulty in having the reports properly bound or in referring to articles contained in them.

JOHN H. SCHAFFNER.

PRESIDENT'S ADDRESS.

THE DOCTRINE OF NERVE COMPONENTS AND SOME OF ITS APPLICATIONS.

By C. Judson Herrick.

The original purpose of the students of nerve components was the analysis of the peripheral nervous system into units which should have at the same time a functional and a structural significance. This obviously is not the case with the cranial and spinal nerves as commonly enumerated. The structural peculiarities of each of the twelve pairs of cranial nerves, for instance, while fairly well defined in the human body, are very diverse in the vertebrate series as a whole. Thus the facial nerve from being predominantly sensory in lower vertebrates (more than half of its fibers in fishes belonging to a sensory system not represented at all in mammals) becomes in man predominantly motor with only a vestigeal remnant of the sensory components, and even the motor component innervates chiefly muscles new to the mammalia. We might multiply illustrations of the structural instability of the cranial nerves. And that the cranial nerves have any special significance as functional units cannot be maintained for a moment, no two pairs in the human body having even approximately the same function.

But the first measurably complete analysis of the cranial nerves into their components for their entire extent showed at once the presence of certain structural and functional systems of components, the laws of whose distribution have apparently little to do with the serial order of the cranial nerves as commonly enumerated.

We have, then, a number of systems of components each of which is defined structurally by similarity of peripheral and central terminal relations, and functionally by the transmission of nervous impulses of the same type or modality. Among these systems are tactile, auditory, visual, olfactory, motor, gustatory, etc., each with very characteristic terminal relations.

Now, this structure is absolutely meaningless apart from its function. Let any one who doubts this spend a few months (as I have done) in trying to master and correlate the existing literature of the cranial nerves of vertebrates. Though these descriptions were for the most part written by famous masters of anatomical science, yet in their aggregate they present an indigestible mass of confused and meaningless detail, crude fact, well spiced with error, for the most part not worth the prodigeous labor of digging it out of the oblivion of classic tomes of by-gone anatomists.

I do not mean to imply that all the problems of cranial nerve morphology are now cleared up; but I do claim that there is no longer any necessity for the further accumulation of uncritical and meaningless fact in this field of research. We have already gone far enough to point the way toward certain lines of fruitful correlation. We can not only correlate structure with structure, but we can interpret structure by function and thus bring out a fuller meaning. We are at least coming into a realization of the fact that we cannot fully understand any structure until we know what it can do.

This point of view of course is not new, but as worked out practically in the peripheral nervous system it is exerting a clarifying influence upon our knowledge of the central system also. The present demand in cerebral anatomy is for conduction paths, for functional systems of neurones, and precise knowledge of the pathways between the brain and the periphery is the first step in such a central analysis.

The primary function of the nervous system is to facilitate the reaction of the organism to the external forces of the environment. Later, as the reacting mechanism becomes more complicated, the nervous system assumes the function of co-ordinating this mechanism, *i. e.*, of reaction to the forces of the internal environment. These two functions lie at the basis of our most fundamental division of the analysis of the nervous system, viz.: (1) the somatic systems (sensory and motor) for bodily responses to external stimuli, and (2) the visceral systems (sensory and motor) for visceral reactions to internal stimuli.

Each of these great divisions has been analyzed peripherally, more or less imperfectly as yet, into systems of components, as suggested above. Every such system of nerve fibers performs a separate function, conducts a single type of nervous impulse, either afferent, *i. e.*, sensory, or efferent, *i. e.*, excito-motor, excito-glandular, etc. The following systems are already distinguishable anatomically:

I. Somatic Systems.

1. *Tactile,* or *general Cutaneous.*
2. *Acustico-lateral,* including nerves for lateral line organs (in the Ichthyopsida) and for organs of equilibration and hearing (in vertebrates generally). These organs and their nerves have probably been derived phylogenetically from the general cutaneous system and, like the organs of the latter type, are adapted for the reception of various kinds of mechanical impact, either rhythmic or non-rhythmic.
3. *Visual* (a system of uncertain relationship, provisionally classified under the somatic sensory).
4. *Somatic motor,* for the innervation of skeletal or voluntary muscles.

II. Visceral Systems.

5. *Visceral sensory,* unspecialized sensory nerves of the viscera, distributed chiefly through the sympathetic nerves.
6. *Gustatory,* innervating specialized sense organs (taste buds) of chemical sense, probably derived phylogenetically from the preceding type.
7. *Olfactory* (provisionally classified here because of the apparent resemblance betwen taste and smell).
8. *Visceral motor,* distributed chiefly to unstriped and involuntary muscles, generally through the sympathetic system.
9. *Excito-glandular,* provisionally classified here because of general resemblance to the last mentioned type.

There are numerous other systems which can be differentiated physiologically, but which cannot as yet be completely separated anatomically and classified, such as nerves for the thermal sensations, muscle sensations, etc., but enough has been done to enable us to lay down the general plan or pattern of the peripheral nervous system as a whole and to define the main pathways by which stimuli of different modalities reach the brain and are reflected back to the responsive organs. Our anatomical knowledge of these pathways is sufficiently well controlled by precise physiological experimentation to enable us to state with confidence that each of the nine systems mentioned above is a real functional unit.

The fibers composing these systems may reach the central nervous system through a series of many nerve roots arranged in a segmental way, like the general cutaneous nerves of the spinal cord, or they may all be represented in a single large nerve, like the optic and olfactory. Thus it happens that some nerves, like those last mentioned, are "pure" nerves, while others, like the facialis or vagus, are "mixed," containing in some cases as many as four anatomically distinguishable components.

It is a general rule that in the body the components tend to be distributed among a large number of nerves in a more or less segmental way, while in the head they tend to be concentrated into a few pathways, or only one, into the brain, an adaptation which presents obvious advantages for the simplification and unification of the secondary reflex paths from these primary centers.

Now, the central nervous system is, as we have already seen, primarily a mechanism to facilitate the reaction of the animal to impressions from without, in other words, to put the body in correspondence with the environment. Its structure is directly determined by the avenues of sense through which these stimuli come in and by the character of the responses to these stimuli which are necessary for the conservation of the organism. In view of the fact that we already possess a detailed knowledge of these peripheral nervous pathways, it is manifest that we have here a most favorable avenue of approach in an analysis of the inconceivable complexity of cerebral structure.

We must know in detail the possible reflex pathways in the brain for all olfactory, visual, gustatory responses, etc., in the vertebrate type, and then on the basis of such a functional subdivision of the brain the problem of the mechanisms of higher cerebral processes may be attacked with a reasonable hope of success. The investigation of the internal organization of the brain may be pursued in several ways:

I. The direct study of the human brain, both normal and pathological. On account of the enormous practical importance of neurology to both human psychology and pathology, research naturally turned directly to the human brain; but a more unfavorable starting point could not be found.

II. It is now generally recognized that the complex human brain can best be understood by finding first a simpler pattern such as is presented by one of the lowest vertebrates. Accordingly the phyletic method has dominated all recent neurological research. The brains of individual species are studied and monographed, particular attention being paid to the lower members of the vertebrate series in the hope of finding in them a schema or paradigm which can be followed upward through the comparative anatomical series and, after comparison with the ontogeny of higher brains, lead to a reconstruction of the phylogenetic history of the brain. While this method has been of great service, especially to such problems as can be approached from the study of external morphology, it is immensely difficult when applied to the histological problems, and as a matter of fact has not as yet taken us very far.

III. A third method, instead of taking an entire brain as the unit of research, concentrates attention upon a single functional system and seeks to get exhaustive comparative knowledge of it in many types. Starting with a fairly accurate and detailed knowledge of the functional systems at the periphery, we have simply to extend the lines of inquiry here blocked out for us.

This gives a type of problem which is much more approachable than the others. It is not so complex, but more intensive. Of still more importance are the facts that the anatomical data can be directly correlated by physiological experimentation, and the method is open to experimental control all along the line. Our degeneration methods open up possibilities here which are incomparably more valuable than the most precise anatomical observation.

And nature has performed for us a series of experiments which are in a sense the converse of our degeneration methods. The various sensori-motor systems are very unequally developed, some animals possessing one in a high state of elaboration, some another. If therefore we begin our studies on the visual system for instance, with animals such as most birds with very highly developed eyes, and then compare with animals with vestigeal eyes, it is evident that we have here a means of isolating the system for scientific study which has some points of superiority over artificial experimental methods. Fortunately within the group of fishes, whose brains are all constructed on a plan fundamentally similar, we have the most remarkable diversity in the degree of development of the several systems, so that this is a favorable starting point for this method, especially since the brain is composed almost wholly of the simpler reflex mechanisms without the complications which we find in mammals due to the enormous developments of higher associational centers in the forebrain. Some fishes have huge eyes, some are blind; some have elaborate olfactory apparatus, some very slight; some show a marvelous hypertrophy of the organs of taste, or touch, etc. These organs are all open to physiological study and so the functions can be accurately determined. Then, having found the cerebral pathways for each system where it reaches its maximum development, we can more easily trace out the system in other types, and thus arrive ultimately at a full knowledge of its evolutionary history.

All scientific method is both analytic and synthetic. In the phyletic type of neurological method, these two processes are apt to be far separated and the observed facts may remain inert and relatively meaningless, because imperfectly understood, incoordinated. In our third type of method, on the other hand, it is easier to correlate the data as we go along, the synthesis accompanies the analysis, and the possibility of experimental control should keep the student in closer touch with his guiding facts and discourage general speculation.

As a concrete illustration of the practical method of applying the doctrine of nerve components in the functional analysis of the nervous system, we may summarize briefly the progress which has been made up to date in the study of the gustatory system.

In man, as is well known, the sense of taste is not very highly developed. The peripheral organs, or taste buds, are situated chiefly on the tongue, those near its base innervated by the glossopharyngeal nerve, and those near the tip probably by the chorda tympani of the facial nerve. But the gustatory pathway toward the brain is very imperfectly understood and many points are still in controversy, while the central path is almost wholly unknown.

But in certain fishes, such as the carp and cat fish, this system of sense organs is enormously exaggerated. Taste buds are found, not only in the mouth, but all over the outer skin and barblets. Direct experiment shows that these fishes actually do taste with these superficial sense organs—unlike some people, their taste is not all in their mouth.

The experiments made on the cat fish (Ameiurus) show that these fishes seek their food by feeling for it with the barblets and by means of them they discriminate between edible and non-edible substances, that they habitually use both the sense of touch and the sense of taste for the purpose and that they can be taught to discriminate between tactile and gustatory stimuli applied to the skin and will turn and snap up savory substances and reject objects which feel like them but are devoid of taste.

The exact distribution of the gustatory sense organs has been determined and their nerves traced back to the brain. We get the gustatory reaction from the skin as described above in fishes which possess these cutaneous sense organs, and the reaction is not obtained from fishes which do not possess such sense organs and nerves.

All of these cutaneous sense organs are innervated from a single nerve, the sensory root of the facial (corresponding to the portio intermedia of human anatomy), which is the biggest nerve in the body. The center in which this nerve terminates in the medulla oblongata is about as big as the entire forebrain, instead of being barely discernable by refined histological methods, as in the human body. And the secondary gustatory path, which in man is totally unknown, is the largest single tract in the brain, both in the cat fish and in the carp!

The primary gustatory center in the medulla oblongata is bilobed, the "facial lobe," receiving the gustatory fibers from the skin and the "vagal lobe" receiving those from the mouth. From these lobes there is both an ascending and a descending gustatory path. The latter passes down to the point where the medulla oblongata merges into the spinal cord and there terminates in a special nucleus which is intimately related to the funicular nuclei, a center for tactile sensations. Here the tactile and gustatory stimuli are co-ordinated and a common descending bundle (tertiary path) passes back into the spinal cord for the body movements necessary to turn toward the food object. The ascending secondary gustatory path extends upward to a big nucleus under the cerebellum, from which tertiary pathways extend forward and downward into the midbrain (chiefly in the inferior lobe), then backward by a descending path of the fourth order into the medulla oblongata to reach the motor nuclei of the cranial nerves.

We have already gone far enough into our analysis of these secondary and tertiary gustatory paths to make it perfectly safe to predict that all of the habitual gustatory reflexes which we have observed in these fishes can be followed anatomically through the brain for their entire extent. And since we have the strongest reasons for believing that the elementary reflex paths are essentially similar in mammals and fishes, we expect to find here an important guide for further research in human anatomy.

So the other sensori-motor systems may be severally investigated, beginning the attack in each case with some species low down in the vertebrate series in which this particular mechanism is highly developed, and then extending the research to higher and lower types.

We may ultimately hope for a subdivision of the brain which shall be both structural and functional, each organ or pathway being given its function or meaning in the system as a part of the machinery of keeping the body in vital, helpful contact with environing forces. The great morphological "head problems," such as the primitive metamerism and the subsequent marvelous kalaidoscopic changes in structure and function of the component segments, these must all be read through the medium of such an intensive study of these factors upon which all differentiation has in last analysis depended.

There is another point of view from which I have been somewhat interested to develop the implications of the doctrine of nerve components, that of scientific methology in general.

It is said that scientific explanation consists essentially in such an organization of facts that they may be generalized or included under certain laws or uniformities which permit a forecasting of future events. Now, without going into an exposition at this time of the implied philosophy of nature, I think that a little reflection will show that this statement, while true in a certain limited sense, is very defective.

What is the nature of this organization of facts from which so great benefits are expected to flow? Can it in last analysis be anything other than the correlation of experience? All of the "facts" with which we deal have grown up in experience; they are in a literal sense the products of our experience. As men of science we have nothing to do with "things-in-themselves," only with phenomena, out of which we have constructed by mental process certain objective things which we regard as real—"constructs," or in common parlance, objects, facts, data.

By these things which grew up in experience (we have in most cases forgotten how) we measure up and evaluate all new experience. If the new sense presentation is a yellow dog with white feet we assimilate it at once with previous experience and approve it as a valid fact. If, on the other hand, it is a green dog with thirteen scarlet heads each with a forked tongue, we are apt to ask, Am I awake or asleep? or, What was I drinking last night? Such an experience may be vividly real to me; but if awake and sane I do not accredit it as an object of sense, as a *fact* of experience, unless I can correlate it with the body of fact already approved.

But scientific laws are merely "facts" of wider import, which rest on a foundation of broader experience such that, when objectified, they remain not as concrete elementary experiences but as general categories including many such elements. The scientific generalization or law must therefore be approved or evaluated in a way strictly analogous with that by which we test sense impressions; that is, to be acceptable it must fit in harmoniously with the whole content of experience—"it must explain all the facts."

In the solution of any scientific problem that method is most likely to lead directly to fruitful results, other things being equal, which favors the correlation of the data all along the line so that each correlation may become at once a datum for future research, instead of reserving the major correlations until near the end of the investigation. And in biological research, to return to our text, we must not forget for an instant that the organism is a *functioning* mechanism. We cannot hope to understand any animal or plant or organ until we have an exhaustive knowledge of how it works. The anatomical fact is dead and inert unless it is vivified not only by the "salt of morphological ideas" as it was so happily phrased years ago, but also by the fresh warm blood of functional explanations.

Anatomy has given place, within the memory of even the younger generation of biologists, to morphology, in which the explanation is indissolubly linked with the fact. Nor can we stop here. No anatomical fact is complete until its physiological significance is added thereto. Like the old-time descriptive anatomist, the "pure" morphologist (or shall we dubb him "poor morphologist?") has no longer any tenable standing ground. What I mean is that anatomical structure cannot be understood as the morphology of today demands that it must be understood without a full knowledge of the functions of the parts, and we must know evolution of function before we can have true knowledge of the evolution of structure. And as a matter of fact the biological public is just now coming into a practical realization of the truth that we must have a comparative physiology parallel with our comparative anatomy. It seems to us now very strange that we have had to wait a whole century after the birth of comparative anatomy for even the beginnings of a realization in practice of this elementary principle.

That researches in descriptive anatomy and in pure morphology are still necessary and will continue to be called for to the end of the age there can be no doubt; but it is important that we remember that no study of strucure is complete until the whole significance of that structure (including the evolutionary history of both its form and its function) is exposed and the whole complex of fact and meaning not only woven together into a single fabric, but fitted into the great pattern of reality as a whole in its proper place.

Now, no one of us can do this perfectly and, as time advances and the totality of the known becomes ever more vast and intricate, the difficulty grows apace. And yet this we must do in some measure in so far as we hope to rank as real builders in the permanent temple of truth. If we find ourselves unable to see the whole edifice in its proper perspective (as indeed who can?) we can at least build harmoniously with that nitch in which we find ourselves. Let no man delude himself with the idea that he is building for himself alone, that he builds on no other's foundation or that he can with safety ignore the labors of his coadjutors. Let no research worker hedge himself about and work in isolation; harmonious co-operation is the only possible way to get that breadth of view which all lack as individuals.

In our work on the nerve components we have endeavored to live up to these ideals. In so far only as we succeed in effecting wide and stable correlations from both the antomical and the physiological side can we hope to be able to build a structure which shall endure as a secure foundation for an ultimately complete functional subdivision of the nervous system.

PROCEEDINGS OF THE OHIO STATE ACADEMY OF SCIENCE

VOL. IV. PART 2

SPECIAL PAPERS, No. 8

The Coccidae of Ohio, I

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COLUMBUS, OHIO

1903

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*THE COCCIDAE OF OHIO, I

INTRODUCTORY.

This paper is the result of two years' study of the *Coccidae* in the Ohio State University Zoological Laboratory, under the able direction of Prof. Herbert Osborn, who has devoted much time to the study of the Hemiptera, of which Order the *Coccidae* comprise a comparatively small group.

It has been the plan of the author to arrange the paper in the form of an illustrated manual, furnishing keys and descriptions for the species reported in Ohio. Several species were not deemed sufficiently important to require an extended description and a figure. In the course of the work the author has added 32 species to the Ohio list, including six species new to science. One of these (*Aspidiotus glanduliferus*) was described by Prof. Cockerell, and five (*Phenacoccus osborni, Chionaspis gleditsiae, Ch. sylvatica, Aspidiotus piceus and Orthezia solidaginis*) were described by the author.

On account of the lack of specimens and literature at hand, the author omits the *Coccinae* in this paper except to list the recorded species, hoping in another year to work up this group in similar manner. Any assistance in the way of specimens or literature will be gratefully received.

In illustrating the *Diaspinae,* the author has shown on one-half of the drawing the dorsal, and on the other half the ventral surface, and has endeavored to be as accurate as possible in delineating the relative size and position of the gland-orifices, both dorsal and ventral.

The male scale has been described immediately after the female scale, it seeming proper to give first the superficial characters of each one before passing to the microscopic characters of either one.

* Presented to the Faculty of the College of Arts, Philosophy and Science of the Ohio State University as the thesis requirement for the degree of Master of Arts, June, 1903
Contributions from the Department of Zoology and Entomology, No. 18

Mrs. M. E. Fernald's catalogue of the Coccidae of the World has been followed with reference to nomenclature, and all the exotic species are italicized in the text.

The author wishes to thank Prof. Herbert Osborn for his many valuable suggestions during the study of the Coccidae, and the preparation of this paper. Also the author is under great obligations to Prof. T. D. A. Cockerell, Prof. R. A. Cooley and Mr. Geo. B. King for suggestions and verifications of species; and to Dr. E. P. Felt for specimens and literature.

LIST OF THE COCCIDAE REPORTED IN OHIO

(Including greenhouse species, indicated by an asterisk.)

ORTHEZIINAE

*Orthezia insignis Dougl.
Orthezia solidaginis Sanders.

DACTYLOPIINAE

Asterolecanium variolosum (Ratz.)
Kermes andrei King.
Kermes arizonensis King.
Kermes galliformis Riley.
Kermes kingii Ckll.
Kermes pettiti Ehrh.
Kermes pubescens Bogue.
Kermes trinotatus Bogue.
Gossyparia spuria (Modeer).
Eriococcus azaleae Comst.
Phenacoccus acericola (King).
Phenacoccus osborni Sanders.
*Pseudococcus citri (Risso).
*Pseudococcus longispinus (Targ.)
*Pseudococcus pseudonipae (Ckll.)
Pseudococcus trifolii (Forbes).

COCCINAE.

Pulvinaria acericola (Walsh & Riley).
Pulvinaria innumerabilis (Rathvon).
*Coccus hesperidum (Linn.)
Eulecanium armeniacum (Craw).
Eulecanium canadense (Ckll.)
Eulecanium caryae (Fitch).
Eulecanium cockerelli (Hunter).
Eulecanium fitchii (Sign.)
Eulecanium fletcheri (Ckll.)
Eulecanium magnoliarum (Ckll.)
Eulecanium nigrofasciatum (Perg.)
Eulecanium persicae (Fab.)
Eulecanium prunastri (Fonsc.)
Eulecanium quercifex (Fitch).
Eulecanium quercitronis (Fitch).
Eulecanium tulipiferae (Cook).
Eulecanium websteri (King).
*Saissetia depressa (Targ.)
*Saissetia hemisphaerica (Targ.)
*Saissetia oleae (Bern.)

DIASPINAE.

Chionaspis americana Johns.
Chionaspis caryae Cooley.
Chionaspis corni Cooley.
Chionaspis euonymi Comst.
Chionaspis furfura (Fitch).
Chionaspis gleditsiae Sanders.
Chionaspis longiloba Cooley.
Chionaspis ortholobis Comst.
Chionaspis pinifoliae (Fitch).
Chionaspis salicis-nigrae (Walsh).
Chionaspis sylvatica Sanders.
*Howardia biclavis (Comst.)
*Diaspis boisduvalii Sign.
*Diaspis bromeliae (Kern.)

*Diaspis echinocacti cacti Comst.
*Aulacaspis pentagona (Targ.)
Aulacaspis rosae (Bouche).
*Hemichionaspis aspidistrae (Sign.)
*Fiorinia fioriniae (Targ.)
Aspidiotus aesculi Johns.
Aspidiotus ancylus (Putn.)
Aspidiotus comstocki Johns.
*Aspidiotus cyanophylli Sign.
*Aspidiotus cydoniae crawii Ckll.
Aspidiotus forbesi Johns.
Aspidiotus glanduliferus Ckll.
*Aspidiotus hederae (Vall.)
Aspidiotus juglans-regiae Comst.
*Aspidiotus lataniae Sign.
Aspidiotus osborni Newell & Ckll.
Aspidiotus ostreaeformis Curt.
Aspidiotus perniciosus Comst.
Aspidiotus piceus Sanders.
*Aspidiotus rapax Comst.
Aspidiotus ulmi Johns.
Aspidiotus uvae Comst.
*Comstockiella sabalis (Comst.)
*Chrysomphalus aonidum (Linn.)
*Chrysomphalus aurantii (Mask.)
*Chrysomphalus dictyospermi (Morg.)
Chrysomphalus obscurus (Comst.)
*Lepidosaphes beckii (Newm.)
*Lepidosaphes gloverii (Pack.)
Lepidosaphes ulmi (Linn.)
*Parlatoria pergandii Comst.
*Parlatoria zizyphus (Lucas).

KEY TO THE SUB-FAMILIES AND GENERA

Family COCCIDAE.

The following table is adapted from Prof. Cockerell's table in the Canadian Entomologist, xxxi, p. 273, (1899).

Subfamilies

A. Males with compound eyes; adult female with conspicuous white, waxy lamellae ORTHEZIINAE

AA. Males with simple eyes,

B. Abdomen of female terminating in a compound segment; anal orifice hairless; scale composed partly of exuviae; adult female without legs DIASPINAE

BB. Abdomen not so terminating,

C. Female with the posterior extremity cleft; anal orifice closed above by a pair of triangular plates; female secreting a waxy scale not separable from the insect COCCINAE

CC. Not as above; triangular anal plates absent DACTYLOPIINAE

Subfamily ORTHEZIINAE.

A. Female with 8-jointed antennae (One genus) **Orthezia Bosc.**

Subfamily DACTYLOPIINAE.

Tribes

A. Female enclosed in a complete sac of waxy or horny texture; skin usually with figure-of-8 glands; legs absent in adult; larva not fringed with spines ASTEROLECANIINI

AA. Female globular or reniform, in a hard shell; anal ring with hairs in larva but not in adult; larva fringed with spines KERMESINI

AAA. Newly hatched larva with rows of dorsal spines ERIOCOCCINI

AAAA. Newly hatched larva without rows of dorsal spines— female with soft, powdery, unarmored body DACTYLOPIINI

Asterolecaniini.

Insect with a fringe of glassy rods **Asterolecanium Targ.** p. 33

Kermesini.

One genus only **Kermes Boit.** p. 33

Eriococcini.

A. Female anal ring with hairs; antennae and legs well-formed in the adult; adult surrounded by secretion but dorsally naked **Gossyparia Sign.** p. 38

AA. Adult forming a cottony sac; anal ring with eight hairs; caudal lobes long **Eriococcus Targ.** p. 38

Dactylopiini.

A. Antennae 9-jointed; anal ring of female with six hairs **Phenacoccus Ckll.** p. 39

AA. Antennae 8- (sometimes 7-) jointed; anal ring with six hairs; body oval **Pseudococcus Westw.** p. 41

Subfamily COCCINAE.

This subfamily, which includes the genera, *Pulvinaria, Coccus, Eulecanium* and *Saissetia*, is omitted from this paper, but the author hopes to be able to publish later an account of the species reported in Ohio.

Subfamily DIASPINAE.

A. Scale of female circular to oval with central, sub-central or submarginal exuviae.

B. Scale of male usually resembling scale of female in color and texture; only slightly elongated,

C. Last segment of female with six groups of circumgenital gland-orifices **Comstockiella**, p. 69

CC. Last segment of female with less than six groups of circumgenital gland-orifices; with much elongated chitinous processes extending anteriorly from bases of lobes **Chrysomphalus**, p. 69

CCC. Chitinous thickenings smaller and shorter or wanting **Aspidiotus**, p. 55

BB. Scale of male white, delicate and carinated **Diaspis, Aulacaspis**, pp. 51, 53

BBB. Scale of male elongated, not white and without carinae **Parlatoria**, p. 75

AA. Scale of female elongated, with exuviae at one extremity,
E. Scale of male similar to scale of female, smaller,
F. Scale of female with sharp, central, longitudinal ridge
Fiorinia, p. 54
FF. Scale of female plain, convex or flattened **Lepidosaphes**, p. 73
FFF. Scale of female plain, with very large exuviae **Parlatoria**, p. 75
EE. Scale of male white, small, with parallel sides, and carinated (except in two species)
Hemichionaspis, Chionaspis, pp. 53, 43
AAA. Scale of female usually mining under the epidermis of the host **Howardi**, p. 51

SYSTEMATIC TREATISE OF OHIO SPECIES

Subfamily ORTHEZIINAE.

Under this subfamily are included only three genera, viz., *Orthezia, Newsteadia* and *Ortheziola*, neither of the last two named being represented in the United States.

Genus ORTHEZIA Bosc.

Mr. C. P. Lounsbury, in his paper on *Orthezia*, published as a part of the 32nd Rep. of the Mass. Agricultural College (1894), gives the following generic characters for *Orthezia*:

"**Adult Male:** Head, thorax and abdomen distinct. Eyes and ocelli present. Antennae long, filiform, nine-or ten-jointed. Wings, two, diaphanous with one furcate nerve. Halteres, each with a bristle which hooks into a pocket in the base of the wing. Legs long, pubescent, with one claw, no digitules. Two or more long, slender, snow-white filaments project from near the posterior end.

Adult Female: Head, thorax and abdomen not separated. Antennae eight-jointed; nine-jointed in *macuariensis* (Doug.). Tarsus with one claw without digitules. Eyes simple. Anal ring with six setae. Body more or less covered with cereous matter arranged in compact symmetrical plates. The eggs are laid in an elongated ovisac which projects behind the body, and are there carried until they hatch. The insect is active throughout its entire life."

Orthezia insignis Douglas.

Fig. 56.

O. insignis Doug., Jn. Quekett Micr. Club, p. 169 (1887).

O. insignis Doug., Ent. Mo. Mag. xxxiv, p. 169 (188).

O. insignis Lounsb., 32nd Rep. Mass. Ag. Coll., p. 111 (1895).

Adult Female: Body broad oval; width, 1.2 mm., length, 1.5 mm., exclusive of lamellae, ochreous mottled to dark green; distinctly segmented. Arranged around the body beginning with the second thoracic segment, are white, waxy plates or lamellae. In the adult female, the lamellae are united posteriorly, forming a long, parallel-sided marsupium, which contains the eggs and young. The arrangement of the lamellae can be better shown by a figure than by description, q. v. Antennae eight-jointed, all fulvous except the black, somewhat fusoid eighth joint; the first joint is very stout, the second the shortest and stouter than the remaining ones. Legs light brown, the darker tarsi bearing numerous fine spines.

Adult Male: The slender dusky body is about 1 mm. in length, and bears two large ovate, transparent wings with two veins united at the base. Wing expanse, 2.5 mm. The last segment bears on either side a long white filament.

Remarks: This insect is a destructive pest in greenhouses, seriously infesting *Lantana*, *Chrysanthemum* and *Verbena* in the Ohio State University Conservatory.

ORTHEZIA SOLIDAGINIS Sanders.

Fig. 57-63, 77.

Sanders, Ohio Naturalist, iv, 4, p. 94 (1904).

Adult female: Length (including marsupium), 6 mm.; width, 2.5 mm. Body completely covered by white waxy secretion in four series; two inner series composed of eight pairs of lamellae extending laterally from median line with tips turned backward and upward, gradually increasing in length to the sixth then rapidly decreasing; the ninth pair jointed at tips forming a ring around anal orifice. The two lateral series are each composed of ten lamellae, all turning backward except the first on either side. The second and third lateral lamellae are subequal, the others increasing in length to the long subequal eighth and ninth, reaching midway on the marsupium; the tenth pair are very short and inconspicuous. A lamella extends downward between the antennae to the ventral surface. The marsupium is fluted on the dorsal surface, plain ventrally and gradually narrowed and elevated posteriorly.

Body, antennae and legs dark reddish-brown. Antennae 8-jointed bearing scattered hairs and with distal ends of joints enlarged; the fusoid eighth joint with a terminal spine and with distal half black. Formula:—3, 8, (4, 5, 2,) 6 (7, 1). Length of joints in mu:—(1) 135, (2) 150, (3) 205, (4) 150, (5) 150, (6) 141, (7) 135, (8) 180. Legs large and strong, rather spiny, with femur and tibia of almost exactly equal length and tarsus more than half the length of tibia; large claw with three to four denticles and a pair of short flattened digitules.

The body is thickly covered with tubules about 20 mu long, and small derm-orifices. The anal ring is elliptical bearing six hairs and a narrow chitinous band on each side of orifice, and is thickly dotted.

Immature stage: Length 3 mm.; width, 2 mm. Completely covered above by four series of waxy lamellae. The two median series consist of eleven short thick lamellae; the 11th pair being very small and the anterior pair protruding forward over the head in a bilobed manner. The first four lateral lamellae are similar to those of the adult, the fifth and sixth pairs are short, the apparently fused seventh and eighth are again longer, giving the insect a rectangular appearance. The ninth lamellae from either side are fused, forming a single long lamella projecting posteriorly on the median line.

On the ventral surface are 12 short, broad, subequal lamellae on each side around the margin of the body, and the entire surface has an armadillo appearance on account of the short plate-like lamellae. This stage has 7-jointed antennae. Formula:—7, 3, 2, 4, (5, 1) 6. (1) 75, (2) 87, (3) 120, (4) 81, (5) 75, (6) 72, (7) 141. The distal half of the eighth joint is black.

Larval stage: With 6-jointed antennae and two series of large, cottony lamellae on the dorsal surface.

Remarks: The author has found only five adults, near Port Clinton, Ottawa Co., O., July 5, 1903. The immature forms have been collected at Port Clinton, Columbus and Georgesville.

Subfamily DACTYLOPIINAE.

This subfamily is represented in Ohio by six genera of more or less economic importance, viz., *Asterolecanium*, *Kermes*, *Gossyparia*, *Eriococcus*, *Phenacoccus* and *Pseudococcus*. The only species which have as yet any economic importance in Ohio, are the "Mealy-bugs," *Pseudococcus citri* and *P. longispinus*.

ASTEROLECANIUM VARIOLOSUM (Ratz.)

Found on *Quercus aurea*, at Mentor, Lake Co., O., by Prof. Wilmon Newell, Feb. 7, 1900. This scale is of very little importance, as far as known in Ohio.

Genus KERMES Boitard.

Globular or reniform Coccids appearing like galls and always found on Oaks; rather large, varying from 3—10 mm. in diameter; segmentation obscure or revealed by dark bands, or by rows of dark spots on both. Anal ring without hairs in adult. Larvae are long-elliptical with a plainly segmented abdomen, which is usually deeply cleft at the posterior extremity, forming two anal lobes which bear each a long hair and one or more shorter ones. Anal ring with six hairs and body fringed with spines. Antennae 6-jointed. Legs usually strong; tarsi longer than tibiae; knobbed digitules on tarsi and claws.

A. Scale very convex, approaching a conical form; segmentation well-marked by three to five dark lines **andrei**

AA. Scale globular or nearly so.

B. Small (3—3.5 mm. in diam.) shiny, covered with fine pubescence **pubescens**

Larger, (4—6 mm. in diam.),

BB. Usually longer than broad, with pale longitudinal mid-dorsal line **kingii**

C. Grayish-white, marbled with terra-cotta, with three or four contrasty, wavy, dark bands **arizonensis**

Dirty-gray with irregular black spots and transverse pale bands **galliformis**

Bright argillaceous to dull gray in color, a dark blotch on each side of front and one around anal orifice **trinotatus**

AAA. Much broader than long with median longitudinal constriction; conspicuous black spots in transverse rows **pettiti**

KERMES ANDRIE King.

Fig. 68.

K. andrei King, Psyche, ix, pp. 22, 78, 81 (1900).

K. andrei King, Can. Ent., xxxiv, p. 160 (1902).

"**Kermes andrei n. sp.** Female scale pyriform in shape, very convex, 5 mm. high and 5 mm. in diameter at the base, varible in some individuals which are nearly hemispherical. Surface shiny. Color, light brown, with three and sometimes four very dark brown bands, these variable in length and breadth. There are also several suffused dark brown, blotchy spots and round dots, more numerous around the posterior cleft. Segmentation obscure; a median posterior keel-like prominence, which is very much wrinkled above near the region of the posterior cleft. When boiled in KOH, the derm is colorless. Rostral loop dark yellow, stout, not very long. No antennae or legs observed. The larvae which were formed in the body of the female are yellow, elongate-oval, 360 mu long, 160 mu broad. Antennae 6-segmented, 3 and 6 about equal and longest; 1 next, then 2 and 5 which are equal. 4 is the shortest. Formula:—(3, 6,) 1, (2, 5,) 4. Antennal segments:—(1) 20, (2) 16, (3) 24, (4) 12, (5) 16, (6) 24. Segments 4, 5, and 6 have a few short hairs. Legs short and stout. Femur with trochanter, 76 long. Tibia with tarsus, 68 long. Tarsal digitules, long fine hairs with knobs; digitules of claw reaching a little beyond the claw. Caudal tubercles quite large, each bearing one long stout bristle (120 mu long) and three long stout spines (28 mu long). The marginal spines point backwards and about the same length and breadth as those on the caudal tubercles. Rostral loop reaching beyond the last pair of legs. Eggs oval 320 mu long, 240 mu broad.

Hab.: Lawrence, Mass., on white and red oaks. Associated with K. galliformis, and found singly, not in clusters as in the latter. They are not common, and the species seems to be viviparous." Original description, in Psyche, IX, p. 22 (1900).

Remarks: Although the author has been on the lookout for *Kermes andrei* over the state, it has been found in but two localities, at Columbus and at Minerva Park, about eight miles north of Columbus. At Columbus it was found on *Quercus acuminata* and *Q. alba* and on *Q. macrocarpa* associated with *K. pubescens* Bogue.

KERMES ARIZONENSIS King.

Fig. 70.

K. arizonensis King, Ent. News, xiv, p. 21 (1903).

The original description follows:

"Kermes arizonensis, n. sp. Dead dry adult females globular, variable in size, transverse diameter 3 and 5 mm. Color grayish-white distinctly marbled with light yellow or reddish-brown, and having four prominent linear transverse dark-brown bands, somewhat wavy, due to quite large pits at intervals; surface not shiny; speckled with minute black dots. Dead dry half-grown individuals, dark red brown. Antennae apparently only 5-jointed; joints, 1 (20), 2 (20), 3 (40) 4 (20), 5 (32) mu long. Derm colorless. Rostral loop stout, dark brown. Mentum small, no legs or other structural characters found.

Hab. On oak at Prescott, Ariz., collected by Prof. T. D. A. Cockerell, March, 1902."

Remarks: Collected by the author on *Quercus alba* at Salem, Columbiana Co., O., Sept. 7, 1903, and determined by Mr. G. B. King. This is a beautifully marked grayish species, marbled with colors varying from light-yellow to reddish-brown.

KERMES GALLIFORMIS Riley.

Fig. 73.

K. galliformis Riley, Am. Nat., xv, p. 482 (1881).

K. galliformis Lint., 12th Rep. Ins. N. Y., p. 316 (1897).

K. galliformis King, Can. Ent., xxxi, p. 139 (1899).

K. galliformis Ckll., Psyche, ix, p. 44 (1900).

K. galliformis King, Psyche, ix, p. 79, (1900).

The following description is taken from Mr. King's article. "The Genus Kermes in North America," Psyche, IX. p. 79 (1900).

"A large dark dirty-gray form, which turns to a nearly white color when exposed a season on the twigs. Female scale 6 mm. long, 7 broad, 6 high, with black spots, and viewed with a hand lens, the scale is seen to be be covered with minute black specks. Newly hatched larvae dirty-gray."

Remarks: First found in Ohio at Wooster, by Prof. Wilmon Newell.

KERMES KINGII Ckll.

Fig. 72.

K. kingii Ckll., Am. Mag. N. H., (7), ii, p. 330 (1898).

K. kingii Ckll., Can. Ent., xxxi, p. 139 (1899).

K. kingii Ckll., Psyche, ix, p. 44 (1900).

K. kingii King, Psyche, ix, pp. 80, 83 (1900).

Female scale longer than broad; about 5 mm. in length, 4—4.5 mm. broad, and 3.5 mm. high. Almost invariably attaching itself in or at the forks of twigs, or at base of leaf petioles. Color bright ochreous or sometimes lighter, marbled with a more reddish tint, sometimes almost terra-cotta, with pale longitudinal dorsal band crossed at segments by short more or less broken dark lines; otherwise the segmentation is very indistinct. Small dark spots not prominent and scattered rather promiscuously; numerous minute specks discernable with hand-lens.

Remarks: Found by the author at Pomeroy, O., Aug. 28, 1903, on *Q. rubrum*, and later on the same host at Salem, and on *Q. velutina*, associated with *K. pettiti* Ehrh., at Lisbon. The specimens from *Q. rubrum*, at Salem, are much lighter in color than those found on *Q. velutina*, at Lisbon, O.

KERMES PETTITI Ehrh.

Fig. 69.

K. pettiti Ehrh., Can. Ent., xxxi, p. 7 (1899).

K. pettiti Ckll., Psyche, ix, p. 45 (1900).

K. pettiti King, Psyche, ix. p, 81 (1900).

The original description from Can. Ent., xxxi, p. 7, follows. "Kermes pettiti, n. sp.

"Female scale about 4 mm. broad, 3 mm. long and 3 mm. high, dark-purplish-brown; some individuals of a lighter color and marbled with brown. A distinct longitudinal groove on the meson indicated by a dark line. Surface without minute black specks. Segmentation not very distinct, indicated by rows of black spots plainly seen through a pocket lens. Ventral surface where it touches the bark, flattened and more or less covered with a yellow secretion. Beak very prominent. When removed from twig, scale leaves a whitish powder. When boiled in KOH, derm colorless except numerous brown spots with dark centers scattered over the dorsum. Antennae very obscurely 6-jointed, joint three apparently longest. Legs very small and stout. Tibia as broad as long, with a stout spine. Femur and tibia almost equal. Tarsus nearly twice as long as tibia. Claw straight."

Remarks: First found in Ohio, by the author, at Cedar Point, on *Q. imbricaria*, June 28, 1903; found later at Lisbon, Columbiana Co., on *Q. velutina*, and at Newark on *Q. imbricaria*.

An undescribed Chalcid parasite, belonging to the genus *Cheiloneurus* is a common foe of this species, about Sandusky.

KERMES PUBESCENS Bogue.

Fig. 55, 67.

K. pubescens Bogue, Can. Ent., xxx, p. 172 (1898).

K. pubescens Ckll., Psyche, ix, p. 44 (1900).

K. pubescens King, Psyche, ix, pp. 80, 83 (1900).

"**Kermes pubescens Bogue.** Female scale spheroidal, 3.5 mm. in diameter, 3 high, pointed and grooved beneath; covered all over with short straggling pubescence. Color rather light brown, with more or less obscure and suffused dark brown bands marking the obsolete segments. Surface shining, with minute concolorous specks but no dark spots or pits." Original description from the Canadian Entomologist, xxx, p. 172 (1900).

The larvae of K. pubescens differ from the larvae of any other known species, by having six rows of short conical spines and short caudal setae. The body is narrower and longer and more attenuated posteriorly. In the larvae of K. pubescens and K. ceriferus, the sixth antennal segment is longer than the third.

Remarks: This species has been found plentifully at Minerva Park, eight miles north of Columbus, on *Q. macrocarpa*. Although there is a Red Oak (*Q. rubrum*) adjacent, there was not a specimen of *K. pubescens* on it.

KERMES TRINOTATUS Bogue.

K. trinotatus Bogue, Can. Ent., xxxii, p. 205 (1900).

K. trinotatus Quaint. & Scott, Cocc. Am., Dec. iii-iv, No. 4 (1901).

"**Kermes trinotatus, n. sp.** Female scale variable in size, averaging about 5.5 mm. long, 6 mm. wide, and 4.5 mm. high; rounded above, somewhat flattened behind, convex beneath, front turned down into a more or less beak-like prominence; median groove obscure or broad and shallow; color varies from bright argillaceous to dull gray; surface uniform, more or less conspicuously speckled with black; segmentation obscurely or plainly marked with dark spots. When the median groove is present, it is crossed with more or less dark lines showing the segmentation. There is a rounded dark spot on each side of the front, and an elongated dark blotch extending for a short distance above and below the anal opening; hence the specific apellation.

"Larvae 416 mu long by half as broad; caudal setae 160 mu long; antennae 100 mu long, 6-jointed; formula, (1, 2,) (3, 4,) 5, 6; 6 longest, 3 and 4 shortest, a few hairs toward tip; marginal spines conspicuous around the head, a prominent one each side of each caudal seta; claws of feet simple, slightly curved inward, accompanied by a few hairs." Original description.

Prof. Bogue then says that the specimens are variable in size, color and markings, so that he thinks it possible that more than one species may be included in the description.

Remarks: First found in Ohio by Prof. J. S. Hine, at Georgesville, Franklin Co., on *Quercus alba*.

GOSSYPARIA SPURIA (Modeer).

Coccus ulmi Geoff. Histoire Abregee des Insectes, 1, 1762, pp. 512-13.

Gossyparia ulmi Howard, Insect Life, ii, 1889, pp. 34-41. 5 figs.

Adult female: Length, 2—2.5 mm., reddish, oval in outline, surrounded by an irregular mass of white wooly secretion, forming a cushion, which at first is in the form of lamellae, but later is more or less fused. The segmentation is fairly distinct and rendered more so by the inward projection of the secretion over each suture. After the birth of the young the female shrivels up and can be easily jarred from the cushion. The antennae are six-jointed, second and third longest, fourth and fifth shortest. The legs are small and slender, the tibia shorter than the tarsus. The ano-genital ring bears eight hairs.

Adult male: There are two forms of the males; one, the first to emerge from the cottony cocoons, is a form with short wing-pads and a large robust body; the other, the full-fledged males appearing later, are delicate two-winged creatures with large heavy, almost moniliform, 10-jointed antennae. The males are not easily disturbed and seldom take flight.

Larvae: The young larvae are easily recognized on leaves and twigs, as small oval specks about 0.5 mm. in length, narrowed posteriorly. Each segment bears laterally a spine, also a ring of six upon the head and a double row on the back. The antennae are six-jointed; joints 1, 2, and 3 the longest. The full-grown male larvae have 7-jointed antennae.

Remarks: This species which is causing alarm in some eastern states is not common in Ohio; in fact, it was reported only last year, (1902), in Columbus, by Mr. A. F. Burgess, Chief State Nursery Inspector.

ERIOCOCCUS AZALEAE Comst.

This Coccid was reported by Prof. Webster, at the Experiment Station at Wooster, on a planted shrub, (*Rhododendron* *catawbiense*). Both males and females are early enclosed in a white, dense, felt-like, ovoid sac about 3 mm. long and 1.5 mm. wide. The females when removed from the sac are dark purple, have 6-jointed antennae and an anal ring with eight hairs. The dorsal surface is covered with numerous spines and tubercles.

PHENACOCCUS ACERICOLA (King).

Pseudococcus aceris Smith, E. A., N. Am. Ent., p. 73 (1880).

Phenacoccus acericola King, Can. Ent., xxxiv, p. 211 (1902).

The adult female is concealed by an irregular cottony mass 6—8 mm. in diameter, on the underside of leaves of hard maple, appearing not unlike the ovisac of a Pulvinaria. The female itself is about 5 mm. in length, oval, yellow and plump; the segmentation showing plainly toward the posterior end. The body surface is covered with spinnerets which are more numerous posteriorly; also groups of spines are found on the margin of the body. The widely separated, 9-jointed antennae bear numerous, long, flexible hairs. Formula: 9, (1, 2, 3, 5,) (4, 6,) (7, 8). Mr. King says in his description that later in the fall when the females are well-filled with eggs, they bear 8-jointed antennae, with the following formula: 4, (8, 2,) 3, (1, 5, 6,) 7.

The adult male issues from a white, closely woven, oval cocoon, usually attached under the rough loose bark of the trunk and larger limbs. Two long waxy filaments issue from the eighth and ninth segments. Antennae 10-jointed almost as long as the red body. Wings large, covered with white powder and iridescent in sunlight.

Remarks: The author has found this species on *Acer saccharum* at Columbus, associated with *Aspidiotus comstocki* Johns.

PHENACOCCUS OSBORNI Sanders.

Plate vii, (lower half).

P. (*Paroudablis*) *osborni* Sanders, Ohio Naturalist, Vol. II, No. 8, p. 284, 1902.

Female: (adult), 2 to 2½ mm. in length, 1 to 1¼ mm. in breadth, flesh-colored and covered with a slight, white powdery secretion. There are seventeen very short, inconspicuous, lateral filaments on each side. Although the filaments are short, spinnerets and numerous hairs are scattered over the surface of the body, being especially numerous in the cephalc region. On the anterior ventral margins of the second and third segment, are two large spiracles. The anal lobes, bear each, two long hairs and three short ones, besides the spines. The large, retracted anal ring bears the customary six long hairs, and is conspicuously dotted. The eyes are prominent, though not large. The antennae are nine-jointed. The formula is as follows: (3, 2,) (4, 9, 5,) 1, 8, (6, 7). The legs are well developed and darker in color than the body; the tibia being nearly three times the length of the tarsi, and bearing a pair of strong spines on the distal end. Numerous hairs are borne by the tarsi but no noticeable digitules. A pair of knobbed digitules is borne by the long single-toothed claws.

The eggs are long-elliptical, golden-brown, rather firm, measuring .3 mm. x .15 mm.

Male (adult) is an active, well-constructed insect; the thorax contsituting one-half the length of the individual. Measurements: From tip of head to tip of abdomen, .85 mm.; wing expanse, 2.8 mm. From tip of head to tip of folded wings along dorso-median line, 1.5 mm.; length of wing, 1.25 mm.; width of wing, .55 mm.; length of balancers, .1 mm. Caudal filaments; two about 1.25 mm., and two about 1 mm. in length. Front legs; femur .25 mm., tibia .35 mm., tarsus, .12 mm., claw .03 mm. in length. Hind legs; femur .3 mm., tibia .4 mm., tarsus .13 mm., claw .03 mm. in length. Antennae are 1 mm. in length, the joints measuring; 1st, 45 mmm., 2nd, 60, 3rd, 160, 4th, 150, 5th, 135, 6th, 120, 7th, 96, 8th, 75, 9th, 63, 10th, 90. Formula: 3, 4, 5, 6, 7, 10, 8 (9, 2,) 1.

Color: Head, dark reddish-brown; eyes, blackish; thorax, reddish-brown except dark, chitinous parts; abdomen light-brown tinged with yellow. Antennae, reddish-brown; legs, brown to olivaceous with dark-brown tarsi. Caudal filaments, white; wings, semi-transparent with iridescent rose-tint in strong light. Balancers, darker, slightly chitinous on costal margin, bearing one long, hooked claw which fits into a pocket in the wing.

Although the head is very small and much reduced, and bears four reddish ocelli, the thorax is very large and well developed and bears a black, shield-shaped chitinous plate on the meso-scutum, from which three dark, chitinous bands extend to the anterior margin of the thorax.

The legs are long and hairy for their entire length; the tibia bear a pair of strong spines on their distal extremity; the tarsi are armed with numerous spines; the claws are long and curved, and bear a sharp denticle on the ventral margin, near the tip. Two knobbed digitules are present, extending beyond the tip of the claw.

The males were found emerging from the pupa-cases from April 13 to 18, and taking wing readily.

The females were found, during the winter, under loose bark on the trunks and larger limbs of *Platanus occidentalis* on the campus of Ohio State University, at Columbus. Not abundant.

A Chalcid parasite was reared from specimens collected in February.

Pseudococcus citri (Risso).

(Mealy Bug)

Figs. 46, 47, 48.

Dorthesia citri Risso, Essai, Hist. Nat. des Oranges (1813).

Dactylopius citri Sign., Ann. Soc. Ent. Fr., (5) v, p. 312 (1875).

Dactylopius destructor Comst., Rep. U. S. Dep. Ag., 1880, p. 342 (1881).

Adult female: Length 3.5—4 mm., width 2—2.5 mm., white or yellow with brownish tinge, darker than P. longispinus, and with less powdery secretions covering body. The seventeen lateral appendages are short and blunt; posterior appendages not much longer than lateral ones. Antennae 8-jointed, less pubescent than in P. longispinus; formula: 832 (17) (564). The penultimate segment bears on either side a very long seta, and two or three very short ones, and two conical projections, the surface of the segment is dotted with orifices. Six slender setae, one-half the length of the setae on the penultimate, are borne by the ano-genital ring, which is somewhat projected from the penultimate segment.

Remarks: This species differs from *P. longispinus* by the absence of the long filaments at the posterior end of the body. The female is oviparous, laying her eggs in a cottony sac, which increases in size with the growth of the adult female.

Pseudococcus longispinus (Targ).

Figs. 49, 50, 51.

Coccus adonidum corpore roseo, etc., Geoff., Abr. Ins., i, p. 511 (1762).

Dactylopius longispinus Targ., Catalogue, p. 32 (1869).

Dactylopius adonidum Comst., Rep. U. S. Dep. Ag., 1880, p. 341 (1881).

Female: Length, 2.5—3 mm., width, 1.5—2 mm. White or tinged with yellow, with brown band on middle of back; each segment with a white waxy filament, which forms a border of appendages of varying lengths around the body; those near the posterior extremity longer, and four at caudal end very long, the inner the longer, sometimes longer than body. Entire body appears as if dusted with flour, which is caused by the waxy secretion. Antennae 8-jointed, each joint bearing several hairs. Formula: 8, (2, 3,) (1, 5,) (4, 6,) 7. The legs are long, stouter than in P. citri, somewhat pubescent; tibia twice as long as tarsus. The penultimate segment presents on either side a rounded group of pores and two short, strong spines, also a seta somewhat longer than the anal setae, and several shorter setae. Anal ring large, dotted, with six long setae.

Larvae: The male and female larvae are similar to adult female in shape and color, but the male larva has 7-jointed and the female 6-jointed antennae.

Remarks: This is a pest in almost every conservatory, and is difficult to control since the waxy secretion protects it from a spray of water, and only by a spray of considerable force can it be dislodged.

Pseudococcus pseudonipae (Ckll.)

Dactylopius nipae Davis, Spec. Bull. 2, Mich. Exp. Sta., p. 28 (1896).

Dactylopius pseudonipae Ckll., Science Gossip, N. S., iii, pp. 189, 302 (1897).

Dactylopius pseudonipae King, Can. Ent., xxxi, p. 112 (1899).

The author found this peculiar *Pseudococcus* on palms in a greenhouse at Painesville, where it was quite a pest.

PSEUDOCOCCUS TRIFOLII (Forbes).

Figs. 52, 53, 54.

Coccus trifolii Forbes, 14th Rep. Ins. Ill., p. 72 (1885).

Dactylopius trifolii Osborn, Contr. Ia. Ag. Coll., p. 2 (1898).

Dactylopius trifolii Davis, Bull. 116, Mich. Exp. Sta., p. 58 (1894).

Adult female: 2—2.3 mm. in length, reddish-brown, covered with granular, waxy secretion. A fringe of seventeen waxy processes extends around the body, longer at caudal end, sometimes one-third the length of the body. The legs are dirty yellow in color, femur and tibia subequal, tarsus of hind leg more than one-half the length of the tibia. Four digitules, the two superior ones long and slender, two inferior stouter and knobbed at tip. Antennae 8-jointed; joint one swollen, stout, as broad as long. Formula: 8 (321)5(467). The fourth joint varies considerably, sometimes smaller, sometimes larger than 5, 6, or 7. Anal lobe bears one long and three short setae, and a mass of small gland-spots with two conical projections. Ano-genital ring large, dotted, with six long setae, about same length as anal lobe setae. Penultimate segment conspicuously dotted with gland orifices.

Remarks: On roots of clover at Columbus, O., not plentiful.

Subfamily COCCINAE.

This group which belongs here in order of arrangement, has been omitted in this paper, with the expectation of a later account. Lack of material and literature have been the main factors in the omission of this group.

Genus CHIONASPIS Signoret.

This genus was founded in 1869 by Signoret, in the Annals of the Entomological Society of France. In 1897 the group was divided, and in Ohio is reported a single greenhouse representative of the genus *Hemichionaspis* Ckll.

I. Scale of male oval, without carinae,
  Scale of female 2—2.5 mm. in length; fifth group of gland-spines with more than four **ortholobis**
  Scale of female smaller, 1.5—2 mm. in length; fifth group of gland-spines numbering less than four **longiloba**
II. Scale of male carinated more or less distinctly, narrow,
A. Median lobes more or less fused,
B. Median lobes fused to near tips, notched on outer margin **americana**
BB. Median lobes fused half-way on inner margins,
C. Lobes broad, entire, close together **caryae**
  Median lobes similar to **caryae**, but serrate on margin; outer lobule of second lobe, triangular, acute **sylvatica**
  Lobes narrower, pointed, second distant from median by half its width **gleditsiae**
AA. Median lobes not fused by inner margins, perhaps approximate,
D. Fifth group of gland-spines from 1-3 **pinifoliae**
DD. Fifth group of gland-spines from 3-11
E. Median lobes broadly rounded,
F. Lobules of second and third lobes decidedly rounded **salicis-nigrae**
FF. Lobules of second and third lobes obliquely pointed **furfura**
EE. Median lobes obscurely pointed, short, divergent **corni**
EEE. Median lobes and lobules of second and third lobes pointed and striate **euonymi**

CHIONASPIS AMERICANA Johnson.

Fig. 31.

Ch. americana Johns., Ent. News, vii, p. 150 (1896).

Ch. americana Johns., Bull. Ill. St. Lab. N. H., iv, p. 390 (1896).

Ch. americana Cooley, Spec. Bull. Mass. Exp. Sta., p. 41 (1899).

Scale of female: Length 2—3 mm. Plainly convex, broadest near the middle, of firm texture, white sometimes with yellowish tinge, but usually blackened by a sooty substance which renders it very inconspicuous. The exuviae are about 0.7 mm. long. A conspicuous white mark is left when removed from bark.

Scale of male: Length 0.7—1 mm. Sides parallel, tri-carinate. Exuvia pale-yellow.

Female: The median lobes are fused nearly to the apex, notched on lateral margin, rounded. Inner lobule of second lobe converging, notched once or twice on lateral margin; outer lobule short, rounded, usually entire. Third lobe broad and flat, scarcely divided, sometimes serrate. A club-shaped process extends anteriorly from between median lobes, also processes at inner margins of second and third lobes. The gland-spines are arranged as follows: 1, 1-2, 2, 2-4, 5-7. Those in the second and third groups are frequently forked at the tip. Second row of dorsal pores absent; third row with 4-6 in the anterior and 4-5 in the posterior group; fourth row with 4-5 in anterior and 4-6 in posterior group. Median group of circumgenital gland-orifices, 20-30; anterior lateral, 18-42; posterior lateral, 20-30.

Remarks: This native species is very common in Ohio on *Ulmus americana*, and is pretty generally distributed, almost attaining economic importance. Each female lays about seventy-five purplish, ellipsoidal eggs, in which stage the insect passes the winter, hatching about the middle of May. In this latitude there are two broods.

CHIONASPIS CARYAE Cooley.

Fig. 29.

Ch. caryae Cooley, Can. Entomologist, Vol. xxx, p. 86 (1898).

Ch. caryae Cooley, Special Bull. Mass. Exp. Sta., p. 40 (1899).

Scale of female: Length, 1.7—2 mm. Dirty white, inconspicuous on bark of host; texture thick; form irregular and rather convex. Exuviae dark-brown, 0.7 mm. long. The first exuviae is easily seen, but the second is somewhat covered by secretion.

Scale of male: Length, 0.5—0.7 mm. Oblong to elliptical with distinct median carina. The pale-brown exuvia occupies nearly one-third of the scale.

Female: Median lobes large, broad, entire, striate, diverging; the inner margins fused half-way to the apex, and a club-shaped chitinous process extending anteriorly. Inner lobules of second and third lobes, much the larger and serrate; the outer lobule of third lobe often obscure or obsolete. The gland-spines are arranged as follows: 1, 1, 1, 1-2, 4-7. The first pair are short and blunt. The second row of dorsal pores represented only by the anterior group of 1-4; third row, 4-5 in anterior and 3-5 in posterior group; fourth row with 4-6 in anterior and 4-5 in posterior group. Median group of circumgenital gland-orifices, 10-18; anterior lateral, 20-29; posterior lateral, 15-22.

Remarks: Collected by the author on Catawba Island, Ottawa Co., July 10, 1902; the first report of its occurrence in the state. Several small white hickory trees (Hicoria alba), were rather badly infested, causing malformation of the smaller branches and twigs.

CHIONASPIS CORNI Cooley.

Figs. 26, 27.

Chionaspis corni Cooley, Special Bull. Hatch Exp. Sta., p. 15 (1899).
Chionaspis corni King, Can. Ent., xxxiv, p. 61 (1902).

Scale of female: Length, 1.6—2 mm. Somewhat irregular in shape, gradually broadened posteriorily, of rather delicate texture, white. The orange-yellow or brown exuviae are about .7 mm. long.

Scale of male: Length, .6—.8 mm.; the pale-yellow exuvia occupies about one-third of the moderately tri-carinate scale.

Female: Median lobes fused for about one-half their length, then they diverge in an almost straight edge to the somewhat pointed apex; usually entire, short and broad. Inner lobule of second and third lobes rounded, entire and much larger than outer lobule. Gland-spines, excepting first, rather long and slender, arranged as follows: 1, 1, 1-2, 1-2, 4-6. Second row of dorsal pores represented by anterior group of 2-5; third row with 4-5 in anterior and 5-7 in posterior group; fourth row with 4-7 in anterior and 6-9 in posterior group. Median group of circumgenital gland-orifices, 9-16; anterior lateral, 17-28; posterior lateral, 10-20.

Remarks: This species was first collected in Ohio, at Sandusky on *Cornus amomum*, by Prof. Herbert Osborn and later by the author. The smaller branches were encrusted with the scales.

CHIONASPIS EUONYMI Comst.

Fig. 28.

Ch. euonymi Comst., Rep. U. S. Dep. Ag., 1880, p. 313 (1881) in part.
Ch. euonymi Kuwana, Pr. Cal. Ac. Sci., (3) iii, p. 75 (1902).

Scale of female: Length about 2 mm., decidedly broadened posteriorly, convex, rather thick and firm in texture, dark grayish-brown. Ventral scale entirely developed, attached along the sides but free at the posterior extremity.

Scale of male: Length, 1.5 mm., white, tricarinated with a yellow exuvia.

Female: Median lobes, and lobules of second and third lobes, serrulate and pointed. The lobes are far apart, and the lobules are distinctly parted to the base, slightly chitinized on the margins, the inner always the larger. Gland-spines rather short, and arranged as follows: 1, 1-2, 1-2, 1-3, 1-4. On the ventral margin the spines are short and inconspicuous, situated near each group of gland-spines excepting the fifth. The dorsal spines are longer and situated mesad of the corresponding ventral spine. Dorsal pores rather numerous and promiscuously arranged. Five groups of circumgenital gland-orifices; median, 4-6; anterior lateral, 5-9; posterior lateral, about 4.

Remarks: This species was originally described on *Euonymus latifolia*, at Norfolk, W. Va. It was reported on *Althea*, sp. at Cincinnati, Ohio.

CHIONASPIS FURFURA (Fitch).

Fig. 30.

Aspidiotus furfurus Fitch, 3rd. Rep. Ins. N. Y., p. 352 (1856).

Chionaspis furfurus Lint., 1st. Rep. Ins. N. Y., p. 331 (1882).

Chionaspis furfurus (Fitch) Comst. Rep. U. S. Dep. Ag. 1880, p. 315 (1881).

Chionaspis furfura Cooley, Spec. Bull. Mass. Exp. Sta., p. 23 (1899).

Scale of female: Length, 2—2.5 mm. Grayish or snow-white, very broad posteriorly, flat, thin and delicate, often bent to left or right from the small, yellowish-brown exuviae. Irregular when massed.

Scale of male: Length, 0.7—1 mm. Distinctly tri-carinate, roughened above. Exuvia pale-yellow, covering about one-third of the scale.

Female: Three pairs of striate lobes; median pair short, broad, rounded, entire, with two oblique, chitinous bars at their bases; second pair usually entire, somewhat truncate, inner lobule the larger, oblique with inner edge thickened; third pair serrate, sometimes prominent, but usually rudimentary. The gland-spines are arranged as follows: 1, 1, 1, 1, 4-9; the first is small or wanting. Second row of dorsal pores absent; third row with 2-4 in anterior and 3-5 in posterior group. Five groups of circumgenital gland-orifices; median, 7-16; anterior lateral, 22-32; posterior lateral, 16-22.

Remarks: This is the most common species of the genus *Chionaspis* in the United States. It can be found upon *Apple* and *Pear* trees in greater or less quantity in almost any locality examined. It rarely becomes a serious pest in Ohio, because the lady-bird beetle *Chilocorus bivulnerus* is predaceous upon it, and usually precludes the necessity of resorting to remedial measures.

CHIONASPIS GLEDITSIAE Sanders.

Figs. 36, 37.

Ch. gleditsiae Sanders, Ohio Naturalist, Vol. III, No. 6, p. 413 (1902).

Scale of female: Length, 1.5—2 mm. Irregular in form, usually very broad posteriorly, somewhat convex. Of rather firm texture, dirty-white, usually blackened and inconspicuous on host. When removed, a conspicuous white patch is left.

Scale of male: Length, .6—.8 mm. Sides parallel, strongly carinated. Exuvia pale-yellow, occupying about one-fourth of the scale.

Female: Broadest toward posterior end, segments prominent. Median lobes broad at base, tapering sharply and serrate. The mesal margins approach at base and apparently fuse, forming a small, club-shaped thickening extending anteriorly. Inner lobule of second lobe very long and narrow, extending posteriorly two-thirds of length of median lobe, and separated from it by almost its own width. Outer lobule rudimentary, rounded. Third lobe rudimentary; lobules faintly serrate. The gland spines are arranged as follows: 1, 1, 1, 1. 3-4; large and conspicuous, decreasing in size toward the median lobes. Spines on the dorsal surface are arranged as follows: first on base of median lobe, lateral of center; second at base of second lobe, between the lobules; third at base of third lobe; fourth about two-thirds of distance to penultimate segment, posterior from the fourth gland-spine. On the ventral surface, the spines are shorter and located just laterad of the corresponding spine. First and second rows of dorsal pores are absent; third row represented by 3-5 in the anterior and 3-6 in the posterior group; fourth row by 2-4 in the anterior and 5-7 in the posterior group. Median group of circumgenital gland-orifices, 4-10; anterior lateral, 15-21; posterior lateral, 8-14.

Remarks: Abundant on *Gleditsia triacanthos* (Honey-locust) at Columbus; also found at Newark, Westerville and Cedar Point.

CHIONASPIS LONGILOBA Cooley.

Ch. longiloba Cooley, Spec. Bull. Mass. Exp. Sta., p. 16 (1899).

Scale of female: 1.5—2 mm. in length, white or dirty-white in color; texture moderately strong, not unlike Ch. salicis-nigrae. Exuviae, light-brown to dull yellow; about .8 mm. long.

Scale of male: Small, .6—.8 mm. long, oval and without carinae; exuvia, delicate light-brown or colorless.

Female: Median lobes and inner lobule of second lobe long and conspicuous. Median lobes obscurely pointed, serrate, slightly divergent with small chitinous thickenings at inner bases. Inner lobule of second and third lobes, serrate, larger than the outer and more pointed than in ortholobis. Inner margin of second lobes bear a small narrow chitinous process; third lobe very oblique. The gland-spines are arranged as follows: 1, 1-2, 1-2, 1-2, 2-3; decreasing rapidly in size toward the meson. Spines are arranged on each surface as follows: first at outer base of median lobes; second and third at bases of outer lobules of second and third lobes respectively; fourth about two-thirds of distance to penultimate segment. The ventral spines are in each case smaller and shorter, and located just laterad of each corresponding dorsal spine. Second row of dorsal pores with only the anterior group of 3-5; third row with 5-7 in the anterior and 4-5 in the posterior group; fourth row with 5-6 in the anterior and 5-7 in the posterior group. Median group of circumgenital gland-orifices, 10-21; anterior lateral, 20-35; posterior lateral, 10-24.

Remarks: Found on Cottonwood at Painesville, Lake Co., O., by Mr. G. A. Runner, one of the State Nursery and Orchard Inspectors. The lobes of *Ch. longiloba* are longer than in any other species except *gleditsiae*, but the latter can easily be distinguished by the fused median lobes and th wide separation from them of the second lobes. In the Ohio specimens the circumgenital gland-orifices are more numerous than in those originally described: median group, 14-21; anterior laterial, 24-35; posterior lateral, 14-24. In most cases the dorsal pores were more numerous than in the original.

CHIONASPIS ORTHOLOBIS Comst.

Ch. ortholobis Comst., Rep. U. S. Dep. Ag., 1880, p. 317 (1881).
Ch. ortholobis Cooley, Spec. Bull. Mass. Exp. Sta., p. 17 (1899).
Ch. ortholobis Newell, Bull. 43, Ia. Exp. Sta., p. 154 (1899).
*Ch. ortholobis*Hunter, Kan. Univ. Quar., ix, p. 101 (1900).

Scale of female: Longer than Ch. longiloba, 2—2.5 mm.; broadly oval, slightly elongated, usually regular; white to dirty-white. Exuviae, 8 mm. long, brown and more noticeable than that of longiloba.

Scale of male: Similar to that of Ch. longiloba.

Female: Median lobes close, parallel half-way on inner margins, then each lobe narrows similarly from each side to an obtuse point, or rounded. Inner lobules of second and third lobes rounded, larger than outer lobules and oblique. The gland-spines are arranged as follows: 1, 1-2, 1-2, 2, 4-5, shorter than in longiloba. The spines are arranged as in the latter. Second row of dorsal pores represented by the anterior group of 4-7; third row with 7-9 in anterior and 5-8 in posterior group; fourth row with 9-11 in anterior and 5-9 in posterior group. Median group of circumgenital gland-orifices, 10-25; anterior lateral, 18-35; posterior lateral, 16-24. They are quite variable in the same specimen.

Remarks: Found by the author on Cottonwood at Newark, O. This species also occurs on willow, poplar and butternut. The median lobes are parallel in general direction and so close along the basal half, as to appear fused. There is a relationship indicated between *Ch. longiloba* and *Ch. ortholobis* in the absence of carinae on the male scale. This feature distinguishes these two species from all other known species, except that *Ch. platani* is very feebly unicarinate or the carinae are sometimes wanting.

CHIONASPIS PINIFOLIAE (Fitch).

Figs. 34, 35.

Aspidiotus pinifoliae Fitch, 2nd Rep. Ins. N. Y., p. 488 (1855).

Chionaspis pinifoliae Comst., Rep. U. S. Dep. Ag. 1880, p. 318 (1881)

Chionaspis pinifolia Cooley. Spec. Bull. Mass. Exp. Sta., p. 30 (1899).

Scale of female: Snow-white with bright orange or brown exuviae, shape depending upon width of leaf of host, but usually broadened posteriorly and very convex. Length, 3—4 mm.; length of exuviae about 1 mm.

Scale of male: Length, 1—1.3 mm. The pale yellow exuvia occupies about one-third the length of the tri-carinate, posteriorly broadened scale.

Female: Three pairs of thin, striate, well-developed lobes; the median almost circular in outline, entire, separated by about one-third their width, slightly diverging at the apex and joined anteriorly by an arched chitinous process. Inner lobule of second and third lobes, the larger and subtruncate. The gland-spines are arranged as follows: 1, 1, 1, 1, 1-3, becoming shorter toward median lobes. The spines on the ventral surface are short and inconspicuous, situated one mesad the base of the first, second, third and fourth gland-spines respectively. Those on the dorsal surface are longer and situated mesad of the corresponding ventral spine. Second row of dorsal pores represented by anterior group of 2-4; third row by 3-5 in anterior and 4-6 in posterior group; fourth row by 3-7 in anterior and 5-8 in posterior group. Median group of circumgenital gland-orifices, 7-13; anterior lateral, 12-20; posterior lateral, 14-18. The eggs are purplish, ellipsoidal; length 0.25 mm.

Remarks: Native on various pines and spruces of the United States, especially in the states east of the Mississippi River. Many trees on the Ohio State University Campus are badly infested, appearing at a distance as if dusted with flour.

CHIONASPIS SALICIS-NIGRAE (Walsh).

Figs. 32, 33, 74.

Aspidiotus salicis-nigrae Walsh., 1st Rep. Nox. Insects Ill., p. 39 (1868).

Chionaspis salicis Comst, Rep. U. S. Dep. Ag., 1880, p. 320 (1881).

Chionaspis salicis-nigrae Cooley, Spec. Bull. Mass. Exp. Sta., p. 19 (1899).

Scale of female: Length, 2.5—4 mm., broadest near middle, distinctly convex, snow-white. Exuviae .8—.9 mm. long, yellowish-brown, sometimes almost colorless.

Scale of male: Length, 1—1.2 mm. Slightly broadened posteriorly, with posterior end rounded; feebly tricarinate. Exuvia varying from brown to almost colorless.

Female: Median lobes broad, short, rounded, entire or serrulate. Inner lobule of second and third pairs larger than outer, sometimes serrulate. The gland-spines are arranged as follows: 1, 1-2, 1-2, 1-3, 4-6. In this species there are two kinds of dorsal pores. Accompanying the anterior groups are smaller circular pores, also grouped. Oval dorsal pores; third row with 6-9 in anterior and 5-8 in posterior group; fourth row with 6-10 in anterior and 7-10 in posterior group. Median group of circumgenital gland-orifices, 21-36; anterior lateral, 31-45; posterior lateral, 28-32.

Remarks: The Willows (*Salix*) are the usual hosts of this species, although it is reported from *Liriodendron tulipifera, Populus sp., Amelanchier canadensis,* and two species of *Cornus.* About 75 reddish-purple eggs are to be found under a scale during the winter, which hatch about the first of June.

CHIONASPIS SYLVATICA Sanders.

Figs. 64, 65.

Ch. sylvatica Sanders, Ohio Naturalist, IV, 4, p. 95 (1904).

Scale of female: Length, 1.5—2 mm., somewhat convex, very irregular in shape, sometimes elongated and rounded posteriorly, and sometimes decidedly broadened and truncate posteriorly, giving it a deltoid shape; dirty-white to light-buff. First exuvia persistent, buff; second exuvia brown.

Scale of male: Length .6—1 mm., white, strongly tri-carinate with parallel sides. Exuvia very small, delicate, semi-transparent covering about one-fifth of the scale. Commonly found on the leaves of its host.

Female: Oval in outline, with third, fourth and fifth lobes anterior from the pygidium prominent. Median lobes fused to near the tip, diverging widely to rounded tips, then truncated obliquely toward the second lobes; serrate or crenulate on lateral margins. Inner lobule of second lobe serrate, produced on inner margin to a rounded tip; outer lobule reduced, triangular, sharp-pointed, entire. Third lobe slightly produced, serrate. On median line, a chitinous band extends anteriorly to base of median lobes, expanding to a bulb-like thickening. Chitinous bands extend obliquely toward this from outer margins. Second lobes slightly thickened on inner margins. The gland-spines are arranged as follows: 1, 1, 1, 1-2, 4-6, the first short and blunt. Second row of dorsal pores represented by 1-2 in anterior group; third row by 3-4 in anterior and 4-5 in posterior group; fourth row by 3-4 in anterior and 5-7 in posterior group. Median group of circumgenital gland-orifices, 7-10; anterior lateral, 15-20; posterior lateral, 14-18.

Remarks: This scale has been found on *Nyssa sylvatica,* at four widely separated locations in Southeastern Ohio: Sugar

Grove, Fairfield Co., Newark, Licking Co., Somerset, Perry Co., Quaker City, Guernsey Co.

Howardia biclavis (Comst.)

Fig. 39.

Chionaspis (?) ***biclavis*** Comst., 2nd Rep. Dep. Ent. Corn. Univ., p. 98 (1883).

Howardia biclavis Berl. e Leon., Riv. Pat. Veg., iv, p. 348 (1896).

Scale of female: Circular, convex, 2 mm. broad, white, variously colored by epidermis of host plant under which it mines. Exuviae marginal, the first projecting beyond the margin of the scale.

Female: Median lobes large, broader than long, approximate at base, somewhat pointed, lateral margins serrate, mesal margins diverging; second lobe small, pointed, simply a projection of the segment; third lobe rudimentary, low serrate; fourth lobe broad, low, incised forming two pointed serrate lobules. Plates simple, spine-like, increasing in size from the meson; two small ones between median lobes, two between first and second, usually three between second and third, four or five between third and fourth lobes, and laterad of fourth lobes six or seven larger plates. Spines accompany each group of plates on both dorsal and ventral surfaces. Dorsal pores rother numerous, very small, in three interrupted rows. Circumgenital gland-orifices wanting. On the ventral surface accompanying each group of plates, is a group of very small spines. Extending anteriorly within the body wall, from the median lobes, are two long, club-shaped, chitinous thickenings, which are characteristic of this species. Anal orifice situated far anteriorly, just anterior of the genital orifice.

Remarks: This Coccid was found badly infesting *Hibiscus aculcatus* in the Ohio State Universty Conservatory. It has a peculiar habit of mining under the epidermis of the host plant and maturing there.

Diaspis boisduvalii (Signoret).

Fig. 42.

Diaspis boisduvalii Sign., Ann. Soc. Ent. Fr., (4), ix, p. 432 (1869).

Diaspis boisduvalii Comst., 2nd Rep. Dep. Ent. Corn. Univ. p. 86 (1883).

Scale of female: 2 mm. diam., circular, sometimes a little elongated, white or light-gray. Very large exuviae slightly darker in color, nearly central.

Scale of male: White, strongly tri-carinated, usually massed in large numbers and covered with white, wooly hairs.

Female: Cephalo-lateral angle of body is prolonged into a small projection. Median lobes are large, wing-shaped, divergent, separated at base, serrate on mesal margins, and attached for entire length of lateral margins to the segment. Lobules of second, third and fourth lobes, subequal; the outer usually lower and broader. Fourth lobe obscure and serrate. There is a gland-spine, located just laterad of the first, second, third and fourth lobe respectively, and laterad of the fourth lobe at subequal distances are 4-6 tubular gland-spines. Between the fifth and sixth gland-spines is a dark-colored, pointed projection of the body wall. The first pair of spines on the ventral surface project caudad between the median lobes; the second and third mesad of the second and third gland-spines; the fourth between the fourth and fifth, and the fifth spine between the seventh and eighth gland-spines respectively. On the dorsal surface, a small spine at apex of median lobe; second and third spines on lateral lobule of second and third lobes respectively; fourth mesad of fourth gland-spine; fifth between sixth and seventh plates. Groups of circumgenital gland-orifices distinct, elliptical in outline; median, 8-16; anterior lateral, 20-28; posterior lateral, 15-18.

Remarks: In greenhouses on Palms, Orchids, *Maranta*, etc.

Diaspis bromeliae (Kerner).

This species, which is a great pest where pineapples are grown, has been reported at Columbus by Prof. E. E. Bogue. It is similar to *Diaspis boisduvalii* except that the smaller median lobes project beyond the margin of the segment; i. e., they are partly free, while in the latter the median lobes are adnate, along the entire side, to the segment.

Diaspis echinocacti cacti Comst.

Figs. 43, 76.

Diaspis cacti Comst., 2nd Rep. Dep. Ent. Corn. Univ. p. 91 (1883).
Diaspis cacti Ckll., Can. Ent., xxv, p. 127 (1894).
Diaspis cacti Osborn, Contr. Ia. Ag. Coll., p. 5 (1898).

Scale of female: Nearly circular, 1.5—1.7 mm. in diam., white to light-gray; exuviae central or subcentral, dark brown.

Scale of male: White, unicarinated; exuvia yellowish to brownish.

Female: Four pairs of small lobes; the mesal with entire margins, apparently extending into the segment, widest near middle, diverge suddenly to a rounded apex. Lobules of second, third and fourth lobes, subequal, parallel and subtruncate. Plates and spines similar to those of Diaspis boisduvalii. Median group of circumgenital gland-orifices, 6-13; anterior lateral, 16-22; posterior lateral, 12-18.

Remarks: Found in Ohio State University Conservatory badly infesting a night-blooming Cereus.

Aulacaspis pentagona (Targ.)

This species was introduced at Wooster on a double flowering cherry from Japan, but did not survive the winter of 1898-99. (Webster.)

AULACASPIS ROSAE (Bouche).

Figs. 44, 45.

Aspidiotus rosae Bouche, Naturg. Ins., p. 14 (1834).

Diaspis rosae Comst., Rep. U. S. Dep. Ag., 1880 p. 312 (1881).

Aulacaspis rosae Ckll., Bull. Bot. Dept. Jam., p. 259 (1896).

Scale of female: Circular or irregular, snowy-white, sometimes with yellowish tinge, 2-3 mm. diam; exuviae sublateral; first larval skin naked showing the segmentation; second covered.

Scale of male: 1.25—1.5 mm. in length; white and tri-carinated.

Female: Body elongated; the ante-penultimate segment prominently lobed and bearing 8-10 gland-spines. Median lobes large, approximate at base, serrulate, diverging, attached to body for entire length. Inner lobules of second, third and fourth lobes, rounded larger than the outer lobule. Fourth lobe nearly obsolete. There is a gland-spine laterad of each of the four lobes and 2-4 near penultimate segment, enlarging as they are further removed from the meson. On the dorsal surface the spines are situated as follows: a very small one on the median lobe, and one slightly larger on the outer lobule of the second, third and fourth lobes respectively, and one about three-fourths of distance to penultimate segment. The spines on the ventral surface are slightly mesad of the corresponding dorsal ones. Dorsal pores in three rows; second row represented by anterior group of 2-3; third row, anterior group, 4-5, posterior group, 5-6; fourth row, anterior, 4-6, posterior group, 6-8. Mesad of second and third lobes respectively, is an elongated pore appearing like a lobe. Anterior group of circumgenital gland-orifices distinct, rounded, 18-22; anterior lateral, 25-32; posterior lateral, 26-34. Lateral groups indistinctly separated, sometimes almost continuous.

Remarks: Generally distributed over Ohio on rose-bushes, raspberries and blackberries.

Genus HEMICHIONASPIS Ckll.

In the members of this genus the median lobes are fused, and together form a dark-colored semi-circle. But one species has been reported, *H. aspidistrae* Sign. in which the scale of the female is brown and the median lobes are small and sunken in the pygidium.

Hemichionasipis aspidistrae (Signoret).
Fig. 38.

Chionaspis aspidistrae Sign. Ann. Soc. Ent. Fr. (4), ix, p. 443 (1869).

Chionaspis latus Psyche, vii, Suppl., i, p. 21 (1896).

H. aspidistrae Cooley, Spl. Bull. Mass. Exp. Sta., p. 45 (1899).

Scale of female: Length, 1.8—2.5 mm. Decidedly broadened posteriorly, rather strong in texture, yellowish-brown or brown. Exuviae concolorlous with the scale but brighter.

Scale of male: Distinctly tri-carinated, 1—1.3 mm. in length. Exuvia bright yellow.

Female: Long, broadest near the middle; the four segments anterior to the pygidium are produced laterally almost into protuberances, at least very conspicuous. Two pairs of well-developed lobes, third pair rudimentary. Median lobes two or three-notched on outer margin; the two lobes forming a semi-circle and a chitinous club-shaped thickening extending anteriorly, all much darker than the other lobes. The second lobe is widely separated from the median by a prominence bearing a marginal gland-orifice. Lobules of second lobe long and spatulate, the inner the longer and with thickened margins at the base. The gland-spines are arranged as follows: 1, 1, 1, 1, 2-4. Second row of dorsal pores and anterior groups of third and fourth rows absent; posterior groups of third and fourth rows with 2-5 each. Median group of circumgenital gland-orifices, 5-15; anterior lateral, 14-22; posterior lateral, 15-23.

Remarks: This species can be easily distinguished from *H. theae* (Mask.) by comparing the broad, ovate exuvia of *H. aspidistrae* with the narrowly elliptical exuvia of *H. theae*. Found on Shield Fern (*Cyrtomium falcatum*) in the Ohio State University Conservatory.

Fiorinia fioriniae (Targ.)
Fig. 21.

Diaspis fiorinia Targ., Studii sub. Cocc., p. 14 (1867)

Fiorinia carnettiae Comst., Rep. U. S. Dep. Ag., 1880, p. 329 (1881).

Fiorinia fioriniae Ckll., Ent. Mon. Mag., xxix, p. 39 (1893).

Scale of female: Yellowish-brown, with first exuvia yellow, and remainder of scale a white thin margin. There is a central, longitudinal, dark-brown ridge, and sloping parallel sides more or less wrinkled.

Scale of male: Similar to scale of female but smaller.

Female: Two pairs of lobes. The caudal extremity of the segment is deeply notched, the median lobes are borne by the margins of this notch; they are confluent at base but widely divergent at apex. The second lobe is deeply incised, the mesal lobule the larger The gland-spines are long, simple, tapering; one laterad of each lobe and one on the margin of the segment toward the penultimate segment. Between the median lobes are two spines, neither dorsal or ventral. On the dorsal surface two spines are situated along the lateral margin of median lobes, the posterior one the larger, one on outer lobule of second lobe, one one-third and one two-thirds of distance to the penultimate segment; on the ventral surface there is a spine situated laterad of each corresponding dorsal spine, except on the first lobe. There is an elongated pore laterad of each lobe, one half-way and one near to penultimate segment. Five groups of circumgenital gland-orifices, the median continuous with the anterior laterals. Median about 9; anterior lateral, 9-12, in partly double row; posterior lateral, 12-16 arranged in double row. Anal orifice far removed from margin, anterior of the genital orifice nearly as far as median group of circumgenital gland-orifices.

Remarks: Badly infesting a *Kentia* Palm in the Ohio State University Conservatory. Excepting the median ridge, this scale is very flat, brownish, and oblong with parallel sides.

Genus ASPIDIOTUS Bouche.

A. Median lobes rather large; second and third usually small or rudimentary; plates small, spine-like; margin with two pairs of incisions bounded by thickened chitinous processes **Diaspidiotus**

B. Median lobes large and well-developed; second and third reduced or wanting; plates conspicuous, deeply furcate and crowded toward median lobes; margins of incisions thickened **Hemiberlesia**

AA. Neither elongated thickenings nor incisions with thickened edges present **Aspidiotus s. str.**

Subgenus ASPIDIOTUS s. str. (Type, **A. hederae** Vall.)

This subgenus is characterized by the absence of chitinous thickenings and incisions with thickened margins in the last segment of the female. The plates are well developed and strongly fringed. The scale is light colored and the exuviae are naked. There appear to be no native American species representing this subgenus. From Ohio two greenhouse species are reported.

A. Median lobes very large, broad, notched on each margin near apex and rounded; second and third lobes scarcely one-third of width of median lobes **cyanophylli**

AA. Median lobes a little larger than second lobes and apparently extending into the segment; five to eight branched and simple plates outside of third lobe **hederae**

Subgenus HEMIBERLESIA Ckll. (Type, **A. rapax** Comst.)

Referring to *Hemiberlesia* Prof. Cockerell says in Bull. U. S. Dep. Ag., t. s. No. 6.;—"This subgenus really represents a southern modification of *Diaspidiotus*, with a convex scale and large median lobes, the others being suppressed. It appears to be exclusively American, and belongs to the tropical and Lower Austral regions, except that one species (*A. convexus*) occurs in the upper Sonoran, and another (*A. ulmi*) in the corresponding zone in Illinois." Four species are reported for Ohio, *A. ulmi* being the only native species.

A. Groups of circumgenital gland-orifices present,
B. Plates long and complex; first and second plates from median lobes wide and multi-branched; third, fourth and fifth narrower and simpler. Two incisions in margin of segment **cydoniae crawii**
BB. Two or three plate-like extensions of the segment outside of incisions; a small incision laterad of second incision **lataniae**
AA. Groups of circumgenital gland-orifices absent,
C. Median lobes broad, notched on inner and outer margins; inner chitinous process of first incision very long and clavate; plates long and spine-like **ulmi**
CC. Median lobes sharply notched near apex; plates toothed and branched, chitinous processes subequal **rapax**

Subgenus DIASPIDIOTUS (Berl. & Leon.) (Type **A. ancylus** Putn.)

The members of this subgenus belong to the North temperate zone, occuring mostly on deciduous trees. The scale is usually dark-colored and the exuviae are covered with secretion. The median lobes are approximate and the margins of the incisions are thickened. In Ohio, eight species of this subgenus are reported.

A. Posterior segment of female with short, simple, inconspicuous plates.
B. With second lobe rudimentary or wanting, orange exuviae **ancylus**
With second lobe rudimentary, orange exuviae covered with black secretion **piceus**
BB. Second lobe slightly developed **uvae**
BBB. Inner angle of second lobe decidedly developed.
C. Median lobes of medium length, usually notched on outer margin.

D. Median lobes converging; inner chitinous processes of first incision, bent or club-shaped **forbesi**

DD. Median lobes about parallel; processes subequal.

E. Circumgenital gland-orifices absent **perniciosus**

EE. Circumgenital gland-orifices present.

F. Chitinous processes of first incisions long **ostreaeformis**

CC. Median lobes short and broad, almost truncate, very close, and with second and third lobes forming a semi-circle; dorsal pores very numerous in four distinct rows **glanduliferus**

CCC. Median lobes short and broad, scarcely notched on outer margin; lobes not forming a semi-circle; dorsal pores less numerous **juglans-regiae**

AA. Plates complex, conspicuous; a toothed semi-circular plate between second and third lobes; second lobes often longer than median **comstocki**

ASPIDIOTUS ANCYLUS Putnam.

Fig. 5.

Diaspis ancylus Putnam. Trans. Ia. Hort. Soc. xii, p. 381 (1877).

Aspidiotus ancylus Putnam, Proc. Davenport Acad. Nat. Sci., ii, p. 346 (1879).

Aspidiotus ancylus Comst., Rep. U. S. Dep. Ag., 1880, p. 292 (1881).

Scale of female: Circular, 1—1.5 mm. diam. Brick-red exuviae covered by gray film of excretion; remainder of scale dark gray, or almost black, except light gray margin. A very delicate, white ventral scale is present. Show a tendency to gather in clusters two or three deep.

Scale of male: Of same color as female scale; is much smaller and elongated. Length, 1—1.5 mm.; width, .5—.6 mm.

Female: Only the median pair of lobes developed, somewhat separated with the mesal margins parallel; notched on lateral margin about one-third of distance from subtruncate apex, and frequently notched near apex on the mesal margin. Second lobes rudimentary, truncate, not extending beyond margin of segment. First interlobular incision rather wide and shallow, with variable, chitinous processes, usually straight, the inner the larger. Second interlobular incision similar; inner chitinous processes usually larger than the outer. Sometimes a very small incision laterad of second incision. Small chitinous process at inner base of each median lobe. There are two plates, usually furcated, caudad of each incision and occasionally a third plate. The spines on the ventral surface are shorter than the dorsal spines, and situated at the base of the lateral margin of the median lobes and the rudimentary second and third lobes. The spines of the dorsal surface are slightly mesad of the corresponding ventral ones; the fourth being about two-thirds of the distance from the median lobes to the penultimate segment. Between the third and fourth pairs of spines, there are three or four irregular, spine-like extensions of the margin of the segment. Four or five groups of circumgenital gland-orifices are present; Median, 0-6, (rarely more than three); anterior lateral, 5-14; posterior lateral, 4-8. Rows of dorsal pores sometimes quite prominent.

Remarks: This scale popularly known as "Putnam's Scale," is not an important economic insect *per se*, but the possibility of mistaking the San Jose' Scale for this one, attaches to it more importance. The scales are lighter in color, and the "dot and ring" is not nearly so prominent as in the San Jose' Scale. Remedial measures for the latter are fully as effective for Putnam's Scale.

ASPIDIOTUS COMSTOCKI Johnson.

Fig. 9.

A. comstocki Johns., Ent. News, vii, p. 151 (1896).

A. comstocki Johns., Bull. Ill. St. Lab. Nat. Hist., iv, p. 383 (1896).

Scale of female: The shape depends upon the position upon the leaf, but usually approaches a semicircular form, attached close to the midrib, veins or veinlets of the leaf. Length, 1.5—2 mm., width, 0.5—1 mm. Large, rather flat, cream-buff, excepting the part which covers the exuviae which varies from yellowish to reddish-brown, or is often concolorous.

Scale of male: Length, 1 mm., width 0.5 mm. Cream-buff or grayish-white, semi-transparent, more or less elongate oval. Exuvia submarginal.

Female: There are two pairs of well-developed lobes, the second pair often as long or longer, and as broad as the median pair, which are commonly notched on the lateral margins near the tip. Plates conspicuous. Between the first and second lobes, they are more or less toothed and about as long as median lobes; laterad of second lobe is a broad circular fringe; laterad of this are three large toothed plates. Spines prominent; a pair at outer base of median lobes, a pair at outer base of second lobes, the third on the rudimentary third lobe, and the fourth just laterad of the plates. Four groups of circumgenital gland-orifices; anterior lateral, about 6; posterior lateral, 4.

Remarks: Found on the leaves of Sugar Maple. (*Acer saccharum*) at Columbus, Ohio, associated with *Phenacoccus acericola* (King).

Aspidiotus cyanophylli Signoret.

Fig. 12.

A. cyanophylli Sign., Ann. Soc. Ent. Fr., (4), ix, p. 119 (1869).

Scale of female: Circular, brownish-yellow; exuviae central, bright yellow, covered by white secretion.

Scale of male: Similar to scale of female, elliptical in outline, exuvia sub-central.

Female: Median lobes very large, as broad as long, notched on each side near apex, appearing to project into the segment; second lobes long, narrow, about one-third the width of the median lobes, slightly notched on each side near apex; third lobe similar but smaller. Plates long, extending beyond lobes, deeply incised; two between median and second, three between second and third lobes, and outside of third lobe five or more simple bi-furcate or tri-furcate plates. Spines long and slender, not exceeding the plates in length; on the dorsal surface there is a spine on each lobe and one two-thirds of distance to penultimate segment; on the ventral surface a spine laterad of each corresponding dorsal spine except on the median lobe. A few smaller spines scattered over surface of segment. Four groups of circumgenital gland-orifices; anterior lateral, 4-5; posterior lateral, 3-5. Anal orifice large, remote from margin of segment.

Remarks: On leaves of palm, *Pritchardia filifera*, in Ohio State University Conservatory. Originally described by Signoret at Paris from *Cyanophyllum magnificum*.

Aspidiotus cydoniae crawii Ckll.

Fig. 19.

Aspidiotus crawii Ckll. Newell,on the North American Species of the Subgenera Diaspidiotus and Hemiberlesia. Bull. Ia. State Coll. of Agr. and Mech. Arts, No. 3. 1899.

Being unable to procure specimens of this species, the following description, and the illustration are taken from the above bulletin:

Scale of female: "Circular, 2 mm. in diam., convex, dull-reddish-gray; exuviae sublateral, inconspicuous with exception of the first skin which shows as a yellow prominence."

Female: "Female anal segment with median lobes long and close together, each lobe notched on both inner and outer margins, outside margin of lobe straight below notch; rudiment of second lobe wide, often notched; rudiment of third lobe slightly raised at inner angle. Median incisions narrow, edges straight; second and third incisions small. A small chitinous process at outer base of median lobe; a broad chitinous band surrounding each second and third incisions, either band sometimes, but rarely, divided at apex of incision so as to appear as two processes. Two plates with numerous branches just laterad of median lobe; about three plates, simple and long, on rudiments of second and third lobes. A pair of spines from each lobe and a spine on lateral margin one-third of distance to penultimate segment. Ventral grouped glands forward, caudolateral group about opposite vaginal orifice; median none; cephalolateral, 5; caudolateral, 4."

Remarks: This species was originally described from specimens brought from Mexico, on grapevine (?), and found by Mr. Alex. Craw in the course of his quarantine work on the Pacific Coast. Reported in this state from a greenhouse at Springfield, on *Satania* sp.

ASPIDIOTUS FORBESI Johnson.

Figs. 1, 2.

A. forbesi Johns., Ent. News, vii, p. 151 (1896).
A. forbesi Johns., Bull. Ill. St. Lab. N. H., iv, p. 380, (1896).
A. forbesi Newell, Contr. Ia. Ag. Coll., No. 3, p. 14 (1899).
A. forbesi Felt., Bull. 46, N. Y. St. Mus., pp. 330, 347 (1901).

Scale of female: Average diam. 2 mm., rather convex, dirty gray, but lighter in color and more delicate than A. ancylus or A. perniciosus, with covered, sub-central, orange exuviae.

Scale of male: Length, 1 mm.; width, .5—.6 mm. Darker than scale of female, elongated; the covered, orange-colored exuvia situated anteriorly and more convex.

Female: Median lobes prominent, rounded at apex and notched midway on lateral margin, converging and almost meeting. Second lobes narrower, about one-half width of median lobes, obscurely pointed or rounded, and two or three notched on lateral margin. First and second inter-lobular incisions bounded by thick, chitinous processes, the inner the larger and of characteristic curved shape; also club-shaped processes at inner base of median lobes. Usually furcated prolongations of the the margin laterad of the second incision are present. Plates, very inconspicuous or absent except one or two caudad of second incision. Spines are borne on the ventral surface as follows: one on the lateral base of each lobe, one laterad of second incision one at one-third, and one at two-thirds of distance to penultimate segment. The dorsal spines are located just laterad of the corresponding ventral ones, except the first on the median lobe which is wanting. Rows of dorsal pores not prominent; first of 3-4; second of 5-12; third of 7-15. Five groups of circumgenital gland-orifices present; median, 1-4; anterior lateral, 4-7; posterior lateral, 3-5.

Remarks: Prof. Johnson proposed the popular name "Cherry Scale Insect" for this Coccid, and speaks of it as the most dangerous scale insect then established in Illinois. As far as we have observed it has not become a pest in Ohio, although found in various localities and on several hosts. It can be distinguished from the San Jose Scale by the much lighter color of the scale and the orange-red exuviae; also the "dot and ring" is not noticeable.

ASPIDIOTUS GLANDULIFERUS Ckll.

Fig. 8.

Aspidiotus glanduliferus Ckll., Ohio Naturalist, ii, p. 287 (1902).

Scale of female: 2 mm. diam., slightly convex, blackish, with large sub-central to sub-lateral orange-ferruginous or almost vermillion exuviae, readily exposed by rubbing; removed from the bark, a conspicuous white patch is left.

Scale of male: Oval, broad, with covered exuvia and a white dot and ring.

Female: Broad oval with deep constriction between head and thorax. Color, bright orange; caudal margin stained with dark red brown. Median lobes very large, broad, scarcely produced; second lobes similar but smaller and more or less serrate, close; third lobes represented by small angular prominence. Chitinous thickenings of interlobular incisions, short and straight, subequal, but the inner the larger. Plates, spine-like; two between median lobes, two caudad of first incision and two or three slightly branched caudad of second incision. Spines quite large; on the dorsal surface, a spine is borne by the first, second and third lobes respectively; the fourth spine at about one-fourth, and the fifth at one-half the distance to the penultimate segment. On the ventral surface, the spines are mesad of the corresponding dorsal ones, except that they are lacking on the median lobes. Five groups of circumgenital gland-orifices; median, 4-5; anterior lateral, 15-18; posterior lateral, 7-10. Dorsal pores very numerous in four series; the first (below first interlobular incision) of 3 in a row; the second of about 17, and after a short break, 9-10 more; the third of over 30; the fourth of about 11. Anal orifice very small, level with second dorsal pore of first row.

Remarks: This scale was discovered in February, 1902, on the branches of *Pinus sylvestris* on the Ohio State University Campus, by the author, and sent to Prof. Cockerell, who described it as *A. glanduliferus*, because of the large number of beautifully arranged dorsal pores in the last segment of the female. Since that time the author has found this scale on *Pinus virginiana* and *Tsuga canadensis* on the O. S. U. Campus.

Aspidiotus hederae (Vall.)

Figs. 10, 11.

Chermes hederae Vall., Mem. Acad. Dijon, p. 30 (1829).

Aspidiotus nerii Bouche , Schadl. Gart. Ins., p. 52 (1833).

Scale of female: Diam. 1.5—2 mm., flat, dirty white. dull-orange exuviae central or sub-central, exposed, usually showing segmentation of first skin.

Scale of male: Slightly elongated, white with light-yellow, sub-central exuvia. Length about 1 mm.

Female: Three pairs of lobes; median and second well-developed; the third small and pointed. The median are deeply notched on each margin near the apex, the mesal notch being slightly posterior, appearing to converge. The thick chitinous median lobes extend into the segment. Second lobes are often notched on lateral margin near the apex. The plates are nearly all deeply fringed; two between median, two between median and second, three between second and third, and about six fringed and two or three forked or simple ones laterad of third lobe. On the ventral surface, there is a spine at the lateral base of each lobe, one at one-third and one at one-half of distance to penultimate segment. On the dorsal surface, there is a spine mesad of the corresponding ventral spine. The dorsal pores are in four irregular rows; first of 3-4; second of about 7; third of about 6; fourth, near margin, of about 4. Four groups of circumgenital gland-orifices; anterior lateral, 8-9; posterior lateral, 6-7, appearing as if surrounded and connected by strips of chitin.

Habitat: On a great variety of hosts; citrus trees, palms, cycads, *Muhlenbeckia*. English Ivy; and on *Hepatica hepatica* being used for experimental purposes in the greenhouse of the Ohio State University.

ASPIDIOTUS JUGLANS-REGIAE Comstock.

Fig. 7.

Aspidiotus juglans-regiae Comst., Rep. U. S. Dep. Ag. 1880, p. 300 (1881).

Scale of female: Circular, flat, pale grayish-brown, 3 mm. diam. Reddish-brown, sub-central exuviae covered with secretion. Ventral scale a white, delicate film.

Scale of male: Similar in color to scale of female, but smaller, elongated, with anterior end and exuvia more convex. Length, 1—1.25 mm.

Female: Median lobes well-developed, produced, broad and close, round at apex with mesal corners well defined, slightly converging, notched near apex on outer margin. Second lobes narrower and distinctly two or three notched on outer margin. Third lobe rudimentary and raised to a point. A small chitinous process at inner base of median lobes; chitinous processes bounding first and second incision, the inner the larger. A pair of simple, inconspicuous plates between median lobes and one or two bifurcated ones caudad of each incision. Spines prominent, borne on the dorsal surface, one by each lobe, one one-third and another two-thirds of distance to penultimate segment. On the ventral surface, they are laterad of the corresponding dorsal spines. Rows of dorsal pores very noticeable and complete; first row of 3-4; second of 18-24; third of 20-22; fourth, in an irregular row, of 14-18. Five groups of circumgenital gland-orifices; median, 0-5; anterior lateral, 8-16; posterior lateral, 4-8. Anal orifice small, level with third dorsal pore of first row.

Remarks: This scale which was first described from English Walnut (*Juglans regiae*) by Prof. Comstock in 1880, has been found infesting various other trees, including some of our more valuable fruit trees, such as peach, apricot, plum, black cherry and pear. It has little economic importance in Ohio.

Aspidiotus lataniae Signoret.

Fig. 18.

A. lataniae Sign., Ann. Soc. Ent. Fr., (4), ix, p. 124 (1869).

Scale of female: Rather elongated, convex, clear-yellow, translucid at center, dirty white at margin of large elliptical exuviae.

Scale of male: Similar to the scale of the female in color, smaller and elongated.

Female: Mesal lobes only present, large, prominent, nearly as broad as long, notched on both margins, the inner notch much the smaller and nearer the apex. Two large interlobular incisions bounded by chitinous processes, the inner the larger, and one very small one, bounded by small chitinous processes, laterad of second incision. Usually a small chitinous process at inner base of median lobes. Two simple plates between median lobes; two incised plates caudad of first and second incision and one or more between them. Outside of the small third incision, the margin of the segment is produced to appear almost like two or three simple plates. On both dorsal and ventral surfaces, spines are located as follows: at outer base of median lobes, between first and second incision, just outside of second incision, and one about one-half of distance to the penultimate segment. Four groups of circumgenital gland-orifices; anterior lateral, 4-6, posterior lateral, 3-4. Second and third rows of dorsal pores of 8-12 each, rather straight and distinct although interrupted. Anal orifice large, rather remote from the margin.

Remarks: On palm, *Areca lutescens*, in Ohio State University Conservatory.

ASPIDIOTUS OSBORNI Newell & Ckll.

A. osborni New. & Ckll., Rep. Ia. Acad. Sci., v, p. 229 (1898).

Just before going to press this species was identified on twigs of *Quercus alba*, collected at Cleveland, Ohio, July 18, 1903, by the author. The grouped-gland-orifices in the Ohio specimens are more numerous than originally described.

ASPIDIOTUS OSTREAEFORMIS Curtis.

Fig. 3.

A. ostreaeformis Curt. (Ruricola), Gard. Chron., iii, p. 805 (1843).
A. ostreaeformis Felt, Bull. 46, N. Y. St. Mus., pp. 323, 352 (1901).
A. ostreaeformis Banks, Bull. 34, n. s., Dep. Ag., p. 18 (1902).

Scale of female: 1—1.5 mm. in diameter, dark gray, lighter near margin, somewhat convex; exuviae large, eccentric, yellowish to orange.

Scale of male: Similar in color to scale of female, smaller with submarginal exuvia.

Female: Median lobes short and broad, notched on outer margin and rounded, similar to A. ancylus, but not so prominent, scarcely converging, with inner margins thickened; inner angle of second lobe produced into a blunt point; rudimentary third lobe represented by a small angular prominence, or absent. Long, straight, subequal, chitinous processes bound the second and third incisions. Plates very inconspicuous, sometimes furcated; two between median lobes and two in each incision. On the ventral surface, a spine is borne at the lateral base of each lobe and one about half-way to the penultimate segment; the dorsal spines are longer and situated just mesad of the corresponding ventral spine. Dorsal pores in four rows as follows: 1st (between first pair of chitinous processes) of 2-3; 2nd, 5-6 and after a break 2-3 more; 3rd of 7-8; 4th, a marginal row of 2-4 and a group of 5-6 near the penultimate segment. The dorsal pores vary greatly in number and position, but there is a certain characteristic arrangement. Median group of circumgenital gland-orifices, 5-8; anterior and posterior lateral of about 10-12 each. Anal orifice small, rather distant from margin and embraced by the inner margins of median lobes.

Remarks: This is an European species, which has been introduced and is rather common in sections of some states, however not common in Ohio.

ASPIDIOTUS PERNICIOSUS Comstock.

Figs. 4, 75.

A. perniciosus Comst., Rep. U. S. Dep. Ag., 1880, p. 304 (1881).
A. perniciosus Howard, Yearbook U. S. Dep. Ag., p. 267 (1894).
A. perniciosus Webster, Bull. 56, Ohio Exp. Sta. (1895).
A. perniciosus Webster, Bull. 72, Ohio Exp. Sta., p. 211 (1896).
A. perniciosus Felt, Bull. 46, N. Y. St. Mus., pp. 304, 349 (1901).

Scale of female: Circular, slightly convex, 1—2 mm. in diam., gray or dark-gray except the prominent, covered, pale or reddish-yellow exuviae. The exuviae are nipple-like with a shallow, depressed ring about them, which is quite characteristic of this species.

Scale of male: Is black in color, rather convex with the nipple-like prominence and depressed ring still more noticeable than in the female. Usually more numerous than the female scales.

Female: Two pairs of lobes well-developed. Median prominent, rounded at the apex, notched on the outer margin near the middle, though somewhat variable, and converging. The thickened inner margins of the median lobes extends anteriorly encircling the anal orifice in a characteristic manner. The second lobes are smaller and narrower, though distinct, quite close to the median, notched on the outer margin, pointed and converging. Between the median lobes, and bounding each incision of the segment, are club-shaped, chitinous processes; the inner usually the larger. There are two inconspicuous plates between the median lobes, two caudad of first incision, and three small, laterally serrate ones, caudad of second incision. Often laterad of second incision are wide, furcated extensions of the margin of the segment. The spines of the ventral surface are situated laterad of the corresponding dorsal spines at the bases of the first and second lobes; the third pair laterad of second incision; the fourth pair at one-half of distance to penultimate segment. Groups of circumgenital gland-orifices are absent. Rows of dorsal pores are not prominent, though variable.

Remarks: The San Jose Scale is perhaps the most insidious of our noxious insects. Its apparent damage is not so great as are the ravages of the Colorado Potato-beetle, Army Worm, Chinch Bug and the Hessian Fly, but frequently a valuable fruit tree becomes so completely encrusted with hundreds of thousands of the scales, and the vitality is so diminished that it begins to wither and die; and then, and often not until then, is the cause discovered. In such a case what would be the proper course to follow? The axe and a hot fire would be the proper thing in such a case. However, if a tree is only partially infested or the vitality not too greatly impaired, there are several spraying mixtures which can be used to advantage, viz., "Lime, sulphur and salt wash," "Oregon Wash," "Resin Wash," "Whale-oil soap wash," "Potash Wash," Kerosene emulsion, Crude petroleum, etc. The U. S. Dept. of Agriculture and various State Experiment Stations have from time to time issued bulletins containing information concerning the San Jose Scale, and recipes for the preparation of the above washes.

ASPIDIOTUS PICEUS Sanders.

Fig. 66.

A. piceus Sanders, Ohio Naturalist, iv, 4, p. 96 (1904).

Scale of female: 1.8—2 mm. in diameter, flat often subelliptical to oval, with sub-central exuviae; black shading to dark gray toward margin, having the appearance of pitch covered with dust. The raised shiny black, deciduous first exuvia is surrounded by an indistinct ring like depression. When rubbed the second orange exuvia appears. The young scales appear not unlike the young male scales of A. perniciosus. When removed a white patch is left.

Scale of male: Elliptical, 1 mm. in length, black, with distinct ring-like depression surrounding the lustrous-black exuvia, the posterior flap shading to gray.

Female: With one pair of lobes, well-developed, prominent, broad, notched midway on lateral margin, with outer corners well rounded off toward inner angle. Inner margins parallel, not close, bounded by large chitinous processes, which extend, somewhat reduced in density, around the outer margin to a denser process at outer base of lobe. Second and third lobes rudimentary, sometimes with inner angle of second lobe slightly developed. Interlobular incisions broad and deep, bounded by elongated chitinous processes, the inner usually the larger. There are two perforations anterior to median lobes on a level with the base of chitinous processes of first incision. Between the median and second and the second and third lobes are pairs of di-pointed spine-like plates, two thirds of length of median lobes. On the dorsal surface there is a spine on each of the second and third lobes, and on the ventral surface, each lobe bears a spine on the lateral margin, laterad of dorsal spine, also spines one-third and two-thirds of distance to penultimate segment. First row of dorsal-pores (between first and second lobes) of 2; 2nd row of about 6; 3rd row of 5—6; 4th row (near margin) of 3—4 orifices. Four or five groups of circumgenital gland-orifices, median sometimes wanting. Median, 0—3; anterior lateral, 15—23, averaging 18; posterior lateral, 6—14, averaging 9.

Anal orifice very large, removed from margin by about three lengths of the median lobes.

Remarks: Found very abundantly on young *Liriodendron tulipifera,* at Painesville, Lake Co., Ohio, July 21, 1903. This species differs from *A. osborni,* its nearest species, by the jet-black exuviae, the very large anal orifice, and the numerous circumgenital gland-orifices.

Aspidiotus rapax (Comstock).

Fig. 20.

A. rapax Comst., U. S. Agr. Report of 1880, p. 307.

Scale of female: Very convex, gray almost white, translucent, appearing yellow because of color of insect beneath; the sub-central exuviae marked by a brown or black dot and a concentric ring. Ventral scale snow-white and usually entire.

Scale of male: Similar to scale of female, scarcely so convex, with exuvia sub-lateral.

Female: Median lobes only, well developed and prominent, sharply notched on either side, the mesal notch nearer the apex. Second and third lobes are represented by small, pointed projections of the margin. A deep incision laterad of the median and second lobes, bounded by subequal chitinous processes. Two irregularly toothed or branched plates caudad of each incision, with a simple one between them and two or three simple or furcated ones laterad of third lobe. On each surface, spines are located at the lateral bases of each lobe; the fourth spine at about two-thirds of the distance to the penultimate segment. The ventral fourth spine is slightly laterad of the corresponding dorsal spine. Groups of circumgenital gland-orifices absent. Dorsal pores in two or three irregular rows; the second of about 6; the third of about 4. The anal orifice is very large.

Remarks: This is a cosmopolitan insect in warm climates, found upon many hosts; the most important ones being almond, quince, fig, olive, acacia, locust, willow, eucalyptus, *Osmanthus* and other citrus trees.

ASPIDIOTUS ULMI Johnson.

Fig. 22.

A. ulmi Johns., Bull. Ill. Lab. Nat. Hist., Vol. iv, p. 388. 1896.

Scale of female: Almost round, 1.5—2 mm. in diameter, dirty white or tan-colored; the latter owing to the corky covering from the bark often apparent. New exuviae bright orange-yellow, older material is usually faded. A well developed, white, ventral scale.

Scale of male: About .7 mm. long, more or less circular, of the same general appearance as the scale of the female.

Female: One pair of lobes, prominent, about as long as wide, notched on each side, somewhat rounded. Only a slight indication of second lobes. Mesal half of median lobes extend anteriorly to a conical tip. Inner process of first incision very long, club-shaped and knobbed at anterior end and is very constant; outer process small, narrow. Processes of second incision subequal. Margin of segment thickened for half of distance to the penultimate segment. Two plates caudad of first incision; between first and second incision, three to four, and laterad of second incision three plates. On the dorsal surface, a spine is located at outer base of median lobes, between first and second incision, laterad of second incision, and about one-half of distance to penultimate segment. On the ventral surface there is a spine just laterad of the corresponding dorsal spine except the first on the median lobe. Dorsal pores very small, inconspicuous with very long ducts, in three series; 1st (extending anteriorly from first incision) of 4—5; 2nd of about 16; 3rd of about 9. Prof. Johnson found no circumgenital gland-orifices, but in 25 per cent. of the specimens examined, from one to three orifices were found in the place of the posterior lateral groups which are marked by chitinous bands. Anal orifice small and located anteriorly in distance three times the length of the median lobes.

Remarks: Found on the trunks and the older limbs of the white elm, *Ulmus americana* and *Catalpa*, at Columbus, Ohio.

ASPIDIOTUS UVAE Comstock.

Fig. 6.

A. uvae Comst., Rep. U. S. Dep. Ag., 1880, p. 309 (1881).

A. uvae Newell, Contr. Ia. Ag. Coll., No. 3, p. 12 (1899)

Scale of female: Circular, 1.5 mm. in diameter, rather flat, dusty tan-colored, lighter than dry bark of host. Exuviae sub-central, bright-yellow, covered. When removed leaves a conspicuous white spot.

Scale of male: Elongated, length 1 mm., width 0.5 mm, slightly darker than scale of female, with exuvia submarginal and more convex.

Female: Median lobes very prominent, parallel, notched on each margin and rounded, the mesal notch slightly nearer the apex; second and third lobes rudimentary with the inner angles slightly produced. Bounding each incision are two subequal chitinous processes, and between the median lobes are two narrow thickenings. There are two simple plates between the median lobes and two serrate ones caudad of each incision. Outside of third lobe, are 3—5 prolongations of the margin of the segment resembling plates and about as long as the spines. Spines on the dorsal surface are borne, one on each lobe and one nearly half-way to the penultimate segment; the ventral spines are shorter and just laterad of the corresponding dorsal spine. Dorsal pores in three rows; 1st (at first interlobular incision) usually 2; 2nd, about 8; 3rd, about 4 and near the penultimate segment a group of 3-5. Median group of circumgenital gland-orifices 0—4; anterior lateral, 4—9; posterior lateral, 3—7. Accompanying the groups are peculiar chitinous bands or folds of the body-wall. Anal orifice embraced by extended inner margins of the median lobes. Immediately anterior from the median and second lobes, the segment is thicker and darker brown.

Remarks: Infests grape-vines, having a peculiar habit of arranging themselves in longitudinal rows on the stem of the host. Not common in Ohio, there being only two infested localities reported as yet.

Comstockiella sabalis (Comstock).

Fig. 25.

Aspidiotus ? sabalis Comst., 2nd Rep. Dep. Corn. Univ., p. 67 (1883).
Comstockiella sabalis Ckll. Check. List, p. 335 (1896).

Scale of female: Approximately circular, snowy white, 1.5—2 mm. broad, exuviae covered, prominent.

Scale of male: Similar to female scale in color, elongated, more convex.

Female: There are no lobes or plates; the margin of the segment is rather deeply notched. The female has rudimentary antennae of about two joints and is viviparous. Near the edge of the segment are five very long spines and two similar ones on the penultimate segment. Beginning at the meson on the ventral surface are four small spines equidistant extending to the penultimate segment, which itself bears two. There are also four orifices in two rows extending anteriorly near the mesal notch. There are six groups of circumgenital gland-orifices, anterior lateral, 4-6; intermediate, 5-7; posterior lateral, 8-15. The dorsal pores are very small, arranged in six cephalo-caudal lines.

Male: Yellow, wingless, with short, spindle-shaped antennae.

Remarks: This Coccid was placed provisionally in the genus *Aspidiotus* by Comstock in his Second Cornell Report. Found by the author on Sabal Palmetto in the O. S. U. Conservatory, at Columbus, Ohio.

Genus CHRYSOMPHALUS Ashm.

[Type, **Ch. aonidum** (Linn.)]

The members of this genus favor the Neotropical regions, although one species is common in Ohio and thrives in spite of our winters. They have large, usually dark scales with covered exuviae. The last segment of the female presents no incisions, but instead, rather long, chitinous thickenings and strongly branched plates.

A. Scale of female with jet-black exuviae **obscurus**

AA. Scale of female delicate, semi-transparent, with orange exuviae; circumgenital gland-orifices absent **aurantii**

B. Circumgenital gland-orifices present in four groups **dictyospermi**

AAA. Scale of female dark reddish-brown, convex; second and third series of dorsal pores in double rows **aonidum**

Chrysomphalus aonidum (Linn.)

Fig. 13.

Coccus aonidum Linn., Syst. Nat., Ed. x, i, p. 455 (1758).

Chrysomphalus ficus Ashmead, Am. Ent., iii, p. 267 (1880).

Aspidiotus ficus Comst., Rep. U. S. Dep. Ag., 1880, p. 296 (1881).

Chrysomphalus aonidum Ckll., Biol. Centr. Amer., ii, pt. 2, p. 25 (1899).

Scale of female: Circular, 2 mm. diam., convex; nipple-like exuviae gray, surrounded by a ring of light reddish-brown; remainder of scale dark-brown to almost black.

Scale of male: Similar to scale of female in color, excepting long posterior gray flap. Diam. 0.6—0.8 mm.

Female: Three pairs of well-developed lobes; the median and second pairs are abruptly narrowed midway on their lateral margin; the third pair have two or three notches on the lateral margin. Six chitinous, linear to spatulate processes extend anteriorly from either margin of the three pairs of lobes. Chitinous processes on lateral margin of median and second lobes and on mesal margin of third lobe, longest. Margin of entire segment thickened with chitin, ending posteriorly in a broad, serrate lobe laterad of third lobe. Plates deeply fringed, conspicuous, slightly longer than lobes. Between median, and between median and second lobes, two; between second and third, three, and outside of third lobe are three compound fringed plates. The short spines on the ventral surface are situated on the lateral margins of each lobe including the apparent fourth lobe. On the dorsal surface, the spines are situated mesad of the corresponding ventral spine, except that they are wanting upon the median lobes. Dorsal pores numerous in three series; first (between median and second lobes) of 3; second in double row of about 20; third of about 23. Four groups of circumgenital gland-orifices; anterior lateral, 7—9; posterior lateral, 4—5.

Remarks: This species infests citrus trees, many palms, oleanders and other ornamental plants. It is a serious pest in conservatories, multiplying with astonishing rapidity.

Chrysomphalus aurantii (Mask.)

Figs. 15, 16.

Aspidiotus aurantii Mask., N. Z. Trans., xi, p. 199 (1878).

Aspidiotus aurantii Comst., Rep. U. S. Dep. Ag., 1880, p. 293 (1881).

Chrysomphalus aurantii Ckll., Check. List, Suppl., p. 396 (1899).

Scale of female: Light gray, translucent revealing the orange or reddish insect beneath. Central nipple-like exuviae similar to Ch. aonidum. Diam. about 2 mm.

Scale of male: Resembling female scale; with posterior gray flap. Exuvia lighter in color. Diam. 0.5—0.6 mm.

Female: Of a light-brown color and reniform shape; the thoracic segment extending posteriorly, exceeding tip of pygidium. Three pairs of well-developed lobes; median deeply notched on both margins, the mesal notch posterior to the lateral. The second and third pair are notched about midway on their lateral and often on their mesal margins. Laterad of the third lobe is a lobe-like, serrate projection of the segment. Extending anteriorly from either margin of the second, the lateral margin of the median and the mesal margin of the third lobes, are short spatulate chitinous processes. The plates are all deeply fringed on their lateral margins and exceed the lobes in length. Two between median, two between median and second, three between second and third lobes, and three compound plates between the third lobe and the serrate margin of the segment. On the dorsal surface, each lobe bears a spine. On the ventral, there is a spine at the lateral base of each lobe except the median. Dorsal pores not prominent, in three series; first of 2—3; second of about 10; third of about 7. Groups of circumgenital gland-orifices are absent.

Remarks: This species infests Citrus trees principally, although palms, etc., are affected. It multiplies rapidly and has caused much loss to growers of citrus fruits.

Chrysomphalus dictyospermi (Morg.)

Fig. 17.

Aspidiotus dictyospermi Morg., Ent. Mon. Mag., xxv, p. 352 (1889).

A., (*Chrysomphalus*) *dictyospermi* Ckll., Bull. 6, T. s., Dep. Ag., p. 23 (1897).

Scale of female: Grayish-white, oval, depressed; exuviae central, light-yellow to dark-orange.

Scale of male: Similar in color to scale of female, elongated; exuvia subcentral, orange.

Female: Three pairs of well-developed lobes, notched on outer margin and narrowed at outer base; third lobe slightly smaller than median and second lobes. Extending anteriorly from either margin of the median and second lobes, and the inner margin of the third lobe, are long clavate, chitinous processes; those on the outer margins the longer. Outside of third lobe is a thickened, serrate, projection of the margin. Plates as long as lobes, fringed; two between median, two between median and second, three between second and third lobes, and outside of third lobe are two peculiarly fringed plates longer than the lobes. Spines short and inconspicuous, borne on the dorsal surface by each lobe and one close to penultimate segment; the ventral spines are just laterad of the corresponding dorsal spines. Dorsal pores in three rows; 1st (between median and second lobes) of two, 2nd of three to four, 3rd of four to six. Four groups of circumgenital gland-orifices; anterior lateral, 3—4; posterior lateral, 2.

Remarks: Occurs as a greenhouse species in the Northern United States. Found in the Ohio State University Conservatory on *Ficus pumila* var. *minor, Palm, Pandanus,* and on a small potted *Arbor Vitae.*

CHRYSOMPHALUS OBSCURUS (Comst.)

Aspidiotus obscurus Comst., Rep. U. S. Dep. Ag., 1880, p. 303 (1881).
Chrysomphalus obscurus Leon., Riv. Pat. Veg., vii, p. 205 (1899).
Aspidiotus obscurus Hunter, Kan. Univ. Quar., viii, p. 7 (1899).
Aspidiotus obscurus Hunter, Kan. Univ. Quar., ix, p. 107 (1900).

Scale of female: Very dark gray, only slightly convex and agreeing in color with the bark of host is difficult to detect; exuviae jet black.

Scale of male: Similar to scale of female in color, oval, convex anteriorly.

Female: Three pairs of well-developed lobes and the posterior tip of the thickened and notched margin of the segment apparently forming a fourth lobe. Median pair broad, rounded; second and third pair rather close, converging and serrate on the outer margin. Eight short club-shaped, chitinous processes on each side of the meson; two bounding the first incision, the inner much the larger; three at second and third incisions respectively, the middle one the larger and longer. The plates are short and inconspicuous, one between the median lobes and the median and first lobes respectively; two between second and third lobes and two slightly furcated ones laterad of third lobes. On the dorsal surface, spines are borne at the outer base of second and third lobes; one laterad of third incision, and one about one-half of distance to penultimate segment. The ventral spines are just laterad of the corresponding dorsal spines. Two kinds of dorsal pores, oval and small round ones, in three rows; 1st, of about 4; 2nd of about 18 oval and anteriorly several round ones; 4th of about five and several rounded ones. Five groups of circumgenital gland-orifices; median of about 6; anterior lateral of 12; posterior lateral of about 7.

Remarks: We have taken this species from *Quercus coccinae, Q. acuminata, Q. macrocarpa,* and *Hicoria alba.* It is difficult to detect on account of its close resemblance in color to the bark of the host.

Genus LEPIDOSAPHES Shimer.

The species of this genus have a long narrow scale with the exuviae at one extremity. The male scale resembles the female scale in form and color, but is much smaller and bears only one exuviae. *Lepidosaphes ulmi* (L), better known as the "Oyster-shell scale" or "Oyster-shell Bark Louse," is a serious pest on Poplar trees in some sections of Ohio, especially in the Northeastern part of the state. *Lepidosaphes beckii* (*Newm.*) occurs in the state only as a greenhouse species, or is shipped into the markets on oranges, as is also *L. gloverii* (Pack.).

Lepidosaphes beckii (Newm).

Fig. 41.

Coccus beckii Newm., The Entom., iv, p. 217, Feb. (1869).

Aspidiotus citricola Pack., Guide to Study of Insects, p. 527, Aug. (1869).

Mytilaspis citricola Comst., Rep. U. S. Dep. Ag., 1880, p. 321 (1881).

Scale of female: About 3 mm. in length, more or less curved, gradually broadened posteriorly, brownish-purple, with exuviae slightly lighter in color. The white ventral scale is well developed.

Scale of male: Length, 1.5 mm., nearly straight, similar in color to scale of female, often darker with exuvia pale-yellow. With posterior hinge as in L. ulmi.

Female: Median lobes short and broad, well-developed, obscurely pointed, serrate; inner lobule of second lobe the larger and usually serrate; third lobe rudimentary, notched in the middle. Plates and spines similar to those of L. ulmi, except that there are 4—7 plates or spines upon the lateral lobules of the penultimate segment. Second row of dorsal pores (extending anteriorly from the 2nd pair of plates) of about 12, remote from margin of segment; third row absent; fourth of about 4. Median group of circumgenital gland-orifices, 5—6; anterior lateral, 10—18; posterior lateral, 7—9.

Remarks: This species infests Citrus trees under glass in Ohio, and is frequently seen on Oranges in the markets.

Lepidosaphes gloverii (Pack.).

Coccus gloverii Pack., Guide to Study of Ins., Ed. i, p. 527 (1869).
Mytilaspis gloverii Comst., Rep. U. S. Dep. Ag., 1880, p. 323 (1881).

This peculiar, long, narrow scale was found on oranges in the Columbus markets. It is often associated with the preceeding species.

LEPIDOSAPHES ULMI (Linn.)

Figs. 40, 75.

Coccus ulmi Linn., Syst. Nat., Ed. x. i, p. 455 (1758).
Mytilaspis pomorum Comst., Rep. U. S. Dep. Ag., 1880, p. 325 (1881).
Mytilaspis pomorum Newell, Bull. 43, Ia. Exp. Sta., p. 159 (1899).

Scale of female: Long, 2.5—3 mm., more or less curved, gradually widened posteriorly, brown or dark-brown, shining, thick in texture, with exuviae yellowish or yellowish-brown.

Scale of male: Similar in color to scale of female, but smaller. The posterior one-fourth of the scale bends upward like a hinge for the exit of the male.

Female: The median lobes are large, broader than long with parallel margins, deeply notched on each side near the apex and rounded; slightly diverging. Lobules of second lobe rounded; the mesal much the larger. Third lobe rudimentary. Plates long, simple; two in each of the folowing places: between median lobes, between first and second and between second and third lobes, laterad of third lobe, and one about half-way to penultimate segment. There is an elongated pore laterad of first lobe, two laterad of the third and fourth pairs of plates respectively, and one laterad of the fifth pair of plates. The spines on the dorsal surface are longer than the ventral spines and situated as follows: one at base of each margin of first lobe, one dorsad of incision of second and third lobes respecitvely, and one between the fourth and fifth pair of plates. On the ventral surface, there is a spine at the base of each margin of the median lobe, third spine at base of outer margin of outer lobule of second lobe, and the fourth and fifth spines between the fourth and fifth pairs of plates respectively. There are four or five spines on the lateral lobules of the penultimate segment. Second row of dorsal pores, (extending anteriorly from the third pair of plates) of about 12 small rounded orifices; third row of about 10; fourth row (near margin) of about 6. Median group of circumgenital gland-orifices, 10—18; anterior lateral and posterior lateral, 16—22 each.

Remarks: This is undoubtedly a cosmopolitan species and has been described under various names in several countries. The scale is popularly called the "Appletree Bark Louse," though not confined to apple trees. Perhaps the greatest damage is done on Poplars and Willows. In the northeastern part of Ohio this scale is plentiful, and in instances many Poplars have been killed by its attack. This is a difficult scale to combat, but the same measures as used for the San Jose' Scale will prove successful.

Genus PARLATORIA Targ.

The two species which are reported for Ohio are both greenhouse species, or rather in this case *P. zizyphus* (Lucas) was found on oranges and lemons in the Columbus markets. *Parlatoria pergandii* Comst. affects Citrus trees most seriously.

A. Scale of female circular — **pergandii**
AA. Scale of female elongated, black — **zizyphus**

Parlatoria pergandii Comstock.

Fig. 24.

P. pergandii Comst., Rep. U. S. Dep. Ag., 1880, p. 327 (1881).

P. pergandii Comst., 2nd Rep. Dep. Ent. Corn. Univ., p. 113 (1883).

Scale of female: Circular to elongated, irregular, dirty-gray, 1.6 mm. in length; exuviae marginal. brown, the first naked and the second covered by a thin film of secretion. occupying nearly one-third of length of scale.

Scale of male: Long and narrow, lateral margins prominent, not carinated, light gray with terminal exuvia darker.

Female: Three pairs of well-developed lobes, nearly equal in size, broadest near the middle tapering anteriorly, notched deeply on each side near the apex. A rudimentary fourth lobe, produced into a papilla, half-way between third lobe and penultimate segment. A crescent-shaped thickening of the body-wall appears between the median lobes, between median and second, second and third, and two thickenings between third and fourth lobes and between fourth lobe and penultimate segment. The plates are as long as the lobes and fringed on the distal margin. Two between median lobes, two between median and second, three between second and third, three between third and fourth, and three palmate plates cephalad of fourth lobe. On the three segments preceeding the last, are five or six plates, each produced into a papilla. A spine on the dorsal surface of each lobe near the margin; on the ventral surface, the spines are situated laterad of the second, third and fourth lobes respectively. Four groups of circumgenital gland orifices, each of about 7, but varying from 5—10.

Remarks: This species infests Citrus trees in Florida, occurring in Ohio only under glass. Being so nearly the color of the bark, it is scarcely noticeable until a tree is badly infested.

Parlatoria zizyphus (Lucas).

Fig. 23.

Coccus zizyphus Lucas, Ann. Soc. Ent. Fr., (3), i, xxviii. (1853).

Parlatoria zizyphi Comst., 2nd Rep. Dep. Ent. Corn. Univ., p. 115 (1883).

Scale of female: The scale is almost covered by the very black exuviae, the first being oval and the second quadrangular. On the middle line is a ridge in a longitudinal depression.

Scale of male: Long, parallel-sided, light-brown, terminal exuvia black.

Female: Similar to female of P. pergandii, except that the three segments preceeding the last bear numerous irregularly incised plates, and the fourth lobe is long and sharp-pointed. The lobes are somewhat smaller than in P. pergandii.

Remarks: This species is a native of Europe, infesting orange and lemon trees, and is frequently seen on imported fruit in the markets.

DIRECTIONS FOR COLLECTING AND MOUNTING COCCIDAE.

A few words in regard to collecting Coccidae might be fitting and helpful to beginners. Coccidae are seldom found in this region on anything except trees and shrubs, although many herbaceous plants are infested by Aphids and Aleurodids. Perhaps the most satisfactory method in collecting scale insects in the field, is to put them in envelopes, properly labeled, until the collector can procure suitable glass tubes or bottles, which should contain all data upon a slip of paper. Until the material is perfectly dry, a plug of cotton should be used; otherwise the contents will soon mould. Finally; when you have collected as much of any species as you think necessary, collect as much more, it will never come amiss; in other words, always collect plenty, if possible.

If the specimens to be mounted belong to the *Diaspinae*, carefully lift the scale revealing the small flat inset beneath, which should be transferred to a drop of water upon a glass slide. (Often under the scales of *Chionaspis* will be found a great quantity of eggs and the female shrunken into the very tip of the scale.) After sufficient have been procured in this way, it is an easy matter with a medicine dropper and a strong solution of KOH (Potassium hydroxide) to run off the specimens into a test tube, in which they should be boiled until clear and transparent, (sometimes it is necessary to prick a hole in the specimens to allow the body contents to escape.) Before the KOH solution cools, the cleared specimens should be run through 50 per cent. and 100 per cent. alcohol. Now they can be put on a slide in proper mounting position, and the excess of alcohol can be taken up with strips of blotting paper. Allow the alcohol to evaporate and then put on several drops of Xylol; after a few moments the Xylol may be removed and the specimens are ready for mounting in the usual manner, in Canada balsam.

If the specimens are of the nature of *Lecaniums* or "*Mealy Bugs*," i. e. not separable from the scale, the entire insect must be prepared and mounted in the foregoing manner.

Complete data as follows should be given on proper labels:—scientific name, host, locality, date, other interesting notes and the collector's name.

INDEX TO GENERA

ALSO A FEW COMMON NAMES OF ECONOMIC SPECIES.

	Page
Aspidiotus	55
Asterolecanium	33
Aulacaspis	53
Chionaspis	43
Chrysomphalus	69
Comstockiella	69
Dactylopius	41
Diaspis	51
Eriococcus	38
Fiorinia	54
Gossyparia	38
Hemichionaspis	53
Howardia	51
Kermes	33
Lepidosaphes	73
Mealy-Bugs	41
Mytilaspis	73
Orthezia	31
Parlatoria	75
Phenacoccus	39
Pseudococcus	41
Scale, Curtis'	64
Scale, Forbes'	60
Scale, Oyster-shell	74
Scale, Putnam's	57
Scale, Rose	53
Scale, San Jose	65
Scale, Scurfy	46

EXPLANATION OF PLATES.

Wherever in illustrating the *Diaspinae,* a vertical line is drawn through a figure, the dorsal surface of the pygidium is shown on the left side and the ventral on the right. The figures are numbered consecutively, and no mention is made of the various plates in the descriptions.

The majority of the plates were designed before Mrs. Fernald's "Catalogue of the Coccidae of the World" was published, hence some of the names inserted with the drawings are to be disregarded, and the following ones adopted:

Plate I. (Original)

Fig. 1. Pygidium of Aspidiotus forbesi Johns.
Fig. 2. Part of same enlarged.
Fig. 3. Aspidiotus ostreaeformis Curt.
Fig. 4. Aspidiotus perniciosus Comst.
Fig. 5. Aspidiotus ancylus Putn.
Fig. 6. Aspidiotus uvae Comst.
Fig. 7. Aspidiotus juglans-regiae Comst.
Fig. 8. Aspidiotus glanduliferus Ckll.
Fig. 9. Aspidiotus comstocki Johns.

Plate II. (Original)

Fig. 10. Aspidiotus hederae (Vall.)
Fig. 11. Aspidiotus hederae (Vall.)
Fig. 12. Aspidiotus cyanophylli Sign.
Fig. 13. Chrysomphalus aonidum (Linn.)
Fig. 14. Chrysomphalus obscurus (Comst.)
Fig. 15. Chrysomphalus aurantii (Mask.)
Fig. 16. Chrysomphalus aurantii (Mask.)
Fig. 17. Chrysomphalus dictyospermi (Morg.)

Plate III. (Original)

Fig. 18. Aspidiotus lataniae Sign.
Fig. 19. Aspidiotus cydoniae crawii Ckll.
Fig. 20. Aspidiotus rapax Comst.
Fig. 21. Fiorinia fioriniae (Targ.)
Fig. 22. Aspidiotus ulmi Johns.
Fig. 23. Parlatoria zizyphus (Lucas).
Fig. 24. Parlatoria pergandii Comst.
Fig. 25. Comstockiella sabalis (Comst.)

Plate IV. (Original)

Fig. 26. Chionaspis corni Cooley.
Fig. 27. Chionaspis corni Cooley.
Fig. 28. Chionaspis euonymi Comst.
Fig. 29. Chionaspis caryae Cooley.
Fig. 30. Chionaspis furfura (Fitch).
Fig. 31. Chionaspis americana Johns.

Plate V. (Original)

Fig. 32. Chionaspis salicis-nigrae (Walsh).
Fig. 33. Chionaspis salicis-nigrae (Walsh).
Fig. 34. Chionaspis pinifoliae (Fitch).
Fig. 35. Chionaspis pinifoliae (Fitch).
Fig. 36. Chionaspis gleditsiae Sanders.
Fig. 37. Chionaspis gleditsiae Sanders.
Fig. 38. Hemichionaspis aspidistrae (Sign.)
Fig. 39. Howardia biclavis (Comst.)

Plate VI. (Original)

Fig. 40. Lepidosaphes ulmi (Linn.)
Fig. 41. Lepidosaphes beckii (Newm.)
Fig. 42. Diaspis boisduvalii Sign.
Fig. 43. Diaspis echinocacti cacti Comst.
Fig. 44. Aulacaspis rosae (Bouche').
Fig. 45. Aulacaspis rosae (Bouche').

Plate VII. (Original)

(Upper half.)

Fig. 46. Pseudococcus citri (Risso)., adult female.
Fig. 47. Pseudococcus citri (Risso)., anal ring and penultimate segment.
Fig. 48. Pseudococcus citri (Risso)., antennae of adult female.
Fig. 49. Pseudococcus longispinus (Targ.), adult female.
Fig. 50. Pseudococcus longispinus (Targ.), antennae of adult female.
Fig. 51. Pseudococcus longispinus (Targ.), anal ring and penultimate segment.
Fig. 52. Pseudococcus trifolii (Forbes), anterior leg of adult female.
Fig. 53. Pseudococcus trifolii (Forbes), anal ring and penultimate segment.
Fig. 54. Pseudococcus trifolii (Forbes), antenna of adult female.
Fig. 55. Kermes pubescens Bogue.
Fig. 56. Orthezia insignis Dougl.

(Lower half.)

Phenacoccus osborni Sanders.

1. Adult male. 2. Balancer with hook fitting into pocket in wing. 3. Posterior tarsus of male. 4. Adult female. 5. Posterior tarsus of female. 6. Lateral anal lobe of female. 7a, 7b. Female antennae.

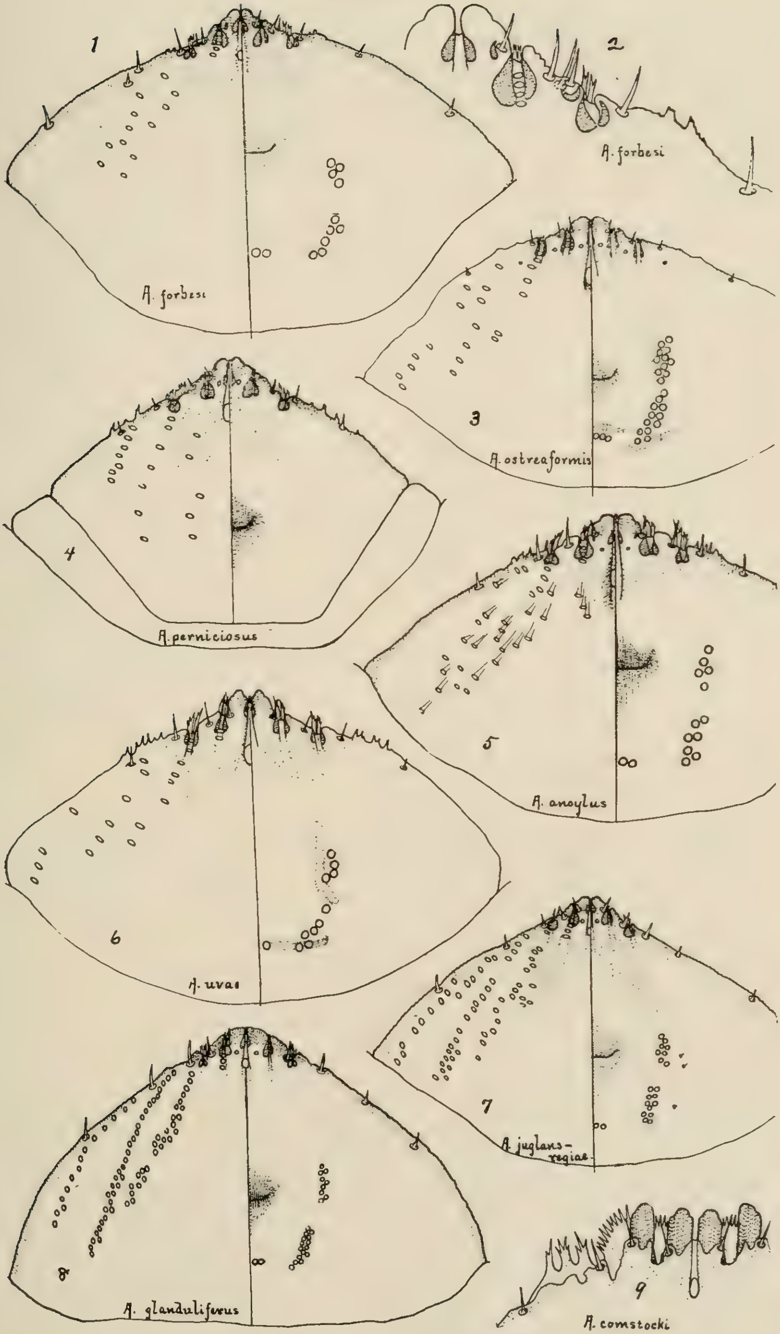
Plate VIII. (Original)

Fig. 57. Orthezia solidaginis Sanders, dorsal view of adult female.
Fig. 58. Orthezia solidaginis Sanders, anterior leg of adult female.
Fig. 59. Orthezia solidaginis Sanders, tarsus and claw of adult female.
Fig. 60. Orthezia solidaginis Sanders, antenna of adult female.
Fig. 61. Orthezia solidaginis Sanders, (immature stage, female) dorsal view.
Fig. 62. Orthezia solidaginis Sanders, (immature stage, female) ventral view.
Fig. 63. Orthezia solidaginis Sanders, (immature stage, female) antenna.
Fig. 64. Chionaspis sylvatica Sanders, pygidium of female.
Fig. 65. Chionaspis sylvatica Sanders, pygidium enlarged.
Fig. 66. Aspidiotus piceus Sanders, part of pygidium.

Plate IX. (Original)

Fig. 67. Kermes pubescens Bogue.
Fig. 68. Kermes andrei King.
Fig. 69. Kermes pettiti Ehrh.
Fig. 70. Kermes arizonensis King.
Fig. 72. Kermes kingii Ckll.
Fig. 73. Kermes galliformis Riley.
Fig. 74. Chionaspis salicis-nigrae (Walsh). (Willow Scurfy-Scale).
Fig. 75. Lepidosaphes ulmi (Linn.) (Oyster-shell Scale).
Fig. 76. Diaspis echinocacti cacti Comst. (Cactus Scale).
Fig. 77. Orthezia solidaginis Sanders.
Fig. 78. Aspidiotus perniciosus Comst. (San Jose' Scale).

Plate 1.

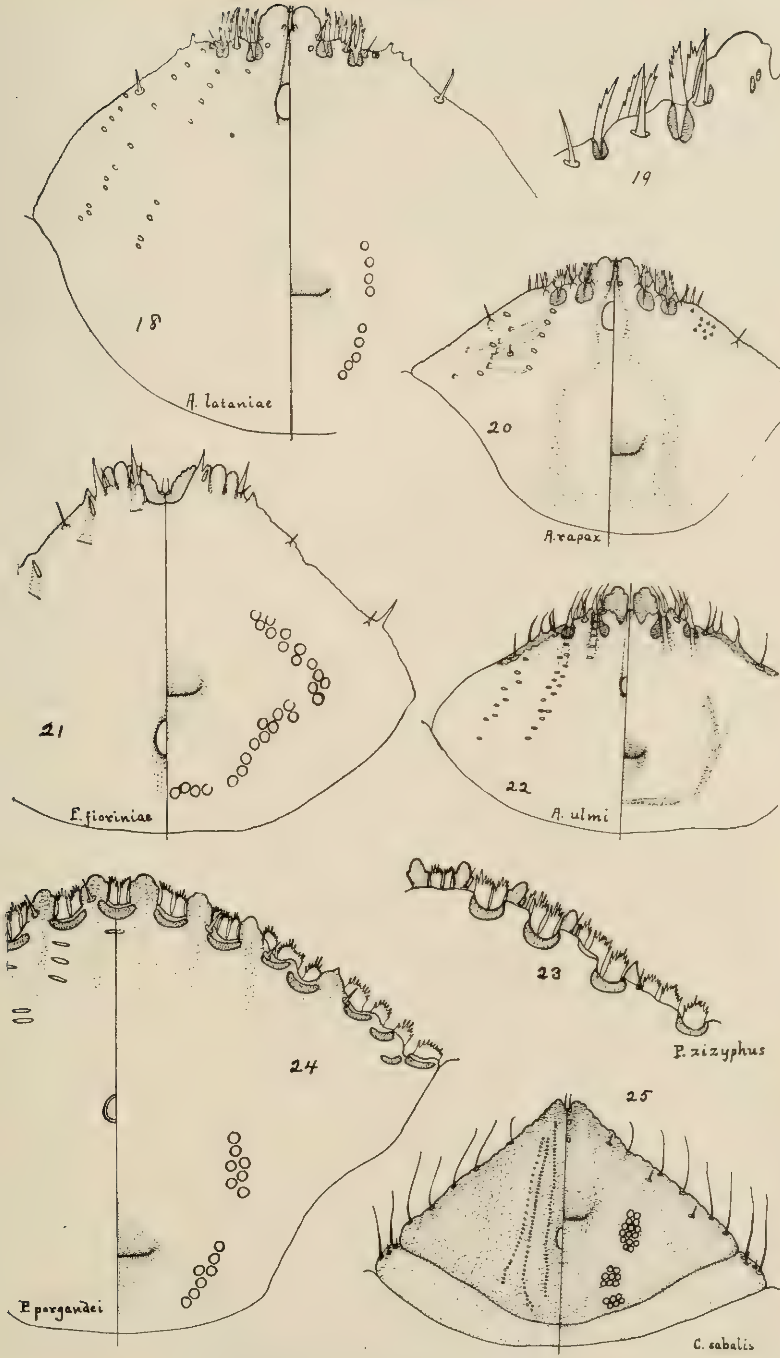


Sanders on Coccidae of Ohio.

Plate 2.

Sanders on Coccidae of Ohio.

Plate 3.



Sanders on Coccidae of Ohio.

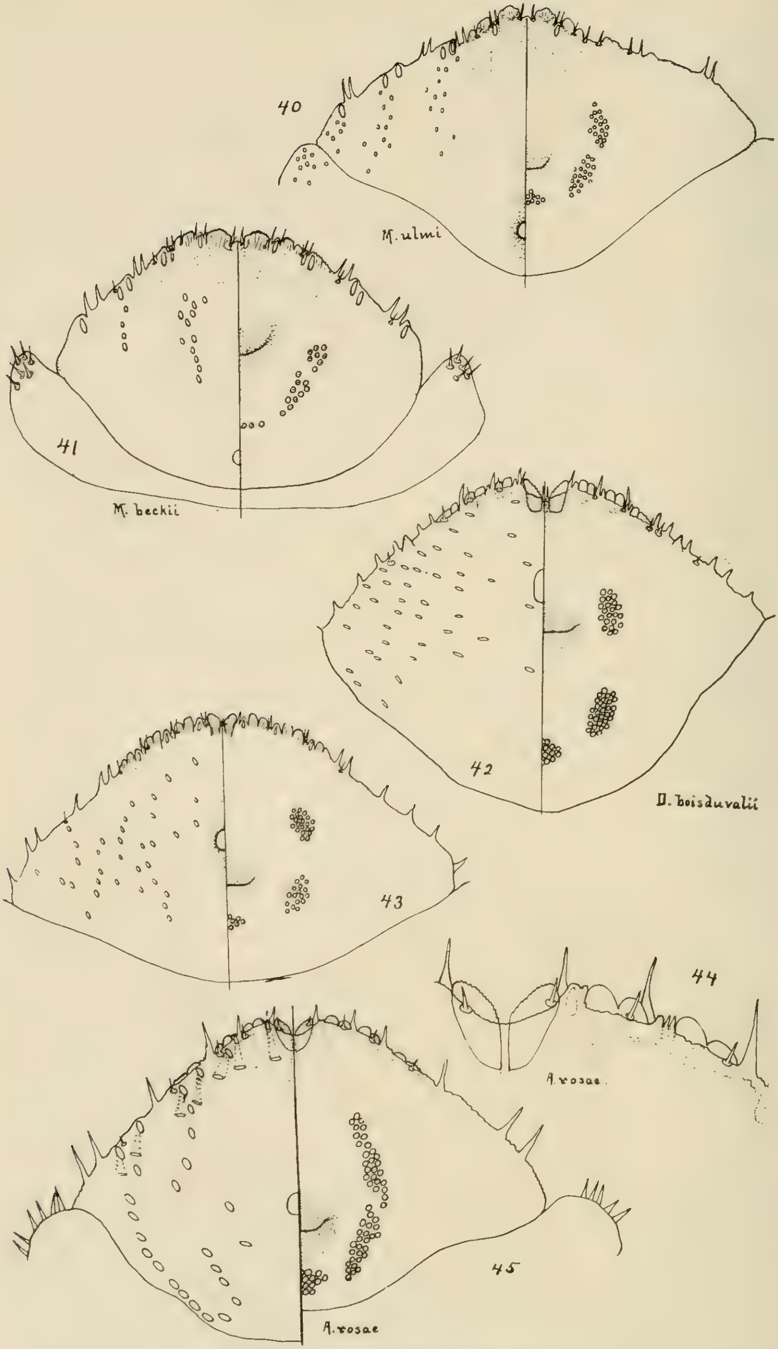
Plate 4.

Sanders on Coccidae of Ohio.

Plate 5.

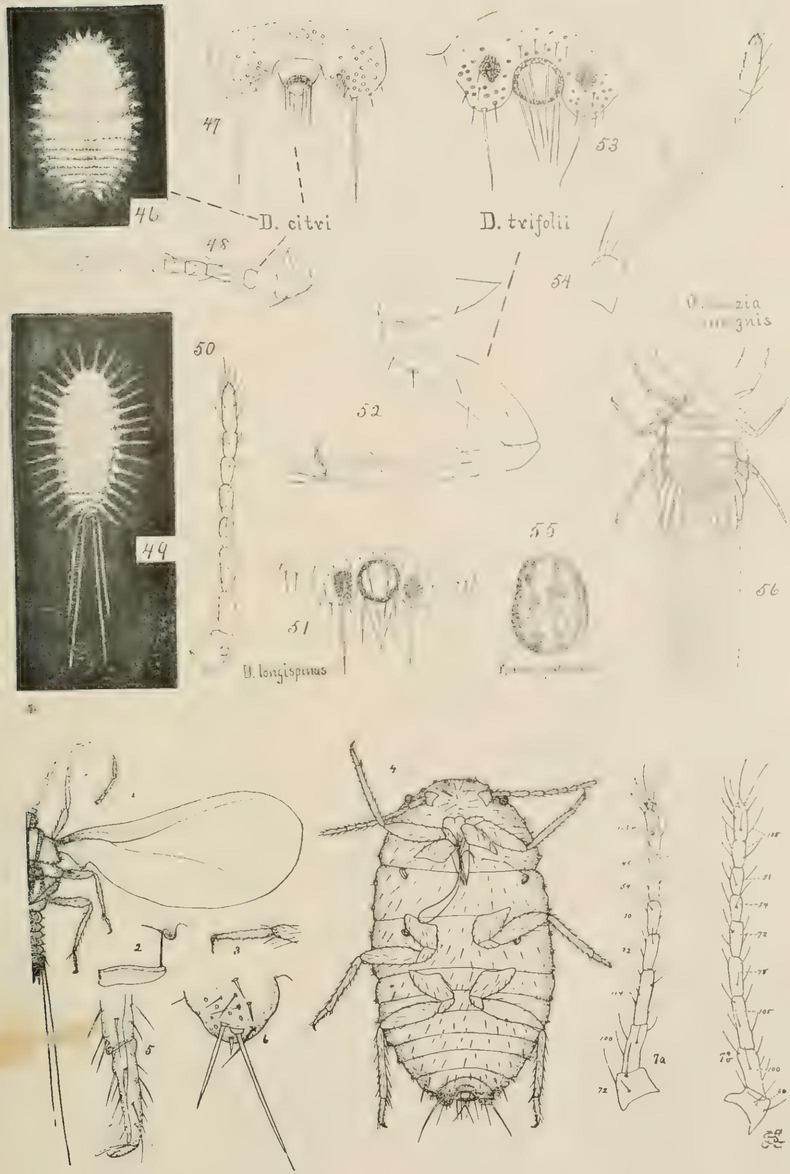
Sanders on Coccidae of Ohio.

Plate 6.



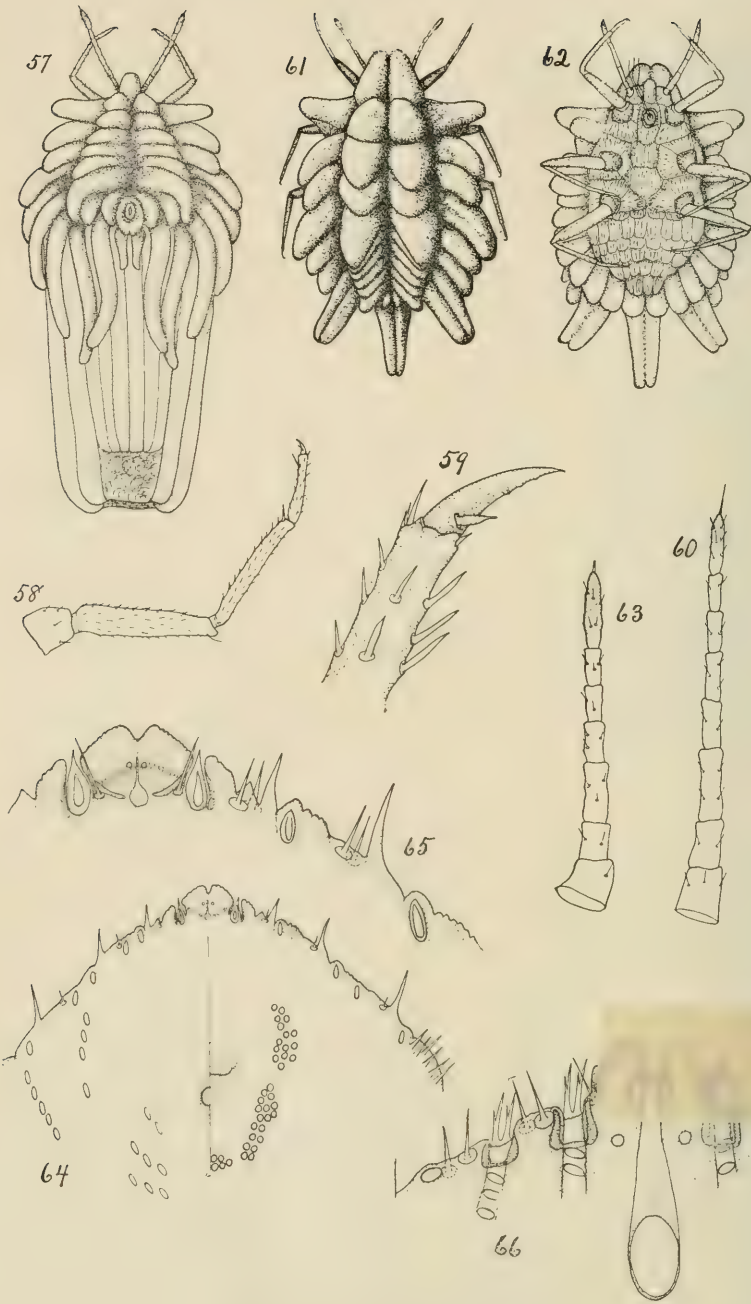
Sanders on Coccidae of Ohio.

Plate 7.

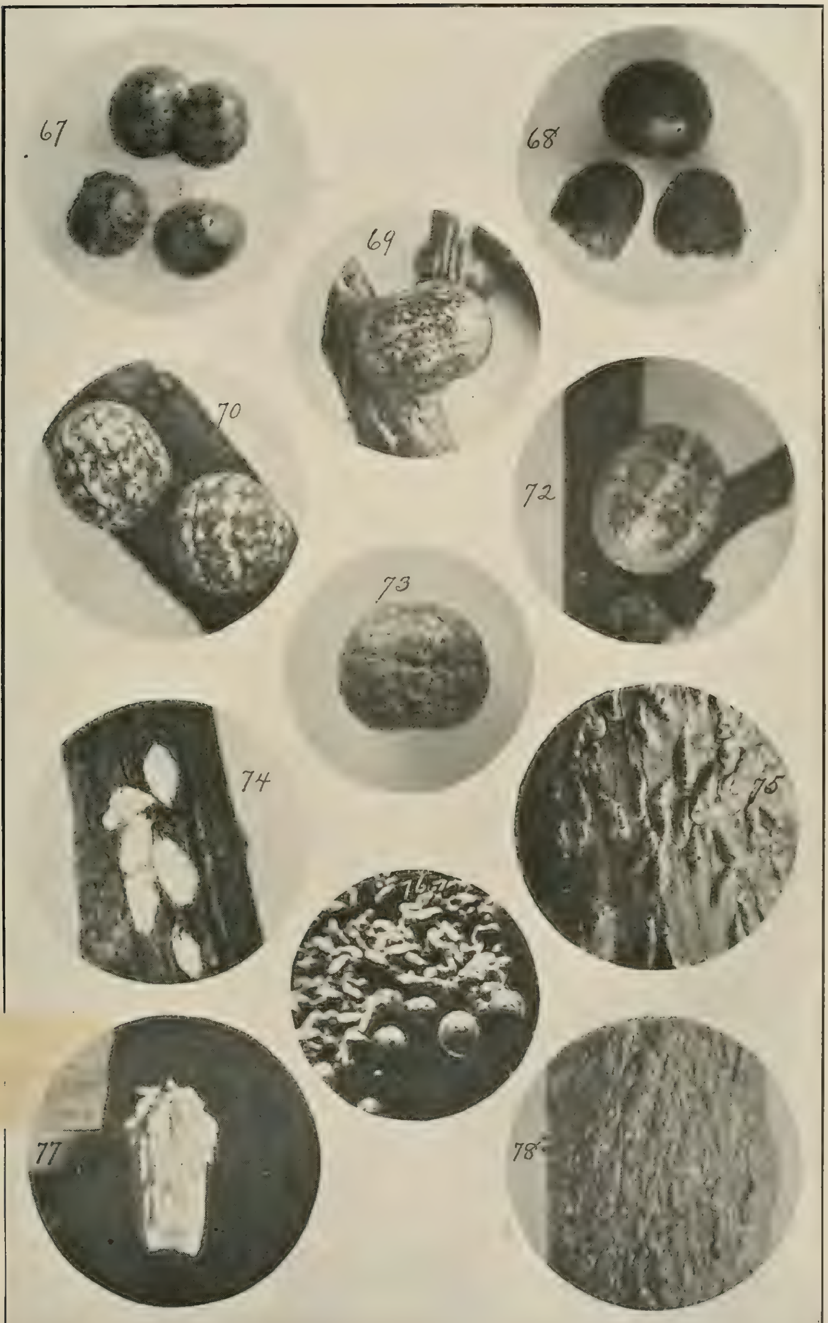


Sanders on Coccidae of Ohio.

Plate 8.



Sanders on Coccidae of Ohio.



Sanders on Coccidae of Ohio.

PROCEEDINGS

OF THE

Ohio State Academy of Science

VOLUME IV, PART 3.

BATRACHIANS *and* REPTILES OF OHIO

BY

MAX MORSE

Special Papers Number 9.

PLATE I. THE COPPERHEAD.– From a cast in the U. S. National Museum. (*After Stejneger.*)

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Volume IV, Part 3.

SPECIAL PAPERS, No. 9.

Batrachians and Reptiles of Ohio

BY

MAX MORSE.

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INTRODUCTORY.

IT is only too often that one, not a specialist in some line of scientific work asks bread of those who have devoted themselves more especially to that department of science and receives but a stone. There are at present many general and local works on the subject of the animals and plants about us, but few are adapted to the non-specialist and fewer still to the layman. To read the majority of these works it is necessary to become conversant, often to quite a degree, with the nomenclature and technicalities used. This, to say the least, is burdensome to a general reader and often results in annulling any interest he may have had in the subject.

The present paper is an attempt to put in a form comprehensible to general readers an account of the reptiles and batrachians of the State. If the paper is too technical to be used by any intelligent person it fails of its purpose. It is, however, impossible to discuss a subject such as this without the use of any uncommon terms; the very fact that the two groups under consideration are themselves generally unfamiliar is a confirmation of this statement. But the attempt has been made in the present paper to reduce such terms to a minimum and to fully explain those that must be used.

HISTORICAL.

Two lists of the Batrachia and Reptilia of Ohio have been thus far published. The first was issued in 1838, by Dr. Jared Potter Kirtland ('38), then at the Medical College of Ohio, in Cincinnati. The list embraced a part of the Report of the Zoology of Ohio, arranged by Kirtland and published in the First Annual Report of the Geological Survey of the State of Ohio. The list embraces twenty-seven (27) Reptiles and twenty-one (21) Batrachians, and brief notes on distribution are added for many of the species. Kirtland collected over a large area and personally examined several of the more important collections in the Eastern States. From such sources he drew the material for his list.

The second list, the only available one at the present time, was prepared by Dr. W. H. Smith ('82), a resident of Michigan. The work was based on collections and notes furnished by several institutions in Ohio and by some workers in general zoology. Many of the species were included merely because they had been found in neighboring States and were supposed to occur, likewise, in Ohio. The work is useful, however, as a synopsis of the forms that probably occur within the State's limits.

Aside from these two general lists there are found promiscuously distributed through scientific literature, notes on our reptilian and batrachian fauna. Thus E. V. Wilcox ('91), published a series of observations on the Batrachia of the State in the "Otterbein Aegis," issued at Westerville, Ohio. The work was based on the Experiment Station Collection and on personal work in several parts of Ohio. Food-habits, dates and places of the occurrence and descriptive remarks are faithfully recorded. In several cases of uncertainty in identification, the species were referred to Prof. Cope and hence are trustworthy. It is unfortunate that the list was not published in a medium of wider circulation. Morse ('01, May and June) listed the Batrachians and Reptiles in the Zoological museum of the Ohio State University, which is almost complete for Ohio.

Such are the works exclusively devoted to the State of Ohio. Lists of species in neighboring States have been published which help in the study of Ohio's fauna. Thus, Michigan is represented by a list published by Dr. W. H. Smith ('79), the author of Ohio's list. O. P. Hay ('92) arranged the list for Indiana, while Garman ('91) did the same for Illinois, and Eckel and Paulmier ('02) for New York. Turning to works of a more general character, we have the two works of Cope—the one dealing with Batrachia ('89), and the other with the Reptilia ('00), exclusive of the Testudinata. These two works are primarily catalogues of the U. S. Nat. Mus., and inasmuch as many of the species occurring in Ohio are represented in that collection and in no other, the publications are invaluable.

The present list is compiled from the works mentioned and the nomenclature is that of Cope as given in the two works above named, modified in some cases. The nomenclature in the group Testudinata is that adopted by Jordan ('99) in the 8th Edt. of his Manual, which is virtually that of Stejneger.

The author has collected in representative localities in the State, covering the northern, eastern, central, southern and a part of the western area. The several museums of the State have been personally visited or lists of specimens have been kindly furnished by the officers in charge.

Species that are not represented in any collection by specimens taken in the State but which very probably occur within our borders are designated by an asterisk. All species, therefore, that are not marked by an asterisk are bona fide Ohio Batrachia or Reptilia.

Acknowledgments are due the officers of the Ohio Academy of Science for funds used in completing the present work and for its publication. Dr. Josua Lindahl, of the Cincinnati Society of Natural History; Professor Lynds Jones, of Oberlin College, and the officers of the Zoological Museum of Western Reserve University have very kindly furnished the writer with lists of Ohio specimens in their respective museums. Professor Herbert Osborn, of the Ohio State University, both in his official and private capacity has materially aided the work, and to him and to his associates, Professors Hine and Landacre, the writer is deeply indebted. Professor C. S. Prosser, of the Department of Geology of the Ohio State University, kindly read the proofs of the portion dealing with the fossil forms.

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'01. Dec. "Salamanders taken at Sugar Grove, Ohio," Ohio Nat., 2 : 164.

'02. "Range of the Fox Snake," Science, 15 : 1034.

'03. (1) "Ohio Batrachians and Reptiles," Ohio Nat., 3 : 360.

'03. (2) "Additions to Ohio Reptiles,' Rept. Ohio Ac. Sc. for 1903, Granville Meeting.

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PRELIMINARY CONSIDERATIONS.

In order to make clear the positions which the two groups under consideration hold in the animal scale, the following brief scheme of classification is given :

Sub-Phylum VERTEBRATA.—Animals with cartilaginous or osseous spinal column.

Class CYCLOSTOMATA.—The Hag-fishes and Lampreys.

Class PISCES.—The Fishes.

Class BATRACHIA.—Skin[1] naked, not provided with scales.

Class REPTILIA.—Skin covered with scales.

Class AVES.—The Birds.

Class MAMMALIA.—Those that suckle their young, as *e. g.*, the horse, dog, man.

From the above it will be seen that the living Batrachians differ from the Reptiles by the former having a smooth skin, without scales, while the reptiles have scales covering the body. The early stages of Batrachia are spent in the water. The eggs are laid there and develop into tailed larvae, commonly called "tadpoles," which swim about for a certain period, breathing by means of gills. Later, in the majority of species, the larvae emerge from the water and assume a terrestrial mode of life, breathing by means of lungs. The lower forms, however, such as the salamander, require moisture, their lungs being poorly developed, and one or two groups never leave the water, but remain in their lowly condition, breathing by means of gills throughout their lifetime. The higher forms, such as the toads and frogs, on leaving the water, lose their tails and develop long and strong hind legs for leaping.

Passing to the Reptiles we have such diverse kinds of organisms as the lizards, with four legs ; the snakes, which have lost their legs, and the turtles, which have acquired a hard covering, the shell, to protect their bodies.

Very frequently salamanders are taken by the uninitiated to belong to the lizard group. From the considerations given above, it is evident what the differences are and no confusion should be

1. In the fossil Batrachia, to be spoken of later, the skin is covered with heavy bony plates.

made. Moreover, when salamanders are considered lizards they are held to be poisonous. This leads to a consideration of the poisonous forms belonging to the groups covered by this paper.

No poisonous Batrachian has ever been found. It is only among the reptiles that we meet venomous species and these are infinitely fewer in number than the general mind assumes. Of lizards, only one known species is poisonous, this being the Gila Monster, of Arizona, which has a poison gland in the lower jaw.[2]

Of the snakes thus far found in Ohio, there are but three venomous, the large Highland Rattler *Crotalus horridus* L., the smaller Lowland Rattler *Sistrurus catenatus* (Raf.), and the Copperhead, These three are dangerous snakes and should be given the greatest deference. As for all the other reptiles found within our borders, they are harmless. But inasmuch as the snakes have teeth which are far finer than a cambric needle, no one cares to be bitten by them. Case after case of tetanus and blood poisoning as a result of a snake-bite has been recorded, but this is a far different matter from introduction of venom into a wound.

So many superstitions are associated with these forms of animal life that it would be impossible to cover them in this paper, to say nothing of attempting to disprove them. As classic examples, we may cite the power of salamanders against fire ; the production of warts by toads ; the charming powers of snakes ; the ability of toads to exist in air-tight compartments for an indefinite period. It is needless to say that all these are myths. By the agriculturist they are generally held to be useless, or even obnoxious. Snakes are killed at sight and without discrimination ; toads, frogs, turtles and lizards are rarely spared, while seldom does a salamander escape with its life.

Condemnation of such wanton destruction of life cannot be made in too strong terms. There are but three forms found in Ohio that should be destroyed and these are the three poisonous snakes mentioned above. Every other species is not only harmless, but of decided benefit to the farmer. The fight for preservation of beneficial reptiles and batrachians must be carried on as it is being fought for beneficial birds.

2. See Cope, '00, 481.

KEYS.

The following Keys are purely artificial and are as non-technical as it is possible to make them without sacrificing accuracy. Only the recent forms are considered in the Keys:

1. Body without scales or plates.— BATRACHIA. 2.
   Body covered with scales or plates.— REPTILIA. 35.
2. Adult with heavy, external gills. Over 1½ feet in length.— *Necturus maculatus*—p. 106.
   Adult without external gills. 3.
3. Adults with tails developed.— URODELA. 4.
   Adults tailless, hind legs longer than anterior pair and fitted for jumping.— SALIENTIA. 24.
4. Length over 1½ feet. Body large and heavy.— *Cryptobranchus alleganiensis*—p. 107.
   Length under 1½ feet. Body small and slender. 5.
5. Whole of body bright vermilion red. 6.
   Body not bright vermilion red. 7.
6. Length 3½ in. Body slender. A row of large spots along the sides.— *Diemyctylus viridescens miniatus*—p. 116.
   Length 6 in. Body heavy, sprinkled with small, black dots.— *Spelerpes ruber ruber*—p. 114.
7. Toes 4–4. Brown, whitish below.— *Hemidactylum scutatum*—p. 110.
   Toes 4–5. 8.
8. Costal grooves under 13 in number. 9.
   Costal grooves over 13 in number. 14.
9. Length under 4 in.— *Amblystoma opacum*—p. 107.
   Length over 4 in. 10.
10. Body with yellow spots or blotches. 11.
    No yellow on body. With bluish spots or uniformly blackish above. 13.
11. Length under 6 in. Yellow spots rounded.— *Amblystoma punctatum*—p. 108.
    Length over 6 in. Yellow in blotches of irregular contour. 12.
12. Tail but little longer than head and body.— *Amblystoma tigrinum*—p. 108.
    Tail much longer than head and body.—*Amblystoma xiphias*—p. 109.
13. No spots ventrally.— *Amblystoma jeffersonianum jeffersonianum*—p. 109.
    Whitish spots below.—*Amblystoma jeffersonianum platineum*—p. 110.
14. Costal grooves numerous, 16 or over in number. 15.
    Costal grooves 13–14 in number. 17.
15. Without red dorsal band. 16.
    With red dorsal line.— *Plethodon cinereus erythronotus*—p. 111.
16. Small, 3½ in. in length.— *Plethodon cinereus cinereus*—p. 111.
    Large, 6 in. in length.— *Gyrinophilus porphyriticus*—p. 112.
17. Length under 3½ in. 18.
    Length over 3½ in. 19.
18. A light bar from eye to angle of mouth; white below.— *Desmognathus ochrophaea*—p. 114.
    No light bar; yellow below.— *Spelerpes bilineatus*—p. 113.

19. Body bright orange yellow, with irregular black spots; tail longer than rest of body.— *Spelerpes longicaudus*—p. 113.
Body not bright orange yellow; no black spots; tale equal to or less than rest of body. 20.

20. Lower jaw projecting beyond upper. Body slender.— *Amblystoma microstomum*—p. 110.
Lower jaw not projecting. Body stout. 21.

21. Habits terrestrial; never in immediate vicinity of water. Body spotted with white.— *Plethodon glutinosus*—p. 112.
Habits aquatic, being found in or near water. 22.

22. A dorsal band of brown. 23.
No dorsal band of brown.— *Gyrinophilous porphyriticus*—p. 112.

23. With a series of small red spots on the sides.— *Desmognathus fusca auriculata*—p. 115.
No series of red spots.— *Desmognathus fusca fusca*—p. 115.

24. Toes without terminal discs or suckers. 25.
Toes with terminal discs or suckers. 32.

25. Size very large, 5–8 in. in length.— *Rana catesbiana*—p. 121.
Size smaller, not over 4 in. in length. 26.

26. Jaws without teeth. Skin warty.— *Bufo lentiginosus americanus*—p. 117.
Jaws with teeth. 27.

27. With a very prominent brownish band running along the sides of head, through the eye, to the angle of the mouth.— *Rana sylvatica*—p. 122.
No brown band through eye. 28.

28. Body uniform brownish or green, without blotches. 29.
Body with large blotches. 30.

29. Ear smaller than eye.— *Rana septentrionalis*—p. 121.
Ear as large or larger than eye.— *Rana clamata*—p. 121.

30. Blotches on back arranged it two rows, the blotches of one row being opposite those of the other.— *Rana palustris*—p. 121.
Blotches irregularly arranged, the blotches of one row alternating with those of the other. 31.

31. A longitudinal band on front of thigh.— *Rana virescens virescens*—p. 120.
No longitudinal band on front of thigh.— *Rana virescens brachycephala*—p. 120.

32. Habits palustrine, on the ground in swamps. 33.
Habits arboreal, living in trees and bushes. 34.

33. Toes webbed; top of head bright green.— *Acris gryllus crepitans*—p. 118.
Toes not webbed; head brownish.— *Chorophilus triseriatus*—p. 118.

34. Length over 1½ in. Green.— *Hyla versicolor*—p. 120.
Length less than 1½ in. Yellowish.— *Hyla pickeringii*—p. 119.

35. Four legs developed. 36.
Legs not developed. 51.

36. Body encased in shell.— TESTUDINATA. 37.
Body not encased in shell. 47.

37. Shell flattened, leathery and pliable. 38.
Shell heavy, firm, more or less arched. 39.

38. Nostrils at end of snout.— *Aspidonectes spinifer*—p. 138.
Nostrils not at end of snout, but beneath it.—*Amyda mutica*—p. 138.

39. Tail with a median crest of tubercles.— *Chelydra serpentina*—p. 139.
Tail without crest of tubercles. 40.

40. Shell highest posteriorly.— *Aromochelys odoratus*—p. 139.
Shell highest at the middle. 41.

41. Plastron hinged, capable of closing, more or less completely, the shell. 42.
Plastron without hinge. 43.

42. Length of shell over 6 in.— *Emynoidea blandingi*—p. 141.
Length of shell less than 6 in.— *Terrapene carolina*—p. 141.

43. Shell with round yellow spots.— *Clemmys guttatus*—p. 140.
Shell without round yellow spots. 44.

44. Shell keeled dorsally, notched behind.— *Graptemys geographicus*—p. 140.
Shell not keeled nor notched behind. 45.

45. Plastron blotched with black. 46.
Plastron not blotched with black.—*Pseudemys hieroglyphica*—p. 140.

46. Middle plates of carapace opposite each other.— *Chrysemys picta*—p. 140.
Middle plates of carapace alternating with each other.— *Chrysemys marginata*—p. 140.

47. Dorsal part or tail bright blue. 48.
Dorsal part of tail not bright blue. 49.

48. Black, with 5 yellow lines.— *Eumeces quinquelineatus*—p. 125.
Black, with 4 yellow lines.— *Eumeces anthracinus*—p. 125.

49. A series of wavy lines running across body.— *Sceloporus undulatus undulatus*—p. 123.
No wavy lines running across body. 50.

50. Three yellow lines on each side of the body.— *Cnemidophorus sexlineatus*—p. 124.
A black and a white but no yellow bands on the sides.— *Liolepisma laterale*—p. 124.

51. With rattles at the end of tail. 52.
Without rattles at end of tail. 53.

52. Blotches on back numerous, smaller arranged in 7 series. Rattles small. Length never over 3 feet.— *Sistrurus catenatus catenatus*—p. 137.
Blotches on back arranged in 3 rows, forming zig-zag cross-blotches. Rattles large. Length 3½–5 feet.— *Crotalus horridus*—p. 138.

53. With a pit between eye and nostril.—*Ancistrodon contortrix*—p. 137.
Without a pit between eye and nostril. 54.

54. Body uniformly colored above, without markings. 55.
Body with markings above. 62.

55. Color brown. 56.
Color greenish or black. 57.

56. Scales smooth.— *Carphophiops amoenus*—p. 125.
Scales rough.— *Natrix fasciata erythrogaster*—p. 131.

57. End of snout upturned. Body short and thick.— *Heterodon platyrhinus*—p. 126.
End of snout not upturned. 58.

58. Scales rough. 59.
Scales smooth.— *Liopeltis vernalis*—p. 127.

59. Greenish below. 60.
Yellowish below.— *Clonophis aestivus*—p. 128.

60. Throat white.— *Bascanion constrictor*—p. 128.
Throat color of belly. 61.

61. A ring around neck.— *Diadophis regalis arnyi*—p. 126.
No ring around the neck.— *Eutainia sirtalis graminea*—p. 134.

62. Tip of snout upturned.— *Heterodon platyrhinus*—p. 126.
Tip of snout not upturned. 63.

63. Top of head bright copper-colored.— *Coluber vulpinus*—p. 128.
Top of head not coppery. 64.

64. Belly reddish or salmon-colored. 65.
Belly not reddish. 68.

65. Uniform below, without markings. 66.
With markings below. 67.

66. Three white dots on back of head.—*Storeria occipitomaculata*—p. 133.
No dots on top of head.— *Natrix fasciata erythrogaster*—p. 131.

67. Scales smooth. A yellow ring around neck.— *Diadophis punctatus*—p. 126.
Scales rough. No collar.— *Natrix kirtlandi*—p. 132.

68. Stripes above, no spots. 69.
Stripes and spots or spots alone. 72.

69. Yellowish below.— *Natrix leberis*—p. 132.
Greenish below, 70.

70. A dorsal stripe. 71.
No dorsal stripe.— *Eutainia saurita*—p. 133.

71. Greyish, dots on either side of dorsal stripe.—*Storeria dekayi*—p. 132.
No series of spots along dorsal stripe.— *Eutainia sirtalis obscura*—p. 134.

72. Scales smooth. 73.
Scales rough. 76.

73. Markings in form of minute black dots, scattered promiscuously.— *Virginia valeriae*—p. 133.
Spots in form of blotches. 74.

74. Scales white-edged.— *Coluber obsoletus obsoletus*—p. 129.
Scales not white-edged. 75.

75. No yellow band running back from eye.— *Osceola doliata doliata*—p. 130.
A yellow band running back from eye.— *Osceola doliata triangula*—p. 130.

76. Ground color whitish.— *Pituophis melanoleucus*—p. 129.
Ground color dark. 77.

77. Belly blotched. 78.
No blotches on belly. 79.

78. A lateral series of blotches.— *Natrix fasciata sipedon*—p. 131.
No lateral series of blotches.— *Natrix fasciata fasciata*—p. 130.

79. Stripes and squarish spots.— *Eutainia sirtalis sirtalis*—p. 134.
Spots, no stripes.— *Eutainia sirtalis ordinata*—p. 134.

Batrachians and Reptiles of Ohio.

Class: BATRACHIA Brongn.[3]

Order: STEGOCEPHALI.

This order includes extinct Batrachia that occur in the Coal Measures of Ohio, mainly in the Upper Barren Measures which are supposedly equivalent to the lower Permian of Western Europe.[4]

They were often of enormous length, with shapes resembling lizards. The head and trunk were heavily armoured by bony scales and plates. Twenty-three genera and forty species have been thus far described from the rocks in Jefferson and Columbiana Counties.

Sub-Order: PHYLLOSPONDYLI Credner.

Family: BRANCHIOSAURIDAE Fritsch.

Amphibamus grandiceps Cope, Geol. Surv. Ill., II, p. 135.
Pelion lyellii Wyman, Am. Jour. Sc. & Arts, 1858, p. 158.

Sub-Order: LEPOSPONDYLI Zittel.

Family: MICROSAURIDAE Dawson.

Brachydectes newberryi Cope, Proc. Ac. Nat. Sc., 1868, p. 214.
Icthyacanthus ohioensis Cope, Proc. Am. Phil. Soc., Vol. XVI, p. 573.
Tuditanus punctulatus Cope, Tr. Am. Phil. Soc., 1874.
brevirostris Cope, Tr. Am. Phil. Soc., 1874.
radiatus Cope, Tr. Am. Phil. Soc., 1874.
mordax Cope, Geol. Surv. Ohio, Vol. II, Paleont., 1875, p. 385.
obtusus Cope, Proc. Ac. Nat. Sc. Phil., 1868, p. 213.
huxleyi Cope, Tr. Am. Phil. Soc., 1874.
longipes Cope, Tr. Am. Phil. Soc., 1874.
tabulatus Cope, P. Am. Ph. Soc., XVI, 573.
Cocytinus gyrenoides Cope, Tr. Am. Phil. Soc., 1874.
Leptophractus obsoletus Cope, Proc. Ac. Nat. Sc., 1873, p. 341.
lineolatus Cope, Proc. Am. Phil. Soc., Vol. XVI, p. 573.
Eurythorax sublaevis Cope, Proc. Am. Phil. Soc., 1871, p. 177.

3. Cope, '89, p. 17.
4. Prosser, '03, 522.

Pleuroptyx clavatus Cope, Geol. Surv. Ohio, Vol. II, Paleont., p. 370.
Colosteus foveatus Cope, Tr. Am. Phil. Soc., 1869, p. 22.
scuttelatus Newb., Proc. Ac. Nat. Sc. Phil., 1856, p. 98.
pauciradiatus Cope, Tr. Am. Phil. Soc., 1874.
Keraterpeton lineopunctatum Cope, Geol. Surv, O., Vol. II, Paleont,, p. 371.
lennicorne Cope, Geol. Surv. Ohio, Vol. II, Paleont., 372.
divaricatum Cope, Proc. Am. P. Soc., 1885.
Oestocephalus remex Cope, Proc. Ac. Nat. Sc. Phil., 1868, 218.
Tr. Am. Phil. Soc., 14:17.
recidens Cope, Tr. Am. Ph. Soc., 1874.
Ptyonius nummifer Cope, Geol. Surv. Ohio, Vol. II, Paleont., 374.
marchii Cope, Tr. Am. Phil. Soc., 14:24.
vinchellianus, Proc. Am. Phil. Soc., 1871, 177.
pectinatus Cope, Geol. Surv. Ohio, Vol. II, Paleont., 377.
serrula Cope, Proc. Am. Phil. Soc., 1871, 177.
Hyphasma laevis Cope, Proc. Ac. Nat. Sc. Ph., 175, 16.
Sauropleura digitata Cope, Proc. Ac. Nat. Sc., 1868, 216.
newberryi Cope, Geol. Surv. Ohio, II, Paleont., 404.
latithorax Cope, Proc. Am. Ph. Soc., 35:83, No. 154.
[5] Thyrsidium fasciculare Cope, Geol. Surv. Ohio, II, Paleont., 365.

Family: AISTOPODA Miall.

[6] Phlegethontia linearis Cope, Geol. Surv. O., II, Paleont.
serpens Cope, Geol. Surv. O., II, Paleont., 367.
Molgophis macrurous Cope, Proc. Ac. Nat. Sc. Ph., 1868, 220.
brevicostatus Cope, Geol. Surv. Ohio, II, Paleont., 369.
wheatleyi Cope, Geol. Surv. Ohio, II, Paleont., 368.

Sub-Order: LEMNOSPONDYLI Zittel.

Anisodexis enchodus Cope, Proc. Am. Ph. Soc., 1885.
Cercariomorphus parvisquamis Cope, Proc. Am. Ph. Soc., 1885.

Order: PROTEIDA.

Family: PROTEIDAE.

Necturus maculatus Raf. Body long, lizard-like; external gills, large, bushy, brownish red in life; limbs four, not strong; toes 4–4. Body ashy, blotched with brownish black. Tail long, compressed. A strong fold of integument across throat. Length 2 feet or under.

The Mud-puppy occurs in all parts of the State. It is frequently taken on hooks while fishing and in nets in the bays and lakes. It is sluggish, but on irritation will snap at an intruding object, and when once it has set its jaws it is a difficult task to

5. Cope ('75) places this genus in the Order Proteida.
6. Zittel ('90) makes these genera synonyms of Dolichosoma Huxley.

remove the captured piece. *Necturus* is sometimes killed in numbers by a fungus, *Saprolegnia*, which grows into the integument. The eggs are the size of peas and are laid in tin cans, sunken timber, etc., and crevices in still water. Lungs are functional at least, at times. The Mud-puppy may be found often under the ice in the coldest winters. Their food consists, as adults, of worms and small animals. The larvae feed on water plants. Aside from the following, this is the largest of our salamanders. From *Cryptobranchus* it may be told at once by the external gills. They are nocturnal in habits.

Specimens in the U. S. Nat. Mus., recorded by Cope, from Toledo, Cleveland and Columbus. In the Cin. Soc. Nat. Hist., collected by Dr. Lindahl, Cincinnati; in Oberlin College, by Lynds Jones, in Lorain Co.; in O. S. U. Mus., by the author, from Sandusky.

Order: URODELA.

Family: CRYPTOBRANCHIDAE.

Cryptobranchus alleganiensis (Daudin). Without external gills. Body flattened, sides extending in lateral folds. Neck wide, skin leathery, brownish in color. Toes 4–5. Tail compressed. Length average 2 feet.

The Hell-bender is a most dangerous-looking creature, but a more harmless one is difficult to imagine. It is extremely sluggish in its movements save when in its normal habitat. In search of food its movements are accelerated. It is widely distributed over the State, but is seldom taken in any numbers. They are very common in the Ohio River, where they are known as the "Little Alligator." Their food as adults consists of crustaceans, mollusks and worms.

Specimens in the U. S. Nat. Mus. recorded by Cope, from Poland. In the Cin. Soc. Nat. His., collected by Dr. Lindahl in the Ohio River, and by W. A. McCord in Hamilton Co.; specimens in O. S. U. Mus., by E. V. Wilcox, at Westerville; by Otto Swezey, in the Scioto River; also reported from Columbus.

Family: AMBLYSTOMATIDAE.

Amblystoma opacum Gravenhorst. Back black, crossed by a series of lighter bands. Sides plain. Below dark plumbeous, plain. Costal grooves 11. No dorsal furrow present. Body stout. Length 7½ in. or under.

This salamander is found under rotten logs in damp places, away from bodies of water. It is sometimes found in quite dry regions. Wilcox (91) mentions one showing little or no dorsal groove. They are almost the last of the salamanders to go into winter quarters and appear early in the spring when, soon after emerging, they begin to breed.

This species is not common in the State.

Specimens in the U. S. Nat. Mus., recorded by Cope from Lancaster and Ripley. In Cin. Soc. Nat. His., collected by Rev. Mark, in Hamilton Co.; in O. S. U. Mus., from Portsmouth and Sugar Grove.

Amblystoma punctatum Linn. Larger than preceding. Body dark brown or black, with a series of large circular yellow spots over the body, head and tail; on the tail the spots are sometimes confluent. Below and a short distance up on the sides are smaller spots that give a pepper-and-salt appearance. Legs also spotted above as the dorsal part of the body. Costal grooves sometimes 10, generally 11. Length 6½ inches.

This species resembles somewhat in size and general features the species *tigrinum*, but in *tigrinum* the spots are not circular as in *punctatum*, but are elongated and often fuse into one another. Moreover, *tigrinum* has twelve costal furrows. Its habits are similar to those of *tigrinum*, both being more terrestrial than many of the other salamanders, being found under rotten wood away from water, in cellars, etc. The eggs are laid in masses in ponds and ditches.

In the State they are found in small numbers, but they are generally distributed. Eastward they replace *tigrinum*.

Specimens in the U. S. Nat. Mus., recorded by Cope from Cleveland. In Oberlin College, collected by Lynds Jones in Lorain Co.; in O. S. U. Mus., collected by J. C. Bridwell and E. V. Wilcox at Columbus; also reported from Sugar Grove.

Amblystoma tigrinum Green. Above, body yellowish brown to black, with irregular blotches and spots of yellow, sometimes almost forming transverse bands. Below, lighter with few spots. Form large, sometimes the spots are inconspicuous. Costal grooves 12. Tail long, compressed. Largest and heaviest of the salamanders, save the first two, *Necturus* and *Cryptobranchus*. Length 10 inches or under.

The larva of this species is the axolotl of the West, where, over the plains, the pools abound in the spring with the young. Later as summer sets in they undergo metamorphosis and begin a terrestrial existence. The gills are lost and the length increases nearly one-half. Breeding takes place about the first of April. The eggs are laid in pools and are attached to water-plants. The adults are commonly found in cellars, under boards, near springs, as well as under logs in damp places. When the colder weather of autumn sets in, individuals are frequently found entering sewer pipes where a promise of warmth is given. Several are taken each autumn in the basement of the Biological Hall at O. S. U.

This species is generally killed outright by those who believe them to be dangerous. They are harmless.

Very common over the State, in fact one of our most familiar salamanders.

Specimens in U. S. Nat. Mus., recorded by Cope from Columbus and Marietta. In O. S. U. Mus., collected by E. V. Wilcox and the author from Columbus.

Amblystoma xiphias Cope. Similar to preceding, but ground color, light yellow. Tail long, exceeding in length that of head and body. Costal grooves twelve. Head small in proportion to body. Lower jaw prominently projecting. Canthus rostralis, distinct.

This is a doubtful species, inasmuch as but one specimen is known. This is in the U. S. N. M., being collected at Columbus, Ohio. The present writer has carefully examined every specimen that has come under his notice and but one showed any approach to Cope's description. (Cope, '89.) This had the length of tail equal to that of head and body and a slightly projecting lower jaw, while the ground color was a light yellow. (Morse, '01, May.) But gradations occur between such a type and the normal form and it is doubtful whether it is a valid species.

Specimen in U. S. Nat. Mus., recorded by Cope from Columbus.

Amblystoma jeffersonianum jeffersonianum Green. Body slender and elongated. Head long, width being four times in length to groin. Costal furrows 12. Tail nearly equal to head and body. Ground color brown to black, with a sprinkling of light spots a quarter of an inch or less in diameter. Sometimes no spots are visible. Length 8 inches or under.

This sub-species differs from the following, *platineum*, by having a wider head, under parts not paler than upper, blotches dirty white, eye smaller.

Specimens in the U. S. Nat. Mus., recorded by Cope from Ripley and Cleveland. In Cin. Soc. Nat. His., collected by C. W. Hohn in Hamilton Co.; in Oberlin College, collected by Lynds Jones in Lorain Co.

Amblystoma jeffersonianum platineum Cope. Plumbeous, paler below. Width of head less than three times in length to groin. Eye larger. Body-length longer. Costal grooves 12.

The sub-species *platineum* resembles somewhat individuals of *Plethodon glutinosus*, but it may be told from that species by its slenderer shape and the absence of parasphenoid teeth.

Little seems to be known of the habits of the sub-species. DeKay gives them as frequenting springy places. (Paulmier, '02, p. 399.) In the State they are not common.

Specimens, in the U. S. Nat. Mus., recorded by Cope from Cleveland. In Oberlin College, collected by Lynds Jones in Lorain County.

[7] **Amblystoma microstomum** Cope. Costal grooves 14. Color blackish, with a plumbeous tinge, spotted indistinctly sometimes with lighter. Head broad, but small, and fusing with the body without a neck being evident in proportion to body. Lower jaw prominent. Tail not as long as head and body, round, compressed posteriorly. Legs small. Altogether the slenderest species. Length 8 inches.

Occurs in the State in general, but more common in hilly regions. They leave the water after breeding and are to be found under logs and partly buried in damp turf. The small eggs are attached to water weeds in little masses. By June they are ready to leave the water. At times this species leaves its winter quarters while it is yet winter, being taken in February. (Garman, '91.)

Specimens in the U. S. Nat. Mus., recorded by Cope from Columbus. In the Mus. Cin. Soc. Nat. His., collected by Chas. Dury in Hamilton Co.; in O. S. U. Mus., collected by E. V. Wilcox at Lancaster, and E. E. Masterman at New London.

Family: PLETHODONTIDAE.

Hemidactylum scutatum Tschudi. Above brown, lighter below where there is a sifting of dark blotches. Sometimes plumbeous dorsally, snout light. A marbling in the median dorsal region. Costal grooves 13. Length 3 inches. Toes 4-4.

This species may be distinguished from those of the genus *Plethodon* by its having only four toes in the hind feet.

It is a rare species for Ohio, but one specimen being thus far recorded. However, Hay ('92) mentions forty being taken at Brookville, Ind., which is within 10 miles of the Ohio-Ind. line.

Specimens in the U. S. N. Mus., recorded by Cope from Ripley, Ohio; collected by Hoy.

7. I follow Stejneger in discarding the genus *Chondrotus* Cope.

Plethodon cinereus cinereus Green. Body slender, plumbeous to ash above; below a pepper-and-salt appearance, turning to uniform light on the mid-ventral line. Inner toes reduced. Length 4 inches. In alcohol the body becomes brownish. Costal grooves 18. Legs small and weak, webbing well developed. Distinguishable from the following by the absence of the dorsal band of red.

At Sugar Grove and elsewhere the writer has repeatedly taken, along with good examples of the following sub-species, specimens that are referable to the sub-species *cinereus*.

At Worthington, a litter of young was found in which about one-half were provided with the dorsal red band, and the remainder showed no sign of it. For reasons such as these, Jordan ('99) does not recognize the sub-species and the position seems a correct one. It may be said, however, that in the great majority of specimens the red band is evident to a greater or less extent.

Specimens in the U. S. Nat. Mus., recorded by Cope from Ripley. In the O. S. U. Mus., collected by E. V. Wilcox at Sugar Grove, and the author at Columbus; in the Cin. Soc. Nat. His. by Dr. Lindahl at Cincinnati.

Plethodon cinereus erythronotus Green. Same as above, but with a median longitudinal dorsal band of red.

Cope, '89, p. 135: "I have been unable to detect any difference in structure, proportions and general character between this supposed species and the foregoing." Again (l. c. 136), "as varieties they are very permanent ones, as I have found all the young of the same brood or set of eggs, whether in the eggs or just escaped from them, uniformly with either dark backs or red ones." From the remarks under the sub-species, *cinereus*, it will be seen that the present writer does not agree with Cope. Wilcox ('91) records "numerous specimens of *erythronotus*" at same date and place and under same circumstances as the preceding. Withal the validity of the sub-species is doubtful.

Dr. Lindahl of the Cin. Soc. N. H., writes: "Common throughout Hamilton Co.; the one colored grey and the chestnut-black varieties often occurring in the same litter, together with intermediate forms with a more or less faint reddish hue along the back."

The commonest of the salamanders in Ohio at the present time. Occurs over the State, being found in numbers almost everywhere, but especially in ravines and around rocky streams. They are not aquatic, their eggs being laid under logs, etc., away from water. The adults are to be found in comparatively dry places under rotten wood and stones.

Specimens in the U. S. Nat. Mus., recorded by Cope from Ripley and Lancaster. In the Cin. Soc. Nat. His., collected by Dr. Lindahl at Cincinnati; in Oberlin College, by Lynds Jones in Lorain Co.; in O. S. U. Mus., by E. V. Wilcox at Sugar Grove and Morgan Co.; by the author at Youngstown, Chillicothe, Worthington, Columbus, Nelsonville and in Licking Co.

Plethodon glutinosus Green. Form stout, little distinction between head, body and tail. Metallic blue above, spotted with specks of silver. Below lighter, similar in appearance to the preceding. Inner toes developed. Costal grooves 14. Length 6 inches.

This species may be confused with the sub-species *Plethodon cinereus* or with *Amblystoma jeffersonianum*. From them, however, it may be distinguished by the presence of fourteen costal grooves. It is purely a terrestrial species, a denizen of the mountains and hills. It is to be found under stones and logs on the sides of hills, often far from water. Smith ('82): "They hibernate beneath wet logs and go into the water to breed in April, in Georgia and probably a little later in our limits." Hay ('92) considers them wholly terrestrial, in all probability.

It is very common in central, eastern and southern parts of the State.

Specimens in the Oberlin College Museum, collected by Lynds Jones from Lorain Co. In the O. S. U. Mus., by the author from Youngstown, Newton Falls and Sugar Grove.

Gyrinophilus porphyriticus Green. Yellow to brown above; sides light, with a reddish tinge. Light or grey streaks and blotches on back. Costal furrows 14. Tail compressed, with a well developed keel. Body flattened. A light line from eye to edge of upper jaw. Below not spotted. Length 6½ inches.

Rare in the State. Intrusions are resented by snapping, and if carried to extremes, by violent contortions. It is, however, utterly harmless. Smith ('82) gives it as aquatic, being found under logs in damp woods and in water. The adults are generally concealed, the larvae being more readily found.

Specimens in the U. S. Nat. Mus., recorded by Cope from Columbus. In the Cin. Soc. Nat. His., collected by Dr. Lindahl in Hamilton Co.; in O. S. U. Mus., from Sugar Grove.

Spelerpes bilineatus Green. Body yellow above, with a brown line running on each side of the median line. Below, white without yellow and without markings. The dorsal bands are made up of confluent spots which are sometimes isolated, causing the bands to be broken. The mid-dorsal region is sprinkled with brown dots. Sides mottled. Tail as long as head and body, not keeled. Costal grooves 14. Length 3⅓ inches.

A common salamander. It is found always near running water, although seldom seen in it, but preferring to remain within ready access. A rock or stick partially placed in the water is a favorite place for concealment. In boggy areas, around springs and ravines, it is common. Its actions are quick, and this with its excessive slipperiness, renders it hard to catch. Its eggs are attached to the under side of stones partially submerged in the water. Eggs have been taken in the latter part of May. The form is distributed over the whole of the State but will be more readily found in the central and eastern portions.

Specimens in the U. S. Nat. Mus., recorded by Cope from Columbus, Cleveland and Cincinnati. In the Cin. Soc. Nat. His., collected by J. C. Galloway in Montgomery Co.; in O. S. U. Mus., by the author at Sugar Grove, Worthington, Youngstown, Chillicothe and Licking Co.

Spelerpes longicaudus Green. Resembling in a way the foregoing, but tail nearly twice length of head and body. Yellow deeper with irregular black markings. A series of such spots runs along the median dorsal line. Below immaculate. Tail compressed, keeled, spotted as above. Length 5⅓ inches.

A terrestrial species. Unlike *bilineatus*, it is found generally away from water, being concealed under logs and stones. In August, at Youngstown, the writer found it abundant along Mill Creek in piles of stones near the water. On being disturbed they would seldom run towards the water but generally in an opposite direction. The common name "Cave Salamander" is a misnomer, as it is seldom found in caves. Smith ('82) gives it as aquatic, which is certainly a mistake. *Vide* Garman ('91): Very common over the State.

Specimens in the U. S. Nat. Mus., recorded by Cope from Cincinnati, Columbus, Lancaster and Highland Co. In the Cin. Soc. Nat. His., collected by Dr. Lindahl from Hamilton and Montgomery Cos.; in O. S. U. Mus., collected by E. V. Wilcox at Ellis Station; Dr. Smith at Lancaster, and by the author at Youngstown and Chillicothe. Also at Sugar Grove.

Spelerpes ruber ruber Daudin. Body vermilion, spotted with black dots above. Sometimes the spots are confluent. Below the dots are smaller and more closely packed together. Head broad and blunt; dark bar across eye. Tail short. Length 6 inches. Costal grooves 15.

A most beautiful animal. It is a most conspicuous object when uncovered amongst stones and leaves, and whatever use the color subserves, it certainly is not protective, unless as a warning. They will remain motionless when uncovered until touched, when they move leisurely away. It occurs in hilly regions and is aquatic, being found in swamps and around springs. In the hilly regions of the State, common.

Specimens in the U. S. Nat. Mus., recorded by Cope from Cincinnati and Columbus. In Oberlin College, collected by Lynds Jones in Lorain Co.; in O. S. U. Mus., from Fairfield Co., and by the author in Licking Co.

Family: DESMOGNATHIDAE.

Desmognathus ochrophaea Cope. Brownish, yellow dorsally, brown laterally. Median dorsal band yellow, with black blotches and dots. Below yellowish, unspotted. Costal folds 13. Size small. Tail cylindrical. No teeth in rear of lower jaw. Length 3 inches.

This salamander may be confused with *Spelerpes bilineatus* or with *Desmognathus fusca*. From the former it may be told by the yellow on the belly and the presence of a light bar from eye to corner of mouth. From the latter, it is readily told by the rounded tail and (in males) by the absence of teeth in the rear of the lower jaw.

It is an eastern species, a resident of the mountains and is placed here on the strength of a single specimen taken at Sugar Grove, December, '01, which agrees with Cope's description. Dr. J. Lindahl, of the Cin. Soc. N. H., kindly examined the specimen and agreed with the writer in his identification. Previously it has not been recorded west of the mountains of Pennsylvania. Its habitat is given by Paulmier ('02) as "under bark; not aquatic." The Sugar Grove specimen was taken far up on a hill, far from the water—a most anomalous place for *D. fusca*, if such it is.

In O. S. U. Mus., collected by the author at Sugar Grove.

Desmognathus fusca fusca Raf. Above dark, with a median dorsal band of lighter generally brown in color and specked with black. Below grey with black specks forming a marbling. Often the ground color above is brown, the median band being a lighter brown on the belly, the light predominating. Very variable in color. Costal grooves 14. Length 4½ inches.

The sub-species *fusca*, the commonest of our more aquatic salamanders, is distinguishable from the following sub-species, *auriculata*, by the absence of a series of reddish spots along the sides and also of a conspicuous ear-spot, the latter giving *auriculata* its sub-specific name. As *fusca* grows older, it becomes darker and darker, the several markings becoming less and less conspicuous. It may be found almost anywhere where a stream of water flows over rocks that may give it shelter. On turning over stones, not completely submerged, a specimen or two of this salamander generally is seen making for the water which affords it concealment. As soon as the intruder withdraws, the salamander emerges from the water and takes its station beneath a convenient stone. In breeding season, the female lies concealed under a stone with the eggs either wrapped in strings about her body or herself curled about the mass.

In Ohio this is the prevalent form and is very common in all parts of the State. The larvae attain a length of three inches before becoming mature and inhabit springs and small bodies of water. They are brown, with black dots above, lighter below, retaining also the black dotting. The gills are short and inconspicuous. Sometimes the back is dotted here and there with livid specks of red, but this disappears in the adult condition. These larvae are the common "lizards" of springs and are held to be poisonous. Of course they are absolutely harmless.

Specimens in the U. S. Nat. Mus., recorded by Cope from Columbus, Highland Co. and Cincinnati. In the O. S. U. Mus., collected by J. C. Bridwell at Dublin; E. V. Wilcox in Warren Co.; by the author at Sugar Grove, Youngstown, Chillicothe, Newton Falls and Licking and Perry Cos.

Desmognathus fusca auriculata Holb. As above, but darker, with a series of red dots along the sides and a black ear-spot. Dark predominant below.

Not common in the State. One specimen in U. S. N. M. from Cincinnati. Habits as above. A form found in the South and West.

In U. S. Nat. Mus., recorded by Cope from Cincinnati.

Family: PLEURODELIDAE.

Diemyctylus viridescens viridescens Raf. Toes 4–5, outer and inner toes on hind foot rudimentary. Body above brown to olive, below yellowish. Sides of adults with a series of large red spots, each encircled by a brown ring. Below speckled with brown. Tail much compressed. Length 3½ inches.

This sub-species is the common Newt of the Eastern States. It is altogether aquatic, living in springs and deep running water. In Ohio it is known from but one specimen from Lancaster, mentioned by Wilcox ('91).

In O. S. U. Mus., collected by E. V. Wilcox at Lancaster.

Diemyctylus viridescens miniatus Raf. Similar to above, but ground color, brick red. The red coloring of the lateral spots therefore is less conspicuous. The skin is rough, being covered with minute warts. Tail cylindrical.

This is the common representative of the genus in the State. It is never found in numbers but may be looked for in all parts of Ohio. It occurs under rotten logs, in stumps and under stones often far from water. The form is very conspicuous and stands out from its environment very decidedly. It is not active in its movements and may be readily captured. The tongue is free and by means of that organ the food is obtained in the manner of the common toad.

Specimens in the U. S. Nat. Mus., recorded by Cope from Cincinnati. In Oberlin College by Lynds Jones from Lorain Co.; in Cin. Soc. Nat. His., collected by E. E. Masterman at New London; in O. S. U. Mus., collected at Lancaster by E. V. Wilcox; at Clintonville by J. C. Bridwell, and at Newton Falls by the author. Also reported from Sugar Grove.

Order: SALIENTIA Laurenti.

This order includes the toads and frogs, *i. e.*, the tailless Batrachia. The larvae are similar to those of the order just completed, being provided with gills and spending their larval period in water, feeding on vegetable matter. They are commonly known as "tad-poles." When metamorphosis takes place, they leave the water, losing the gills and the tail and gaining four strong legs and a pair of lungs; the alimentary canal becomes shortened for a carnivorous habit. The order is divisible on anatomical and physiological grounds into two tribes, viz:

1. Thoracic region capable of expansion by virtue of the fact that the cartilage connecting the two clavicles and coracoids in the median line is double, the two parts sliding on each other.—ARCIFERA.

2. Thorax not capable of expansion because the cartilage is single and immovable.—FIRMISTERNIA.

The *Arcifera* embraces the tree-toads and toads; the *Firmisternia*, the frogs.

Tribe: ARCIFERA.

Family: BUFONIDAE.

Bufo lentiginosus americanus (Le C.). Brownish to olive, vertebral line yellowish. Adults with skin covered with warts of varying size. Head $4\frac{1}{2}$ times in total length of body. Below yellowish. Bony ridges above and behind eye; eye small. Length $3\frac{1}{2}$ inches.

This is the common toad in Ohio. It is extremely variable, both in point of structure and color. At Cedar Point, Sandusky, Ohio, the majority of the toads found are light grey in color, whereas on the mainland around Sandusky, where a more humid condition obtains, a dark brown color is prevalent among the toads. A reddish hue is sometimes met with in the toads on the bleak hills in southern and south-eastern Ohio. Thus at Nelsonville the writer obtained several brick-red specimens. In each case the color must have been assumed after the adult condition had been reached since the young were of a uniform brownish or olive color. The specimen labeled *Bufo lentiginosus lentiginosus* Shaw, in the O. S. U. Zoological Museum from Columbus and Knox Co., is referable to the sub-species *americanus*. (Morse, '01, May.)

Toads lay their eggs as soon as the warmer weather of spring begins. The eggs are laid in strings which are wrapped around water weeds and debris in general in small running streams. The eggs are smaller than those of the frogs, the latter being laid in mulberry-like masses, by which the two may be distinguished

Wilcox ('91) records a specimen taken on November 29th, while another was captured January 10th. These are extreme dates as toads generally appear for the first time about April 1st, and begin to hibernate in October.

The toad is one of our best friends inasmuch as the number of flies and insects that he devours daily is prodigious. It is needless to say in this connection that the superstition that holds among many, that evil effects will follow the killing of a toad is a most advantageous belief, but bears a different interpretation. Did there exist more such superstitions the cause of scientific agriculture would be strengthened tenfold.

Generally distributed over the State, common everywhere.

Specimens in the U. S. Nat. Mus., recorded by Cope from Marietta. In the Oberlin College Museum, collected by Lynds Jones from Lorain Co.; in O. S. U. Mus., collected by the author at Cedar Point, Vinton, Youngstown, Chillicothe, Newton Falls and Licking Co.

Family: HYLIDAE.

Acris gryllus crepitans Baird. Above olive-brown, with an inverted "Y"-shaped green area; the median parts of the "Y" extend along the vertebral line, the forking taking place on the rump. Brown triangle between eyes. Sides marked with three oblong blotches. White line from eye to shoulder. Disks of fingers small, not webbed. Toes with broad webs. Snout blunt. Inner surface of thigh immaculate. Length 1⅓ inch.

The Cricket-frog is well known to anyone who frequents the river-side or the swamp--less, however, by its appearance than its note. If one can imagine a rattling of pebbles mingled with the screech of a violin string in a high note, he may have a suggestion of the Cricket-frog's note. When given it is either a continuous chirp or given in sets of chirps of three each, each rising in pitch. So nearly does the color of the frog blend with that of its surroundings that it is detected with but the greatest difficulty.

In the Cricket-frog we have virtually a Tree-frog with terrestrial habits. The presence of the terminal suckers on the toes would seem to indicate a former arboreal mode of life. Common everywhere.

Specimens in O. S. U. Museum from Central College, Franklin, Delaware, Lawrence, Warren, Fairfield, Ottawa and Knox Cos., and collected by the author from Ross and Trumbull Cos., and at Youngstown, Newark and Vinton.

Chorophilus triseriatus Wied. Toes scarcely webbed; fingers without webs. Ground color above ashy, with a brownish median dorsal stripe, dividing into two above in middle of body. Lateral to this on either side and running parallel on level with ear is a brownish stripe. A third stripe runs along the sides of the head from the snout backward, making in all six stripes running more or less parallel. Length 1 inch.

This is the so-called "Little Tree-Toad," a name that would probably be appropriate if the little fellow ever climbed trees! It is to be found in swamps on low herbage or on the ground. It has a note somewhat similar to the preceding species, but the pitch is higher and the rattle is less definite. The note is seldom heard in daylight hours except on dark days. The writer has never heard it, as Cope says, in the hottest hours.

Smith ('82) gives this form as rare in Ohio. At the present time this is scarcely true since it has been found common in various parts of the State. Thus along the Ohio shore of Lake Erie it is common in the swamps. Prof. J. S. Hine found several at Kent, and in the north-eastern part of the State.

The species is very variable. An extreme was taken on Cedar Point, Sandusky, which was brick-red all over, with the faintest hint at the dorsal bifurcated marking.

Cope ('89, p. 339) gives as a species distinct from *triseriatus* Wied., the species *feriarum* Baird. Hay (*v.*, Jordan, '99, p. 360), however, considers these two species as simply varieties of *nigritus* Le C. He would make, then, our eastern form *C. nigritus feriarum* (Baird).

Specimens in Oberlin College, collected by Lynds Jones in Lorain Co. In O. S. U. Mus., collected by J. S. Hine at Kent, and by the author at Cedar Point; also at Sugar Grove.

Hyla pickeringii Storer. Disks on fingers and toes large and conspicuous. Skin rough. Toes webbed. Ground color above, yellowish, with two narrow lines, forming an oblique cross, darker in color. Brownish blotches also on dorsal surface. Below yellowish. Lines along sides of head. Legs barred. Length 1 inch.

In the spring and summer this little animal is to be found in moist places among fallen leaves. As fall approaches it ascends trees where it remains until hibernation time, which is late, since it is quite hardy. Its note is a squeak combined with a whistle, and, as Cope says, "bearing considerable resemblance to the note of the Purple Finch."

Found only here and there over the State. It seems to be erratic in point of occurrence, although in the States east of Ohio it is common.

Specimens in the U. S. Nat. Mus., recorded by Cope from Marietta. In Oberlin College, collected by Lynds Jones in Lorain Co. In O. S. U. Mus., collected by E. V. Wilcox at Hanging Rock and Sugar Grove.

Hyla versicolor Le Conte. Skin granular above, colored ash-gray to brown. Superciliary lines of brown, converging on back. In middle of back an H-shaped brown blotch. Yellow below. Ear large. Fingers one-third webbed; discs large. Length 2 inches.

This is the common Tree-toad with its reputed prognosticating powers with respect to the weather. That the toad foretells a period of rain by its chirping is a myth of the first magnitude. If there be any foundation of truth in the matter, the Tree-toad chirps only toward evening or when clouds obscure the sun, the latter being a condition concomitant with rain. A clear evening following a rain is par excellence the Tree-toad's hour of song.

The toad has, to a limited extent, the power of changing the the color of its skin similar to the Chameleon, but it is a matter of chance that it assumes the color of the substratum. Common everywhere.

Specimens in Oberlin College Museum, collected by Lynds Jones from Lorain Co. In O. S. U. Mus., collected by E. V. Wilcox at Westerville and Columbus; by the author at Vinton, Chillicothe, Youngstown and Licking Co.

Tribe: FIRMISTERNIA.

Including the remaining BATRACHIA, the Frogs.

Family: RANIDAE.

Rana virescens virescens Kalm. Green above, with irregular black or brownish blotches with white edges arranged in two irregular rows, the blotches alternating. Two spots between eyes. Front of thigh with a longitudinal band of brown. Head short. Length 3 inches.

The common frog of river, stream and swamp. Often found in thick grass far from water, perhaps migrating. Abundant everywhere.

Specimens in Oberlin College Museum, collected by Lynds Jones in Lorain Co. In O. S. U. Museum, by E. V. Wilcox at Gypsum and Sugar Grove; by the author at Vinton and Youngstown.

***Rana virescens brachycephala** Cope. Form with shorter head ($3\frac{1}{2}$ times in length of body). Spots on upper part of body larger. Transversely-running markings on crux not interrupted. No longitudinal band on anterior border of thigh.

Given by Cope ('89, p. 403) as ranging from Massachusetts to the Sierras. No record for Ohio.

Rana palustris Le Conte. Similar in coloration to preceding save that the dorsal blotches are arranged in two longitudinal series, each blotch being approximately opposite its fellow. The livid green, however, is replaced here with brownish or olive. Length 3 inches.

The Swamp-frog is to be found in marshy places, but it is frequently met with in high grass in fields and along roadsides. It is much commoner than would be supposed as it is with difficulty distinguished from its environment and unlike the foregoing species, it remains quiet until almost touched. Common over the entire State.

Specimens in the U. S. Nat. Mus., recorded by Cope from Toledo. In the O. S. U. Mus., collected by J. C. Bridwell at Dublin and by E. V. Wilcox in Ottawa, Lawrence, Franklin and Delaware Cos.; by the author at Sugar Grove and Gypsum.

* **Rana septentrionalis** Baird. Olive brown above, light yellow below. Back with irregular streaks. Length 1½ inches. Skin smooth. Eye large.

This species has never been taken within the limits of the State, but owing to its range it very probably will be found in the north-eastern or eastern portion. Its range is northward from Minn. to N. Y.

Rana clamata Daudin. Uniform brownish green, with faint black spots. Below white. Ear large, as large as eye. First finger reaching end of second. Length 3 inches.

This is a heavier frog than any that have thus far been considered. It is somewhat gregarious, especially in spring and early summer. It is never found far from water. This species is the least noisy of the genus, its note being a miniature of the Bull-frog's gutteral croak. The conspicuous lateral fold distinguishes it from the Bull-frog. Abundant over the State.

Specimens in the U. S. Nat. Mus., recorded by Cope from Columbus and Portage and Highland Cos. In the O. S. U. Mus., collected by E. V. Wilcox in Lawrence and Licking Cos. By the author at Vinton, Castalia, Newton Falls and Chillicothe.

Rana catesbiana Shaw. Lateral fold scarcely discernable. Above brown to olive, interspersed with brownish blotches, sometimes running together. Head bright green. Ear large. Toes with web reaching the tips. Length 5-8 inches.

This is the common Bull-frog, the largest of our frogs and of the Batrachia in general. It is seldom seen but is to be heard along almost any of our streams. At times of high water these big frogs leave the inundated regions and migrate to higher ground. They are caught for the market in great numbers, and were it not for their great fertility, they would soon become extinct, as indeed is the case in some parts of the country. Frog farms exist to supply the market and when well conducted are ready sources of revenue. Common over the State.

Specimens in the U. S. Nat. Mus., recorded by Cope from Marietta and Elyria. In the O. S. U. Mus., collected by R. C. Osburn at Columbus, and by E. V. Wilcox at Central College and Lake Erie.

Rana sylvatica Le Conte. Sides of head with a chocolate band running from snout backward. Below this a light line. Brownish spot on base of arm. Above brown, below lighter. Lower jaw mottled in front with brown. Lateral fold brown, conspicuous. Legs barred transversely. Length 1½ inches.

The Wood-frog is, in the mind of the writer, the most beautiful of the frogs. It cannot be confused with any other species when the markings are considered. It is an anomaly among its brethren inasmuch as it is never found in the immediate vicinity of water after the eggs have been laid in the early spring. Its home is among the fallen leaves of an upland woodland where it lives a solitary life. It is extremely hard to distinguish among the leaves as protective coloration is so well developed.

Kirtland ('38) gives the following note under this species: "It is impossible to move in our Ohio woods during summer without stepping on them, they are so abundant." Whether this was meant to apply to the whole of Dr. Kirtland's period of observation or to a limited period is not evident. What is evident, however, is that there has most certainly been a marked change in the distribution of the species since 1838, for as it occurs now in our State it is found as isolated individuals. Only during breeding seasons do they become in any sense gregarious and this only for a few weeks in early spring.

Found over the entire State, but erratic, occurring only as isolated individuals.

Specimens in the U. S. Nat. Mus., recorded by Cope from Yellow Creek and Toledo. In Oberlin College, collected by Lynds Jones, Lorain Co. Sandusky High School, by E. L. Moseley, Sandusky. O. S. U. Museum, by E. V. Wilcox in Lawrence, Warren and Delaware Cos.; by the author at Gahanna and in Licking Co. Also reported from Knox and Fairfield Cos.

Class: REPTILIA.

But one fossil reptile is known from an Ohio formation, this being a portion of the anterior end of an animal together with a portion of the vertebral column and the right posterior leg, showing crux and tarsalia. The specimen was taken at Linton, Ohio. It is considered by Cope as the only reptile positively identified from the Coal Measures and therefore the oldest known reptile. In speaking above[8] regarding the fossil Batrachia, an attempt was made to correlate the horizon at Linton, from which the several specimens were taken, with the Permian. In case the identification is correct, the statement of Cope would not be true, since the Theromorpha embraces many families found in the Permian of both the old and new worlds.

Order: THEROMORPHA Cope.

Family: PARIOTICHIDAE Cope.

Isodectes punctulatus Cope, Proc. Amer. Phil. Soc., 36:88.

Order: SQUAMATA Latr.

Family: IGUANIDAE.

Sceloporous undulatus undulatus Latr. Above brownish olive, with undulating brown cross bars edged with livid green. Legs similarly transversely banded. Throat and sides of chest bright blue, scales keeled. Head somewhat flattened. Length 7 inches.

The Pine-tree lizard is common in the non-glaciated region of Ohio, its range in the State being limited, in the main, by the glacial boundary. It is a beautiful object, a statement, could antipathy be overcome, no one would care to gainsay. It is extremely quick in its movements and therefore difficult to capture. The vertebrae of the tail are so constructed that that appendage may be readily parted with, with whatever disadvantage, gaining the life of its owner.

This little animal is absolutely harmless and makes an excellent pet.

Specimens in the U. S. Nat. Mus., recorded by Cope from Columbus. In Cin. Soc. Nat. His., collected by Dr. Lindahl at Cincinnati; in O. S. U. Mus., by J. S. Hine at Vinton, and by the author from Chillicothe and Fairfield Co. Also recorded from Sugar Grove.

8. *Supra*, p. 105.

Family: ANGUIDAE.

Ophisaurus ventralis Linn. Olive-green or brown, yellowish below. Legs wanting, body snake-like. Tongue not cleft as in snakes. Preanal scales generally eight (8) in number. A conspicuous fold along sides. Tail very brittle. Length 2 feet.

The Glass-snake derives its name from the readiness with which the tail breaks in pieces. This is due to the fact that the vertebrae in the tail are bony only at their ends, the centres remaining unossified and hence are readily separable. Although a snake in appearance, it is yet a lizard without legs. It may be told at once from any other Ohio reptile by its snake-like appearance and its non-forked tongue.

It is included here on the strength of a single specimen taken on the University farm by Dr. Townshend and is at present in the O. S. U. Zool. Mus. It was killed in a hay field, having been shaken out of a stack of hay. That it is valid is certain and it is but a few hundred miles out of its usual range. Hay ('92, p. 542) gives it as occurring in northern Indiana.

In the O. S. U. Mus., collected by Dr. Townshend at Columbus.

Family: TEIDAE.

***Cnemidophorus sexlineatus** (L.). Brownish above, with six dorsal streaks. A silvery spot on throat. A median dorsal band of brown. Tongue bifid, snake-like. A double fold across neck. Length 6–7 inches.

This is a very common form within its range, which is, in the main, southerly and westerly. It occurs from New Jersey to the mountains in the West. It has no Ohio record.

Family: SCINCIDAE.

***Liolepisma laterale** Say. Head angular, pyramid-shaped, with apex directed forward. Above reddish-olive to bronze or greenish. A light line on sides, below which, on level of eye runs a second darker line, while below the two, a white line. Ventro-laterally, striped alternately light and dark. Under parts yellowish. Tail blue below. Length 5 inches.

This is a Southern form, straggling north to Indiana. Its status as an Ohio lizard is not without question. Smith ('82) states that he has not seen it from the State. Kirtland ('38) speaks of it in a note as follows: "*S. lateralis* was shown to me by Mr. Dorfeuille, as an inhabitant of Ohio." Dorfeuille was a citizen of Cincinnati and a naturalist of some ability. In 1835 he owned a private museum in that city which, on his death, was lost to science by the specimens being promiscuously distributed or destroyed. Nothing now is known of the museum and hence his record of the species in question is based solely on Kirtland's assertion. That it should occur in Ohio is not strange since Robert Ridgway took it at Wheatland, Ind. Prof. J. S. Hine, of the Ohio State University, believes that he has seen it at Ft. Ancient, near Cincinnati.

Eumeces quinquelineatus L. Above black, with five longitudinal yellow streaks, one median and two lateral on either side. The median stripe bifurcates on occiput, each branch running to rostrum. Variable with respect to the color, the stripes being sometimes obsolete, while the ground color becomes reddish. Tail brilliant blue. Length 11 inches.

The Blue-tailed Skink is a beautiful little animal. When in the woods one often catches a glimpse of a train of livid green, resplendent in the sun shooting across his path—a glimpse only, for once among the fallen leaves search for the skink is useless. They readily part with a portion of their tail to a would-be captor. During the darker hours and during cloudy weather they secrete themselves beneath loose bark or among fallen leaves.

In the State the skink is common, but is never conspicuous, and therefore is generally unknown to the farmer.

Specimens in the Cin. Soc. Nat. His., collected by Dr. Lindahl in Hamilton Co. In O. S. U. Mus., collected by Chas. W. Souder in Franklin Co.; by the author at Chillicothe.

***Eumeces anthracinus** (Baird). Similar to the foregoing save that there are only four stripes, the interspaces being coal black.

Given by Cope ('00, p. 661) and Jordan ('99) as having a range from Pennsylvania to Missouri, and hence may be found within the State's limits. No specimen, however, has been taken in the State.

Order: SERPENTES Wagler.

Family: COLUBRIDAE.

Carphophiops amoenus Say. Uniform chestnut above, below uniform red. Head small, fusing with body without interpolation of neck. Scales iridescent and glossy. Tail short. Scales 13, not keeled. Anal plate bifid. Length 1 foot.

A snake too inconspicuous and uncommon for a common name. It occurs in sparse woodland and among underbrush. Sometimes it visits houses. A more inoffensive creature could not well be imagined. The species *helenae* Kennicott having but a single pair of frontal plates is a variation of the species under consideration. Rare in the State, but probably occurs in all parts of Ohio.

Specimens in the U. S. Nat. Mus., recorded by Cope from Morton and Ironton. Mus. of Antioch College, Yellow Springs, from Yellow Springs. In O. S. U. Mus., from Meigs Co.

Diadophis regalis arnyi Kenn. Slender; above leaden black, below yellow, thickly spotted with black. An occipital ring light yellow. Scales smooth, 17. Length 2 feet.

Ohio seems to be the eastern limit of this form. It is recorded for the State in but one place, viz.:

Specimens in U. S. Nat. Mus., recorded by Cope from Hughes.

Diadophis punctatus Linn. Tail short, below yellowish-orange, without spots save at times a faint median series. Above blue-black. A yellowish to salmon red occipital ring. Tail beneath unspotted. Scales smooth, 15. Length 1½ feet.

A beautiful snake. Found in hilly regions, often under bark or under rotten logs. Its food consists of insects, toads, etc. It may be handled without its manifesting any annoyance. It lies quiet during the daytime and forages at night. It breeds in June. Rare in the State.

Specimens in the U. S. Nat. Mus., recorded by Cope from Marietta and Cleveland. In the Cin. Soc. Nat. His., collected by Dr. Lindahl in Hamilton Co. In O. S. U. Mus., collected by the author from Fairfield Co.

Heterodon platyrhinus Latr. Occurs in two forms, normal and melanistic. Former as follows: Above brownish, with a series of irregular dark blotches replaced on tail by saddle-shaped blotches. Below greenish yellow. Snout recurved, forming a "rooter." Scales keeled, 25. Anal plate bifid. Second form above uniform blue-black, below greenish. Length nearly 2½ feet.

The Blow-viper, of all its kindred, is most persecuted. Absolutely harmless, it is killed at sight. In a way it is responsible, for its attempts at bluffing and passing itself off as a dreadful creature have rather tended to heap abuse upon it. When approached it will lie quiet until assured that its presence is known when it will begin to hiss, inflate its body and extend its ribs until it is a minature cobra. When teased it will strike, but the stroke is but a half one, degenerating into a twist which sends the body away from its apparent victim. When teased to an extreme it will throw itself on its back after passing through a series of contortions and frothing at the mouth. Once on its back it lies as dead, without a motion and with open mouth. It will remain thus until all is quiet, when with a sly twist it surveys the surroundings and if no offender is near it silently flops upon its belly and beats a hasty retreat. Should any intruder appear it immediately throws itself upon its back again and feints death anew.

Its eggs are laid in the sand. They are about an inch long and half an inch wide. It is very common in hilly and sandy regions. By the countryman it is often confused with the copperhead, which it resembles somewhat, or even it may be that the dangerous copperhead is called blow-viper and held to be harmless, as the writer found to be the case among some farmers in the eastern part of the State. In such cases it would be safer to assume that all snakes were dangerous than to confuse poisonous and non-poisonous.

The food of the Blow-viper consists of mice, toads, frogs, insects, etc. It is one of the most valuable reptiles to the farmer owing to its food habits.

Very common over the eastern and northern parts of the State, rarer west.

Specimens in the U. S. Nat. Mus., recorded by Cope from Marietta. In the Cin. Soc. Nat. His., collected by Dr. Lindahl in Hamilton Co. In O. S. U. Mus., by the author at Sandusky and Licking Co.

Liopeltis vernalis De Kay. Uniform dark green above, lighter on sides; below yellowish white. Head long, marked off from body by a slender neck. Eyes large. Scales smooth, 15. Length 20 inches.

This snake is common over the State, but is seldom noticed by one unless especially looking for it, as protective coloration is carried to such a degree in it that it blends perfectly with the surroundings. It is seldom seen in the daytime, but is to be found at dusk or during the early evening hours when it goes in search of food. Its food is largely made up of insects.

Smith ('82) gives it as frequenting marshes. It sometimes is seen on low bushes. It may be distinguished from the following by its smooth scales.

Specimens in the U. S. Nat. Mus., recorded by Cope from Columbus. Cin. Soc. Nat. His., collected by Dr. Lindahl from Hamilton Co. In O. S. U. Mus., by E. L. Moseley from Sandusky, and by E. F. Crans from Ira, Summit Co.

Cyclophis aestivus L. Scales keeled. Brilliant green above, yellowish below. Scales 17. Neck quite small. Length 33 inches.

Habits similar to preceding species. It frequents drier ground than *vernalis*, however. Like it, also, it is docile and readily handled. Not common in Ohio; a southern form.

Specimens in the Cin. Soc. Nat. His., collected by Dr. Lindahl in Hamilton Co. In O. S. U. Mus., by Prof. Tuttle at Ironton.

Bascanion constrictor L. Glossy blue to black, changing to greenish below. Anteriorly, belly and throat light. Scales smooth, 17 or 19. Body long and slender, eye large. Length 5 feet. Young differing from adults by having brown ground color above with black blotches.

The Black-snake or Blue-Racer is one of our largest snakes. It is a familiar animal, occurring over the whole of the State. It is generally found in woodland, although it may be met with in meadows or on roadsides. Its food, consisting as it does of mice, rats, insects, etc., makes it a valuable vermin-destroyer, but few are the farmers that pass one by without destroying it. As to the tales of its prodigious strength whereby it can crush a man by wrapping itself around him it may be said that they are without foundation. This snake is a splendid tree-climber, running up a tree trunk by means of projecting knots and limbs with readiness. If the Blue-racer can be arraigned for any misdeed it is his love of eggs, and hen's nests often pay high for his retention on the farm. Kirtland ('38) mentions this snake as on the increase as the country becomes cleared.

Specimens in the U. S. Nat. Mus., recorded by Cope from Hughes, Salt Creek and Delaware Co. In O. S. U. Mus., collected by W. H. Smith at London and Lancaster, and by the author at Cedar Point. Also reported from Hocking Co.

Coluber vulpinus B. & G. Above yellow, with a median series of large, irregular, chocolate blotches and a lateral series of smaller alternating with the larger ones. Head copper-colored above. Below yellow, with rectangular, black spots forming a checker-board appearance. Scales smooth, 25. Length 5 feet.

The Fox-snake is like the last, a large snake. It is a denizen of woodland areas and a splendid tree-climber. The writer watched a five-foot specimen crawl up a small elm tree. It used its head as a fulcrum to a large extent and would take advantage of the least irregularity in the bark as a means of aiding its ascent.

The range of this snake has been a matter of dispute, but now it seems that Ohio holds the eastern-most record. Cope ('00) asserts that it does not occur east of Illinois, but it occurs throughout Indiana and northern Ohio. For a full consideration of the case the reader is referred to "Science," Vol. XV, page 1034, where the present writer reviews the matter in question. The snake is common in the northern part of the State, but does not occur in central or eastern Ohio.

Specimens in the O. S. U. Mus., collected by Seth Hayes at Cedar Point, and by the author at Castalia.

Coluber obsoletus obsoletus Say. Above brownish black, scales edged with white. A series of irregular, quadrate blotches with a series of smaller blotches lateral to and alternating with them, both being at times obscure or even obsolete. Median scales somewhat keeled, the remainder smooth. Below very dark brown, somewhat mottled. Scales 27. Length 6 feet or over.

This is our largest snake. The vernacular name is Pilot Black-snake. It is to be found only in wooded areas and seems to retreat to the heaviest forests with the advent of the axe. It is easily handled and makes little defence when captured. They are often found sunning themselves after a period of rain.

The snake is not well known among the farmers in general, but wood-cutters in the region of native forests are familiar with it.

In the wooded areas of the State fairly common, but apparently growing rare.

Specimens in the O. S. U. Mus., collected by R. C. Osburn at Columbus; by Prof. Tuttle at Yellow Springs; by the author at Nelsonville and Licking Co.

* **Pituophis melanoleucus** (Daudin). Ground color above white with a series of brown blotches, bounded by black rings. Scales 29. Postorbital scales 3. Head almost white. Length, maximum 70 inches.

A resident of the pine woods and wooded sandy regions. Its range is southerly. The Pine or Bull-snake, as it is called, has no Ohio record.

Osceola doliata triangula Boie. Ground color greyish, with a series of median dorsal blotches of brown edged with black. A series of smaller blotches lie lateral to these and alternate with them. Occipital spot triangular. Below yellowish, with quadrate black blotches. Scales 21, smooth, Length 4½ feet.

The Milk-snake can be confused with either the Fox-snake or the Water-snake. From the former it is readily told by its entire anal plate, while the scales in the Water-snake are keeled. The common name of the snake has nothing to do with the color, but is indicative of its habit of prying around milk-houses. It is often found in houses in the country where it doubtless wanders for food. It is absolutely harmless. Common all over the State.

Specimens in the U. S. Nat. Mus., recorded by Cope from Hughes. In the Cin. Soc. Nat. His., collected by Dr. Lindahl in Hamilton Co. In O. S. U. Mus., by J. S. Hine at Akron, and by the author at London and Nelsonville.

Osceola doliata doliata L. Similar to preceding, but no yellow line running back from eye along sides of head. Ground color reddish.

Rare in the State. Given in the present connection because of Specimen No. 10,084, U. S. N. M., from Hughes, Ohio, collected by R. T. Shepherd.

Ophibolus calligaster Say. Above light, with chestnut blotches arranged in three series, a median and a lateral on either side. Scales in 25 rows.

To be distinguished from the two preceding species of the genus *Osceola* by the number of scales. Rare in Ohio.

Specimen in O. S. U. Mus., collected by Prof. Tuttle at Lancaster.

Natrix fasciata fasciata L. Lozenge-shaped patches of black on back and sides—a single series. No alternating lateral blotches save an alternating series of lateral reddish spots. Scales keeled, 23 or 25. Head long. A black postocular band. Length 4½ feet.

This is the Southern Water-snake. It is distinguishable from the following sub-species by the absence of a lateral series of blotches of black alternating with the dorsal series.

In the State it is represented by a single specimen in the Zoological Museum of the Ohio State University from Warren County.

Natrix fasciata sipedon L. As above, but blotches brownish and with a series of small blotches of brown alternating on the sides with the larger dorsal blotches. Below yellowish to ashy, each gastrostege, with a black quadrangular blotch. Body thick and heavy. Scales 23, sometimes 25.

The common Water-snake is to be found in every stream of the State. It is very variable in color and markings, but cannot well be confused with any other snake. It is never found far from the water, and generally places itself so that it may, at a moment's notice, glide into that element which affords it an effective retreat. When handled it is very aggressive and strikes violently. While not poisonous, its bite is, to say the least, unpleasant, as the teeth are long and very sharp. Its food consists of fish, insects and toads.

The members of this genus are all ovoviviparous, retaining the eggs in the body until hatched. The Water-snake is held by some to swallow its young when unduly pressed. This is a mistake, and the error may be due to the observer thinking that the unhatched young in the oviducts were in the alimentary canal.

The Water-moccasin of the South is often confused with this species. The poisonous snake has been reported from the Ohio River near Cincinnati, but no specimens exist and it is very probable that the supposed cases are large individuals of the present species.

Specimens in the U. S. Nat. Mus., recorded by Cope from Poland, Columbus, Lima, Richland Co., and Maumee and Cuyahoga Rivers. In the Cin. Soc. Nat. His., by Dr. Lindahl at Put-in-Bay and Hamilton Co.

Natrix fasciata erythrogaster Shaw. Head long, Uniform dark bluish-black above, growing paler on sides. Below copper-colored, with a series of punctations along sides of gastrosteges. Scales 25. Length 3½ feet.

The Red-bellied form of the Water-snake is limited in its range to the north-western part of the State. Among the islands of Lake Erie the writer has taken specimens. Thus at Put-in-Bay it is common, but *sipedon* is found along with it. This fact cast a doubt in the writer's mind, but careful inspection of the specimens warrants such identification. Prof. H. L. Clark ('03) has made a statistical study of the species of *Natrix* occurirng in Michigan, and to it the reader is referred for a better definition of the several forms.

Specimen in the O. S. U. Mus., collected by the author at Put-in-Bay.

Natrix leberis L. Chestnut brown, with three black longitudinal stripes and a lateral yellowish stripe. Below yellow with a black line running along the ends of the gastrosteges. Scales 19. Length 2 feet.

Common in all parts of the State. It is often to be found hanging over a stream from projecting limbs of willows from which it glides rapidly into the water when disturbed. It bites viciously when caught and, while non-poisonous, yet inflicts an ugly wound.

Specimens in the U. S. Nat. Mus., recorded by Cope from Lima and Highland Co. In Cin. Soc. Nat. His., collected by Dr. Lindahl from Hamilton Co. In O. S. U. Mus., collected by the author at Youngstown and Chillicothe.

Natrix kirtlandii Kenn. Purplish-brown above, with four rows of black blotches, alternating one with another. Below salmon-colored, the ends of the gastrosteges being black, forming two longitudinal lines. Body flattened. Scales 19. Length 1½ feet.

Common in marshy land, especially in hilly regions. They lie quiet during the daytime and emerge late in the afternoon to search for food. The snake is inconspicuous and is often passed off for *N. f. sipedon*. It is variable in color, the dorsal blotches sometimes being scarcely discernable, while the red of the ventral parts may be dull or even brownish. Its habit of making the naturally flattened body flatter still by the expansion of the ribs is interesting from the point of view of the student of animal behavior. The first specimen recorded below was taken in January.

Specimens in the Cin. Soc. Nat. His., collected by Dr. Lindahl from Hamilton Co. In O. S. U. Mus., by C. R. Diltz, Perry Co.; E. E. Masterman, New London, and by the author at Sugar Grove.

Storeria dekayi Holbrook. Clay-colored above, with a light vertebral stripe and a dotted line on either side. Below ashy. A dark spot on either side of occiput. Scales keeled, anal plate double. Scales 17. Length 1 foot. The ground color above may be brownish and the streaks may become very inconspicuous or obsolete.

Not a common snake in the State. Frequents marshy land, but Hay ('92) does not bear this out. Smith ('82) gives it as occurring at Cleveland and in the north-western part of the State. It probably occurs over the whole State sparingly.

Specimens in the U. S. Nat. Mus., recorded by Cope from Columbus, Madison, Grand Rapids and Highland Co.

Storeria occipitomaculata (Storer). Above similar to preceding. Below salmon-red. Occiput with 3 light dots. Scales keeled, 15. Length 1 foot.

Common over the State in dry upland woods. Its food consists of insects in the main. Smith ('82) gives it as "not rare around Columbus," At the present time it is never found in any numbers.

Specimens in the U. S. Nat. Mus., recorded by Cope from Madison, Yellow Creek and Hughes. In Cin. Soc. Nat. His., collected by Dr. Lindahl in Hamilton Co. In O. S. U. Mus., from Sugar Grove, and collected by R. C. Osburn at Kent.

Virginia valeriae B. & G. Greyish brown, punctated above with black. Below light yellowish. Scales 15. Length 1 foot.

This little snake resembles somewhat *Carphophiops amoenus*, but it may be readily distinguished from that species by the pepper-and-salt appearance of the back. It feeds on insects and worms. Its movements are slow and it is very shy, appearing generally towards evening.

Known for the State by but one specimen, which is its northernmost record.

Specimen in O. S. U. Mus., from Richmondale, collected by the author.

Tropidoclonium lineatum Hall. Head small. Brown above, with 3 narrow, yellow stripes. Below yellow, spotted. Scales keeled, anal entire. Length 16 inches.

Cope ('00) lists a specimen of this snake from Hughes, Ohio, collected by R. T. Shepherd and now in the U. S. N. M. Dr. Leonard Stejneger, Curator of Reptiles in the Museum, would identify the specimen as a species of *Storeria*. The species is a Western one and has not been reported in Indiana, for which reason the Ohio record is problematic.

Eutainia saurita L. Lateral stripe of yellow on third and fourth rows of dorsal scales. Chocolate-brown above, with a broad median yellow stripe. The lateral stripes subtended by one of brown. Scales somewhat rough, 19. Length 3 feet.

Smith ('82) gives this snake as common in Ohio, but the present writer has watched carefully for it with no success. It doubtless is to be found especially in the eastern part of the State, but certainly in no great numbers. It is said to frequent lowland woods and about water.

Specimens in the U. S. Nat. Mus., recorded by Cope from Toledo. In the Cin. Soc. Nat. His., from Hamilton, collected by Dr. Lindahl.

Eutainia sirtalis graminea Cope. Above uniform light green ; below yellow, clouded with green. No markings anywhere. Scales 19, somewhat keeled. Length 15 inches.

This Garter-snake is very common in central Ohio as well as in other parts of the State. It is not, however, the prevailing form, as *sirtalis* is much the more common. It is doubtless a good variety, but has been held in question by Stejneger.

Specimens in the U. S. Nat. Mus., recorded by Cope from Columbus, Cloverdale, Grand Rapids and Lima.

Eutainia sirtalis ordinata L. Stripes not evident, but the component spots distinct on sides. Gastrosteges spotted. An occipital patch of black.

This sub-species is met with in various parts of the State, but is uncommon in collections. Its status as a variety is doubtful, as intermediate forms occur ranging between *sirtalis* on the one hand and *graminea* on the other.

In O. S. U. Mus., collected by the author at Columbus.

Eutainia sirtalis sirtalis L. Spots and stripes both distinct. Above dark olive. Below greenish. A narrow vertebral line of yellow. Three series of small, square spots on the sides.

Of the four sub-species of *Eutainia* listed here, this is the most common. It is the type form and to it the others are to be referred. The species of *Eutainia* are all ovoviviparous and the young are born in great numbers, as high as eighty having been taken from a single specimen. The food consists of worms, insects, small toads, etc. They are absolutely harmless, having short teeth and also little inclination to bite.

Specimens in the U. S. Nat. Mus., recorded by Cope from Port Clinton. In the Cin. Soc. Nat. His., collected by Dr. Lindahl from Hamilton Co. In O. S. U. Mus., from Columbus, Yellow Springs and Lancaster.

Eutainia sirtalis obscura Cope. As above, but with the spots entirely obscured. Body blackish between the well defined stripes of yellow. Gastrosteges spotted at the lateral ends.

Not a common variety in the State. The specimens that were taken by the writer were found in lowland regions.

In O. S. U. Mus., collected by the author at Columbus and Sandusky.

Family: CROTALIDAE.

This family embraces all of our poisonous snakes. One character is present in them which is found in none of the non-poisonous snakes and hence is an excellent criterion by which one may tell poisonous from non-poisonous forms. Between the eye and the nostril (Fig. 1) on either side is a deep pit that is simply an infolded part of the skin in that region. The function of the pit is not known. It has, however, embedded in its walls, termini of nerves which would suggest that it was a sense-organ, of the same category, perhaps, as Leydig's corpuscles.

The fangs (Figs. 2 and 3) of the poisonous snakes are simply long, sharp teeth in the upper jaw, perforated with a tube (a') that connects with the duct of the poison gland (a), the whole forming a hypodermic injection apparatus. The poison gland (a) lies above and posterior to the base of the fangs. Above and below it run two large muscles (b and i) which serve to compress the gland and force out the venom. Should a fang be broken off another stands ready to replace it, (Fig. 3.) In our poisonous snakes the fangs are borne on the maxillary bone, which is hinged so that the teeth may be folded back and drawn into a sheath. (Fig. 2, *f.*)

When disturbed these snakes throw themselves into a coil from which they strike at the intruder by suddenly straightening the body. They are not able, however, to strike more than half their length, so that a four-foot snake could strike but two feet from coil.

All our venomous reptiles are sluggish and will strike only when annoyed. The Rattle-snakes are provided with a series of chitinous "rattles," which are simply modified scales. These grow on the end of the tail, being formed continuously. The first one formed in the young snake is known as the "button," it being smaller than the subsequent ones. The rattles are frequently broken off, as may well be supposed. The age of the animal hence, for this reason alone cannot be told from the number of rattles even if one rattle were formed a year, which is by no means the case since they vary in their periods of growth. Thus, at times, two or more rattles may be formed within a twelve-month or but one. It may be said that a rattle is formed at each hedding of the skin.

PLATE II.

Fig. 1. EXTERNAL VIEW OF RATTLER'S HEAD.
The pit is seen between and below the eye and nostril. (*From Stejneger.*)

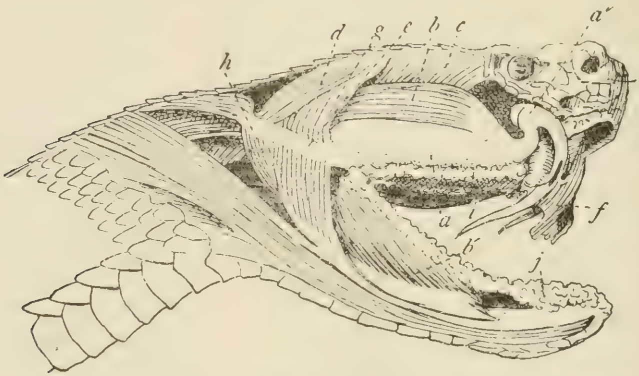

Fig. 2. HEAD OF RATTLER.
a, venom gland; *a′*, duct; *b b′*, temporal muscle; *f*, sheath of fang.
(*After Stejneger from Duvernoy.*)

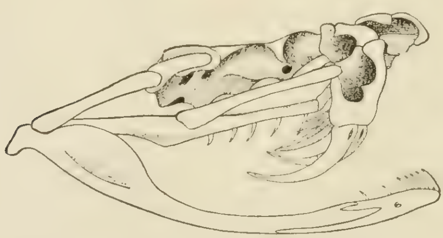

Fig. 3. SKULL OF RATTLER—(*from side.*)
The long fangs in the upper jaw are fixed in the maxillary bone; this bone is hinged on the lachrymal (above) and the pterygoids (posteriorly). The excavation for the pit in the maxillary bone is seen at the end of the pterygoid bones. (*From Stejneger after Jan.*)

Ancistrodon contortrix L. Above light hazel brown, becoming coppery on the head; everywhere spotted with minute black dots. A series of darker brown, V-shaped blotches alternating with one another on either side. Below yellowish, with black quadrangular blotches. Scales 23. Length 3½ feet.

This is the dangerous Copper-head. It is a frequenter of low, swampy places in hilly regions. It is not confined to damp soils, however, but wanders over the uplands except in the hottest summer months. It strikes, when approached, without warning and, while its teeth are but half an inch long, they are exceedingly sharp and may even penetrate leather. The venom is perhaps not as active as that of the Rattlers, but nevertheless a small amount, properly injected is almost certain death. The snake never reaches a length of over 3½ feet, and this is uncommon, the normal being 2¾ feet.

In the State the Copper-head occurs mainly in the southern and eastern portions, among the hills. It is never what may be called common, but individuals are frequently killed in the region mentioned. The snake is not as common as formerly and is undergoing certain extermination.

Specimens in the Museum of the Cin. Soc. Nat. His., collected by Chas. Dury in Hamilton Co. In the O. S. U. Mus., collected by J. S. Hine from Sugar Grove; by W. M. Mills from Chillicothe and from Knox Co.

Sistrurus catenatus catenatus Raf. Brown to grey above, with a series of darker brown blotches edged with black. A yellowish streak through eye to neck. Below blackish, with yellowish shade. Scales 23–25. Length 2½ feet. Rattles small. Form heavy.

The Massasauga or Prairie Rattler is the smaller of the two species of Rattler in Ohio. It is found in lowland swamps or in grassy meadows. It is sluggish and will not show fight until driven to do so. Its stroke is quick, but not effective beyond a foot.

Formerly the Prairie Rattler was one of the commonest snakes, but now it is undergoing rapid extermination. Its haunts are being invaded by the plough and every year sees many of its strongholts destroyed. Its range in the State is wide, but its distribution is erratic.

Specimens in the U. S. Nat. Mus., recorded by Cope from Columbus, Warren and from Trumbull Co. In O. S. U. Mus., from Urbana, collected by Dr. Kellicott.

Crotalus horridus L. Above yellowish, with three rows of dark brown spots, irregular in shape and somewhat confluent. A light line from angle of mouth to eye, subtended by a black blotch. Tail darker. Below yellowish to dark grey. Scales 25, sometimes 23. Length 3 feet.

This species is found only in rocky portions of the State. They are now nearly exterminated, but a few remain in certain localities. Thus, among the hills in the Scioto Valley from the line of glacial drift southward, they are met with in small numbers. In the south-eastern portion of the State they are perhaps more frequently taken than elsewhere. On Mouse Island, off Catawba Point, in Lake Erie, there is a small colony that grows smaller every year.

It is the most dangerous of our poisonous reptiles, both because of the venom being very efficient and because of the strength and size of the animal. The fangs are long, reaching even an inch in length. The musculature is powerful.

The food of this reptile consists of small rodents, birds, frogs, etc. It is sluggish in its habits and will not strike unless provoked unduly. Its stroke reaches about two feet.

The writer has seen specimens taken in some of the places mentioned, but there are but few specimens in museums to substantiate its being included here.

One specimen in the zoological collection of the Sandusky High School has a definite record.

Order: TESTUDINATA.

This order includes the turtles, and concludes the list of Reptiles. No general work on the order is extant and the nomenclature adopted is that given by Jordan ('99), which is that of Dr. Leonard Stejneger of the U. S. N. M.

Family: TRIONYCHIDAE.

*__Amyda mutica__ (Le Sueur). Median line of back depressed. No tubercles. Nostrils not terminal, but rather placed below the end of the snout. Not recorded for Ohio.

Aspidonectes spinifer (Le Sueur). Above flesh color to clay color, covered with black spots. Head and neck striped. Ground color greenish. Feet spotted. Nostrils at tip of snout. Length 1½ feet. Feet broadly webbed. Body very flat.

The Soft-shelled turtle is common in every stream of the State. Its flesh is excellent as food. Fishermen frequently catch it on hooks bated with liver or beef. When caught it is very savage and snaps with a will. It may be seen floating at the surface of the river or lake and doubtless derives its food to some extent by this means. Its long proboscis-like appendage bears the nostrils, and this may be pushed above the surface of the water without the body as a whole being conspicuous.

Specimens in the O. S. U. Mus., from Columbus, Sandusky and London, collected by the author.

Family: CHELYDRIDAE.

Chelydra serpentina (L.). With median crest, with strong tubercles. Head narrow, pointed, with dark spots. Tail also crested. Plastron small, cross-shaped. Toes 5-4, well webbed. Length 2 feet.

The Snapping-turtle is common over the State. It is, like the preceding, prized as food. It is never seen out of water save when it lays its eggs in the spring. During the winter it buries itself deep in the mud, but during the warmer days it very probably emerges for a short while or until it becomes cold again.

The Snapper is very savage when caught, and the tenacity with which it grasps a stick or better still a finger is proverbial. Indeed when once the jaws are set down on an object the head may be severed from the body without causing the mouth to open.

Specimens in the Cin. Soc. Nat. His., collected by Dr. Lindahl from Hamilton Co. In the O. S. U. Mus., from Columbus, Sandusky and London, collected by the author.

Family: KINOSTERNIDAE.

Aromochelys odoratus (Lat.). Carapace long, narrow, high, the highest point being in anterior third of the shell. Carapace somewhat keeled. Above dark, spotted with black. Below yellowish. Length 6 inches.

The Musk-turtle, or Mud-turtle, as it is sometimes called, is very common in the eastern half of the State and in Lake Erie. Westward it becomes abundant. It is never conspicuous. Fishermen very frequently catch it, an operation not especially pleasing to them as it generally means the loss of a hook. They are often seen sunning themselves on rocks and other elevations from the water, but at the slightest disturbance they drop into the water.

The strong musky odor which gives it its specific name is a ready means for telling it from its brethren.

Specimens in the O. S. U. Mus., from Sandusky, and from Georgesville, collected by the author.

* **Pseudemys hieroglyphica** (Holb.). Shell flattened, without corrugations. Plastron yellow. Head and neck ornamented with yellow streaks. Upper jaw hooked. Not taken as yet in Ohio. It ranges from New York to Wisconsin and southerly.

Family: EMYDIDAE.

Graptemys geographicus (Le Sueur). Yellowish brown, with greenish and yellow lines forming a reticulation over the carapace. Below yellowish. Carapace denticulate behind, flattened, porterior edges flaring. Toes short. Length 1½ feet.

An aquatic turtle, leaving the water only to deposit its eggs. Its food is largely clams and gasteropods.

In Ohio it is common in the larger rivers flowing into Lake Erie and the Ohio River.

Specimens in the O. S. U. Mus., from Sandusky, Toledo, Rockport and Cincinnati, collected by W. H. Smith.

Chrysemys marginata (Agassiz). Plates of carapace alternating, never in transverse rows of threes. Above black with a metallic cast, each plate edged with yellowish. Marginal plates with red markings. Plastron yellow, generally blotched with dark brown, Lateral plates sculptured.

This is at once our commonest and most conspicuous turtle, and is too familiar to need any consideration of its habits. Its food consists of mollusks, worms, insects and is indeed omnivorous in its habits. Its eggs are laid in sandy places, a short distance from the water. The young hatch about June 20th or later, according to the latitude and temperature.

Specimens in the O. S. U. Mus., from Columbus, and from Newton Falls, Vinton and Sandusky by the author.

* **Chrysemys picta** (Hermann). As above, but dorsal plates arranged in sets of three, not alternating.

This turtle is given by Smith ('82) as found in eastern Ohio, and other writers follow him. However, careful collecting in eastern Ohio has failed to reveal its presence. If it occurs it does so sparingly.

Clemmys guttatus (Sch.) Carapace black, covered with circular orange spots about one-fourth inch in diameter. Plastron yellow, heavily blotched with black. Length 5 inches.

This is a gaudy creature and is noticeable in its environment. It frequents still ponds and streams or marshy places, In Buckeye Lake, where it is to be found sparingly, it is seen sometimes in the interior of one of the *Sphagnum* bogs away from water. It is also seen among several individuals of *C. marginata* sitting on a log in the sunshine. They are shy and are in the water at once when disturbed. They feed on mollusks, frogs, tad-poles, etc., while insects enter largely into their diet.

While not rare in Ohio they are by no means common. However, they doubtless occur in small numbers in all parts.

Specimens in the O. S. U. Mus., collected by the author from the Licking Reservoir, Castalia and Columbus.

Emynoidea blandingi (Holbr.). Carapace black, covered with small, yellow spots. Plastron with large, black blotches. Yellow spots on head. Length 8 inches.

Found in the larger streams flowing into Lake Erie and the Ohio River. It is a large species, but inconspicuous, and its habits are not well known. The species is nowhere abundant, even in its more normal habitat. It has been observed by the writer in the sand on Cedar Point, Sandusky, early in July, apparently ovipositing. On approaching it it draws in head and legs and closes its shell and no amount of thumping will cause it to open the hinged plastron.

Specimens in the O. S. U. Mus., from Columbus and Sandusky.

Terrapene carolina (L.). Carapace short, high and thrown into many rugosities. Above yellow, with black markings. Plastron hinged in front and behind, capable of closing the shell tight. Length 6 inches. Variable.

This is the common Box-turtle. While nowhere common in Ohio, it is met with now and then in every portion of the State. It is strictly terrestrial. Their food consists of insects mainly, but unlike any other turtle of the State, is a vegetarian to some extent, eating fungi, roots, potatoes, etc. They are long-lived, and stories are commonly heard of their extreme longevity, based on a specimen that had been discovered bearing an inscription, carved on its shell, which had been made years before.

Specimens in the Cin. Soc. Nat. His., from Hamilton Co., collected by Dr. Lindahl. In the O. S. U. Mus., collected by Prof. J. H. Schaffner from Sugar Grove; from Georgesville, by Mr. Coberly, and from Vinton by the author.

COLLECTING AND PRESERVING.

Inasmuch as it is very desirable that further collecting of the reptiles and batrachians of the State be made, directions are given for capturing and preserving these forms. For the salamanders, which are slippery and very difficult to hold, a noose of fine wire is a splendid instrument ; the noose can be slipped over the head of the specimen without disturbing it, and a quick jerk will close the noose and the specimen can be dropped into the collecting box. Frogs are difficult to catch and resort is often made to the use of a small-bored gun, loaded with dust shot. A thirty-two calibre collecting gun with shot cartridges is an efficient instrument. The writer has never had any success with the use of a fish-hook, covered with a red cloth which is suspended over a frog by means of a pole and line and the hook fastened by a sudden jerk into the lower jaw of the specimen, a method recommended by some.

For lizards, a gun somewhat as described above is almost necessary as their motions are very quick. Snakes may be caught by grasping with the fingers or with long forceps, just back of the head. Gloves may be worn to advantage with the larger species. This is, however, not a method that recommends itself for the capture of our venomous reptiles, as mistakes of a very serious nature may arise. For the larger snakes and the venomous ones, forceps may be used or a forked stick may be pushed over the head of the specimen—the specimen and fork being pushed into the ground. To kill snakes and turtles, there is but one practical method, as far as the author's experience goes, and that is to soak a piece of cotton with ether or chloroform and push it by means of forceps into the mouth. The specimen may then be left until dead, which time varies with the kind of specimen from a few minutes, as with some snakes, to a day, as with the larger turtles. A large cyanide bottle, as used by entomologists, serves to kill salamanders and frogs. Otherwise an air-tight box can be used, in which the specimens can be placed and into which cotton, saturated with chloroform, can be dropped.

Specimens may be best preserved in a 5 per cent. solution of formalin.* Formalin is the anglicized form of the German formol, which is a more correct term, chemically speaking. It is a 40 per cent. solution of the gas formaldehyde, CH_2O, in water.

*Formalin or formol or formaldehyde, as it is variously called may be bought on the market at a small expense. A pound bottle, which costs about 40 cents will preserve a large number of specimens.

GLOSSARY.

Anteorbital Plates. Plates bounding the eyes in front.

Arboreal. Living in trees.

Canthus Rostralis. Tubercle at angle of jaw.

Carapace. The upper shell of a turtle.

Carinate. Keeled. Said of a structure when a ridge runs along the median line.

Costal Folds. The furrows on the sides of a salamander which mark the position of the ribs.

Fangs. The enlarged front teeth of a venomous snake which are used as hypodermic needles for the injecting of venom.

Fauna. The animal life of a region, taken as a whole.

Gastrosteges. The scales on the belly of a snake in front of the tail.

Larva. The young or immature form of an animal before reaching the full-grown or adult stage.

Lateral. Pertaining to the sides of an animal.

Occipital. The hinder portion of the head, immediately in front of the neck.

Oviparous. Producing eggs that are hatched outside the parent's body.

Ovoviviparous. Producing eggs that are developed within the parent's body.

Palustrine. Inhabiting swamps.

Plastron. The lower shell of a turtle.

Postorbital. Plates lying behind the eyes, bounding them posteriorly.

Punctate. Dotted.

Scales. The number of vertical rows of scales running across the body from the gastrosteges.

Rostrum. The beak-like structure at the tip of the snout in some snakes.

Striate. Streaked.

Ventral. Pertaining to the lower surface of an animal.

Viviparous. Bringing forth young alive.

INDEX.

Acris . . . 118
Amblystoma . . . 107
Amphibamus . . . 105
Amyda . . . 138
Ancistrodon . . . 137
Anisodexis . . . 106
Aromochelys . . . 139
Aspidonectes . . . 138

Bascanion . . . 128
Black-snake . . . 128
Blow-viper . . . 126
Blue-racer . . . 128
Blue-tailed Skink . . . 125
Box-turtle . . . 141
Brachydectes . . . 105
Bufo . . . 117
Bull-frog . . . 121
Bull-snake . . . 129

Carphophiops . . . 125
Cercariomorphus . . . 106
Chelydra . . . 139
Chorophilus . . . 118
Chrysemys . . . 140
Clemmys . . . 140
Clonoplus . . . 128
Cnemidophorus . . . 124
Cocytinus . . . 105
Colosteus . . . 106
Coluber . . . 128
Common Water-snake . . . 131
Copper-head . . . 137
Cricket-frog . . . 118
Crotalus . . . 138
Cryptobranchus . . . 107

Desmognathus . . . 114
Diadophis . . . 126
Diemyctylus . . . 116

Emynoidea . . . 141
Eumeces . . . 125
Eurythorax . . . 105

Fox-snake . . . 129

Garter-snake . . . 134
Glass-snake . . . 124
Graptemys . . . 140
Gyrinophilus . . . 112

Hell-bender . . . 107
Hemidactylum . . . 110
Heterodon . . . 126
Hyla . . . 119
Hyphasma . . . 106

Icthyacanthus . . . 105
Isodectes . . . 123

Keraterpeton . . . 106

Leptophractus . . . 105
Liolepisma . . . 124
Liopeltis . . . 127
Little Tree-toad . . . 119

Massasauga . . . 137
Milk-snake . . . 130
Molgophis . . . 106
Mud-puppy . . . 106
Mud-turtle . . . 139
Musk-turtle . . . 139

Natrix . . . 131
Necturus . . . 106
Newt . . . 116

Oestocephalus . . . 106
Osceola . . . 130

Pelion . . . 105
Phlegethontia . . . 106
Pilot Black-snake . . . 129
Pine-snake . . . 129
Pine-tree Lizard . . . 123
Plethodon . . . 111
Pituophis . . . 129
Pleuroptyx . . . 106
Prairie Rattler . . . 137
Pseudemys . . . 140
Ptyonius . . . 106

Rana . . . 121
Red-bellied Water snake . . . 131

Sauropleura . . . 106
Sceloporous . . . 123
Sistrurus . . . 137
Snapping-turtle . . . 139
Soft-shelled Turtle . . . 139
Southern Water-snake . . . 130
Spelerpes . . . 114
Storeria . . . 133
Swamp-frog . . . 121

Terrapene . . . 141
Thyrsidium . . . 106
Toad . . . 117
Tree-toad . . . 120
Tuditanus . . . 105

Wood-frog . . . 122

Virginia . . . 133

PROCEEDINGS

of the

OHIO STATE ACADEMY *of* SCIENCE

Volume IV, Part 4.

Special Papers No. 10.

ECOLOGICAL STUDY *of* BRUSH LAKE

BY

John H. Schaffner
Otto E. Jennings
Frederick J. Tyler

COLUMBUS, OHIO,

1904.

Fig. 1. Brush Lake from the south end; Decodon and Water-lily Zones in the foreground. (*Photograph taken August 6, 1887.*)

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William R. Lazenby,
F. M. Webster,
John H. Schaffner,
Trustees.

INTRODUCTION.

SINCE a considerable part of the State of Ohio was once covered by the continental glacier of the glacial epoch, the present surface is in many places covered by a thick deposit of drift. In the regions of terminal moraines and moraines of recession, the surface is usually diversified by hills and hollows with a comparatively new and irregular drainage system. The depressions thus formed give rise to the numerous swamps, ponds and lakelets, which constitute a very characteristic feature of the landscape and have a very important bearing on the plant distribution.

Being interested in the plant geography and ecology of the State, the authors proceeded to make a systematic study of one of these glacial lakelets. Brush Lake being favorably situated was chosen for study and the work of observation and collecting has been carried on for several years. To help defray necessary expenses, several small grants were obtained form the McMillin Fund of the Ohio State Academy of Science and we wish here to express our thanks to the Academy for the assistance received. Thanks are also due to Mr. C. F. Wheeler, of the United States Department of Agriculture, for kindly determining the species of Cyperaceae, and to Mr. Geo. Riddle, owner of the lake, for the photograph of the lake taken in 1887.

Ecological Study of Brush Lake.

GENERAL DESCRIPTION OF THE LAKE.

BRUSH LAKE is situated in the north-east corner of Champaign County, on the north side of the "Panhandle" Railway, at Brush Lake Station, about thirty-five miles west of Columbus. It is a pond covering about eleven acres, occupying a depression of the glacial deposit which covers the entire region for miles around. This deposit represents a moraine of recession and the surface is diversified by hills and hollows, the district being one of the most beautiful in central Ohio. In the neighborhood there are numerous small swamps and ponds, some of which have been entirely filled up with sediment from the surrounding banks and hills. It is said that Brush Lake was formerly about eighty feet deep. If this is true there has been a large amount of filling in recent times from the adjoining cultivated hillsides; for at present the water is not over thirty-five feet deep in the deepest place. The elevation of the surface of the lake is given as 1,120 feet above sea level.

There is a small ravine opening into the lake at the north-west and an outlet at the south-east from which water usually flows, forming a small brook, except in very dry weather when the loss from evaporation and other causes is greater than the supply. The outlet seems to be eroded very slowly and the decrease in the size of the lake due to this cause is at present insignificant. The water supply comes from a small drainage area and from springs which are evident on the west and north-west sides. From wells drilled at Fountain Park, about one mile south-east of the lake, it appears that the underlying rock is the Cedarville Limestone, belonging to the Niagara formation. There are several shallow artesian wells from this limestone at Fountain Park, but whether any of this rock water comes up into Brush Lake is not known.

Around the margin of the lake is a fringe of trees, the remnants of the former general forest, and within this is a series of concentric zones of vegetation which finally disappear in the water, as is usual in such locations. Evidence of rapid filling is present on the west side, where a new series of zones has produced considerable confusion in the centripetal progression. On the east side there is a wide mud flat inside of the shrub zone, which is just now beginning to be invaded by hydrophtic shrubs. The most perfect and primitive arrangement of the vegetation appears at the north end, where a small, low wood-lot has afforded protection from the cultivated field beyond. At the south end the natural conditions have been entirely changed; here the vegetation has been removed in order to enlarge the available ice-producing surface. The water is thus shallow and some of the zones are either entirely absent or represented only by isolated individuals. There is here also a patch of low woods which lies between the railroad and the lake and formerly the zones were very perfectly developed, as will appear from the photograph taken in 1887 (Fig. 1).

Glacial lakes are of interest in many ways, but especially because of the rapid changes which must have taken place in comparatively recent times in climate and soil. How far these lakes present similar plant societies as one passes from their southern limits northward is still to be determined. Several glacial lakes have recently been studied in detail, among which may be specially mentioned the "Three Sister Lakes," near Ann Arbor, Mich.[1]

One of the authors of the present paper is quite familiar with the vegetation and surroundings of these "Three Sister Lakes," having often botanized on their banks, and though there are striking similarities in some of the zones, on the whole there are very great differences, as will appear by comparing the reports of Reed and Weld with the description of Brush Lake. That the difference is not primarily due to latitude will be evident from the fact that a number of plants characteristic of the Michigan lakelets also occur in the Licking Reservoir, about thirty miles east

1. Reed, Howard S. A Survey of the Huron River Valley. I. The Ecology of a Glacial Lake. Bot. Gaz. **34:** 125–139. 1902

Weld, Lewis H. Botanical Survey of the Huron River Valley. II. A Peat Bog and Morainal Lake. Bot. Gaz. **37:** 36–52. 1904.

of Columbus. Probably the most important factor is the presence of Sphagnum, which is abundant in some parts of the Licking Reservoir. But why the Sphagnum should be abundant in the reservoir and entirely absent in Brush Lake is not so apparent. The general character and surroundings of Brush Lake are much the same as those of the "Three Sisters."

For the present the writers will content themselves with a report of the conditions as found at Brush Lake, leaving generalizations to some future ecologist. No special work could be carried on in regard to physiological adaptations. In order to do such work it is necessary that one should be able to *live* with his plants for a considerable period of time. But ecological phytogeography is still in its embryonic stage and it is perhaps better for the present to continue work more along geographical lines until better facilities are at hand for accurate and continuous observations on physiological adaptations. Besides, our present plant societies are being destroyed so rapidly that it is of primary importance that an historical record should be made. This may be of the utmost importance in the future.

THE PLANT SOCIETIES.

As stated above, the plant societies of the lake are arranged in concentric zones, as is usual where there is a gradual change in the environment. The zones determined are as follows:

1. Submerged Zone.
2. Water-lily Zone.
3. Half-submerged Zone.
4. Decodon Zone.
5. Uliginous Zone.
6. Shrub Zone.
7. Forest Zone.

Of these, all may be regarded as normal except the uliginous zone, which to a large extent represents a recent society developed on the mud flats intercalated between the Decodon and shrub zones on the east and west sides of the lake.

1. SUBMERGED ZONE. In this zone existence is almost entirely under water, for rarely do any of the plants composing it have even their tips extending above the surface. It is essentially a Potamogeton-Ceratophyllum-Myriophyllum-Chara zone.

It extends in typical places from a depth of 5 feet on the outer side, where it is bounded by water-lilies, to a depth of 10 feet or more on the inner side. At the north end where conditions are ideal the zone is 15 feet wide between the 5 and 10-feet limits. On the west side it is 20 feet between these limits. Beyond the 10-feet limit the depth increases very rapidly. The water of the lake is considerably colored, which must have an important effect on the submerged vegetation. All the plants in this zone have slender, wand-like stems with narrow and slender or much dissected leaves or branches. They are all highly specialized and thoroughly adapted to their habitat. They appear to occupy the ground because no other plants are able to follow. On the outer side they are pushed back by the water-lilies as far as these are able to invade the water. The typical plants are :

Potamogeton zosteraefolius Schum.
" lucens L.
Ceratophyllum demersum L.
Myriophyllum sp.
Chara sp.

Other species are :

Potamogeton foliosus Raf.
" pectinatus L.
Naias flexilis (Willd.) R. & S.
Zannichellia palustris L.

On the surface are frequently found the free-floating duckweeds :

Spirodela polyrhiza (L.) Schl.
Lemna minor L.
Wolffia columbiana Karst.

2. Water-lily Zone. This is a Nymphaea-Castalia zone, the two plants that give character to the society being Nymphaea advena Soland. and Castalia odorata (Dryand) W. & W. It is said that the Castalia was introduced artificially, but it is now well established. At the north end the zone is 40 feet wide and extends from water five feet deep to two feet deep. On the west side it is 28 feet wide. This is a very striking zone on account of the large, upright leaves of Nymphaea. The comparative absence of Nymphaea in water shallower than two feet must be accounted for on the grounds of a severe struggle with the plants

of the next zone, since it will grow readily in much shallower water. The inner limit of the zone appears to be determined by the depth of water alone, the plants being able to advance readily so long as the petioles are able to elongate sufficiently to bring the leaf blades above the surface. On the west side there are several small gaps, probably because of the recent origin of the present zone on this side and these gaps are filled with great masses of Chara. Another prominent plant of this zone is Potamogeton natans L., which in several places covers considerable areas.

The water-lilies occupying the shallow water are very efficient agents in building up the shore of the lake. The stout rhizomes are able to creep inward and bind the loose soil together, while the petioles and leaves tend to produce a calm where debris may accumulate quite rapidly.

Among the floating and aerial leaves of the water-lilies and other plants are usually great swarms of duckweeds, especially Spirodela polyrhiza (L.) Schl., Lemna minor L., and Wolffia columbiana Karst. Riccia fluitans L. is also common. Ricciocarpus natans (L.) Corda., although occurring in large quantities in the swamps near by, was not collected in the lake. Batrachium divaricatum (Schr.) Wimm. is abundant in some places at the outer edge of the water-lilies, but Ranunculus delphinifolius Torr, common in the swamps and ponds of the region, was not present.

Other plants collected in the water-lily zone were :

Sparganium eurycarpum Engel.
Potamogeton foliosus Raf.
" pectinatus L.
" lucens L.
Naias flexilis (Willd.) R. & S.
Zannichellia palustris L.
Ceratophyllum demersum L.
Myriophyllum sp.

3. Half-submerged Zone. This is essentially a Rumex-Polygonum-Typha zone. It is characterized by plants which have their roots, rhizomes, and the lower parts of their erect stems under water, but the larger part of the erect stems is exposed to aerial conditions. It is much more complex and variable than the two preceding zones. It extends outwards from

the edge of the water-lily zone at a depth of two feet to water about one-half foot deep. At the north end it is twenty-four feet wide and on the west side about fifteen feet. It is most perfectly developed at the north end (Fig. 2), where Rumex verticillatus L., Polygonum amphibium L. and Polygonum emersum (Mx.)

Fig. 2. North end of the Lake, showing plant zones. The Half-submerged Zone and Decodon Zone are not well marked in the picture because of the undeveloped condition of the latter. (*Photograph taken June 18, 1902.*)

Britt. are the characteristic species. On the east and west sides, owing to more typical uliginous conditions, Typha latifolia L. and Sparganium eurycarpum become prominent. On the south side the wide, shallow, artificial area of water corresponding to this zone is mostly covered with Chara sp., various pond weeds, Batrachium divaricatum (Schr.) Wimm., and Zannichellia palustris L.

An interesting plant also is Cicuta bulbifera L., which is covered in the fall with little bulbs. These drop off and float around on the surface of the water. Although found in several places this plant does not seem able to hold much ground considering the great advantage it has of being distributed into every favorable nook and corner by means of its brood buds. Eleocharis palustris (L.) R. & S. and Scirpus lacustris L. are also prominent in this zone. The floating plants of the water-lily zone are abundant, as would be expected. Other plants which are present are as follows:

Roripa palustris (L.) Bess.
Naumbergia thyrsiflora (L.) Duby.
Scutellaria lateriflora L.
Bidens cernua L.
Polygonum punctatum Ell.
Alisma plantago L.
Sagittaria latifolia Willd.

4. Decodon Zone. This is one of the most remarkable societies surrounding the lake. It is a Decodon-Solanum dulcamara zone. The characteristic plant, which in many places forms almost a pure society, is the tall crownformer, Decodon verticillatus (L.) Ell. The twining bittersweet, Solanum dulcamara L., is also very prominent. Some of these plants develop as floating individuals, having no connection with the ground, but developing numerous water roots along the submerged part of the stem. This zone is 30 feet wide at the north end. It begins in water from one to one-half foot deep and ends at the outer edge in water of about three or four inches, or even beyond the water's edge. At the north end it is limited on the outside by the shrub zone which extends to the edge of the water or beyond. The tall shoots of the Decodon, many of which are fasciated, form a tangled mass through which it is very difficult to pass both when they are green and in winter when dry. The Decodon is especially well adapted for holding air in the cortical layer of the much branded base and is thus well fitted to carry on

the life of an aquatic crown-former. The Decodon zone is almost entirely wanting at the south end of the lake, having been recently destroyed as stated before. It was very perfect here formerly, as appears in Fig. 1, and at the south-east it is still very wide. On the west side the zone is rather narrow, being only abont fifteen feet wide.

Other plants in this zone are:

Alisma plantago L.	Ranunculus abortivus L.
Sagittaria latifolia Willd	Roripa hispida (Desv.) Britt.
Scirpus lacustris L.	Naumbergia thyrsiflora (L.) Duby.
Carex comosa Boott.	Cicuta bulbifera L.
Iris versicolor L.	Cephalanthus occidentalis L.

The Cephalanthus is here and there an invader from the outside and will finally establish a new shrub zone because of the changed conditions produced by cultivation of the surrounding hillsides. Had the lake remained in its natural condition surrounded by dense forest the progress of the zones would probably have been gradual and continuous, but as it is there will be from time to time comparatively sudden advances, thus producing confusion in the established order of the old societies.

Uliginous Zone. The distinctive peculiarity of this zone is the presence of various species of Carex, Eleocharis and Scirpus, together with Equisetum fluviatile L., which is very abundant in some places. Besides these there are a number of other moisture and mud-loving species. This zone is intercalated on the east and west sides where wide mud flats have been formed between the Decodon and shrub zones. It is very prominent on the east side where there has been much filling in from the cultivated field beyond. The zone is absent at the north where there has been no such filling and was probably also absent from the south end when natural conditions still prevailed. In the moister parts the Equisetum, Eleocharis and Scirpus are characteristic, while in the outer, dryer margin the various species of Carex form a thick sod in which occur a number of uliginous herbs. Some isolated pioneers among the shrubs, especially Cephalanthus, have also taken a foothold on the east side although still few in numbers. On the west side the zone has been much invaded and is now in a transition state, progressing rapidly toward a thicket and forest society.

The plants in the zone are as follows:

HOMOSPOROUS PTERIDOPHYTES.

Equisetum fluviatile L.
Dryopteris thelypteris (L.) Gr.

SEDGES.

Cyperus strigosus L.
Eleocharis palustris (L.) R. & S.
" palustris glaucescens [(Willd.) Gr.
" acicularis (L.) R. & S.
Scirpus fluviatilis (Torr.) Gr.
" atrovirens Muhl.
" lineatus Mx.
Carex albolutescens Schwein. (?).
" comosa Boott.
" cristatella Britt.
Carex frankii Kunth.
" granularis Muhl.
" hystricina Muhl.
" lanuginosa Mx.
" shortiana Dew.
" stipata Muhl.
" stricta Law.
" straminea ferruginea Bail. [(C. alata ferruginea Fern.)
" vulpinoidea Mx.

GRASSES.

Echinochloa crus-galli (L.) Beauv.
Panicum capillare L.
Panicularia nervata (Willd.) Ktz.

OTHER MONOCOTYLS.

Sparganium eurycarpum Engel.
Spathyema foetida (L.) Raf.
Juncus tenuis Wild.
" torreyi Cav.

HERBACEOUS DICOTYLS.

Batrachium divaricatum (Schr.) [Wimm.
Caltha palustris L.
Cardamine bulbosa (Schreb.) B. S. P.
" pennsylvanica Muhl.
Roripa palustris (L.) Bess.
Penthorum sedoides L.
Geum virginianum L.
Naumbergia thyrsiflora (L.) Duby.
Asclepias incarnata L.
Lycopus americana Muhl.
Mentha canadensis L.
Mimulus ringens L.
Pedicularis lanceolata Mx.
Angelica atropurpurea L.
Galium claytoni Mx.
" tinctorium L.
" asprellum Mx.
Valerianella radiata (L.) Dufr.
Lobelia syphilitica L.
Aster puniceus L.
Senecio aureus L.

SHRUBS.

Cephalanthus occidentalis L.

6. SHRUB ZONE. This is a Salix-Cephalanthus-Cornus-Rosa zone. It is almost continuous around the lake except at the south side where it is poorly developed, forming only a narrow, interrupted belt between the forest and water. At the north end the zone is 30 feet wide. Here abound some of our

typical moisture-loving shrubs, forming at some places an almost impassable hedge. At the north-west where the small ditch opens into the lake the shrubs have invaded the water, Salix sericea Marsh. and S. lucida Muhl. advancing farthest.

The most characteristic plants are a number of species of Salix, Cephalanthus occidentalis L., Cornus stolonifera Mx. and Rosa carolina L. The complete list of shrubs found numbers fifteen species and two forms, as follows:

Salix discolor Muhl.	Rosa carolina L.
" sericea Marsh.	Solanum dulcamara L.
" cordata Muhl.	Cornus stolonifera Mx.
" cordata augustata (Pursh.) And.	" amomum Mill.
" sericea x cordata.	Cephalanthus occidentalis L.
" lucida Muhl.	Viburnum opulus L.
" nigra Marsh.	" lentago L.
" amygdaloides And.	Sambucus canadensis L.
Ribes cynosbati L.	

Several of these develop into large trees, but none had advanced beyond the shrub stage, either on account of age or other causes. Because of the great density of the shrub thicket very few herbs gain a footing in this zone except in the more open places. The following sixteen species were collected:

Spathyema foetida (L.) Raf.	Naumbergia thyrsiflora (L.) Duby.
Polygonum persicaria L.	Asclepias incarnata L.
Caltha palustris L.	Blephilia hirsuta (Ph.) Torr.
Ranunculus abortivus L.	Mentha canadensis L.
Geum canadense Jacq.	Monarda fistulosa L.
Cassia marylandica L.	Veronica peregrina L.
Lathyrus palustris L.	Campanula americana L.
Viola obliqua Hill.	Rudbeckia speciosa Wend.

7. FOREST ZONE. The inner part of the forest zone is hydrophytic or semi-hydrophytic. It is typically an Acer-Ulmus-Fraxinus-Salix zone. The soil is largely made up of vegetable and shell humus, in which, besides the tree growth, are found large numbers of semi-hydrophytic and mesophytic shrubs and herbs. On the east and west sides there is only a narrow fringe of forest left, the hillsides having been entirely denuded of their former mesophytic forest. On the north and south ends there are still rather wide strips of hydrophytic forest, but beyond these the forests have also been destroyed so that it is impossible at

present to obtain the transition from the lake shore forest to the culmination forest of the region. For this reason the normal upland forest will not be considered here. The typical trees are :

Acer saccharinum L.	Salix nigra Marsh.
Fraxinus americana L.	" amygdaloides And.
" pennsylvanica Marsh.	" discolor Muhl.
Ulmus americana L.	

All of these are reproducing well and advancing inward upon the shrub zone.

In the drier, outer parts of the forest zone are also found the following trees :

Gleditsia triacanthos L.	Prunus americana Marsh.
Populus deltoides Marsh.	Cornus florida L.
Morus rubra L.	Rhus glabra L.
Viburnum prunifolium L.	Juglans nigra L.
Viburnum lentago L.	Quercus macrocarpa Mx.

There are comparatively few shrubs in the typical swamp forest. The following were collected :

Cornus amomum Mill.	Opulaster opulifolius (L.) Ktz.
Sambucus canadensis L.	Rubus occidentalis L.
Viburnum opulus L.	

In the drier parts the three lianas given below are quite abundant :

Rhus radicans L.
Parthenocissus quinquefolia (L.) Planch.
Vitis vulpina L.

In the outer, drier portions of the forest zone herbs are quite numerous. This is probably due to the changed and still changing conditions, as a considerable number would probably be absent if conditions were normal as formerly, when the hydrophytic forest was continuous with the vast mesophytic forest of the region. Probably most of the herbs present were collected, and the following is the complete list of species, none of which is especially prominent over others in the society :

Equisetum arvense L.	Cinna arundinacea L.
Arisaema triphyllum (L.) Torr.	Poa pratensis L.
Spathyema foetida (L.) Raf.	Elymus striatus Willd.
Panicum capillare L.	" virginicus L.
Muhlenbergia mexicana (L.) Trin.	" canadensis L.

Cyperus diandrus Torr.
Carex comosa Boott.
" frankii Kunth.
" grisea Wahl.
" stipata Muhl.
" cristatella Britt.
Allium canadense L.
Iris versicolor L.
Sisyrinchium graminoides Bickn.
Urtica gracilis Ait.
Adicea pumila (L.) Raf.
Boehmeria cylindrica (L.) Willd.
Parietaria pennsylvanica Muhl.
Rumex altissimus Wood.
Polygonum lapathifolium L.
" punctatum Ell.
Phytolacca decandra L.
Claytonia virginica L.
Alsine media L.
Syndesmon thalictroides (L.) Hoff.
Ranunculus abortivus L.
" recurvatus Poir.
" hispidus Mx.
Thalictrum dioicum L.
" purpurascens L.
Caulophyllum thalictroides (L.) Mx.
Podophyllum peltatum L.
Sanguinaria canadensis L.
Barbarea barbarea (L.) MacM.
Roripa palustris (L.) Bess.
Cardamine purpurea (Torr.) Britt.
Bursa bursa pastoris (L.) Britt.
Camelina sativa (L.) Crantz.
Arabis hirsuta (L.) Scop.
" laevigata (Muhl.) Poir.
Fragaria virginiana Duches.
Potentilla monspeliensis L.
" canadensis L.
Geum canadense Jacq.
" virginianum L.
Cassia marylandica L.
Lathyrus palustris L.
Oxalis grandis Small.
" violacea L.
Euphorbia corollata L.
Impatiens biflora Walt.
Hypericum maculatum Walt.
" mutilum L.
Viola papilionacea Ph.
" pubescens Ait.
Samolus floribundus H. B. R.
Asclepias incarnata L.
Cuscuta gronovii Willd.
Phlox divaricata L.
Verbena urticifolia L.
" hastata L.
Scutellaria lateriflora L.
Glecoma hederacea L.
Prunella vulgaris L.
Monarda fistulosa L.
Blephilia hirsuta (Ph.) Torr.
Koellia virginiana (L.) MacM.
Mentha canadensis L.
Solanum carolinense L.
" dulcamara L.
Verbascum thapsus L.
Scrophularia marylandica L.
Chelone glabra L.
Veronica officinalis L.
" serpyllifolia L.
" peregrina L.
" arvensis L.
Afzelia macrophylla (Nutt.) Ktz.
Ruellia ciliosa Ph.
Plantago lanceolata L.
" major L.
Sanicula gregaria Bick.
" canadensis L.
" trifoliata Bick.
Washingtonia claytoni (Mx.) Britt.
Thaspium barbinode (Mx.) Nutt.
Pastinaca sativa L.
Galium aparine L.
" tinctorium L.
" claytoni Mx.
" asprellum Mx.
Valerianella radiata (L.) Dufr.
Campanula americana L.
Lobelia cardinalis L.
" syphilitica L.
Ambrosia trifida L.
Vernonia maxima Sm.
Eupatorium maculatum L.
" perfoliatum L.
" ageratoides L. f.
Solidago canadensis L.
Aster novae-angliae L.
" puniceus L.
" tradescanti L.
Erigeron philadelphicus L.
" annuus (L.) Pers.
Polymnia canadensis L.
Heliopsis scabra Duval.
Rudbeckia triloba L.
" speciosa Wend.
Bidens, cernua L.
" connata Muhl.
" trichosperma (Mx.) Britt.
Carduus discolor (Muhl.) Nutt.
" muticus (Mx.) Pers.
Taraxacum taraxacum (L.) Karst.
Lactuca canadensis L.

GENERAL CONSIDERATIONS.

That the plants around the lake are arranged in rather definite zones appears to be due to two general causes : first, because of the gradual change in the character of the substratum and other factors from one condition to another ; second, because certain plants are especially adapted to certain conditions and are thus able to hold their ground against invaiders from the outside. In an ordinary pond the successive modifications of the substratum occur in concentric belts and hence the succession of more or less perfect zones or belts of vegetation. Between each two contiguous zones there is a tension line where the struggle for existence among the opposing individuals becomes very severe. Each zone, therefore, has a fighting line on its inner and outer edge, while in the central part the struggle is only between plants of the community, both old and young, and such chance strangers which may be able to gain a foothold in the less densely populated areas. That many plants almost entirely restricted to a single zone can hold their own, either farther in or out, if once established is readily seen where normal conditions have been disturbed. There may thus be considerable difference in the result, depending on whether plants have had the opportunity of occupying a bare soil or whether they must contend for the soil already occupied by others. Certain species might hold their own indefinitely in a certain environment if once firmly established, while they might not be able to gain a foothold if the soil is already occupied by others.

The seven zones of Brush Lake are slowly traveling inward, as the lake is filling up with the wash from the surrounding hills. Each zone follows up its ideal environment and is crowded out on the outer margin by its next neighbor. The filling must have been quite slow and gradual in former times, but at present it is rather cataclysmic and will continue to be so in the future. There are therefore unusual disturbances in the progression of the zonal societies which have been alluded to above. The physiographic changes determine the changes in the zones. If these are gradual and slow in their progression the same will be true of the plant societies, but if the filling is sudden and large additions are made to the lake shore, in a comparatively short time the societies become disturbed and may make sudden advances without definitely occupying the intervening ground.

The final result of the filling of the lake and the progression of the zonal societies will be a moist mesophytic forest. Near Brush Lake there are many small swamps and ponds, in various stages of destruction, which show quite strikingly what the actual history with any given set of conditions will be. If the filling is slow and uniform, the final stage before the hydrophytic forest is a swamp, shrub society. In these swamps the same shrubs mentioned above as occurring in the shrub zone of Brush Lake are the predominant vegetation. Cephalanthus, various willows, dogwoods, and swamp roses take possession and these are followed by the silver maple, white elm, white and red ash, black and peach-leaf willow, and other trees.

There is an interesting extinct or nearly extinct pond about three-fourths of a mile north of Brush Lake on rather high ground in a small, unpastured forest. A ploughed field extends near one side which has evidently been responsible for some rapid filling in recent years. The fringe of hydrophytic shrubs is still near the margin and just outside of this is a young and very thick zone of white ash. The whole centre inside of the shrub zone is an open, flat, nearly circular area with a small depression in the centre about ten feet across. During dry seasons the water disappears entirely and the area is covered with rank moisture-loving weeds, while in a wet season it is covered with water several feet deep.

In the fall of 1902, Nymphaea advena Sol. was present in the small depression in the centre, although the leaves were mostly dry. No pond lilies were evident outside of this depression, although the area was carefully searched. Along with the Nymphaea and around it was an abundance of Polygonum punctatum Ell., and surrounding this was a dense growth of Polygonum hydropiperoides Mx. The last mentioned plant extended outward to the shrub zone. But at some distance from the centre the Polygonum was intersperced with very tall plants of Erechtites hieracifolia (L.) Raf. and other moist ground weeds as—

Echinochloa crus-galli (L.) Beauv.	Solanum nigrum L.
Panicum capillare L.	Ambrosia artemisiaefolia L.
Polygonum pennsylvanicum L.	Leptilon canadense (L.) Britt.
Phytolacca decandra L.	Carduus lanceolatus L.

The Phytolacca did not extend very far beyond the shrub zone. In and outside of the shrub zone, which was composed mainly of Cephalanthus, willows, dogwood and rose, there was an abundance of sedges belonging mainly to the species—

Carex lupulina Muhl.	Carex muskingumensis Schw.
" squarrosa L.	

As stated above, in and about this sedge society and extending down to the narrow shrub zone there is a remarkable zone of young saplings and seedlings of Fraxinus americana L., forming almost a continuous circle around the shallow bank of the filled pond. These trees have probably developed within recent years since the pond has practically become extinct. The forest zone just outside of the sapling zone is rather dry and mesophytic and consists of elms, ashes, cottonwoods, oaks, hickories, hackberries, dogwoods, etc.

In the spring of 1903 there was a partial reversion to former conditions. A long period of abundant rains had filled the dry basin, flooding even the shrub zone; and the surface of the pond was diversified by an abundance of the green leaves of Nymphaea advena Sol. One visiting this spot for the first time would never have dreamed of the moist-ground weed society which had covered the place eight months before. With the return of the water the pond lillies revived, although had the dry season continued for a year longer they would probably have mostly perished.

In this pond there will be an oscillation between hydrophyte and mesophyte societies for many years to come. But finally the last pond lily will disappear, having struggled not only against living enemies, but against the inevitable change in the physiographic conditions. The surface of the pond will then be rapidly covered by a mesophytic forest, if man does not overrule the orderly process of nature. At some distant day Brush Lake will be in the same condition as the dying pond and only the spade or drill will reveal the former existence of the present basin with its hydrophytic flora.

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Herms, W. B........................German Wallace College, Berea
Herrick, C. Judson.................................Granville
Herzer, H., *Paleonology*........................... Marietta
Hillig, Fred J.........................St. John's College, Toledo
Hine, J. S., *Entomology, Ornithology*..............O. S. U., Columbus
Hobbs, P. L., *Chemistry*........................... Cleveland
Hock, Lulu............................... Bowling Green
Holt, W. P., *Botany*................................. Toledo
Houk, Eliza P. T., *Chemistry*..........................Dayton
Hunt, Thomas F., *Agriculture*.......................Ithaca, N. Y.
James, C. B...........................Adeblert College, Cleveland
James, Davis, L....................127 W. Seventh St., Cincinnati
Janney, John J., *Horticulture*............93 Fifteenth Ave., Columbus
Jennings, O. E., *Botany*........Carnegie Museum Annex, Pittsburg, Pa.
Jones, Lynds, *Ornithology*.................College Museum, Oberlin
Judson, C. A., *Botany*................235 Columbus Ave., Sandusky
Keeler, Miss H. L., *Botany*..................93 Olive St., Cleveland
Kellerman, William A., *Botany*......175 W Eleventh Ave., Columbus
Kellerman, Mrs. W. A., *Botany*......175 W. Eleventh Ave., Columbus
Kiefer, R. J.. Attica
Landacre, F. L., *Zoology*.......................O. S. U., Columbus
Lazenby, Wm. R., *Horticulture, Botany*...........O. S. U., Columbus
Lindahl, Josua, *Zoology*............... 312 Broadway, Cincinnati
Lloyd, John Uri..................Court and Plum Sts., Cincinnati
Louth, E. V., *Botany*.............................Ashtabula
Mally, C. W., *Entomology*...............Grahamstown, South Africa
Masterman, E. E., *Zoology, Botany*....................New London
Mateer, H. N., *Biology*............................ Wooster
Mathews, Mary E.................................Painesville
McCoy, C. T., *Botany*.................317 E. Mulberry St., Lancaster
McElhinney, Frank B., *Botany*......................New London
McFadden, L. H., *Chemistry*....................... Westerville
MacKinnon, J. A., *Ornithology*.............................
..................care of Beecher, Peck & Lewis, Detroit, Mich.
Mead, Chas. S., *Zoology, Botany*...........217 King Ave., Columbus
Mercer, W. F., *Biology*....................Ohio University, Athens
Metcalf, Zeno P...................................Plympton
Mills, W. C., *Archaeology, Biology*................O. S. U., Columbus
Morse, Max W., *Zoology*..........600 W. 125th St., New York City
Moseley, E. L., *Zoology, Botany, Physiography* ....Sandusky
Nelles, Geo. T., ...U. S. Engraver's Office, Hickox Bldg., Cleveland
Newell, Wilmon, *Entomology*............Box 583, Shreveport, La.
Oberholser, H. C......1454 Sheridan Ave., N. W., Washington D,. C.
Odenbach, F. L., *Meteorology*...........St. Ignatius College, Cleveland
Osborn, Herbert, *Entomology, Zoology*...........O. S. U., Columbus
Osburn, Raymond C., *Zoology, Ichthiology*..510 W. 124th St., New York
Outhwaite, Joseph H, *U. S. Ordnance*................. Columbus

Oviatt, H. L., *General Science*.............................. Norwalk
Pallister, H. D.....................1128 Independence St., Cleveland
Parrott, P. J., *Entomology*.........................Geneva, N. Y.
Peppel, S. V., *Chemistry*............431 W. Main St., Louisville, Ky.
Pickel, Geo. J., *Chemistry*.............St. Ignatius College, Cleveland
Piwonka, Thomas.....................243 Superior St., Cleveland
Prosser, C. S., *Geology*.........................O. S. U., Columbus
Rhoades, W. R.,......................Gas Works, Springfield, Ill.
Rice, Edward L., *Zoology*............................. Delaware
Riddle, Lumina C., *Botany*.....................O. S. U., Columbus
Roudebush, Lowell................................. Owensville
Royer, John S., *Biology*.............247 N. Seventeenth St., Columbus
Sandres, J. G., *Entomology*, *Botany*..142 "A" St., N. E. Washington D.C.
Sanger, U. G., *Botany*.................................Newark
Schaffner, John H. *Botany*.....................O. S. U., Columbus
Seaton, Miss F.,....................103 Glen Park Place, Cleveland
Selby, A. D., *Botany*....................Experminet Sta., Wooster
Simkins, J. D., *Glacial Geology*..........................Newark
Slocum, Mrs. Belle......................Wayne Bldg., Toledo
Slocum, C. E.. Defiance
Smith, J. Warren, *Meteorology*...........Weather Bureau, Columbus
Snyder, F. D., *Zoology*, *Ethnology*.......................Ashtabula
Soule, William......................1804 S. Union Ave., Alliance
Stair, L. D...........................92 Wadena St., Cleveland
Sterki, Victor, *Conchology*, *Botany*................New Philadelphia
Stickney, M. E., *Botany*............................ Granville
Stockberger, W. W., *Botany*....Dept. Agricluture, Washington, D. C.
Stoner, Minnie A., *Domestic Science*.............O. S. U., Columbus
Surface, F. M., *Zoology*, *Botany*............................ Eaton
Sutton, J. G., *Physics*, *Geology*.......................Rushsylvania
Sweezey, Otto H................1019 Olaho Lane, Honolulu, Hawaii
Taylor, Albert.................................... Bedford
Thompson, Mrs. King................167 W. Tenth Ave., Columbus
Tillman, Miss Opal I., *Botany*..................O. S. U., Columbus
Tight, W. G., *Geology*.........................Albuquerque, N. M.
Todd, Joseph H., *Geology*, *Archaeology*.......Christmas Knoll, Wooster
True, H. L.....................................McConnelsville
Tyler, F. J., *Botany*.......Bureau of Plant Industry, Washington, D. C.
Van Nostrand, Miss N. A..............Lake Erie College, Painesville
Waite, F. C..................Western Reserve University, Cleveland
Walton, L. B., *Biology*............................. Gambier
Webb, R. J., *Botany*..............................Garrettsville
Webster, F. M., *Entomology*..U. S. Dept. Agriculture, Washington, D. C.
Wells, W. E., *Biology*................Antioch College, Yellow Springs
Werthner, William, *Botany*.............Steele High School, Dayton
Westgate, Lewis G., *Geology*.......................... Delaware
Wetzstein, A., *Botany*..............................St. Marys
Whetsel, J. A. G., *Botany*, *Zoology* ....Brooklyn, N. Y.
Whitney, W. C., *Biology*, *Geology*.......................Westerville
Williams, Stephen R., *Biology*...........Miami University, Oxford
Williamson, E. Bruce, *Ichthiology*, *Ornithology*.........Bluffton, Ind.
Wilkinson, E., *Botany*.............................. Mansfield
Wolfe, E. E., *Botany*....................Marietta College, Marietta
Wright, G. Frederick, *Geology*..........................Oberlin
York, Harlan H., *Botany*.....................O. S. U., Columbus

Total Membership, 158.

Report of the Fourteenth Annual Meeting

OF THE

Ohio State Academy of Science

ANNUAL MEETING

The fourteenth annual meeting of the Academy was held at Cleveland, Ohio, November 25 and 26, 1904, in the Biology Building of Adelbert College.

The Academy was called to order at 1:30 on Friday, November 25, by President E. L. Moseley. The President appointed a membership committee consisting of Professors Comstock, Edwards, and Landacre, after which the reports of officers were heard.

The minutes of the previous meeting were read and accepted.

The secretary reported a proposition submitted to the newly formed Mathematical Society to affiliate with the Academy. Circular letters were mailed to all the Academy members and to all the Teachers of Mathematics, Chemistry and Physics in the State setting forth what seemed to be the obvious advantages of such an affiliation and while the members of the Mathematical Society seemed favorably inclined to the proposition it was not discussed before the society and was referred to a committee and nothing further came of it.

The secretary also reported the work done by the Allied Educational Association of Ohio and the appointment of the Secretary as a member of Executive Board of said Association until the Academy could act on the invitiaton of the A. E. A. to participate in its midwinter meeting. After a discussion of this invitation on motion of Professor A. A. Wright it was referred to the newly elected Executive Committee with power to act.

On the presentation of the reports of the treasurer and Board of Trustees, Professor Waite and Professor Walton were appointed an Auditing Committee to report at the next business meeting.

The report of the Treasurer showed the total receipts to be for the year, $182.01 and the expenditures to be $117.16, leaving $64.85.

The following is a brief summary of the report submitted by the Treasurer:

REPORT OF THE TREASURER FOR THE YEAR 1904.

To The Ohio Academy of Sciences.

For the year since our last annual meeting the receipts including balance from last year have amounted to $182.01 and the expenditures to $117.16 leaving a cash balance on hand of $64.85.

Summarized these receipts and expenditures are as follows:

RECEIPTS.

Balance from last year	$ 21.92
Membership dues	155.00
Publications sold and miscellaneous receipts	5.09
Total	$182.01

DISBURSEMENTS.

Ohio Naturalist, 127 subscriptions, 50 cts. each	$ 63.50
Printing of Annual Report	27.00
Miscellaneous expenses, postage, printing, etc.	26.66
Balance on hand Nov. 25th, 1904	64.85
Total	$182.01

Respectfully submitted,

Herbert Osborn.

The report of the Board of Trustees showed the total receipts of the year to be $308.89 and the disbursements to be $194.00 leaving a balance in the treasury of $114.89.

The Board of Trustees reported that the annual contribution of Mr. Emerson McMillin of $250.00 to the research fund had been received.

The matter of enlarging the size and scope of the Program Committee so as to include five members, one for Zoology, one for Botany, one for Geology and Physiography, one for Anthropology and Archeology and Ethnology, and one for Chemistry, Physics and Mathematics, was discussed and a motion to that effect was introduced by Professor Walton but was referred to the next business meeting by the President with the request that it be handed in in writing.

On motion of Professor Osborn the business meeting was adjourned and after a recess of ten minutes the reading of papers was begun.

At 3:30 P. M. the Academy assembled to hear the President's address on the Formation of Sandusky Bay and Cedar Point.

This was followed by the paper by Professor Halstead on Mathematics and Biology. The Academy here adjourned to the Physics Building to hear the illustrated lecture by Professor D. C. Miller on Radium.

At 7 P. M. the Academy met in the Biological Building for the business meeting.

The Academy elected Dr. Lindahl, Professor Osborn and Professor Wright a Committee on Nomination to report at the last business meeting.

On motion of Dr. Lindahl the Secretary was instructed to communicate to Mr. Emerson McMillin a vote of thanks from the Academy for his generous support of the research work of the Academy.

On motion by Professor Osborn a vote of thanks was extended to Professor Miller for his illustrated lecture on Radium.

At 7:30 P. M. the Academy adjourned to the Physics Building to hear an illustrated lecture by Professor Herrick on the Building Habits and Home Life of Birds.

The Academy reconvened at 8:30 on November 26 for a short business meeting. The Program Committee reported that all authors offering titles had complied with the provision passed at the preceding annual meeting, namely "that no titles should be read before the Academy unless an abstract was in the hands of the committee" except Mrs. Houk and Professors Kellerman and Schaffner. The committee recommended that the first paper by Mrs. Houk be admitted to the program and the second be deferred to a later time and made no recommendation in regard to the papers of Professors Kellerman and Schaffner as they were not present. The reading of papers was then taken up.

At 11 A. M. after the reading of papers was finished the final business meeting of the Academy occurred in which Professor Walton's motion that the Program Committee consist of five members was discussed and passed. This makes the committee consist of one member for Zoology, one for Botany, one for Chemistry, Physics and Mathematics, one for Geology and Physiography, and one for Anthropology, Archeology and Ethnology, in the order named.

The report of the Committee on Nominations was presented by Dr. Lindahl and is as follows:

For President.............. PROF. HERBERT OSBORN
1st Vice President............ PRES. C. W. DABNEY
2nd Vice President........ PROF. F. M. COMSTOCK

Secretary	Prof. L. B. Walton
Treasurer	Prof. J. S. Hine
Exec. Com. Elec.	Prof. F. C. Waite Prof. S. R. Williams
Mem. B. of Trustees	Prof. C. J. Herrick
Pub. Com.	Prof. E. L. Rice

A communication was read from Dr. Lindahl of the Cincinnati Society of Natural History and one from Pres. Dabney of the University of Cincinnati inviting the Academy to hold their next annual meeting at the University of Cincinnati.

On motion of Professor Osborn the Academy accepted these invitations and agreed to meet in Cincinnati for the next annual meeting.

The Committee on Membership reported the following named persons elected by the Executive Committee:

Chas. W. Dabney, Chemistry	Cincinnati, Ohio
Leslie H. Ingham, Chemistry	Gambier, Ohio
Albert Taylor, Entomology	Cleveland, Ohio
David Gibbs, Entomology	Norwalk, Ohio
F. C. Waite, Anat. and Hist.	Cleveland, Ohio
W. F. Heilman, Phys. and Biol.	Columbus, Ohio
E. P. Durrant, Zoo. and Geo.	Westerville, Ohio
G. B. Halsted, Mathematics	Gambier, Ohio

The following were elected by the Academy on motion of the Membership Committee:

E. L. Fullmer, Biology	Berea, Ohio
E. B. Eisenhard, Phys. and Zoo.	Cleveland, Ohio
C. B. James, Zoology	Cleveland, Ohio
Miss N. A. VanNostrand, Chemistry	Painesville, Ohio
G. J. Pickel, Chemistry	Cleveland, Ohio
W. M. Gregory, Phys. and Geo.	Cleveland, Ohio
Harlan E. Hall, Natural History	Mansfield, Ohio

The Academy adjourned at 11:30 a. m.

PAPERS READ.

President's Address—The Formation of Sandusky Bay and Cedar Point	E. L. Moseley
Mathematics and Biology	George B. Halsted
Radium—(Illustrated	D. C. Miller
The Building Habits and Home Life of Birds (Illustrated from original photographs	Professor Francis H. Herrick
Episodes in the Development of Rocky River	A. A. Wright
Some Ohio Mammals	James S. Hine
Our Smallest Carnivore (Putorius Allegheniensis) with Exhibition of Specimen	A. A. Wright

A List of Isopoda from Ohio........................JOSUA LINDAHL
Report of Progress in the Study of the Hemiptera of the State.....
.... HERBERT OSBORN
A Land Planarian in Ohio............................L. B. WALTON
The Protozoa of Brush Lake...................MISS LUMINA C. RIDDLE
Actinolophus Minutus, a new Heliozoan, with a Review of the Species
Enumerated in the Genus........................L. B. WALTON
Report of Progress on the Survey of the Protozoa of Sandusky Bay
and Vicinity..................................F. L. LANDACRE
Note on the Rate of Growth in Stalked Infusoria.......F. L. LANDACRE
Mat Plants.................................JOHN H. SCHAFFNER
Plants with Nodding Tips......................JOHN H. SCHAFFNER
Annual Report on the State Herbarium with List of New Plants for
the Ohio Collection........W. A. KELLERMAN and H. A. GLEASON
Some Ecologic Studies of Ammophila and other Dune Plants of
Cedar Point...............W. A. KELLERMAN and C. F. BROWN
Second Report on the Flora of Cedar Point......................
............................W. A. KELLERMAN and H. H. YORK
Notes on the Culture of Rusts in 1904.........................
Mycologic Flora of Cedar Point...............................
Some Phases of the Priority Question in Mycologic Nomenclature..
....W. A. KELLERMAN

A meeting of the Academy was held at Columbus, Ohio, on Friday, December 30, at the Great Southern Hotel. At this meeting a paper was presented by Mr. J. C. Hambleton on "The Relative Value and Extent of Scientific and Literary Teaching in a High School Course." The discussion was opened by Mr. Boyd, and participated in by Messrs. Walton, Hall, Landacre, Misses Wilson, Riddle, Orton, and Dr. Dabney.

F. L. LANDACRE, *Secretary.*

PRESIDENT'S ADDRESS

Formation of Sandusky Bay and Cedar Point

E. L. MOSELEY

NORTHEAST GALES.

No wonder people talk about the weather! What else affects the fortunes of men so much? The night of June 28th, 1902, having decided to take an early train for Pittsburg and so not sleeping as well as usual, I listened to the rain beating against my east windows. Walking with rubber boots to the depot I found gutters overflowing, all the ditches between Sandusky and Cleveland carrying torrents of muddy water, and creeks swollen to the size of small rivers bearing on the load of sediment toward the bay and lake.

Others too had reason to remember that northeast storm. The water in the bay rose higher than for fifteen years before. Along the southwestern shore several acres of land were washed away. In Sandusky thousands of feet of lumber were washed off the docks. No boat ventured out of the bay.

In the lake the steamer Dunbar foundered southeast of Middle Island. Of the ten on board five took to the life raft and five to a yawl boat. The boat capsized and two of its occupants drowned. "The others, Captain Little, his wife, and daughter supported by life-preservers drifted about for several hours until they were borne to the vicinity of Kelley's Island," where they were rescued by the heroic efforts of Fred Dishinger, Sr., Fred Dishinger, Jr., and James Hamilton. The next morning a corpse was found on the beach less than two miles west of Huron and a little farther west on Cedar Point close to Rye Beach two more with a life raft bearing the word "Dunbar." On one was a watch still running and keeping nearly correct Eastern time!

On the east point of South Bass Island the waves piled up the gravel into a ridge which remains to this day. Along the east side of the Marblehead Sand Spit at the entrance to Sandusky Bay is a ridge supporting a growth of young willows and cottonwoods. It was probably formed at the same time.

"Not only is it true that the work accomplished in a few days during the height of the chief flood of the year is greater than all that is accomplished during the remainder of the year, but it may even be true that the effect of the maximum flood of the decade or generation or century surpasses the combined effect of all minor floods. In littoral transportation the great storm bears the same relation to the minor storm and to the fair weather breeze. The waves created by the great storm not only lift more detritus from each unit of the littoral zone, but they act upon a broader zone, and they are competent to move larger masses. The currents which accompany them are correspondingly rapid and carry forward the augmented shore drift at an accelerated rate."—Gilbert.

The greatest storms of the past century or those which were most effective because occurring at time of highest water were those of 1857–1862.

The water covered the land where the Sandusky Tool Factory stands and the street adjacent so that the workmen went to the building, then a saw mill, in row boats. It flooded the cellars on the south side of Railroad Street. The part of the city near the end of First Street and east of it was under water. These storms damaged the bridge across Sandusky Bay and the railroad near Port Clinton. Along miles and miles of shore and over hundreds of acres of lowland they killed trees that had stood for centuries. They cut away large slices of Eagle Island at the head of the bay and the last remnant of Spit Island at the mouth of the bay. They cut through the land west of Port Clinton giving an outlet for the Portage River about one-fourth mile farther west than before, but the breach was afterwards closed by the L. S. & M. S. R. R. Co. They built up on the northeast shore of Cedar Point long sand ridges twelve feet high on which hundreds of cottonwoods have since grown to a height of fifty or sixty feet.

The preceding statements may suffice to illustrate the sort of changes effected by northeast gales but those who have seen Lake Erie only when it is calm or stirred by winds of moderate force will be further impressed with its power by a brief notice of particular storms which are remembered by old residents or noted in the journal of the weather observer.

The northeast storms of 1857–1862 are said to have been more frequent and usually of longer duration than those of late years. Regarding this point a number of old residents agree and they are probably not mistaken, for the records of rainfall at the stations in this part of the country where records were kept so early show that the precipitation of 1857 and 1858 has not been equalled since.

Captain Freyensee and Mr. Haas, then in charge of the Swan, are sure that the water became exceedingly high in August, 1857, during a thunderstorm accompanied by a violent wind from the northeast. They think this was the highest water ever een at Sandusky. It was, however, of short duration, coming up early in the afternoon and falling during the night.

Captain Magle, then in command of the schooner H. C. Post, recalls a storm August 11, 1859, as occasioning the highest water he ever saw in Sandusky Bay.

Several persons have told me of a great storm in August, 1861. Northeast gales may have been more violent at other times, but this one coming when the water was already high and lasting several days was probably in its effect the greatest storm of the century. East of where the water works are now located it lifted the railroad track from its bed, and pushed it, in places, twenty feet away. At the foot of Columbus Avenue the dock was about a foot lower than now and did not extend so far north. A track then ran onto the dock from a turn-table south of it. In this storm water covered the dock and a great sea struck two empty cars that had been standing there with such force as to move them along the track and cause them to fall into the tu n-pit.

This storm washed away the steamer dock at Kelley's Island. The water went over the dock at Put-in-Bay, so that no landing could be made. The water has probably never reached so high a stage since.

Allan Winters recalls a northeaster in the spring of 1860, a greater one in the spring of 1861, but the greatest of all that of August, 1861.

Captain Haas remembers a great northeaster in 1862. There appear to have been none especially memorable in the spring of 1859 but the water was then so high that northeast gales not regarded at the time as extraordinary produced changes in the shores of considerable importance.

The Sandusky station of the U. S. Weather Bureau was established in 1877. In the next few years several northeast storms occurred more violent than any in recent years.

September 11, 1878, a gale began at five A. M. continuing until 5:45 P. M., Sept. 13, direction northeast and north backing to northwest in the afternoon of the 13th. Maximum velocity Sept. 11, thirty-four miles northeast; Sept. 12, forty-eight miles northeast; Sept. 13, fourty-four miles northeast. Total wind movement in twenty-four hours ending at noon Sept. 13, nine hundred and one miles. Unusually heavy rain on night of the 12th. Twenty-seven steamers, "Among them the largest propellers on the lake" and sailing vessels anchored behind Kelley's Island.

July 11, 1879, a gale began at 10:15 A. M. and ended at 3:10 P. M. both direction and velocity quite variable. A lull from

2:40 to 2:45 was followed by "a storm of wind and rain whose fury was almost indescribable, though fortunately of short duration, the wind reaching a velocity of sixty-nine miles from the north while the rain came down in such a deluge that one could not see two feet from the window, the thunder and lightning being appalling. The wind for ten minutes or from 2:45 P. M. to 2:55 P. M. reached and maintained a velocity of seventy-two miles per hour. At least 2.25 inches of rain fell during the fifteen minutes that the storm raged so violently. Heavy seas were dashed over railroad cars standing at least fifty feet from the water. At least one hundred chimneys were blown down."—From journal of Sandusky Weather Bureau Office. Some of these statements may be exaggerated as others in the journal, but not quoted, certainly are.

August 15, 1879, a severe northeast gale set in at 12:30 P. M., the velocity ranging from thirty to forty miles that day, but from midnight till six A. M., August 16, averaging forty-eight miles and attaining a maximum of fifty-nine miles at 3:30 A. M. In the afternoon of August 16, the direction was north and the gale ended with a velocity of twenty-five miles at 5:10 P. M. It caused very high seas and damaged several boats in the lake, no vessels of any kind entered or left the bay after the storm began. The total wind movement in twenty-four hours ending at noon August 16th, was nine hundred and fourteen miles. This and the average of forty-eight miles per hour for six hours are, I believe, unsurpassed in the records of the Sandusky office, while the maximum of fifty-nine miles has been surpassed but three times, viz., in the brief storm of July 11th, already mentioned; in a squall, August 9, 1885, sixty-three miles, northeast; and the following:

Jan. 31, 1881, a gale from the northeast began at 7:30 A. M., reaching its height, sixty-four miles northeast, at 9:35 A. M., Feb. 1st, and ending at 5:30 P. M. "The storm was one of the most severe known in these parts, the wind average forty-two miles per hour for eighteen hours; no extensive damage done." The water that winter was too low to be raised to an extraordinary height even by such a gale.

The highest water in Sandusky Bay since 1862 occurred April 23, 1882. The northeast gale began at 10:15 A. M. April 22, and continued till 4:30 P. M. April 23, the maximum, forty-four miles, occurring at 2:15 A. M. It averaged 32 5-12 miles per hour for twenty-four hours. The bay flooded everything on Railroad Street from one end to the other. At Marblehead a dock was washed away and three others damaged. The schooner Gallatin was wrecked about two miles from Pelee Island. Thirty vessels took shelter behind Kelley's Island.

The effect of some of these same storms in producing lasting changes on Cedar Point and elsewhere about the bay will be mentioned in subsequent chapters. Storms of much less violence than these seem awful to those who are on the lake at the time. On May 31st, 1903, the water striking the Ohlemacher dock on Marblehead was dashed so high that people at a distance could see it over the tops of the limekilns and on another occasion Alex R. Clemons estimates that the spray went more than fifty feet above the top of this high dock. In front of the large stone house which stands near the lake in Marblehead village a piece of limestone estimated to weigh two and one-half tons was broken loose from the bed rock and moved along shore twenty-seven feet by a single storm. Looking from this place Mr. Clemons has counted as many as seven wrecks, all in sight at one time.

EFFECT OF TILTING OF THE LAND.

LAKE BEACHES.

When the glacier had retreated beyond the northern boundary of Ohio a lake extended along the southern border of the ice. The south shore of this lake was at first about twenty miles south of where Sandusky now is. Its western extremity was at Fort Wayne, Indiana, whence the water flowed to Huntington and via the Wabash and Mississippi to the gulf. As the ice melted from the southern part of Michigan, outlets were formed into the Grand River valley through which the water flowed to another glacial lake occupying the southern part of the basin of Lake Michigan and thence toward the Mississippi through the depression now utilized for the Chicago drainage canal. The later outlets were lower than the earlier ones and consequently the lake level fell and each time it fell its southern shore came nearer Sandusky. Each position of the shore is marked by a beach. The highest beach extends from Fort Wayne through Van Wert, Tiffin, Pontiac, the southern part of Norwalk and Berlin Heights, from there on east continuing only a few miles from Lake Erie. The middle beach extends through Bellevue, Monroeville, the main street of Norwalk, Berlin Heights and Elyria. The lowest beach passes through Clyde, south of Milan through Berlin Heights and along Euclid Avenue, Cleveland, through northwestern Pennsylvania and western New York.

Each beach, when formed, must have been approximately level as it followed the shore of a lake. But they are no longer level. Leverett has found that the lowest one is 168 feet higher at Crittenden, N. Y., than at Cleveland, showing that the land between these places has been tilted to that extent. Old beaches near the other Great Lakes indicate that the whole region has undergone tilting.

GILBERT'S RESEARCHES.

Whether this tilting is still going on or ceased long ago does not appear from an examination of these old beaches. In 1895 Mr. G. K. Gilbert found evidence that it was still continuing. By comparing the heights above the normal lake level of a bench-mark in Cleveland and one at the head of the Welland Canal with the heights of the same as carefully determined in 1858, it appeared that the land near the northeast end of the lake had risen as compared with Cleveland. In like manner he found that tilting was still going on in the region of Lake Ontario and Lake Huron and Michigan.

DEEPENING OF THE WATER.

Inasmuch as the tilting produces a rise of the land toward the northeast as compared with that toward the southwest it is elevating the point of outlet of Lake Erie as compared with the rest of the lake. As the lake is continually receiving water through the Detroit River and other sources the elevation of the point of outflow raises the level of the water throughout the entire basin.

In 1860, H. A. Winters now living in Sandusky, had occasion to visit Eagle Island many times. In a pond too deep for hip boots, but which he crossed with his boat, was a walnut stump whose sapwood had rotted away. The heartwood about four feet in diameter was still well preserved and showed that it had been neatly chopped off. Alvin Fox told him that he had helped to chop the tree in 1828, when the land about it was all dry. Through the summer of 1860 the stump stood in about two feet of water.

According to J. W. Lockwood, who lives on the north side of Sandusky Bay near the Plaster Beds, a man named Craighill cut an oak supposed to be two hundred or three hundred years old about 1823 or 1824 on what was then a dry prairie but where there has been a marsh ever since. This marsh borders what is known as West Harbor in the peninsula north of Sandusky Bay.

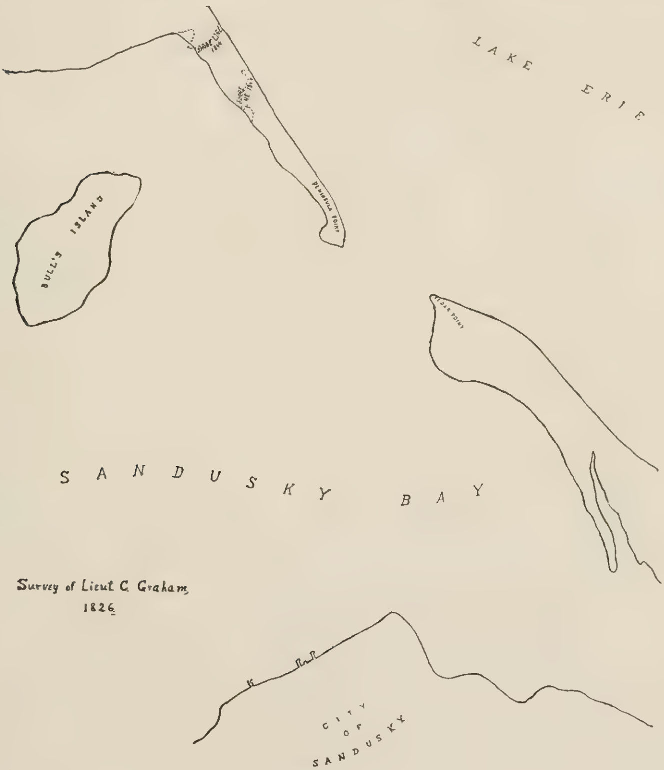
These observations and many others made it clear that the water had deepened but in view of the fluctuations produced by rainfall and the lack of early records of rainfall they did not afford a means of calculating with any degree of accuracy how fast the deepening would progress if the rainfall remained uniform. Not until the fall of 1904 was any means discovered of making such a calculation. It came from studying the parallel ridges which traverse the terminal portion of the Cedar Point peninsula. These have been built up by great northeast storms and the approximate age of each of the principal ones has been determined from the vegetation upon it. The older ones are lower than those formed in the past century. By dividing the difference in height between the highest aqueous deposits in two ridges by the number of centuries intervening between their formation I have obtained the average number of feet the water has risen each century. It is about 2.14. A detailed description of these ridges is given in the part of the paper dealing with Cedar Point.

EFFECT OF VARIATION IN THE RAINFALL.

The deepening of the water produced by tilting of the lake basin has not been noticeable within the past half century because of greater fluctuations produced by variations in the rainfall. Those who recall the high water of 1858 to 1862 know that it has not been so high since. Moreover in 1894 and 1895 it was lower than they had ever seen it before, unless their observations began before the middle of the century. These facts seemed to disprove the theory that the water is gradually getting deeper. In an article in the National Geographic Magazine for August, 1903, I showed that, since 1870, when the Weather Bureau established stations about the Great Lakes, there has been a very close correspondence between rainfall and lake level. When the rainfall is above normal the lake rises, and when below normal it falls, whether we consider particular years, parts of years or periods of years. More recently I have learned that at the places in this part of the country where a record of rainfall was kept as early as 1857 the rain that year or the next was very heavy. Bulletin C., U. S. Weather Bureau, gives the rainfall of the United States from the earliest records to the end of 1891. In it are twenty-two places within one hundred miles of the Great Lakes that have a record for the year 1858. From data in this bulletin I have made the table, which includes besides these, St. Louis, Peoria and Marietta, although they are somewhat farther away. In fourteen of the twenty-five places the maximum rainfall for the whole period of record—in one instance seventy-one years—was in 1857 or 1858. In most of the other places the rainfall of 1857 or 1858 has been exceeded not more than three times. No wonder there was high water in 1858 with such precipitation as that. If the table were brought down to 1901, the years given above would still stand pre-eminent, for the rainfall from 1891 to 1901 was generally light—lighter in 1895 when the lake was also lowest than in any other year since the Weather Bureau was established.

Town	State	Years in record	No. of yrs. surpassing 1857 & '58	Maximum Rainfall	Year
St. Louis........	Mo.	55	0	68.8	1858
Aurora..........	Ill...	16	0	47.4	1858
Ottawa.........	"	18	0	47.2	1858
Peoria..........	"	36	0	53.4	1858
Winnebago......	"	14	0	45.2	1858
Marengo........	"	39	1	56.9	1851
Janesville.......	Wis.	5	0	42.6	1858
Milwaukee.......	"	48	2	50.4	1876
Marquette.......	Mich.	29	5	42.9	1881
Grand Rapids....	"	11	2	51.9	1855
Bellefontaine....	Ohio	13	0	54.1	1858
Cleveland.......	"	36	4	53.6	1878
Marietta........	"	71	0	61.9	1858
New Lisbon.....	"	10	1	47.1	1866
Steubenville.....	"	19	0	55.1	1857
Buffalo.........	N. Y.	34	9	60.3	1878
Cooperstown.....	"	38	1	58.1	1890
Geneva.........	"	25	0	42.6	1857
Hamilton.......	"	20	0	61.9	1857
Lowville........	"	24	0	47.3	1857
Mexico..........	"	21	0	57.3	1857
Palermo.........	"	38	8	51.3	1859
Penn Yan.......	"	52	0	44.4	1857
Pierrepont Manor	"	21	3	50.7	1866
Rochester.......	"	57	3	48.7	1878

December 28, 1904, the wind having blown from the southwest all night with velocity between twenty and twenty-five miles an hour, the water in the bay was 4.1 feet below the zero of the gauge, which represents approximately the mean lake level from 1861-1895. Continuous gauge readings have not been kept at Sandusky except for short periods, but men whose business has been on the docks for more than twenty years said this was the lowest water they could remember. The high water in the northeaster of June 29, 1902, which was the highest for fifteen and perhaps for twenty years, is said to have reached nearly to the top of H. C. Post and Company's dock. December 28, 1904, I found the water seven feet, eight inches below the top of this dock, so that the difference was not far from seven



Map I.

and a half feet. Only about half a foot of this was due to difference in the stage of water preceding the storms, about three feet to the southwest wind and the remainder to the northeast wind. The maximum wind velocity in the northeaster of June 29, 1902, was only thirty miles. In 1888 the anemometer of the U. S. Weather Bureau office at Sandusky was removed from the West House to the government building which is lower and not so near the bay, causing considerable decrease in the total wind movement registered, so a satisfactory comparison of wind velocity in the later and earlier storms cannot be made. In the great storm of April 23, 1882, the water was probably more than a foot and a half higher than on June 29, 1902. This I infer from information furnished by men at the docks. The record of gage readings at Cleveland shows the stage of water to have been about a foot and a half higher at the time of the earlier storm so that the wind effect may have been nearly as great in the later one.

Only once in several years is the water at Sandusky raised or lowered from its normal level so much as three feet by the wind, while a change of four feet must be very rare. At Cleveland the change of level due to the wind is generally less than a foot, while at each end of the lake in extreme cases it is six or seven feet.

The fluctuations in level of Lake Erie due to changes in the amount of water received and lost in a single year are never much more than two feet, and in some decades do not exceed two and a half feet.

LAND LOST IN A SINGLE CENTURY.

PENINSULA POINT.

Map I, taken from a U. S. Government Chart shows Peninsula Point as it was in 1826. The distance between it and Cedar Point was about 3,000 feet but the water off the end of Peninsula Point was so shallow that when lowered by drouth and wind the distance from point to point was much less. H. A. Lyman, the old lighthouse keeper, told me he had seen the water so low that he thought the distance across was only about 300 feet. The Indians used to swim their ponies across and B. F. Dwelle, who lived until 1902, and many others of the early settlers on the Marblehead peninsula crossed in the same way. Cattle raised on the peninsula were driven to market this way, but not after 1830.

L.H.
Port Clinton
PORTAGE
Plaster Beds
Shore Line 1820
BAY
Shore Line 1820
Eagle Is
SANDUSKY
Winous Point
Mud Creek Bay
Sandusky River
Raccoon Creek
Pickerel Creek
Shore Line 1820
Willow Point
ERIE CO
SANDUSKY CO.
Martins Point
Presqueisle Bay
Bridge
Venice
Hartshorn
Sand Spit
Johnsons Id.
BAY
LAKE ERIE
Cedar Point
Ridges
Dunes
Sandusky
Pipe Creek
Marsh
Bar
580'
580'
Rye Beach
RILEY
TOWNSEND
MARGARETTA
PERKINS
HURON

Map II.

Some of the sand dunes near the south end of Peninsula Point were nearly as high, Mr. Lyman said, as the highest on Cedar Point. Three other persons recall their height as twenty feet or considerably more. Along the west side was clay covered with black soil several inches deep. The trees were not willows and cottonwoods alone, as on Marblehead bar which has since formed farther west, but white oak 2½ feet in diameter, red oak, shell bark hickory, ash, elm, buttonwood, basswood and red cedar. Mr. Lyman wrote me: "quite as large timber on it as there is on Cedar Point, viz., sycamore and oak." At one time there was an orchard.

Before 1834 the lake had made an opening through the northern end, after which it was known as Spit Island. The government spent "$40,000" in trying to save it. A large boarding house was erected for the workmen who built a crib along the whole length of the lake side. But in spite of efforts to protect it from the waves, it was worn away at both ends and the last remnant disappeared in the high water of about 1860.

EAGLE ISLAND AND SQUAW ISLAND.

In 1820, when the first survey was made Eagle Island in the western part of the bay (see Map II) contained 134.42 acres.

There are now, 1904, two remnants which together contain less than two acres. The western one of these as seen from the Steamer Hayes Aug. 30, 1904, appeared to be entirely marsh. The island being located where the waves of the bay attain considerable force has suffered from every northeast storm, those of 1858–'62 dealing it some severe blows.

Miles Pearson told me that his mother, who was born in 1809, when a girl used to walk to the island from the south, crossing a channel on a plank, or in dry times stepping across. At that time the cattle used to go there to graze. Porter Wright told me that he walked to the Island and could have ridden a horse all the way; there was no danger of miring. He remembers when it had more than a hundred eagles' nests and it was unsafe, after the eaglets were out of the nests and on the ground, for a man to cross the island without carrying a club. Eagles' nests were also numerous on the neighboring mainland.

Squaw Island at the mouth of the Sandusky River, throughout the early part of the century was connected with the peninsula to the west, which was much wider than now. As late as 1855 it was separated merely by a channel for small boats. In 1873 the channel had widened to 230 feet, and in 1904 it was about 600 feet. It is said that the Indians used to swim their ponies from Peach Island to Squaw Island and then ride along the north bank of the river to Fremont.

Recession of the Bay Shore.

Map II shows the present shore line taken from the topographic sheets of the U. S. Geological Survey except the northeast portion, the sheet for which has not yet been issued. The broken line shows a portion of the shore as it was at the time of the first surveys 1809–1820. In quite a number of places lines running from section lines to the bay shore whose length is recorded in the original surveys have been remeasured in recent years by local surveyors or by myself and these data, as well as a comparison of the old plats with the recent maps published by the U. S. Geological Survey, have enabled me to estimate the amount of land lost. The greatest change has been along the south shore from Martin's Point west. Here the bay is wider than farther east and as erosion is accomplished mostly by the northeast storms, which raise the level of the water, the waves beat upon this shore with greater force than on the shore opposite. The west line of section 34 Portage Annexation, northwest extremity of Erie county I found in 1904 had shortened about 66 rods since the first survey. The middle line of the west half of section 35 Charles Judson found in 1895 had shortened 62 rods. At other places the change shown by surveys is not so great. However, the survey by Sylvanus Bourne, 1820, of Township VI North, Range XVI East 1st Meridian, at the west end of the bay, gives no measurements for the portion lying south of Mud Creek Bay and the shore line in this part of the township is not correctly drawn on his plat. Porter Wright who has owned much of the land in this region told me in 1904 that the whole west shore of the bay south from Eagle Island had washed away as much as eighty rods within his remembrance. He is seventy years old. At Dudrow's in Townsend Township he knows the recession of the shore is more than that. Miles Pearson thinks 100 rods of land north of the mouth of Raccoon Creek has washed away in the last fifty years and 60 rods between Raccoon Creek and Pickerel Creek in the same time. These estimates H. A. Winters who also has long been familiar with the region considers not too high.

At five places on the south shore of the western half of the bay, according to estimates of the several land owners, encroachment of the water has been from three to six rods in as many years, most of it in the last three years, because the water has been high. For seven or eight years preceding the last three there was hardly any encroachment in some of the places. In the western extremity of Erie county, where the road turns south, I found the bay eating it away, Sept. 2, 1904. The old plat shows the nearest part of the shore 49 rods away. Charles W. White estimates that the shore was 15 or 20 rods farther north about twenty-five years ago. Just west of this the northwest quarter of section four, Townsend, contained:

1820		122.21	Acres.
1886	about	80	"
1890	"	70	"
1904	"	65	"

About an acre of this farm, i. e., a strip a rod wide, disappeared in the storm of June 29, 1902, already referred to and another acre in a northeaster the latter part of March, 1903.

The whole north shore of the bay from the mouth of the river nearly or quite to the bay bridge has receded since 1820, but less than twenty rods in most places. The west line of Section 4 Danbury township is given in the original survey, Wright and Mulhall's, as fifty-seven chains. In 1904 I found it to be but 47.11 chains, showing a loss of nearly forty rods. The shore line in their time was probably near where Presque Isle is now. South of section 9, Portage Township, were 21.42 acres of school land according to the survey of P. F. Kellogg, 1820. Only three acres of this now remain, but some forty rods south of the present shore may still be seen at time of low water the remains of a chimney marking the site of a house. J. W. Lockwood remembers being there about 1835 when there was quite a yard between the house and bay.

Between Venice and the western part of Sandusky the shore has receded about twenty rods.

The amount of land replaced by open water since 1820 may be roughly estimated as 2⅔ square miles, without counting any west of Eagle Island. The amount converted into marsh, including the marshes west of Eagle Island, is probably eight or ten square miles so that the total loss of land about Sandusky Bay may be as much as twelve square miles.

MARSHES.

The recession of the shore line has been due both to erosion and higher water, the formation of marshes to the latter cause alone. The greatest change has occurred at the head of the bay. Seen from the deck of the Steamer Hayes, August 30, 1904, when about half a mile west of Winous Point, the marsh and open water appeared to extend three miles or more from north to south. A great part of this was dry land during the early part of the 19th century, but how large a part it seems impossible to ascertain. A plat of the region giving the results of a survey completed in 1893 by Edgar Brennan, C. E., distinguishes tillable land, including woods, from marsh. By inspecting this map and making a rough estimate of the percentage of tillable land in each section, I conclude that in the sections, Nos. 21, 22, 23, 26, 27, 28, 34 and 35, the total amount is not more than half a section. From the plat of Bourne's survey of 1820 it would appear that these eight sections then contained about 5½ sections of land. Part of this is now open water, part of it marsh. In several other sections of Bay township a good deal of marsh has formed within the past century. Porter Wright who went there in 1836 remembers that section 35, now nearly all marsh, used to be dry land. In section 2 of Riley township he owns 200 acres of marsh which formerly was dry land. Mulberry stumps are still standing there where now the water stands half the time. He estimates that more than a thousand acres of marsh south of Graveyard Island used to be dry land except after heavy rain. "Honey locust, elm and poplar used to grow over a good deal of the land where the water now (1904) is 2½ feet deep. All the way from the bay to Peach Island was good dry land, mostly prairie; there was a streak of timber half or three quarters of a mile south of the river, some of it still standing on the highest ground. All the marsh from Raccoon Creek to South Creek was prairie land covered with blue joint and hoop pole grass (Spartina cynosuroides), a grass seven or eight feet tall which does not grow where it is wet. The region between South Creek and Green Creek is now marsh, but when I came here it was mostly dry land."

The total amount of land west of Eagle Island converted into marsh or open water since 1820 is probably six or eight square miles. In Margaretta Township, Erie County, the recent topographic map shows about 1⅔ square miles of marsh. Most of this was probably above lake level until after 1820. On the north side of the bay the marshes are less extensive.

At the east end of the bay the marsh that extends from the mouth of Pipe Creek to Rye Beach has spread over considerable of the low land along its inner margin within the past century. Two miles east of Perkins Township the late Albert Judson, county surveyor, found the line originally run by Almon Ruggles and supposed to mark the border of the land at the time of the early survey, to cross the marsh about half a mile out from the present margin of the land, the water and mud over the intervening region being a foot to 18 inches deep. This was in 1887. A lot, half a mile square, had been converted into marsh. Between this and the Perkins Township line the recession of the shore line he found to be very much less. Walter Devlin says, cattle used to go out half a mile toward Cedar Point farther than now and find pasture and places to lie down, though they had to wade through perhaps a foot of water near the hard ground from which they started, where the water was deeper than farther out.

WHAT THE WATER HAS COVERED.

SUBMERGED HUMAN REMAINS.

Squaw Island at the present mouth of Sandusky River rises two feet or a little more above mean lake level. The soil is sandy and probably alluvial. Graves have been found in all parts of the island including parts washed away in recent years. In some of these the bones were below the present water level. On August 27, 1904, I visited this island with John Fitzgerald, keeper of the Winous Point Club House, who had often found bones there. A cottonwood fifteen inches in diameter whose roots had been loosened by the high water had fallen on the land the year before, and had earth still clinging to its upturned roots. Imbedded in this earth I found a molar, a rib and two cervical vertebræ, all human, also fragments of Indian pottery. All of these must have been beneath the water, probably a foot or more below the level of August, 1904. A few yards from this cottonwood another had fallen from the same cause and lay parallel to the first, its diameter about thirty inches. In the earth brought up by its roots Mr. Fitzgerald had seen human leg bones, which before the tree was uprooted must have been below the water a foot or so. That these graves on Squaw Island are not very ancient may be inferred from the fact that in one of them was found a silver gorget on which is engraved the lily of France. This is now owned by Charles Sadler of Sandusky.

The early French settlers about the head of the bay used to bury their dead on Eagle Island, which at the time was probably part of the mainland. Some thirty years ago the graves had been washed out and skulls still sound and other bones in great numbers lay on the beach.

Graveyard Island where the "French" or "British in 1812" buried their dead has been almost if not completely submerged at times of very high water.

On the north shore of the bay east of Hartshorn's dock, on land owned by Mary Cook, a grave was found in 1903 close to shore. There was a tradition among the old residents of the peninsula that at this point an Indian burying ground had once extended out where the bay is now.

At the northeast corner of the city of Sandusky, near the ship yard, copper kettles and Indian trinkets were washed out by the high water of 1858.

Graves of some of the early white residents of Sandusky just west of Ilg's brewery were opened by the waves so that coffins stuck out of the bank and bones fell out 1850-'52.

SUBMERGED FORESTS.

Persons who came to Erie county in the forties remember seeing about the marshes connected with the bay many dead trees which they believed had been killed by high water, as the trees were standing where it was too wet for such trees to grow. Allen Remington, who came in 1839, saw great numbers of dead trees that had been recently killed by high water standing where there is now marsh in the eastern part of Sandusky Bay. Lake Erie in 1838 reached a higher level than ever before. Many trees were killed also by the high water of 1858–62. George Hinde, who owned a large tract of land in the northeast corner of Perkins Township, Erie County, had hickory trees two feet in diameter killed at that time. In the northwest corner of Huron Township eighty acres or more from a tract of 213 owned by Walter Devlin had become marsh by 1904. On a good deal of this were walnut trees.

J. W. McGookey, who lives in Margaretta Township, Portage Annexation, says: "About 1858–'62 large trees of oak, elm, and many other kinds were killed by water standing over their roots, along all the farms near his place and on the school lands in the northwestern part of the township. Many other forest trees were washed into the bay, as was also an orchard north of the land now owned by Lewis Neill."

Jonas Pearson of Vickery, informs me that in or near the northeast corner of Riley Township, Sandusky County, sixty acres of timber, hickory, oak and ash, were killed a number of years ago when the water came up and stayed up several years. Porter Wright told me that in section 36, Riley Township, on land he formerly owned, oak, hickory and large elms were killed by high water at about the time of the Civil War. Also on land he still owns in sections 35 and 36, well back from the bay shore, all the biggest and best ash, oak, elm, and hickory, many of them he thinks two hundred years old, were killed at the same time. He never saw elsewhere such a heavy growth of timber as on Graveyard Island and Eagle Island. It was principally honey locust. In 1860 Allan Winters rowed his boat among the standing trees at the head of the bay. He says a hundred acres or more of them were killed by high water at that time. His observations were chiefly north of the river and so refer to different sections from those mentioned by Wright or Pearson.

In the part of the bay north of Townsend Township abundant remains of a prostrate forest extend out half a mile from the present shore, according to J. W. Lockwood, who found them so close together as to make it difficult to steer a scow among them. Later J. G. Yeckley, who lives near, confirmed the statement that trunks with roots attached extend out half a mile from the present shore. He took from the water some five hundred trees still quite sound, using them for posts. They were mostly oak and hickory, though others got out a few of walnut. The main object in removing the timber was to clear the bottom so as to permit the hauling of seines. He spent parts of three years in this work.

In the marshes east of Sandusky I found in March, 1898, a number of prostrate trunks with roots extending down some distance so that I thought they must have grown there before the land had been converted into a marsh. A number of these were sixty rods or more from the present shore of the marsh. From the shallower part of the marsh nearer shore I was informed that in a dry season hundreds of walnut trunks had been removed for timber, and that a number of walnut stumps were still standing where the ground was too wet for trees of that kind.

"In tracing the west line of Huron Township across the marsh in 1885 it was found that the original survey made about 1810, referred to trees standing at different places where for many years past has been only marsh."—Ed. Hinde.

Hunters in pushing their skiffs through the marsh often strike submerged timber with their setting poles. Besides walnut I found basswood, cedar, pine, beech, and sassafras, but it is not certain that all of these grew near where they now lie. Planks have been found two or three feet below the surface of the marsh. The floods of 1858–'61 carried not only these but many trees that had been uprooted. All that had been growing on Cedar Point between the Carrying Ground and the vicintiy of Rye Beach were swept off into the marsh. These have perhaps all rotted since, but others of kinds more enduring that grew along the Huron River or other streams may have been carried into the lake by the freshets of that time and washed over the Cedar Point bar by the northeast storms.

Cedar stumps still standing where the trees grew have been found in several places about the bay, their roots and in some instances their tops below the water level. Sept. 11, 1904, the high water of the summer having washed away a portion of Rosebush Point (near the end of Cedar Point) I noticed a number of stumps, cedars and others, with roots at or below water level. A root of one of the cedars was fourteen feet long. Nov. 19 when I was on another part of Cedar Point the dredge at work near the south end of the lagoon between ridges No. 2 and 3 brought up a cedar stump whose roots the men said must have been two or three feet below water level. The water at the gage at the time was about .6° below 0. They had previously found in the work on the lagoon three or four cedar stumps below water level, the roots two or three feet below.

In 1894 or 1895, Chas. Dildyne saw several cedar stumps in a group west of the Black Channel and not far from its mouth. They had been cut with an axe but their tops are below water except in very dry times. Three other persons have told me of seeing these same stumps or some in the same vicinity.

In 1894 and 1895 William Hertlein worked a piece of land between Venice and Bay Bridge, which other years has been covered with water. He found many cedar stumps still in place, The muck was three or four feet deep but the cedar roots were, partly at least, in the clay underlying it. The water in May, 1904, he said was as much as three feet above the uppermost roots.

Submerged Marl Beds.

The marl used by the Sandusky Portland Cement Works at Bay Bridge was formed from calcareous springwater probably above lake level. The greater part of the two hundred thousand tons used for cement has been taken from below mean lake level, the bottom of the deposit being about five feet below.

At Willow Point a gravel beach half a mile long several rods wide and rising two or three feet above mean lake level has been formed of pebbles most of which are calcareous tufa. The marsh back of the beach rests upon clay and contains no tufa. The pebbles must have been derived from tufa beds that formerly existed where the bay now is, but at what level cannot be told.

SUBMERGED VALLEYS AND THE BOTTOM OF THE BAY.

The possibility of tracing the valleys of streams through the bay occurred to me in 1898 while gathering data in regard to submerged timber in the marsh east of Sandusky. A hunter who had often pushed a boat through the marsh told me that along a line extending out from the mouth of Plum Brook a setting-pole would go down through the mud about 12 feet whereas on either side it struck hard bottom at two or three feet. A fisherman of whom I enquired regarding the character of the bottom of the bay told me that in setting stakes for his nets west of Johnson's Island he had found that the soft mud was very deep along a line from the bay-bridge toward the range-lights south of the island.

In January, 1901, I began making holes through the ice and testing the bottom by means of an auger welded to an iron rod along which would slide an arm provided with a set-screw, making it convenient to push, turn or lift the auger at any depth the rod would reach. The water of the bay is mostly less than 12 feet deep. The rod used the first winter was 18 feet long. Where the mud was very deep extensions were put on. The original rod was lost with the point about 30 feet in the mud and 39¼ feet below the surface of the ice near the old range lights south of Johnson's Island. Later I used a rod 20 feet long with an extension piece 12 feet long.

The bottom of the bay is nearly level so that soundings giving the depth of the water do not disclose any valleys (Map IX). By testing the bottom at numerous points along lines transverse to the general course of the stream it was found that off the mouth of each stream was soft mud containing organic matter and readily distinguished from the glacial drift on either side. It had been thought the glacial clay might be softened by being covered by water so long, but experience showed that as a rule the weight of two men would push the auger but a few inches or a foot or two into this clay, whereas it might be pushed twenty feet or more into the deposits made since the glacier. The agitation of the water by waves has caused the loose mud to fill the original valleys, making the bottom of the bay approximately level. These valleys made by the streams, when they flowed miles farther than now to reach lake level are thus traceable by the lines of soft mud.

On the maps showing the location of borings it is not a fault of the draftsman that the lines are not parallel and do not intersect others exactly at right angles. On these maps I have attempted to give the location of the borings as actually made, though it may have been the intention to make them along north and south or east and west lines. The difficulties in always carrying out such intentions were several; unreliability of a compass in determining the directions accurately; mist obscuring landmarks I had intended to use; errors in maps and charts. In some of the earlier work the drawbridge across the bay in the L. S. & M. S. bridge was used as a landmark. After a time it was discovered that more than ten years before the drawbridge had been changed to a position nearly 1000 feet farther southeast but that the charts of Sandusky Bay with corrections to date still represented it in the old position. The platting of work done east of the mouth of Pipe Creek and in the marshes beyond was especially difficult because the border of the marsh is so indefinite and there was nothing in the vicinity

MAP III.

Figures show distance in feet from upper surface of the ice to upper surface of glacial clay; ( ) location or depth a little indefinite.

from which measurements could be made, and scarcely anything visible within two miles whose location is given on any chart or map. The plat in the auditor's office was found to be in error to the extent of forty-five rods. No detailed and accurate map of the region exists to this day. In the work done the first winter the importance of careful location of the holes with reference to points on shore was not realized, their location with reference to other holes sufficing to show—what was not previously known—that it was possible to trace these submerged valleys. Sometimes in tracing a valley it became desirable to test the bottom a short distance to one side of the line we had been following. Accordingly we measured off 16 rods or some other distance at what seemed to be a right angle to the main line and on making a hole there decided to go farther in the same direction. The deviation from the direction intended was usually discovered in some way either before or at the time of platting the work on the charts, even though it required a journey of several miles the next day to reach the spot again and trace the angles on paper. The location of borings shown on Map III, with the exception of those enclosed in parenthesis, are believed to be correct within ten rods or a little more, most of them much nearer than this. With reference to other borings in the vicinity the error in the location is very small, if made the same winter.

Nearly a hundred boys have assisted in this work and in determining the age and height of the aqueous deposits in the ridges on Cedar Point, some of them many times. Altho serving without pay, often in bad weather and enduring fatigue they have made no complaint. I wish there were space to mention their names. On one occasion a boat was taken along on the ice, at another time a life preserver. Both proved useful. Twice at least the shore has not been reached until after dark and on one of these occasions there were some anxious parents. Many mittens have been lost or discarded and many tools, large or small, gone to the bottom of the bay or farther, but no lives have been lost or limbs broken. Feet have been wet and sometimes more, but few colds have been taken and many probably avoided or cured by the vigorous outdoor exercise.

I am indebted to Mr. August Klotz who has generously put at my disposal without charge the resources of his machine shop, and to Charles Judson, C. E., who has often loaned me his instruments and assisted in other ways.

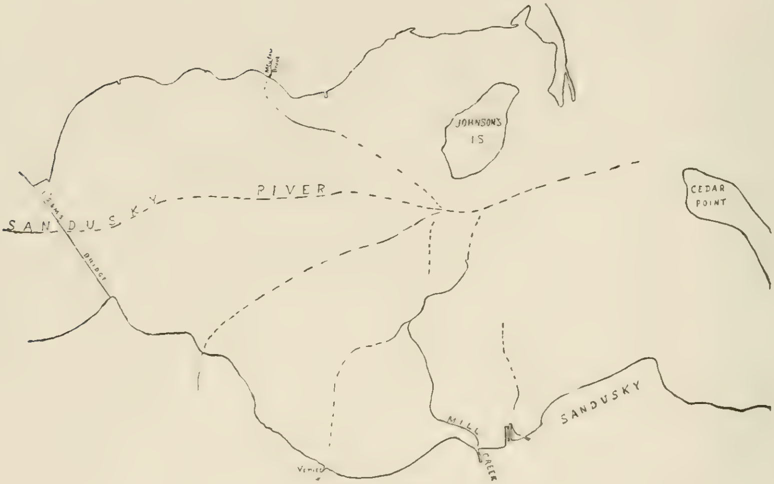
Sandusky River.

I have not tested the bottom of the bay farther west than Danbury, 82 degrees, 50 minutes west longitude, but Adam Hayder in driving stakes for fish-nets has noticed a zone of deep mud extending from Eagle Island to the Bay Bridge. Into this he drives the stakes six feet and then does not know that they touch clay. This belt of deep mud is as wide as the length of eight leaders, 35 rods each, and the northern margin of it is about this distance, seven-eighths of a mile, from the shore at the Plaster Beds and as much as a mile at the Port Clinton road. From the south side of this belt of mud on the meridian of Port Clinton hardpan extends toward Willow Point. Off Willow Point for the length of six leaders, stakes will hold, but the next six lengths stakes do not hold, the blue clay or hardpan being too hard.

I found no place near the bay bridge where the hard bottom was quite thirty feet below the ice. It is not likely that anywhere farther west the river ever cut much deeper than this, for in the portions of the bay bridge where piles were driven the rock is nowhere much more than thirty feet below mean lake level. Nor does the valley deepen appreciably for about three miles east of the drawbridge. South and southwest of Johnson's Island a depth exceeding thirty feet was found in quite a number of places. Here the river received several tributaries and its valley is probably considerably deeper than farther west. The borings do not show any tributaries farther west and it is not likely that any important ones existed between the bay bridge and the vicinity of Johnson's Island. Among the old dismantled range lights southeast of Johnson's Island the hard bottom is at least forty feet below mean lake level and may be considerably more than this. The greater part of a day was spent in attempting to trace the valley farther east but deep sand prevented reaching the clay except in a few places. The deep water off the end of Cedar Paint and in 1842 a deep depression between the end of Cedar Point and the dismantled range lights, with glacial clay only 20 feet below lake level a short distance to the south and to the north, show that the Sandusky River once flowed where steamers now pass in and out of the bay.

Tributaries to the Sandusky River.

Lines of borings across the bay indicate the course, though they do not show in detail, the submerged valley of Meadow Brook which now enters the bay west of Hartshorn's dock on the Peninsula, and a stream now entering the bay east of Bay



MAP IV.
Buried Valleys under Sandusky Bay. Compare with Map III.

Bridge station giving outlet to the water from the Rockwell springs and formerly the other bold springs at Castalia. By means of a canal the water of these other springs has been diverted to the stream that discharges at Venice. This stream five hundred years ago extended nearly two miles farther northeast than now, joining Mill Creek about 82 degrees, 45 minutes W. longitude, 41 degrees, 28 minutes N. latitude. The former course of Mill Creek has been worked out in detail but near its confluence with Sandusky River south of Johnson's Island its location is not entirely certain. Here the river valley was probably so deep below the surrounding country that even short tributaries cut deep ravines on approaching it and the multiplicity of these makes it difficult to work out the ancient topography in detail.

Between Mill Creek and Pipe Creek no important streams enter the bay nor do the numerous borings indicate that they were ever here. North of Sandusky the surface of the clay slopes gradually toward the former course of the river.

East of the Pennsylvania Railroad dock a little creek formerly entered the bay. Its water is now carried by Whiskey Run sewer. The valley was easily traced as far as the dock but, owing to its small size and the fact that its banks were cut down by the waves of the bay, I was long puzzled to know what became of it beyond the dock or dredged channel. Certain spots farther north where the mud is deep, found when making lines of borings not designed to show the valley of this stream, were supposed to be due to it, but the connection was not found until a number of trials were made. From the Pennsylvania dock the valley extends nearly north.

PIPE CREEK.

The tracing of the former course of Pipe Creek was not satisfactorily completed until parts of four winters were devoted to it. The first attempt, March 16, 1901, served to show that it was traceable, but the work could not be carried far because of the weakening of the ice which in the warm sun thawed rapidly that day—more rapidly than in the open bay where the water under it is deeper and consequently not warmed so fast. In the following winter many borings were made between Pipe Creek and Cedar Point and the valley appeared to reach the Point near the west line of Huron township. When, however, the borings were platted as well as the poor maps would permit it seemed probable that the deep muck near the west line of Huron Township was due to the former confluence there of two small streams not shown on the maps, though they may be seen by one walking along the L. S. & M. S. R. R. east of Pipe Creek. They must have broadened and deepened as they went on through what is now marsh. Deep muck found near the Carrying Ground was assumed to be in the submerged valley of Pipe Creek. The next winter we were disappointed in finding the ice unsafe east of Pipe Creek, but in December, 1903, we traced the valley without any difficulty from the present mouth of the creek to the Carrying Ground and later in the winter under the Carrying Ground and out into the lake.

VALLEYS UNDER THE MARSH.

Some long lines of borings in the marsh east of Pipe Creek together with some shorter ones near the mouths of the streams served to show quite well the buried valley of Guston Inlet and less fully that of Plum Brook and a small stream entering the marsh beyond the West Huron Club House. All these valleys are filled with muck that is easily penetrated by the auger. Mingled with the organic matter is alluvium brought by the streams in time of flood and in the vicinity of Cedar Point a small amount of sand, some of it no doubt having been blown over the ice in winter.

Map V.

Buried valley of Pipe Creek and of streams entering the marsh farther east. Figures show depth in feet of clay below upper surface of ice.

THE BLACK CHANNEL.

This does not properly belong under the head of submerged valleys but as it is popularly believed to be a remnant of some former stream, it seems best to mention it here. As the entrance to Sandusky Bay was much narrower in the early part of the 19th century than now, it has been supposed that at an earlier date no opening existed there but the course of the Sandusky River was continued by the Black Channel and the outlet was at the farther end. This is disproved by the fact that glacial clay and even rock make a continuous barrier between Sandusky and Cedar Point.

The Black Channel and the smaller channels running through the marsh do not follow the buried valleys. The latter pass under them and have no connection with them. These modern channels give outlet to the bay for the streams which a few centuries ago had separate outlets into the lake. They also serve to distribute the water over the marsh or carry it from the marsh when the wind raises or lowers the level of the bay. At such times the currents may be quite strong and this serves to keep them open and deep as they are. They may be compared to the tidal inlets in the salt water marshes.

The Black Channel has had its present position for at least sixty years. It is not, however, very old because three centuries ago Pipe Creek and the streams farther east had no connection with Sandusky Bay. Then there was not a continuous marsh extending from Pipe Creek to Rye Beach but each creek was bordered by marsh separated from those on each side by dry land.

CHARACTER OF THE POST-GLACIAL DEPOSITS AT THE BOTTOM OF THE BAY.

These have not been studied carefully, the aim having been to find the depth of the glacial deposits below the surface. In the West Huron marsh the material overlying the glacial clay is composed largely of the remains of marsh vegetation, black or dark brown, extending in places to a depth of twenty feet. In the submerged valley of Mill Creek muck was found at a depth of 32 feet of such purity as to show that a marsh once existed there. Sometimes on withdrawing the auger marsh gas bubbled up through the hole in the ice; on one occasion it issued in considerable volume so that when lighted it produced quite a blaze. In this and other valleys in the bay muck has been found at various depths, but it does not constitute a large percentage of the material filling the valley. This must have been transported and in most instances probably consists of a mixture of materials from many places, some of it washed into the bay by streams, some derived from action of the waves on the shore. Materials from the same sources are found over much of the bottom of the bay but I do not recall finding muck or other remains of old marshes far from the present shores except in the submerged valleys.

The thickness of the post-glacial deposits in any part of the bay can be determined approximately by subtracting the depth of the water given on the government chart of Sandusky Bay from the depth of the clay shown on Map III, allowing one or two feet for difference in water level at the times depths were determined. The water in winter is lower than in summer and so I have generally found its depth less than that shown on the government chart.

In some places scarcely any mud covers the clay. In many places the uppermost part of the clay is so soft that the precise level at which it is struck cannot be told from its resistance to the auger pushed into it, but when pulled out it clings to the auger and an inspection of it as it is being removed with a stick rarely leaves any doubt as to whether it is clay or mud. The latter not only looks different, but has much less tenacity. In a great majority of cases the clay is blue, but in some places both near the south shore and the north shore it is red, not having been long enough in contact with organic matter to reduce the ferric to ferrous compounds.

In some places, e. g., along the line extending north from the foot of Wayne Street to the Outer Range Rear Light, the transition from mud to clay is abrupt. Here the mud is so soft that it is difficult to tell when the auger first touches it and the weight of one man is sufficient to push the auger nearly or quite to the clay. The hard and nearly level surface of the latter probably indicates that it was planed off by the waves a few centuries ago when the lake and bay had reached a high enough level. Shore currents probably carried the products of erosion away, leaving the bottom free from sediment. When the water had become so deep that the lower layers were no longer subject to agitation by the waves, light particles easily held in suspension and so carried far from their source were deposited here, gradually forming a bed of soft mud resting upon the firm glacial clay.

In going north along this same line, which is on the meridian of the court house, no sand was noticed until we were a mile from shore, where it was barely perceptible, gradually increasing toward the north. At a mile and a quarter it was necessary to turn the auger through six or eight inches of sand. From here on the sand increases rapidly. A quarter of a mile south of the Rear Range Light we bored through six feet of it without reaching the bottom. The layer of sand found between a mile and a mile and a quarter north of the city is not at the surface of the mud but a few inches below it, while several feet of mud intervene between the sand and the clay. As long as the entrance to the bay remained narrow it is probable that great waves traversing the lake were checked enough there to prevent sand being carried so far toward Sandusky, but when the washing away of Spit Island widened the opening much of the obstruction was removed and the great storms of about 1860 distributed sand (some of it, no doubt, derived from Spit Island) farther in the bay than it had come before. In later years the narrowing of the entrance by the construction of a submerged jetty extending northwest from the Outer Range Front Light as well as the scarcity of great northeasters may have prevented further accessions of sand and given time for mud to be deposited on top of that which was left here in former years.

We have never found thick deposits of sand except where it had apparently come in from the lake. The bar west of Biemiller's cove has much sand and gravel which has been moved along shore from the north, but a short distance west of the bar the sand forms only a thin surface layer.

WORK OF THE GLACIER AND PREGLACIAL CHANGES.

The glacier rested heavily on the region about Sandusky and left its impress on the rock in many places, the grooves of Kelley's Island and Marblehead being larger than are known elsewhere. Near the north shore of the bay large grooves have been noticed north-east of Hartshorn's dock and at the Ohlemacher quarries. Along the south-east shore of Johnson's Island are numerous distinct grooves extending beneath the water. On the higher ground back from shore they are continually being uncovered in stripping the rock as the quarry is extended and a number of fine ones have been quarried away in the last three years. In the city of Sandusky wherever the overlying clay is sufficiently deep to protect the rock from weathering, its removal discloses glacial marks. Near the bay we have noticed them at the Ship Yard and in the basement of Emerich's drug store. In the summer of 1904 when the foundation was being prepared for the concrete work at the foot of Columbus Avenue, a piece of limestone showing plain glacial marks was broken off twelve feet below the surface of the water.

Besides the valley now partly filled by Sandusky Bay several other rock valleys in the vicinity lie sensibly parallel to the main axis of Lake Erie.

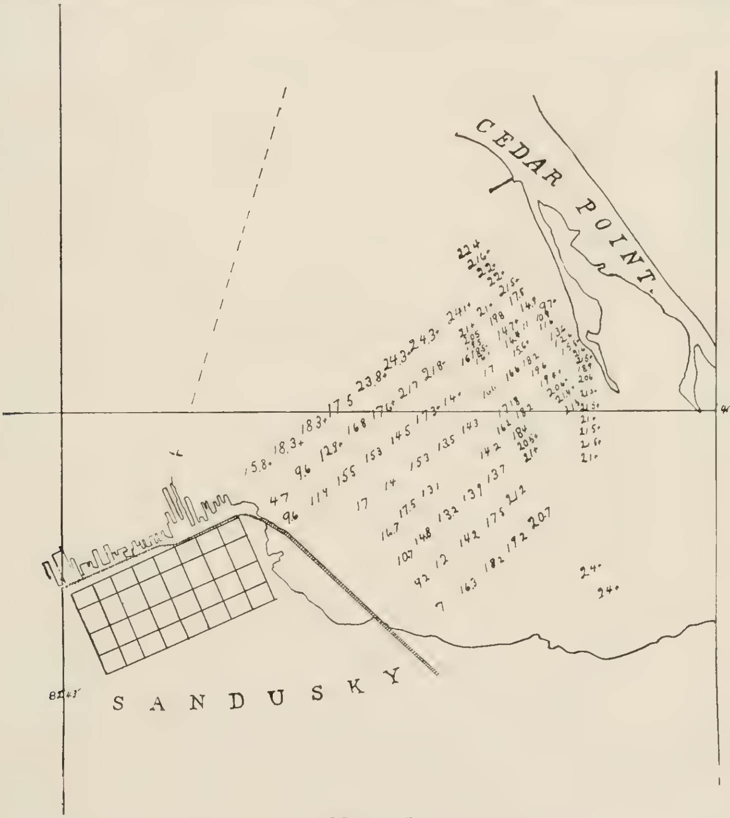
The parallelism of these valleys to each other and to the grooves makes it probable that all of them were made by the glacier. Although the general movement of the glacier over Ohio was more nearly southward the motion of the lower portion of the ice in this vicinity during the time that most of the erosion was done was about seventy-five degrees west of south, the direction being determined by the valley now filled by Lake Erie.

Under the bay the glacial deposits are of the same character as on the land. Overlying the rock is hardpan from a few inches to two feet or more in depth, containing pebbles and boulders in abundance, the greater part of them of limestone which the glacier transported but a short distance. The matrix in which the stones are imbedded contains a large percentage of calcium carbonate which probably accounts for its toughness compared with the clay above it, which the auger penetrates with much less difficulty. In the lower part of the clay are boulders but not so many as in the hardpan. Pebbles are very numerous within a foot or so of the rock. Limestone boulders appear to predominate near the rock to a greater extent than at a higher level—judging from some exposures on the land. Except within four feet of the rock the clay seems to be almost free from stones of any size. It must have been held in suspension by the water of the glacial lake and gradually settled to the bottom at a distance from the foot of the glacier.

PREGLACIAL CHANGES.

No deep preglacial valley runs through Sandusky Bay. At the power house on Cedar Point the rock is 46 feet below water level. Off the end of Cedar Point the water is 40 feet deep. West of the entrance to the bay in 1842 was a circular depression in which the water was 42 feet deep. In the vicinity of the old range lights south of Johnson's Island soft mud extends to a depth of forty feet or more below mean lake level. I know of no attempts to find the rock at greater depths at the entrance to the bay or west of it. In the bay bridge of the L. S. & M. S. Ry. the piles are driven to rock which is in most places less than 30 feet below the surface of the water. The longest space without piles is 1700 feet but the rock does not slope toward it in such a way as to indicate a rock valley there. How much of the broad but shallow valley occupied by Sandusky Bay resulted from preglacial erosion I have no means of judging.

Gypsum has been quarried near the north shore of the bay, 3 miles west of the Bay Bridge, for about three quarters of a century. At first it was ground by a windmill, but about 1835 by a steam mill. Thirty-ton schooners anchored a mile out in the bay and loaded for Detroit, Erie and other ports. This is said to have been the only locality on the Lakes where plaster was obtained at that time. The gypsum beds lie mostly below lake level. Long ago about four acres of the bay at Plaster Beds were diked off, the water pumped out and gypsum quarried. A few years ago one of the plaster companies operating at Fletcherville several miles west of Plaster Beds mined gypsum



MAP VI.

Rock between Sandusky and Cedar Point. Figures give depth in feet and tenths below 0 of water gage. + indicates rock was not reached, but, if following a number less than 21, was probably within one foot.

under the bay until the water broke through the roof of the mine. Gypsum has also been found near shore between Fletcherville and Plaster Beds, and in 1902 a good bed was found 1½ miles south of the bay on Mr. Meggit's farm in Margaretta Township. In view of its occurrence both north and south of the bay and near the bay near the north shore it seems probable that it once extended over considerable of the region now occupied by the portion of the bay west of the bay bridge. The relatively rapid solution and erosion of the gypsum compared with the more resisting limestone may have produced this broad valley. Much of the earlier plaster was derived from boulders, so it is likely that the glacier assisted in enlarging this valley. East of Sandusky the depth of limestone below the surface is shown on Map VI. An inspection of this chart will show that over most of the region the rock is not far from level. It rises near the Sandusky shore and near Biemiller's cove. It drops off rapidly to the north just as it does along the city front, also to the east of a line extending from the Jarecki Chemical Works to the Lake Laboratory.

In other parts of the bay I have never struck rock except in a few places near shore, e. g., near the mouth of Mill Creek and near the south end of Johnson's Island.

CEDAR POINT.

Cedar Point is the peninsula, 7¾ miles long, forming part of the eastern boundary of Sandusky Bay. It is not, as has been supposed, a mere sand spit, but has a foundation of clay resting upon the rock and extending, in the middle section, nearly up to low water level. It may be divided into three portions which we will call the bar, :the middle or dune section, and the terminal or ridge section.

THE BAR.

This is a low narrow strip of sand extending from Rye Beach, 2¼ miles west of the Huron River, to the Carrying Ground, a distance of about 4¾ miles. The height of the crest above mean lake level averages about 6½ feet, in the highest places barely exceeding ten and in the lowest descending to a little less than five. From the crest toward the lake a bare beach slopes steeply for a foot or two then gradually to the water whose height of course determines its breadth. At low stages of the water, such as prevail in fall and winter, the breadth is about four rods, continuing for miles with little variation. It does not at any place extend out into wide reaches of sand flats for the water off shore deepens more rapidly than that adjacent to the terminal portion of Cedar Point. Away from the lake the slope is quite gradual and the distance from crest to marsh is between eleven and sixteen rods throughout a great part of the length. In the vicinity of the west line of Huron Township and the mouth of the Black Channel the breadth is twenty-four rods or more. Quite near Rye Beach the breadth in the fall of 1904 was only 2–4 rods and most of the way for the first mile between three and six rods. In a number of places the lake has washed the sand over onto the marsh making little projections two or three rods long, so that the shore of the marsh has not an even outline like that of the lake. Some of these were made in 1904 and others apparently within a year or two before.

Composition of the Bar.

The visible material of the bar like that of the remainder of Cedar Point is largely sand, consisting of quartz, magnetite and garnet, but unlike the remainder it has throughout its whole length gravel at the surface. On the bare beach the gravel is abundant and many of the pebbles are as large as hens' eggs, the quantity and to some extent the size increasing as one goes toward Huron, the direction from which they have come. They consist largely of quartzite and other metamorphic rocks derived presumably from boulders in the clay between Rye Beach and Huron. Limestone is scarce and not from any beds in the vicinity. Shale fragments flat, angular and dark are scattered over the beach or strewn thickly upon the sand more or less apart from the hard pebbles. They too increase in abundance as one approaches Dr. Esch's place where a bed of Ohio shale outcrops, showing many spherical calcareous concretions three feet in diameter, some of them with tops cut off by the glacier and still bearing the scratches.

Near Rye Beach fragments of brick of various sizes, rounded like the other pebbles, attract attention by their red color. These are probably from a brick house belonging to Jabez Wright, grandfather of Mrs. Esch, and a well known surveyor three quarters of a century ago. The house stood north of the present shore and south of a road, on the north side of which was an orchard. The lake took the orchard, the road, the house, and finally the man, who after a dark night was found dead at the base of a high bank where the lake had encroached upon the new road.

A list of the things washed ashore or drifted along the Cedar Point beach would fill pages. Among the more common are fragments of wrecks, and other driftwood, articles of various sorts thrown or lost from boats, coal, cinders, nuts, fish, bones of various vertebrates and shells of molluscs. We once found on a lonely part of the beach the skeleton of a swan which probably after being wounded perished on the lake and was entombed in the sand near the crest of the beach by the same storm that brought it ashore. Even the cartilages of the trachea with its curious convolution inside the sternum were still preserved. Various things through long attrition by sand and pebbles have come to resemble the latter so closely that their nature is a puzzle to the novice—wood, coal, peat, brick, drainage tile, pottery and glass made opaque and quite free from sharp points or edges. The source of the last when its nature is comprehended may not be so puzzling to account for as that of the peat which occurs at various places along the lake shore to the very end of Cedar Point. This is derived from the remains of marsh vegetation which once flourished where the lake is now. The bar is not so far out as formerly and part of the marsh that was originally behind it is now in front of it. These fragments are perhaps broken loose in winter, when the water is low and the ice that has been resting upon the exposed marsh, sometimes in winrows ten or fifteen feet high, is drifted ashore by the wind. At least I found many large and angular ones nearly free from sand after the ice had broken up Jan. 1, 1905. Some of them were fifteen inches thick and more than four feet in length. A long line of these extended northwest from a point about 2½ miles from Rye Beach. Toward Rye Beach for quite a distance none were noticed though within a mile or so of it there were a dozen or more, increasing in size toward the beach, the largest eighteen inches long. There are never large ones on this part of the beach. The small ones are derived from the marsh at the outlet of Sawmill Creek close to Rye Beach. The portion of this marsh now covered by the lake bristles with the roots of button-bush so close together that no large masses of muck are loosened from among them. A third locality from which the muck is derived is probably along the shore of the Carrying Ground.

Between the buried valleys of Plum Brook and Sawmill Creek the clay is probably so near the surface that soon after the marsh muck was uncovered by the lake moving the bar over onto the marsh, it was torn loose and perhaps ground to pieces by the waves but I cannot say but what some still remains where it was formed and now covered by the sand and water of the lake.

Allen Remington and Jacob Lay have seen large quantities of peat cast ashore by storms occurring when there was no ice. The former says the storms accompanying the high water of

1859 uncovered the bog and threw large masses of peat on the shore in such numbers that one could follow the shore for miles jumping from one to another. In 1904 we found peat in the sand between two ridges near the lighthouse which were formed about 1860. It had been moved along the shore and cast up by the waves. Years later Mr. Lay saw peat strewn along the beach almost as thickly as described by Mr. Remington.

VEGETATION OF THE BAR.

The vegetation of the bar is scanty and limited with rare exceptions to such species as grow on poor soil. Andropogon scoparius, Panicum virgatum, Populus monilifera and Salix of several species amygdaloides, wheeleri, cordata, lucida, alba vitellina—constitute probably nine-tenths of it all. On October 8th I walked the whole length but with that exception have not traversed the greater portion of it, save in winter. Besides the species mentioned above, the following are all that I have noticed, those among the first being more common than those toward end of the list.

Solidago canadensis
Teucrium canadense
Ascelpias syriaca
Verbascum thapsus
Oenothera biennis
Euphorbia polygonifolia
Ptelea trifoliata
Cornus
Vitis riparia
Celastrus scandens
Rhus typhina
Nepeta cataria
Erigeron canadense
Andropogon furcatus
Sporobolus cryptandrus
Muhlenbergia mexicana
Cenchrus tribuloides
Lycopus sinuatus
Gentiana andrewsii
Pastinaca sativa
Equisetum robustum
Equisetum pratense
Prunus virginiana
Platanus occidentalis, 8,
Ulmus americana, 4,
Quercus velutina, 5, all small,
Quercus imbricaria, 1,
Fraxinus pubescens, 2,
The last three species near Rye Beach only.
Rosa carolina
Achillea millefolium
Xanthium canadense
Gnaphaluim polycephalum
Eupatorium perfoliatum
Strophostyles angulosa?
Lathyrus maritimus, about a mile and a quarter from Rye Beach, the only place I have found it in Ohio.
Liriodendron tulipifera, one,
Neillia opulifolia, one.

Doubtless a dozen more could be found by searching in summer for a single day, perhaps a score by trespassing on the marsh a yard or two, but compared with the 395 species, or thereabouts, which I have found on the older portion of Cedar Point, this list is small indeed. In all this barren waste of nearly five miles there is not a cedar nor pine and I believe no maple, black cherry, hackberry, mulberry, basswood, locust or any nut bearing tree, except a few oaks within three quarters of a mile of Rye Beach and too young to bear. Aside from cottonwoods, willows and one of the buttonwoods I noticed but a single tree more than about twenty-five feet tall. Of plants as common in the dune section of Cedar Point as the cactus, bearberry and sea sand-reed I saw not one on the bar.

Between the crest and the vicinity of the marsh only a few of the plants in the preceding list are met except at rare intervals, a waste of beard-grass and panic-grass with here and there a cottonwood or willow being all that meets the eye. Throughout the entire length of the bar and also in much of the dune section the vegetation is scanty except in a narrow belt along the bay shore. Here the wind that blows across the sand transporting the finer grains has its velocity checked by the marsh vegetation and so drops its load. Moreover the bar slopes so gradually from the crest that a strip several yards wide near the bay is but a few inches above water level.

As water may be found anywhere by digging down to lake level, the sand near this level is kept continually moist by capillary action, but several feet above it the sand at the surface often becomes quite dry. Even at the same height above the water the fine sand contains much more water than the coarse and so is better suited to meet the needs of plants. To test the two sorts, sand was taken from among the bushes near the bay and from a point a few rods nearer the lake where the vegetation was scanty. The former was much the finer. The following experiments were tried with them. Hollow cylinders of glass and iron with cloth tied over the bottom were filled with sand and made to stand upright in shallow water so that the water was drawn up through the sand by capillary action. The fine sand contained a small amount of organic matter and when thoroughly dry was not readily wet even by water poured upon it but once wet it drew up much more moisture than the coarse sand and retained it longer as shown by the tables.

CENTIGRAMS OF MOISTURE FOUND IN TEN GRAMS OF SAND TAKEN FROM TOP OF SAND FILLING PIPES STANDING IN SHALLOW WATER.

Date	Conditions	Height above bottom. cm.	Coarse sand	Fine sand	Difference
Nov. 9	Water in jar barely exhausted	14	45	115	70
" 10	Water supply exhausted more than 24 hours.............	14			40
Dec. 14	Water supply exhausted about five days...........	14	3	41	38
" 19	Water 3 cm. deep in jar......	14	40	110	70
" 19	Water 1 cm. deep in jar......	23	3	5	2
" 21	Taken from about 2 cm. below surface.............	20		38	
" 21	Taken from about 4 cm. below surface.............	17	33		
Jan. 16	Taken from middle of cylinder which had contained 14 cm. of sand. Water exhausted several weeks......	7	4	56	52

RESULTS FROM PLANTING OATS IN COARSE SAND AND FINE SAND.

Date of planting	Number		Height above water cm.		Date Examined	Number sprouted		Height of tallest mm.		Height of shortest mm.	
	Coarse	Fine	Coarse	Fine		Coarse	Fine	Coarse	Fine	Coarse	Fine
Nov. 10	10	10	12	12	Nov. 15.	0	2				
					Nov. 16. 8 A. M.	1	7				
					Nov. 16. 11 A. M.	2	9				
					Nov. 17.	3	9				
					Nov. 18.	3	9	47	71	3	37
					Nov. 22.	4	9				
					Nov. 28.	4	9	90	122	5	70
Oct. 26.	6	6	20	21	Nov. 7.	0	1				
					Nov. 9.	0	1				
					Nov. 12.	0	2		21		13
Oct. 26.	6	6	70	70	Nov. 9.	0	0				
					Dec. 12.	*	†				
Oct. 27.	4	4	8	8	Nov. 9.	1	0				
					Nov. 17.	1	0	120			
Nov. 17.	4	4	8	8	Nov. 22.	3	2				
					Nov. 28.	4	2	67	65	25	63
					Dec. 12.	4	3	95	80		55
Oct. 27.	2	2	8	10	Nov. 22.	0	2		60		32
					Dec. 12.	0	2		100		97

* No roots. † One with roots 40 mm. long, another 23 mm.

The Bar Encroaching on the Marsh.

In 1885 Albert Judson, county surveyor, found that the west line of Huron Township had shortened "twelve rods" since the original survey made by Almon Ruggles in 1807. Near Rye Beach he found the shore had moved landward about "twenty rods." A survey made by Rolla Chase in 1903 at the eastern border of Rye Beach showed the lake had there encroached on the land about 25 rods since 1816. The marsh at the outlet of Sawmill Creek, just west of Rye Beach, formerly extended out where the lake is now. The present marsh is well filled with living buttonbushes. In the lake on the other side of the bar the roots still stand where buttonbushes formerly grew. They have been seen as far out from the present shore as "fifteen rods." Some may also be seen projecting through the sand of the bare beach and one of these was noticed with green leaves. The cut bank and a few undermined trees show recent encroachment of the lake on the part of the bar extending from Rye Beach a little more than a mile. Some of the sand and gravel washed out has been carried over onto the marsh as may be seen in a number of places; more of it has probably been transported along the beach toward the northwest.

At the mouth of the Black Channel I found that on the bar near the bay shore the auger after being turned through three or four feet of sand could be pushed to a depth of ten feet below water showing that here the bar had encroached on the marsh. This was Dec. 27, 1901. Attempts made the following month at four other places on the bar were unsuccessful in finding muck. In one of them the auger after boring 8 feet through the sand was stopped by a pebble or other obstruction. In the others it was turned after much labor to a depth of 11, 13, and 18 feet, and pulled out with improvised levers and in the case of the deepest a little turning. This led me to doubt whether the whole bar had moved onto the marsh. However, Jan. 28, 1905, I found a place in the marsh several rods from the bar where so much sand was mingled with the muck as to make it impossible to push the auger through it. The same day we succeeded in pushing the auger through several feet of muck beneath the bar a little less than two miles from Rye Beach. This convinced me that at the places where I had failed to find muck, the reason was that it had become so filled with sand as to prevent pushing the auger through it. In one at least of the places where trial was made Jan., 1902, the sand brought up was blackened with organic matter.

At the Carrying Ground the bar rests on marsh muck and the muck extends out under the lake at least 38 rods, probably much farther. At one place the muck under the bar was found to extend to a depth of 18 feet below water level. In the lake 30 rods from shore the muck extends to a depth of 10 to 13 feet along a line parallel to shore more than 60 rods in length. In the deepest place it doubtless is quite as deep as under the bar, 18 feet, though where borings were made, the clay was not more than 13 feet from the surface.

Much of this submerged bog had but a few inches to a foot or two of sand over it when I examined it in February and March, 1904.

At two or three places in the lake between the Carrying Ground and Rye Beach unsuccessful attempts have been made to push the auger after turning it some distance into the sand. A little more than two miles from Rye Beach the auger was turned down to 9 feet below top of ice and turned more easily the last two feet than nearer the surafce, as if the muck still remained, but with sand enough in it, to prevent pushing the auger through it. In driving stakes for fish nets more than a hundred rods off shore a mile and a half or so southeast of the mouth of the black channel Captain Steible tells me they used to strike what they believed to be muck. A large blunt stake would rebound and penetrate but little at each blow. This was where the water was sixteen feet or more in depth. He has seen along the beach when the water was low a sheet of muck two or three rods long. The sand usually prevents one from seeing any muck until it is washed ashore.

In the season of low water from 1891–1901 there was probably no encroachment on the marsh excepting that produced by the wind, and the trees along the shore of the marsh show that there has been no general encroachment for several decades. But the northeasters at time of the high water of 1858–1862, swept away the trees, and moved the whole bar over onto the marsh. Allen Remington remembers one cottonwood in particular, which served as a landmark for fishermen, much larger than any tree now on the bar. It stood not far from the mouth of the Black Channel and about 1856 was nearer the bay shore but when he began fishing, 1859, was about midway between the bay and the lake. In a few years more the beach had moved to it and it fell into the lake. At the point where this large cottonwood stood the encroachment on the marsh prior to 1857 could not have amounted to much during the life of this tree, else the shore of the marsh would have been farther from the tree but the fact that throughout much of the length of the bar there were no large trees probably indicates that it had not remained stationary for a great length of time.

Later than 1864 John Steible used to tie his boat to large stumps in the lake about where Remington's cottonwood stood. He remembers a three-foot cottonwood that stood a short distance southeast of the Carrying Ground and a few other large ones near it but no large trees of any sort on other parts of the bar.

Openings Through The Bar.

At times of very high water openings have been made through the bar deep enough for the passage of fishing boats. According to Jacob Barker there was an opening in 1838 at what he called the lower carrying ground at or near the mouth of the Black Channel. The high water of 1858–'60 raised by northeast gales washed over the bar throughout its whole length. About 1858 Palmer Jackson witnessed the rapid enlargement of an opening at the Carrying Ground. When first seen it was about ten feet wide, but in half an hour had widened to twenty rods and later to more than a quarter of a mile. Many willows and other bushes were swept away. In the spring of 1859 the high water cut through the bar about 2½ miles from Rye Beach, i. e., a few rods west of the east line of section 4 of Huron Township. Allen Remington remembers this as being open all that season. James Galloway thinks it remained open four or five years. He says it was about thirty feet wide at the top and deep enough in the deepest part for a pound boat. The correctness of the location as given by him is confirmed by the fact that near the spot he assigns I found in the marsh several rods from the bar so much sand mingled with the muck as to prevent pushing an auger through it. Captain Steible recalls an opening at or near the same place about 1867–'69 though it was not open for about three years after he began going there, i. e., 1864. On the lake side it was choked with sand and re-opened a number of times. The Clarks who used to haul their fish along the beach to Huron were prevented for some time by this opening. He has seen the water go over the bar for its entire length. He built a breakwater to prevent his fishing shanty located on about the highest ground from being washed away. The water covered the floor of the shanty a number of times. He says the bar is higher now in many places than it was then.

About 1876 or 1878, also years of high water, an opening was made through the bar near the southeast end of the Carrying Ground. Through this Jacob, Henry and John Lay, who had nets in the lake, passed several times with a pound boat. It was formed by a severe northeast storm in the spring, the water going over the bar for a mile or more. It remained open at least till some time in the summer but was closed again in the fall and reopened a year or two later. The sand point projecting into the bay at the west line of Huron Township is supposed to have been formed by sand washed through an opening. In the bay near this point the muck extends to a depth of twenty feet. A few centuries ago two small streams united a short distance to the southwest of this point as shown by borings in the marsh. The valley of the united streams passes under the bar at this point. (See Map V.) In the bay near by is sand overlying the muck and probably brought in through the opening. Jacob Lay remembers the opening of 1876 or '78 as being near this place, but others say it was farther northwest.

Since 1878 I think there has been no opening through the bar except at the mouth of Sawmill Creek near Rye Beach which in time of flood sometimes forms an outlet into the lake which soon becomes choked with sand like the mouths of all the small streams entering the lake and, it is said, even the mouth of the Huron River in the early part of the 19th century.

The Carrying Ground, as it is generally known in Sandusky, is at the northwest extremity of the bar. The Indians and later the white fishermen used this as a portage, for it is narrow and low and conveniently located for reaching from the lake either Sandusky or the mouth of Pipe Creek. Prior to 1875 whenever the wind was not fair for sailing around Cedar Point, the fish which were often caught in the lake in large quantities were carried across here and much labor and trouble saved thereby. At that time the pound boats were smaller than now and not so well adapted to beating around the point. Until about three centuries ago Pipe Creek had its outlet here.

DUNE SECTION OF CEDAR POINT.

This part of Cedar Point extends from the Carrying Ground to the head of Biemiller's Cove, a distance of two miles. Its topographic features are to be shown on a revised edition of the Sandusky sheet published by the U. S. Geological survey. Underlying it the clay, deposited when a glacial lake still covered the whole region, has its upper surface but little below the present water level. Here there has been land ever since the disappearance of that ancient lake, known as Lake Warren, caused by the retreat of the glacier. Until less than three centuries ago this land was connected with Sandusky by a strip of land lying north of Pipe Creek as shown by borings. (See Map V.) It is not, like the bar, a mere wave built formation. Its breadth and its irregularities are due, in part at least, to the surface of the underlying clay which had been modified by subaerial erosion when Lake Erie was yet at a distance. This erosion, moreover, must have been held in check in so level a region by the proximity of the underlying rock which in parts of Biemiller's Cove is less than 12 feet below the mean lake level of recent years.

BIEMILLER'S COVE.

Biemiller's Cove does not represent a valley in the clay but the crest. At one point the clay was found immediately under the ice and extending down to rock less than nine feet lower. At another point it was less than three feet from the surface. About sixty rods from the north end the clay is covered with some ten feet of muck. Several centuries ago, before the lake had attained its present level sand and gravel were piled up along the northeast shore of this land and the bay formed smaller deposits on the southwest shore. In time the water became high enough to cover most of the land between these deposits, forming a marsh both margins of which have since been covered by the sand. Near the cove and northwest of the Lake Laboratory the roots of large trees and an old cedar stump still retain about the same relation to the surface as when the trees started two or three centuries ago. A scow run ashore south of the Lake Laboratory about 1881 shows no appreciable change in the shore since that time. But in driving pipes for the Laboratory well, 1903, Mr. Appell found that after the point was down 12 or 14 feet below the surface of the ground, it drove the next 18 inches or so very easily, and after that hard again. When the point was in the part where it went down so easily he pumped up water that was dark colored, containing fibers as if from a marsh or bog. How much farther east this marsh extended I do not know. On the other side of the cove just inside of the bar and nearer the head than the mouth of the cove I found beneath a few inches of marsh at the surface some three or four feet of gravel and beneath that about four feet of muck. This narrow part of the peninsula that shuts in Biemiller's Cove appears to be a wave built bar connecting the wider part toward the end with the land at the head of the cove. In the wide part the clay must be near the surface; at least I have found it near the surface at several points in the bay not far away and inside the cove a short distance from it.

The terminal portion of this peninsula has been built up by the bay in recent years; it appears to have extended about 18 rods in 1904 and double that amount since the survey made by the War Department in 1872. In the survey of 1826, however, it extended a quarter of a mile farther than in 1872. (See Map I.) A map "60 years old" representing Cedar Point as divided into city lots shows two islands off the end of this peninsula and in line with it, named Big Sandy Island and Little Sandy Island. The water is still very shallow there.

The chart of 1826 shows the cove narrower and the land both sides of it much wider than now. Part of what appears on the chart as land must have been marsh. These changes have been produced mainly by the rising of the water but on the bay side of the peninsula land has been cut away by the waves. A number of trees were overturned in 1904. People remember seeing the same thing years ago along the lake shore not very far from the laboratory, and a chart issued in 1864 marks this shore "wearing away."

THE DUNES.

Irregularities of the original surface and the existence of trees and bushes have caused the wind to build up numerous sand dunes, the highest of which according to Kellerman is 27 feet. The other parts of Cedar Point having been built up anew are much more regular.

The sand which here has been heaped into dunes and the sand which in the terminal portion of the peninsula has been piled into ridges is from two sources.

(1st) It has been transported along the beach from Rye Beach and beyond, most of the pebbles, having been reduced to sand while in transit. Sticks tossed into the lake usually drift toward the northwest, though sometimes in the opposite direction. The movement of sand and other things along the beach is almost always toward the northwest for its motion is accomplished by the combined action of waves and shore current, the waves lifting the materials and the current carrying them forward. Waves on this shore are raised by an east wind and the accompanying shore current I believe is always toward the northwest. The crest of the wave is oblique to the shore and its left strikes first causing the water to rush along shore toward the right carrying the sand with it while the portion of the sand carried lakeward by the undertow is moved by the shore current in the same direction as that on the beach.

(2d) Sand swept out of the mouth of the bay by the rapid current is carried ashore on Cedar Point, some of it probably going nearly or quite to the Carrying Ground. Recently my attention was called to the existence of such an eddy by Lorenzo Anthony who long ago used to set fish nets east of Cedar Point. I recalled that a certain bottle which I had set adrift in the bay was found broken and among timbers at or near the Carrying Ground. This was Bottle No. 37A, dropped half way between Sandusky and the west end of Johnson's Island at I p. m., Sept. 26, 1902, and carried by the current into the lake and cast ashore nearly 3 miles from the lighthouse, where it was found the next morning at nine o'clock. Bottle 42A set adrift at the entrance to the bay went ashore on the lake side of Cedar Point about half mile from the lighthouse. Both of these must have gone out beyond the end of the jetty. A number of my bottles were dashed to pieces on the jetty. After Mr. Anthony told me of his observation, I had a bottle thrown in the lake beyond the end of the jetty; Captain Magle reported that he threw it near the can buoy. This was about 3 p. m., Dec. 3, 1904. Dec. 6, at 8:30 a. m., a man who had crossed the bay on the recently formed ice found the bottle on the lake beach more than two miles from the lighthouse.

Part of the sand brought ashore by such a current may have come originally from the vicinity of Huron, having travelled the whole length of the beach, in and out of the bay a number of times and then ashore on Cedar Point again some where between the Carrying Ground and lighthouse perhaps to be pushed along to the end again and go the rounds once more. It would be interesting to know how many times some of the grains have taken such a journey. Another part of the sand which is swept out of the bay originated at Marblehead. This of course becomes mingled with that from the southeast.

The wider beach along this part of the peninsula gives the wind more opportunity to take up sand, while its fineness caused by long attrition favors its transportation by the wind.

RIDGE SECTION OF CEDAR POINT.

This is the terminal portion of the peninsula, extending from the end to Biemiller's Cove, about one mile. Its maximum width is over half a mile when the water is low but less when it is high. It is made up of parallel ridges which have been built up by the lake and consist of beach gravel and sand. It contains no clay or rock near the surface. At the power house clay was found about 23 feet below lake level and rock 46 feet below. Farther north both are probably deeper still.

In crossing this part of Cedar Point not very near either end eight ridges are easily distinguished. Towards the end, especially the south end, are others which do not extend so far. These eight ridges I have numbered beginning on the bay side. In describing them, however, I will begin with the most recent.

MAP VII.

Ridges of Cedar Point. Contour line of

Ridge	1,	2 feet above Lake Erie.
"	2,	2 " " " "
"	3, s-w side,	2 " " " "
"	3, n-e side,	4 " " " "
"	4,	4 " " " "
"	5, n-w part	2 " " " "
"	5, s-e part	8 " " " "
"	6,	8 and 10 " " " "
"	7,	8 and 10 " " " "
"	8,	4 " " " "

The ridges are not interrupted but in places descend a little below these levels so that these contour lines make them seem broken.

Recent Ridges.

Ridge 8 extends along the lake to within 36½ rods of the Beacon Light at the inner end of the jetty. It is only three or four feet higher than the valley behind it, but is growing. Its crest is well covered with cottonwoods whose lower branches are partly buried in the sand and whose tops rise only eight feet above it. Several of these cut with a jack knife showed five rings. It has evidently formed since the jetty was begun, Oct., 1896, and probably because of the accumulation of sand produced by that obstruction. At the north end is a group of cottonwoods 11 to 14 feet tall. These may have been a factor in determining its location. Besides cottonwoods Ridge 8 has a number of small willows, but no other trees.

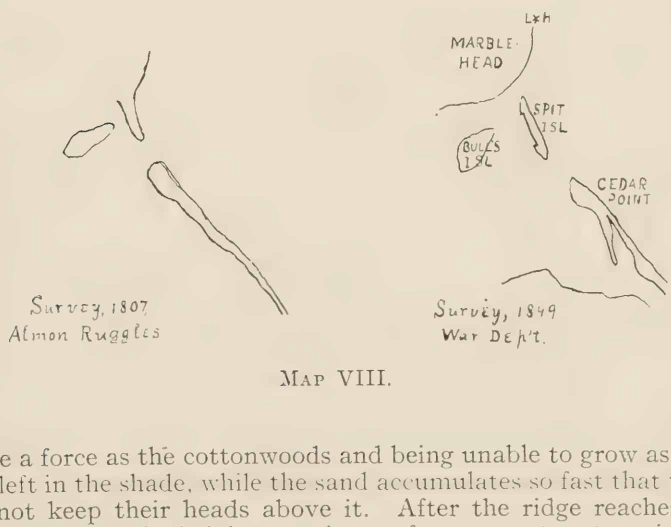
In the valley behind Ridge 8, is a conspicuous line of driftwood and many fragments of coal from wrecks marking the place where the waves came before this ridge was formed.

Ridge 7 is longer, broader and higher, rising 12 to 16 feet above the lake. Its crest is covered with cottonwoods 35–50 feet tall growing almost to the exclusion of other trees. In one spot are several buttonwoods 12–17 inches in circumference. There is a willow (Salix amygdaloides) 17 inches in circumference quite a number of white ash, the tallest 6 feet, an oak and a maple less than 2 feet. Two cottonwoods were found with a circumference of 37 inches. One of them 52 feet tall was cut three feet from the ground and 21 rings counted. As the section was 3½ feet above the roots and the inner circle thick, three or four years may be added in estimating the age, making it 24 or 25 years. Ridge 7 has no trees much older than this. It probably originated in 1878 the year of maximum rainfall at Cleveland and Buffalo. This is the year in which a ridge was formed on the Marblehead Sand Spit on the other side of the entrance to Sandusky Bay from Cedar Point according to a fisherman who lived there. On September 11, 1878, occurred the great storm described in the first chapter. No doubt this or the storm of August 15, 1879, probably both, were instrumental in the building of this high ridge. Cottonwoods started on it in 1880 and were not all destroyed by the great storm of April 23, 1882, but their roots more deeply covered. The ridge was then finished so far as the work of the waves was concerned.

In the valley behind ridge 7 and resting upon the base of ridge 6 is a line of driftwood, some of it rotten. In it were found a cleat of a boat and a large cinder or clinker. There are also shells of clams and other mollusca that live in the lake. Shells and coal were found both on and below the surface, a fish bone below the surface.

Ridge 6 resembles ridge 7 in breadth, height, and vegetation but the trees are larger. Its southern portion is single but toward the north are two ridges of about the same age which I have designated 6 (1) and 6 (2), the former being the highest of all the ridges, in one place nineteen feet. These will be included in any reference to Ridge 6. Here too cottonwoods predominate over all else. One locust (Robinia pseudacacia) is 37 inches in circumference and about 62 feet tall. White ash is perhaps ten times as numerous as on Ridge 7, the tallest about 18 feet, but most of them less than 12 feet. There are several cedars 10 feet or less in height and a very few trees of other kinds. Most of the cottonwoods are not much more than a foot in diameter but two were found 55 inches in circumference One of these near the big locust was cut and found to have been 64 feet tall and to have 41 or 42 rings about 3 feet above the roots, indicating an age of about 44 years. This Ridge was doubtless formed at the time of the high water 1858–62, probably by the same storms that swept the trees from the bar and moved the bar over onto the marsh. The oldest trees on the bar appear to be of about the same age as those on Ridge 6. In the valley between 6 (1) and 6 (2) we found clam shells, decayed driftwood and peat such as one finds on the present shore. A few inches below the surface in a thin layer of organic particles such as one finds at the margin of littoral pools we found pieces of coal and cinders. As late as 1866 steamers entering Sandusky Bay with coal smoke issuing from their funnels attracted some attention, for most of the steamers burned wood. This shows that Ridge 6 (2) which must have been formed after the coal and cinders had been washed ashore is not much older than 1859. Ridge 6 (1) may have started in 1857 or 1858 and have been completed in 1859 while Ridge 6 (2) may have been built by the great storms of 1861 and 1862. This part of Cedar Point was surveyed for the War Department by Lieutenant Colonel Graham in 1862. The shore line shown on his chart is farther northeast than it was in 1849 when the last survey previous to 1862 was made. In a map illustrating a report on Sandusky Harbor by Colonel T. J. Cram, U. S. Engineer, 1864, taken partly from Graham's survey in 1862 the northeast shore of what I have called the dune section of Cedar Point is marked "wearing away." Doubtless much of the sand removed from that section was built into these ridges. Besides, sand derived from dunes lately demolished on the other side of the channel after being swept into and out of the bay must have found a resting place here.

Before proceeding to consider the age of the older ridges it may be well to draw some further inferences regarding these that were formed in the 19th century. The mode of formation is probably as follows: A great northeast storm occurring at a time of high water piles up the sand to a height which is beyond the reach of the ordinary storm or a great storm occurring when the water is not above its ordinary level. In the spring numerous seeds from the cottonwoods that grow in such profusion on the ridges farther west are wafted by the wind to the newly formed ridge or possibly cast upon it by the waves, after falling into the lake. Here they have sufficient moisture, yet the roots are never below water level. As they grow they help to hold the sand that is blown by the wind and other sand that may be tossed up by the waves of other great storms, so that their roots are soon deeply buried. The willows too send their seeds in good season to take possession of the new land but they cannot muster so



MAP VIII.

large a force as the cottonwoods and being unable to grow as fast are left in the shade, while the sand accumulates so fast that they cannot keep their heads above it. After the ridge reaches its full height seeds lodging on its surface cannot get moisture enough. So the cottonwoods are left in undisputed possession. When they have grown so large that birds frequent them or roost in their branches the seeds of poison ivy and other vines are dropped and germinate. The dead leaves begin to accumulate over the sand and form a mulch. A few herbs spring up and help the vines to keep the dead leaves on the ridge. The wind brings keys of the white ash and birds drop seeds of red cedar and some of these find moisture enough to enable them to grow.

CEDAR STUMPS.

In determining the age of most of the older ridges I have depended on data furnished by cedar stumps. Several points must be considered. 1st. The ridge was formed probably nearly or quite 40 years before cedars started to grow on it. Ridges 8 and 7 have no cedars. Following ridge 6 a certain distance, Fred Lay counted 13 cedars, all quite small, and returning to the starting point along Ridge 5, he counted 160. On the bar, which has cottonwoods over 40 years old, are no cedars although it is nearly 5 miles long. On the Marblehead Spit which has formed northeast of Johnson's Island since 1858 the only cedar is one that is said to have been planted. 2d. The large cedars on Cedar Point were cut more than half a century ago. Mr. Samuel Catherman who came to Sandusky in 1835 says "right along after that cedars were cut on the Point; there was quite a business of cutting and transporting them to Sandusky, where all the fence posts were cedar and the frames of quite a number of houses, some of them still standing. The wood was used also for other things. Most of the largest ones had been cut by 1850 or about that time." Mr. Louis Adolph, who came in 1863, says, "they had been cut long before that." Captain Freyensee remembers that in 1849 or 1850 in a warm day in January he helped load a scow with cedar posts about half way between the present dock of the Cedar Point Company and the U. S. Government dock. The yawl used to carry the posts out to the scow was loaded so high that it turned over spilling the posts with him into the bay. He does not remember seeing cedar timber brought from Cedar Point after that. According to John Homegardner, Sr., and others the last of the large cedars were removed from Cedar Point by D. C. Richmond who used them for posts on his farm where they have remained sound to this day. This was in February, 1850. One of the men employed in the work was drowned. Mr. Homegardner too says, "they began taking them from the Point as early as 1835." Dan Myers came in 1852. He says "some cedars were cut in 1853 or '54. Probably these were not among the largest. 3rd. After counting the rings on a stump a number equal to five-eighths of the number of rings in the outer inch is added on account of the sap wood that has rotted away. 4th. The largest stumps are hollow and in estimating their age it is not right to assume that the number of rings to the inch in the missing portion was about the same as in the portion remaining. As a general rule the number to the inch increases toward the outside, though this is not very noticeable in small stumps;

in some of them the reverse is true. If the stump has a large hollow, estimates of its age are probably not very close. If the hollow is larger than in other stumps of similar size growing near, it is perhaps an indication not of greater age but of more rapid growth. If the stump is on low ground I think it is more likely to be hollow and Bartelle Reinheimer who has assisted in count- the rings has observed that stumps on low ground average fewer rings to the inch than those on higher ground. Doubtless the character of the wood and the abundant moisture both contribute to hasten decay. Many of the medium sized stumps are still nearly sound. For the first four inches from the center the number of rings averages about 13 or 14 to the inch and for the next four inches about 17 to the inch. Near the outside of one large stump 59 rings were counted in a single inch.

OLD RIDGES.

Ridge 5 back of the new hotel rises 13 feet above the lake, being higher than any of the ridges farther west. The theater, main pavilion and several other buildings stand upon it. Toward the northwest it diverges from Ridge 6 (1) giving room for a swamp containing a small pond. Although low in this part it is distinctly traceable to the vicinity of the lighthouse. Upon it is the rankest growth of poison ivy and other vines and an abundance of scouring rush and False Solomon's-seal. The cottonwoods have attained to old age and many other trees have grown to considerable size—black oak, white pine and basswood, more than 5 feet in circumference, white ash, red elm, sycamore and willow (Salix amygdaloides) more than 3 feet. Several of the cottonwoods exceed 8 feet in circumference. One measuring 111 inches was broken off probably by the wind, not less than 18 years ago according to Chas. Baetz. Where broken it is rotten but by chopping to the center of it 15 feet from the roots we were able to count about 141 rings. Allowing 10 years for the first 15 feet of growth we conclude that this tree started about 170 years ago. A few other cottonwoods are larger and were likely larger when this ceased growing. The living cedars on this ridge do not exceed ten inches in diameter but there are a few stumps a foot in diameter. On one of these 85 rings were counted. Another a little larger was not in such condition that the rings could be counted. It was probably but little older. Adding 90 to the number of rings counted for reasons given in a preceding paragraph we conclude from this cedar stump that Ridge 5 is not much less than 175 years old. It is likely older but probably not 200 years. We will take 180 years as its approximate age.

Ridge 4 is not very distinct from Ridge 3 toward either end but throughout the remainder of its length well defined, though rising only four or five feet above the valley on either side and only about four rods wide. It may be easily found by going west from the new hotel, "The Breakers," across Ridge 5, which is much higher. Its cedar stumps are but little larger and older than those on ridge 5. I estimate its age as 220 years.

Ridge 3 is ten or twelve rods broad and has an undulating surface. The power house and a number of other buildings stand upon its southern portion. In places it looks as if formed of two parallel ridges so close together as to be distinguished with difficulty. It has a rich vegetation—herbs of great variety and large trees of many kinds. It has ten cedar stumps 20 inches or more in diameter, three or four of them being about two feet. The age of the older ones has been estimated at 163, 165, 194, and two, less carefully determined, about 210 years each. Ridge 3 is probably about 310 years old.

Ridge 2 is situated between the two lagoons. It has large trees of various kinds, including black cherry which would not start until the soil had become enriched. It has many cedar stumps about 20 inches in diameter and two that exceed two feet. On one of these 26 x 27 inches, I counted 189 rings in the outer ten inches. Nearer the center of growth indicated by a knot, most of the wood has disappeared but some chips showed 8–16 rings to the inch. Allowing 13 rings to the inch the remaining 4 inches would add 52 rings, the sap wood 15, making a total of 256. On account of its size and location it was probably among the earlier cedars to be cut. Adding 65 years for this and 40 for time elapsing after formation of ridge before this tree started we have a minimum age for Ridge 2 of 361 years, but it is older than that. Ridge 2A, low and narrow, lies to the northeast of Ridge 2 and terminates about one-sixth of a mile from the cement walk. It has two stumps larger than any on ridge 2. One of them, 37 x 37 inches is probably the oldest stump on Cedar Point. When discovered, Oct. 22, 1904, I estimated the age as about 300 years. Feb. 19, 1905, I visited it again and made a more careful estimate. I found about 80 rings in the outer 3½ inches, the remaining portion being too much decayed to admit of counting many consecutive rings. The average of four fragments taken from different parts of the decayed portion was 13½ rings to the inch. This with 15 years for sap wood gives an age of 297 years. Ridge 2A, therefore, cannot be much less than four hundred years old, and as it was formed after Ridge 2, we will call the age of Ridge 2 four hundred years.

Ridge 1, on which the "White House" is located has many large black oak, American elm and other trees. Its cedar stumps are evidently older than those on Ridge 2, being larger and more decayed. Eight or more exceed 27 inches in diameter and four range from 30 to 36 inches. The ages of eight of the older ones were estimated at 185, 200, 220, 229, 236, 245, 261 and 262 years. The oldest, then, are but little older than the oldest on Ridge 2, and not so old as the oldest on Ridge 2A. It does not follow, however, that the ridge is only a few years older than Ridge 2 and 2A. In a forest that has been standing for centuries one is likely to find on five acres of ground one or two trees much older than any others of the same kind. Out of a hundred cedars starting at about the same time few live to be two centuries and ordinarily not one to be three centuries old. So the three-century cedar on Ridge 2A must be regarded as one that was exceptionally favored. The ten or twelve largest stumps on Ridge 1 appear to average fully six inches greater in diameter than the ten or twelve largest of Ridge 2. As these large stumps have an average of about 25 rings to the inch in the outer part we may take their average age as 75 years greater. The percentage of cedars to attain a diameter of 27 inches must be much less than of those that attain a diameter of 20 inches. It is therefore not improbable that Ridge 1 exceeds Ridge 2 in age by more than 75 years.

Number of Ridge	Name of Ridge	Estimated Age, Years.	Probable Error, Years.	Approximate Date of Formation.
1	Oak	475	50	1429
2	Cherry	400	25	1504
3	Cedar	310	35	1594
4	Pine	220	20	1684
5	Poplar	180	15	1724
6	Locust	45	2	1859
7	Buttonwood	26	2	1878
8	Willow	5	1	1899

BLACK SOIL.

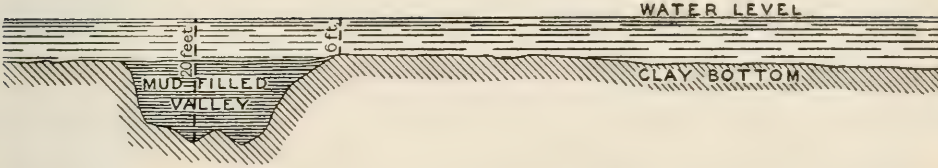
As we pass from the new to the old ridges, we notice a difference in the quantity of leaf mould that has accumulated. Ridges 8 and 7 have no covering of black soil. Ridge 6 has a little in places. On Ridge 5 it is about an inch deep, on Ridge 4, two inches, and on Ridges 3, 2, and 1, two to four inches or more. On Ridge 1 it is quite uneven, due, no doubt, to this ridge being so much exposed to the wind. The roots of many of its cedar stumps are well covered with sand.

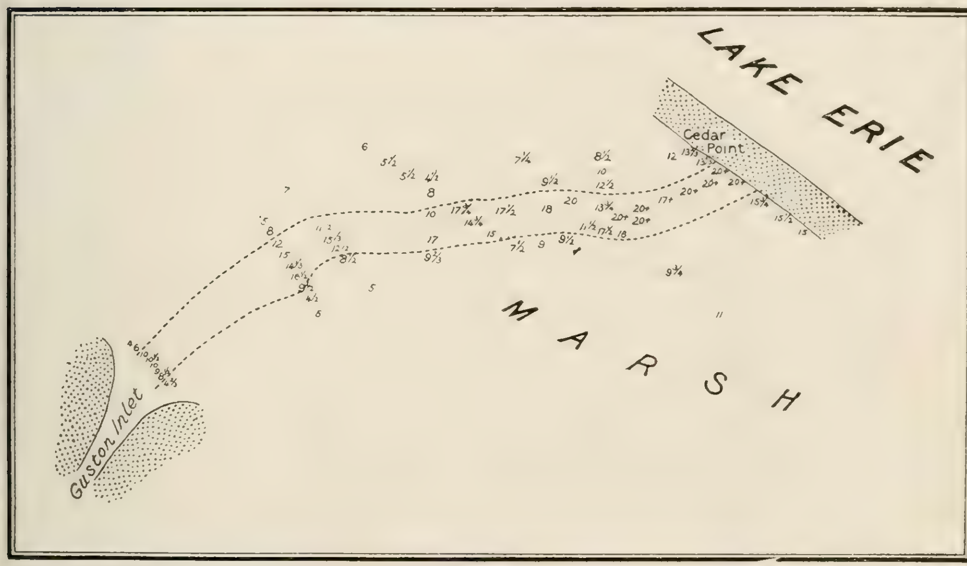
HEIGHTS OF VALLEYS AND OF AQUEOUS DEPOSITS IN RIDGES.

Soon after I began studying the ridges I noticed in going from the bay toward the lake a progression in the height of the valleys between them. In periods of high water the valley between ridges 1 and 2 could be traversed for quite a distance with a row boat and in very high water such as that of 1858 with larger boats. At such times it connected with the bay at its northwest end. This has been open once at least in the last 25 years. In October, 1904, it was opened by the dredge which made the lagoon in this valley and cutting through Ridge 2 made a lagoon between Ridges 2 and 3. Here also was water though not quite so deep as in the first valley. Between Ridges 3 and 4, and between 4 and 5, grow the swamp rose, cornel, and blue-joint grass showing that the soil is damp. Until 1904 I had never seen water standing in these valleys. All through the nineties the lake was too low but in 1904 a little water was visible at the surface between Ridges 3 and 5 beyond the northwest end of Ridge 4 and extending quite a distance. Between Ridge 5 and the lake the valleys are so high above water level that the sand is too dry for most plants and the scanty vegetation reminds one of the barren zone of the bar.

When I found that the ridges had been built up successively by the lake and that considerable time had elapsed between the formation of the earlier and later ones, it seemed likely that each valley might be higher than its predecessors because the lake itself had become higher than when the earlier valleys were formed. This hypothesis was strengthened when it was found that the valley behind Ridge 6, which was formed by the very high water that prevailed for some years prior to 1863, was higher than the valley behind Ridge 7, which was formed about 1878, and this higher than the valley behind Ridge 8, which was formed at a time of relatively low water.

Having noticed a progression in the heights of the valleys, it seemed possible that the aqueous deposits in the ridges them-





MAP IX.

East and west section one mile long, north of the western part of Sandusky, intersecting the submerged valley of Mill Creek.

Valley extending under marsh from Guston Inlet to Cedar Point, about a mile and a quarter. Thirty-three borings within the lines all show a greater depth to clay than the nearest ones outside.

selves might also ascend from the bay toward the lake. So the ridges were dug into in about 150 places altogether with a view to finding the highest trace of water action in each. The accompanying table gives the result, the data being reduced to mean lake level.

HEIGHTS OF PRINCIPAL RIDGES AND OF VALLEYS SOUTHWEST OF THEM.

Number of Ridge.	Approximate height of valley southwest of ridge, feet.	Highest aqueous deposits found	Height of aqueous deposits above valley.
1		2 .66	
2	−3.	4.55	7.55
3	−2.5	5.4	7.9
5	1.5	9.4	7.9
6	4.5	12.13	7.63
7	3.3	11.35	8.05

DEEPENING OF LAKE ERIE.

As each of the principal ridges was formed by a great northeast storm occurring at a time of high water the progression in level from the older to the higher is due to an elevation of the level of Lake Erie compared with the land. The approximate rate of change is determined by dividing the difference between the heights of the aqueous deposits in any two of them by the number of centuries intervening between their formation. Each ridge higher than all those to the southwest of it was probably formed by one of the greatest if not the greatest storm of the century or one that was more potent than others because of the high water at the time of its occurrence. That they were formed under similar conditions is evidenced by the fact that in each the highest indication of water action is about 7½ or 8 feet higher than the valley behind it. The accompanying table shows the rate of subsidence based on a comparison of the older ridges with Ridge 6, the highest. Ridge 3 gives a rate considerably higher than the others. It may be that it was not formed at the time of the highest water that occurred for many years, though at a time of high water. If we compare it with Ridge 7 we get a rate of 2.1 feet per century, which closely approximates the rate obtained by comparing the others with Ridge 6. It is quite possible that Ridge 3 is older than I have estimated.

On some of the recent ridges are aqueous deposits at a higher level than that at which the main roots join the trunks of the trees, indicating that the ridge was not the work of a single storm. If these deposits were left long after the trees started they would vitiate the results shown in the table. I have found no evidence that they were left long after and in the case of Ridges 2 and 6, it is certain that they were not, because new ridges were soon formed in front of each. The percentage of probable error in the determination of the age of Ridge 2 is less than in the other old ridges. It is old enough to give a long time interval. The rate based on comparing it with Ridge 6 is near the mean of the rates based on other comparisons. For several reasons then it may be regarded as the best.

Rate of Subsidence of the Land Based on a Comparison of Heights and Ages of Older Ridges With Ridge 6.

Number of Ridge	Maximum h'ght of aqueous deposits, feet	Approximate age, 1904	Older than Ridge 6	Lower than Ridge 6	Change of level feet per century
1	2.66	475	430	9.47	2.20
2	4.55	400	355	7.58	2.14
3	5.4	310	265	6.73	2.54
5	9.4	180	135	2.73	2.02
6	12.13	45			

The scarcity of gravel in all the later ridges and the valleys between them is in marked contrast to its abundance in and between the older ones. Ridge 4 and those more recent contain but little gravel; ridges 6, 7 and 8, probably not a hundredth part as much as ridges 1 and 2. It is scarce also along the present lake beach, but on the bay shore the old gravel deposits have been exposed by recent erosion. When the older ridges were formed the hardpan overlying the rocks of the Dune Section and containing an abundance of pebbles and boulders was in reach of the waves; but when the later ones were formed the lake had attained a higher level and the hardpan was too far below the surface to furnish more material. Most of the sand in the recent ridges and present beach has either been transported many miles from the southeast or carried by currents at the mouth of the bay.

The extension of Cedar Point lakeward and the formation of so many ridges in the last half century is probably due to the washing away of Peninsula Point on the other side of the entrance to the bay, the material being derived largely from that source.

Surveys show the width of Cedar Point from Rosebush Point to the lake to have been about 2350 feet in 1896, about the same in 1872, and about 2340 feet in 1826. If these measurements are correct the bay has worn away about as fast as the lake has built up. The jetty begun in 1896 and not completed for several years has already caused the accumulation of many acres of sand.

CONCLUSION.

LOOKING BACKWARD.

The broad and shallow rock valley occupied by Sandusky Bay was formed partly by preglacial, partly by glacial erosion. Upon the retreat of the glacier the greater part of this valley was filled with glacial clay nearly or quite to the present water level.

When the melting of the ice made an outlet to the east for the glacial lake, Lake Erie was established. At first it occupied only the eastern part of the basin it now occupies. The Sandusky River then flowed much farther than now, cutting a valley in the clay. Its tributaries also made valleys. The depression of the west end of the Erie basin relative to the point of outlet caused the lake to extend westward. In time slack water extended up the valley of Sandusky River as far as the present entrance to Sandusky Bay. The depression of the land continuing, marshes were formed along the river and its tributaries and after a time the water southeast of Johnson's Island had become so deep and wide that the waves cut away the clay between the valleys. The bay thus started was enlarged both by the rising of the water and by wave action, the latter proceeding more rapidly as the enlargement went on.

The rising of the water has continued with a nearly or quite uniform rate—about two and one-seventh feet a century—for at least four centuries. If the rate was about the same during the preceding centuries we may conclude that at the beginning of the Christian Era slack water extended up the Sandusky River valley as far as Johnson's Island. Fifteen hundred years ago it extended up the valley of Mill Creek about a mile and a half from its junction with the Sandusky River south of Johnson's Island and to within a mile and a quarter of the present mouth of Mill Creek. The islands of the Put-in-Bay group were still part of the mainland. Until about a thousand years ago the Indians might have walked from Sandusky to Kelley's Island at any season, having merely to swim across one or two streams and wade through some marsh. East of Johnson's Island the river may then have been as wide as the Portage west of Port Clinton is now.

Before America was discovered the shore of Lake Erie was where Cedar Point is now, and at the time of the discovery was not far from Ridge 2 between the two lagoons. By this time Sandusky River valley had probably become wide enough south of Johnson's Island to form quite a bay, which, however, extended less than two miles west of the island, though slack water and marsh continued several miles farther.

When Jamestown was founded Pipe Creek and the streams beyond still entered the lake and not the bay. The land was as yet continuous from Cedar Point to Sandusky. West of the Bay Bridge was considerable marsh but little or no open bay.

In the eighteenth century the bay was known to French traders. A French map of "Louisiana and the Course of the Mississippi" dated 1718 was exhibited by the government at St. Louis in 1904. It shows Lac Sandouské. Other maps made in the eighteenth century also call it a lake. They show a narrow opening into it from Lake Erie. The American Gazeteer, 1797, says: "Sandusky Lake or Bay at the south-western side of Lake Erie is a gulf shaped like a shoe, and entered from the lake by a very short and narrow strait." None of the maps of the eighteenth century give the outlines with any approximation to accuracy. The first actual survey of the region south and east of the bay appears to have been made by Almon Ruggles in 1807. Map VIII shows a part of this survey, but Johnson's Island and the Peninsula, although shown on the map, had evidently not been surveyed.

Within the memory of Captain Freyensee and others still living bulrushes grew in all the water between Johnson's Island and the Peninsula and in some other parts of the bay where for many years has been open water.

Looking Forward.

One can never be quite certain as to future events. It looks as if the peninsula that separates Biemiller's cove from the bay, part of which has been land for thousands of years, would disappear in our own time. Now that the top of the clay has been reached by the rising water, the whole of Cedar Point may share the fate of Peninsula Point at no distant date unless jetties, piers, cribwork, etc., suffice to save it.

The bay with the connected marshes is probably twenty per cent larger now than in 1820. So far as the enlargement is due to erosion it should proceed more rapidly the wider the bay becomes, for the waves attain greater force. The effect of the waves, however, is diminished by the bay bridge, by jetties at the entrance to the bay, by docks and by stones put on the shore purposely to protect the land. The enlargement of the bay due to the subsidence of the land may be partly prevented by dikes and may be effected to some extent by changes at Niagara Falls produced by human agency. We may reasonably expect, however, that the bay will continue to spread over the adjacent lowland much as it has been doing for centuries past.

The rise of the water due to tilting of the land, 2.14 feet in a century, is about the same as the change of lake level that sometimes occurs within a year in consequence of variations in the rainfall and is considerably less than that produced in Sandusky Bay by a single northeast gale. It is, however, cumulative. The present generation is likely to see the water higher than it was in 1858 and in northeast gales the lower parts of Sandusky submerged, but at the present rate of subsidence the bay at ordinary stages of the water will not extend up Columbus Avenue as far as Market Street for about eight hundred years. Port Clinton is not so fortunately situated. Northeast gales will cause much trouble there as soon as there comes a period of several years when the rainfall is considerably above normal, and before the middle of the next century the water at such times will go quite across the peninsula from Port Clinton to Sandusky Bay. After two or two and a half centuries the water will cover this part of the peninsula for months at a time and after three centuries will do so at ordinary stages. Marblehead will then be an island and Sandusky Bay will show no resemblance to its present form.

Biology and Mathematics

DR. GEORGE BRUCE HALSTED

That which is most characteristic of the present epoch in the history of man is undoubtedly the vast and beneficent growth of science.

In things apart from science, other races at times long past may be compared to the most civilized people of today.

The lyric poetry of Sappho has never been equaled. The epic flavor of Homer, even after translation, comes down to us unsurpassed through the ages.

Dante, the voice of ten silent centuries, may wait another ten centuries before his maedieval miracle of song finds its peer.

The Apollo Belvidere, the Venus of Milo, the Laocoon are the glory of antique, the despair of modern sculpture. To mention oratory to a schoolboy is to recall Demosthenes, and Cicero, even if he has never pictured Caesar, that greatest of the sons of men, quelling the mutinous soldiery by his first word, or with outstretched arm, in Egypt's palace window, holding enthralled his raging enemies, gaining precious moments, *time*, the only thing he needed to enable him to crush them under his dominant intellect.

There is no need for multiplying examples. The one thing that gives the present generation its predominance is science.

All criticisms of life made before science had taken its present place, or attempting to ignore its prominence are obsolete, as are of necessity any systems founded on pre-scientific or anti-scientific conceptions.

Now the latest of the great sciences is biology, and it could be so widely interpreted as to include many of the others, for example, physiology, psychology, sociology; but chiefly it takes for itself the broad general beginnings.

These older sciences were really engaged upon narrow domains, narrow ramifications in the universe of biology; and the general has helped the pre-existent special by giving the broader conceptions connoted by comparative physiology, comparative psychology, comparative sociology.

Since Woehler, the distinction between organic and inorganic matter has become merely schematic; but the line drawn at life has resisted obliteration

It is true that my friend, Professor Herrera has said:

"I conceive the human organism as a machine containing some five or six litres of blood employed in appropriating to itself the nutritious principles of food, absorbing oxygen, and carrying it to the nerve to make it vibrate by discharges of carbon-dioxide.

"Life is now to be defined as the result of the physico-chemical action of protoplasmic currents, the cause of such currents being diffusion, heat, and some other secondary factors."

But until someone sees such currents set up in some way differing from the natural transmission of pre-existent life, a thing which no one at present even hopes for, the old boundary remains undisturbed.

If any benefit is obtainable from a physico-chemical nomenclature and notation, science will not object to their use.

Suppose, then, we put it in the boldest form, that biology is now engaged in the creation of an available representation of the activities and laws of activity of these wonderful protoplasmic currents.

The definition then would be something like this: Biology is the science created to give understanding and mastery of the protoplasmic activities on this earth; to make easy the explanation and description of such activities and the transmission of this mastery.

The association, the suggestion is immediate:

Beyond the microtome, the microscope, the statistics of observation, of experiment, of what instrument of world-conquest must the new science avail herself? The answer is patent; of mathematics, that giant pincers of scientific logic which showed Newton the moon as simply a bigger apple trying to fall straight down on his head, flashed out in the mind of Adams the unseen planet Neptune, told Rayleigh that the chemists had always been breathing vast quantities of argon without knowing it, pointed to Mendeljeeff the places of unknown chemical elements, and through Helmholtz and his pupil Hertz has given us the Lenard rays, the Roentgen rays, radium itself, and wireless telegraphy based on Hertzian waves.

In mathematics, the part which is being recognized as pure deductive logic is ever greater. The residuum takes from biological advance itself new form and new statement.

After the questions, what are facts? what is reality? questions not to be answered either by biology or mathematics, there come, if we decide to retain as rough working hypotheses the expressions fact, reality, subsequent questions, such as what then is a *geometric* fact, a *geometric* reality?

These latter questions involve a wrestling with primitive origins in physiological psychology, now entangled with metaphysical constructions, all being studied at present with help of the biologically given hypothesis of evolution.

To note the essential inter-relation of biology and mathematics it is only needful to recall that evolution postulates a world independent of man, preceding man, and teaches the production of man from lower biologic forms by wholly natural causes.

If this be so, then skipping the fundamental puzzle as to how a living thing gets any conscious knowledge, any subjective representation of that independent world, it remains of the very essence of the doctrine of evolution that man's knowledge of this independent world, having come by gradual betterment, trial, experiment, adaptation, and through imperfect instruments, for example the eye, cannot be metrically exact.

In the easiest measurements it is said we cannot even with the best microscopes go beyond one-millionth of a meter; that is, we are limited to seven significant figures at most. What is the meaning then of the mathematics which, as in case of the evaluation of π, has gone to seven hundred places of significant figures?

If then we are to hold to evolution, science must be a construction of the animal and human mind; for example, geometry is a system of theorems deduced in pure logical way from certain unprovable assumptions precreated by auto-active animal and human minds.

So also is biology. But here the assumptions are more fluctuating, and many of them are still on trial.

Since every science strives to characterize as to size, number, and, where possible, spatial relations the phenomena of its domain, each has need of the ideas and methods of mathematics. One of the fundamental ideas of mathematics is the idea of variation, the variable, qualitative and quantitative variability.

When related quantities vary, one may vary arbitrarily, this is called the independent variable. Others may vary in dependence upon the first. Such are called dependent variables or functions of the independent variable. The change of the variables may be continuous or discontinuous. The blind prejudice for the assumption of continuity is so profound as to be unconscious.

But if biologists did but know it, the characteristics, peculiarities and methods of investigation for continuous functions differ essentially from those for discontinuous functions.

Our calculus assumed continuity in all its functions, and also that differentiability was a necessary consequence of this continuity.

Lobachevski, the creator of the non-Euclidean geometry, emphasized the distinction between continuity and differentiability, therein also being half a century in advance of his contemporaries.

The mathematicians of the eighteenth century did not touch the quetsion of the relation between continuity and differentiability, presuming silently that every continuous function is *eo ipso* a function having a derivative.

Ampere tried to prove this position, but his proof lacked cogency. The question about the relation between continuity and differentiability awoke general attention between 1870 and 1880, when Weierstrass gave an example of a function continuous within a certain interval and at the same time having no definite derivative within this interval (non-differentiable).

Meanwhile, Lobachevski already in the thirties showed the necessity of distinguishing the "changing gradually" (in our terminology: continuity) of a function and its "unbrokeness" (now: differentiability).

With especial precision did he formulate this difference in his Russian Memoir of 1835: "A method for ascertaining the convergence," etc.

"A function changes gradually when its increment diminishes to zero together with the increment of the independent variable. A function is unbroken if the ratio of these two increments, as they diminish, goes over insensibly into a new function, which consequently will be a differential-coefficient. Integrals must always be so divided into intervals that the elements under each integral sign always change gradually and remain unbroken."

In more detail Lobachevski treated this question in his work, "On the convergence of trigonometric series," in which are also contained very interesting general conisderations on functions.

"It seems," he writes, "that we cannot doubt the truth that everything in the world can be represented by numbers, nor the truth that every change and relation in it can be expressed by analytic functions. At the same time a broad view of the theory admits the existence of a dependence only in the sense that we consider the numbers united with one another as if given together."

Now biology deals largely with aggregates of individuals, and then, like the pure theory of numbers, its variables are discrete, and must change by jumps of at least one individual.

A mathematics proper to such investigations has not been accessible to the biologist, for not only has his calculus been founded solely on continuity, but also his geometry has been developed for him on continuity assumptions from the very beginning.

The very first proposition of Euclid is to describe an equilateral triangle on a given sect (a given finite straight line). It begins: "Let AB be the given sect. From the center A with radius AB describe the circle BCD. From center B with radius BA, describe the circle ACE. From the point C, at which the circles cut one another, etc." But the whole demonstration is the assumption of this point C. Why must the circles intersect? Not one word is given in proof of this, which is the whole problem.

You may say the circle is a continuous aggregate of points. If so, then the circle cannot represent a biologic aggregate of individuals.

Geometry can be treated without any continuity assumption, without continuous circles, in fact without compasses.

Such a geometry for biologists, is my own Rational Geometry, the very first text-book of geometry in the world without any continuity assumption.

How biology has been misled in its mathematics you will realize when you recall that geometry and calculus have been the basis of mechanics, mechanics the basis for astronomy and physics, physics the basis for physical chemistry, while even the theory of probability had no discontinuous mathematics specially its own.

Therefore biologists had clapped over their eyes spectacles of green continuity, and these spectacles colored biologic theories with the following characteristics as enumerated by the Russian Bugaiev:

(1) The continuity of phenomena;

(2) The permanence and unchangeableness of their laws;

(3) The possibility of characterizing a phenomenon by its elementary manifestations;

(4) The possibility of unifying elementary phenomena into one whole;

(5) The possibility of sketching precisely and definitely a phenomenon for a past or future moment of time.

These ideas make the very essence, the framework, the skeleton of modern biologic theories. They have forced their way in and imbedded themselves as being necessary to make possible the application of the methods of continuity-mathematics to the investigation of nature. They follow out the fundamental characteristics of continuous analytic functions. Therefore we may designate our modern biology as a continuity-biology.

Thus, as the Russian Alexeieff has pointed out, after the continuity world-scheme had captured the fundamental natural sciences, geometry, mechanics, astronomy, physics, chemistry, had intrenched itself in them and dowered them with generality, uniformity, universality, it went over gradually with scientific investigators by habit so to say into flesh and blood, and began to penetrate and dominate in physiology, in psychology, in sociology, in biology.

Darwin's attempt to found the law of the evolutionary origin of species is an outcome of the continuity world scheme, permeated, saturated with its basal idea, continuity.

Just so strengthens itself more and more the persuasion of the continuous growth and continuous perfection of all the elements of human society in its natural advance.

The evolutionary development of social life permeates always more and more the view of the historian. Many writers are so habituated to this continuity world-scheme, that without sufficiently critical consideration, they apply it where it is essentially inapplicable and inappropriate.

So we have the doctrine of a fatalist causality, denial of efficient freedom of the will, belittling of the idealistic endeavor of mankind, hence the pessimistic attitude toward the whole of human existence.

Paraphrasing a Russian poet, Nature thus speaks to man:

Thou mayst be head of creation,
But who gives thee any crown?
Dost thou believe, poor fool, in blind delusion,
That I am slave to thee, and thou my lord and master?
Of the thick veil lift I a corner tip
And pygmy, then presumst thou
All through me that thou seest?
Seeing thine own small law and plan, art then deluded
Into the holy of holies to have pushed?
Oh fool! I do but nod and wretchedly thou'llt shudder,
Cower like timid dog on the sod. The earth
I shake and suddenly is dust
Thy pride and might, the greatest of thy cities.
War I send and pestilence its sister,
The blooming fields transform I into deserts,
The sea I drink up and the sun shroud I in darkness,
And thou, brute-like, wilt howl with pain, with anguish.
What you strive for and hope,
To me that is indifferent.
Pity know I none, and my law of the number

Knows neither weal nor woe, knows
Neither praise nor blaming.
To unknown lands I stride in war, in whirlwind.
I know no aim, no end and no beginning.
I beget and I destroy, not prating, never angry,
The elephant and the worm, the
Wise man and the foolish.
So live as all live. Float out on the
Flood eternal
One instant brief, and vanish then forever.
Presume not stupid-bold with me to wage a contest,
With me eternal mother of all living and all dead."
So thunders Nature with a million voices
In hail, in surge, in storm-wind and the lightning.

So much for the continuity world-scheme in biology.

But the latest advances in mathematics have rendered unnecessary for biology the wearing of this mis-fit garment.

The new mathematics gives now a standpoint for the explanation and treatment of natural phenomena from which the individuality of the biologic elements need not be suppressed.

It has triumphed for its own domain in cases where the continuity methods were wholly inapplicable, where arithmology, discrete mathematics was called-for and victorious.

Such are the problems which relate to the properties of whole numbers, solved so brilliantly in number-theory.

Such again are the questions relating to the enumeration of the geometric forms within parameters which satisfy n given conditions. These even in the simplest cases showed themselves insoluble until finally between 1860 and '70 the French mathematicians created special discrete methods. Thence sprang a wholly new branch of mathematics, Enumerative Geometry.

A third, an epoch-making universe of discrete mathematics is the wonderful Invariant Theory of the great Sylvester and his brother-in-arms Cayley, two men whose loss left the English-speaking world without a single mathematician of first rank, of the rank of Hilbert and Poincaré.

In chemistry this discrete mathematics has shown itself of such use and power that we may assuredly say chemistry owes its present stand-point almost wholly to two lines of advance both discrete, the atomic structure theory of Kekule, and Mendelieev's periodic system of the chemical elements.

The brilliant and rapid advances in chemistry have come not from suppressing but from stressing the individuality of the elements. Its mathematics has been essentially discrete.

The arithmologic scheme of chemical research, the atomic structure theory of Kekule, coincides completely with the scheme of the symbolic invariant theory, though both were worked out independently.

Now to biology and sociology, having to do with single individuals differing from one another, in biology cells, in sociology human personalities, the continuity mathematics with its universalism is so ill adapted by its nature that the discrete way of thinking must here soon take the chief role, giving as it does large and free play to the individual peculiarities of the elements to be studied.

The continuity thought-way strives to reduce all phenomena of nature to a general mechanism with fate-determined movement. Just contrary to this then is the view that living nature is a rationally-correllated realm, in which everything is harmonic, shows adaptation, strives toward perfection.

Are not the mechanical form-phenomena of the living organism only its most elementary properties, upon which are built others higher, psychic? Now the psychic properties of a living organism cannot be studied by observation and comparison of the accompanying mechanical properties unless they flow from these mechanical properties. If these accompaniments be unessential, the psychic properties cannot be concluded from them. Here is even yet the battleground.

Biologists are at present emphasizing the statistical method, but upon this modern mathematics has for them another message. They rely upon the method of least squares and mean value. But Chebyshev has demonstrated that not the great number but the independence of the metric phenomena plays the chief part in the application of the theory of mean value. This independence is the essential requisite, and it is the very thing whose unwarranted assumption vitiates much biologic research.

An illustration may be drawn from fire insurance. From the records of past conflagrations of single houses, if the burning of each one is independent of that of every other, the theory of mean value can get a number which can be counted upon to recur with slight variation from year to year, and upon it can be based the charges for insurance.

To realize how completely this essential requirement may be lacking, we have only to remember the Chicago fire, or the Baltimore fire.

Biologists have treated their combinations as if they were simple summations of independent elements.

More likely are the combinations composed of interdependent factors whose symbolization must be at the simplest a product.

A tremendous illustration of variation under change of stimuli is given by Japan. For centuries environment and potential variability were in static balance; variation was zero.

Then came Commodore Perry, humiliations to the inordinate pride of a hermit nation, defeats, contempt, a tremendous response to the changes in stimuli, and today dark pagan Japan is easily defeating the largest European Christian white nation: variability unchanged, variation the greatest recorded in human history.

According to Quetelet's celebrated law of variability published some years after Darwin's Origin of Species, it is subject to the law of probability, and according to this law the occurrence of variations, their frequency and their degree of variation can be calculated and predicted in the same way as the chance of death, of murders, of fires.

But such applications did not fit actual evolution, since the law is to deal with different degrees of the same qualities, giving a continuity production of species, while as De Vries has so stressed, the origin may be by abrupt jumps, by sports, by mutations.

De Vries has said that a thorough study of Quetelet's law would no doubt at once have revealed the weak point in Darwin's conception of the process of evolution. It would have shown that the phenomena which are ruled by this law and which are bound to such narrow limits, cannot be a basis for the explanation of the origin of species.

It rules the degrees and amounts of qualities, but not the qualities themselves.

Species, however, as De Vries says, are not in the main distinguished from their allies by quantities, nor by degrees; the very qualities differ.

How such differences of qualitative character have been created is the burning question. They have not been explained by continuous accretion of individual variations.

The attitude of the new mathematics strongly favors attempts like the mutation theory, based on the abrupt, explosive changes, wholly discrete, which under the name of "sports" had long been observed and known in horticulture and animal breeding, and of which DeVries has found a whole fusillade being shot off by "Lamarck's evening primrose."

Here he says there is no gradual, no continuous change or modification, nor even a common change of all the individuals. On the contrary, he says, the main group remains wholly unaffected by the production of new species. After eighteen years it is absolutely the same as at the beginning. It is not changed in the slightest degree. Yet it produces in the same locality, and at the same time, from the same group of plants, a number of new species diverging in different ways.

The vastly vaunted natural selection, then, can only destroy new species, never create them.

The Relative Value and Extent of Scientific and Literary Teaching in a High School Course

J. C. HAMBLETON

In the preparation of a course of study for our High Schools it is necessary to bear in mind that there are two classes of pupils to be served, those who expect to continue their studies in some university and those who will not, at most, more than finish the High School course. Of these two classes the latter is far the more numerous and consequently the more important and should receive the greater attention. Usually they are the children of the middle classes and have parents whose opposition has had to be overcome before they are permitted to complete the High School course. It is for this class it seems to me we should endeavor to build a course of study, such that it will best fit them for the life that they will, by force of circumstances, be obliged to lead.

High school pupils are not all alike any more than are their parents. The child very early manifests the likes and dislikes that are to control its actions during life, and wise is the teacher or parent who is able to discover these tendencies and develop rather than attempt to destroy them. This then is ample reason for having a varied course of study wherever this is possible. Then, also the pursuits of men today are exceedingly varied, and to follow them successfully makes necessary many different kinds of preparation. Our colleges and universities have already learned this and now we see that almost every human occupation that requires knowledge and skill in its pursuit is taught in our institutions of higher education.

But the question is, shall this same latitude in the choice of studies be allowed in our high schools? Is it true, as some contend, that nothing but a few years of literary training will give a person that culture which is so essential to the true gentleman? Or, can he study the sciences and acquire that same mental ability that the study of the classics is reputed to give him? Will the time ever come when the study of Physics or Chemistry or Botany will occupy as prominent a place in our curricula as that which is occupied by Latin today?

We are all, of course, familiar with the early educational movement in Europe. That was an age when the mind of man was just awakening from a long slumber, aroused by the beauties of the literatures of old Greece and Rome. Soon after, the wave of religious enthusiasm in the form of the Reformation, that swept over Europe, gave to men an intense desire to study deeper into the mysteries of God's word. As a result of this awakening the study of Language and Literature grew in popularity and men thought that nothing more was required for a complete education. And were they not right? Would anything else have awakened men from the stupor of the Dark Ages?

Civilization, as we understand the term today, was then in its infancy. Simplicity marked all the pursuits of life. Machinery, all but the simplest types, was unknown. Streams were forded instead of being spanned by bridges. The great Ocean was a mystery upon which they dared not venture. But as time went on changes came. The science of Aristotle no longer satisfied the demand. Something larger, something truer, more real must come or men would again sink into that Chinese stagnation that had characterized their thought for so many hundreds of years.

The story is too well known to be related here. The demands of the world today are not what they were a thousand years ago, nay, nor a hundred years ago. Then will the education that they gave their youth a thousand years ago or a hundred years ago be the one that is best suited to prepare *our* youth for the complex struggle that is to meet them in a few years?

It seems to me that no sane man will say that our educational system is so perfect that it should be stereotyped for all time. Let us then leave these petty bickerings as to the greater value of this study than that, and recognize the one great general principle that when an organ is properly exercised its power is increased.

The progress of the world during the last half century has been phenomenal in many ways. Along what lines has this progress been most marked? Has it been along the line of literary production? Has the world been made broader or has it become a more comfortable or pleasant place to live in because of its literary productions? Can we truthfully say that the literature of the present day is very far in advance of that of the Elizabethan Age several hundred years ago? Then can we ascribe this wonderful advance in the world's progress to its influence?

Is the railroad, the factory, the coal mine, the telegraph and the thousand and one other things that make life livable at the present time due to the classical education that is dealt out by our institutions of Higher Education? Surely he must be a prejudiced partisan who will dare to answer this question in the affirmative.

Unquestionably, my friends, the scientific side of life has the upper hand at the present time. The greatest advancement in modern times has been along all lines of science and no one can doubt that this will continue for many generations to come.

Our secondary schools are and, of course, should be conservative institutions, but they like everything else must bow to the inevitable. They cannot maintain a course that is not in harmony with modern development. It is difficult to make an engineer believe that his success is due to the classical education that he may have had in his youth, and it will be still harder to make him see how his son's prospects in life will be spoiled by pursuing the sciences in the high school rather than Latin.

A new doctrine of philosophy put forth today, however plausible it may be, does not cause more than a ripple on the surface. The world reads about it, gives it a moment's thought and then forgets it. It is not so with the fate of some new invention or discovery. Surely no philosopher or literary man of modern times has stirred the world of thought as has Marconi. Nothing but theories in former times could furnish wings to the imagination, while today man finds outlet in things that are real, in things that will benefit the human race in a material way.

This is a materialistic age, however much we may regret the fact, yet fact it remains. The whole tendency of modern times is in this direction. Man is no longer punished for what he *thinks*. Little does it matter to me what my neighbor's theories and beliefs are, provided his *acts* are right and he allows me to live in peaceable possession of what I call my own. The modern institution of learning, be it Higher or Secondary, must recognize these facts and govern itself accordingly.

If we but pick up the text books of science of twenty years ago we shall see that the science work that was done at that time by our colleges is now being better done by our high schools. Is this true of other things? Did not our youth who were intended for the university in former times begin the study of Latin at the age of seven or eight years? Does anyone advocate this idea at the present time?

Then is it not plain that this scientific idea has already influenced and is still influencing our schools? And who will dare to say where the end may be? No, my friends, hard as it may seem to some of us, our schools must and will reflect, and be in harmony with the modern tendency, and all the argument and eloquence of a Demosthenes or a Gladstone can not prevent it.

While we all may recognize these facts, none can but acknowledge that the so-called scientific teaching in our high schools is in a chaotic condition. In fact, I think the principal objections to the science work is due to the fact that very often the classes are in charge of some one who has not been trained to do the work properly. How often do we find such classes thrust upon some one who has no natural aptitude or liking for the work, because there is no one else to take them. Not less frequently are such classes brought into ill repute because the teacher who has charge of them is not given the facilities that the proper pursiut of the study requires. Too often is it the case that the teacher of some branch of scinece in which laboratory work is essential, and without which it is but a memory exercise, is called upon to do as many hours actual teaching in the class room as the teacher of Latin or Mathematics, and then if he fail to obtain the results that are expected of him, either he or the study has to bear the blame when neither is at fault.

Then again the proper pursuit of such studies as Botany, Chemistry and Physics requires a more or less expensive outfit, which school authorities are often loth to give. But they too are advancing with the times and we now see the high schools in many small towns and even villages equipped with more adequate chemical and physical apparatus than that possessed by our largest high schools of fifteen or twenty years ago.

The march of progress is irresistible and the tendency of the times is unmistakable. The rapidity of its advance will be measured by the ability of our science teachers to bring order out of chaos. We must decide upon what is the best course for our high schools and then work for its universal adoption. Again we must not forget that the course of study does not make the school. Perhaps in no other department is the teacher so large a factor. Our universities should at all times be on the look-out for men and women who seem to have peculiar fitness for teaching these studies and encourage them to take up high school work. Pure scholarship and wide learning, while desirable, are not the most essential qualities of a good high school teacher. Take for instance, the teacher of Botany, He can find no text book to put into the hands of his class to which he can adhere closely. He must go to Nature for his text book, and have the ability to select such types for study as will give his pupils a lasting knowledge of the vegetable kingdom. He should be so well acquainted with the local flora that he can give his pupils an intelligent answer in regard to any specimen they may bring to him. He need not be a specialist on Mosses nor Fungi, but he should be able to tell one of these from the other and point out to his pupils the essential differences between them. He should not be satisfied to give up his class until his pupils are acquainted in a general way with the whole vegetable kingdom and can look with intelligent eyes upon the thousands of plants that surround them, from the lowest to the highest, and are acquainted with the great facts that underlie the science of vegetable physiology.

Zoology is another study that is destined to occupy the attention of our educators in the future to a much greater extent than it has in the past. However, once that the foundation principles of plant life have been well grounded much less time need be spent on this study than on Botany, in order to give the class as good an understanding of the animal kingdom as they have of the vegetable.

Nowhere in the whole course of study can such an opportunity be found to emphasize the importance of scientific classification as in the two branches just mentioned. Every successful man has his business systematized, and system means nothing but scientific classification. It seems to me that the teacher who does not bring out this principle misses the greatest opportunity that is offered to him.

Need anything be said of Mathematics and Physics? The former, by unanimous consent has long occupied a most prominent place in every course of study, and in recent years the latter has also taken its proper place as is made manifest by the fact that all high school teachers are now required to pass an examination in it before they are given a certificate to teach. This as you are aware only became law at the last session of the Ohio legislature.

Perhaps greater difficulty will be encountered in the systematic introduction of Chemistry into our high schools than in that of any other branch of science. This arises because of two conditions: first the expensive apparatus required, and second, the amount of time necessary for laboratory work, without which Chemistry is of little value. In no other branch of science teaching is there so little system and harmony. Even our colleges and universities can not agree upon what they want for admission. Some require a year's work with plenty of laboratory work, while others require none at all. Still others will accept a year's work, counting it as a science credit, for entrance, yet give no credit for it once the pupil is admitted. So long as this state of affairs exists in the college, little but chaos can be expected of the high schools.

As yet, the teachers of Chemistry in our high schools are not agreed as to the nature of the work that they should give their pupils. Some think a thorough grounding in the foundation principles of the science should be insisted upon, with a well selected list of laboratory exercises to illustrate them, while others wish to make more of a point of analytical work with laboratory work to suit. Still others, and these are by far the greater number. are obliged by force of circumstances to give their classes but a smattering of general principles with, perhaps, a poorly selected list of laboratory exercises, or none.

Whatever the solution to all these difficulites may be in time, there is one reform that must come about before this science can become firmly established. Nowhere is there enough attention paid to the industrial side of Chemistry. Our best text books have little to say about the subject and as a result the pupils finish the course without getting any adequate idea of what an important factor Chemistry is in modern life.

In my opinion the high school Chemistry, just as every other science, should not be too technical but should be developed along lines that come in contact with every day human experience. This would give those who will not pursue the study further a lasting knowledge of it and at the same time furnish a good foundation for more advanced study. But as I said before, some agreement must be arrived at by the colleges and then the high schools can have a basis upon which to work out a uniform system. Then and then only will Chemistry take the place it deserves in our high school course.

But ladies and gentlemen, I would not have you think for a moment that I wish to detract one iota from the importance of literary work. Great lessons can be drawn from the intelligent study of History that will be invaluable and indeed essential to the education of those into whose hands must fall the reins of government in the years that are to come. And of Language it is unnecessary for me to speak, especially of the mother tongue. Too much importance can not be attached to it, especially when we see so large a percentage of our high school graduates that can not write a correct business letter. One is almost inclined to think at times that we should again go back to the old spelling book.

Unquestionably, at least, one foreign language should be studied, and that thoroughly, and in my humble opinion, that language should be a modern one. But let this be left to the choice of the pupil or his parents.

I hope I have made myself plain; the scientists do not want everything. They only ask for a proper recognition of what they consider equal in importance to the literary work. They ask and have a right to demand that the science work be placed on a par with that of any other department, and that the pupils who select this course may not be made to feel that they are doing inferior work.

Robert F. Griggs

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A MONOGRAPH

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Trustees.

INTRODUCTION.

The purpose of this paper is to make the willows of Ohio knowable to persons of moderate skill in the determination of plants. Perhaps it would be too much even to hope that it will enable beginners in Botany to deal with the willows. But if it helps those who have already some knowledge of the native flora to extend their acquaintance to this very common gen us, it will have justified its preparation. For Salix, like Carex and Crategus is considered by many Botanists too difficult for any but the specialist. Many competent workers seem to be unable to cope with Salix and there are few even of the larger herbaria in which the willows are correctly determined. The reason for this the writer believes to be not in any inherent difficulty of the group for it is not so difficult as many better known genera, but in the fact that an adequate description of it has never been presented. It is toward filling this need that the present effort is directed.

The species are all rather similar and variable but the differences between them are not as inconstant as has been supposed. But the space that has been devoted to them in the manuals is entirely too small for their accommodation even when treated by such a master as Bebb, whose account published many years ago in Gray's manual remains the best treatment of the species within our area. Nor can their character be represented by line drawings such as appear in Britton and Brown's Illustrated Flora; even the lithographs of Sargent's Silva are but little better. The *character* of a willow leaf is too subtle a thing for the ordinary scientific artist to portray; for that, the camera is necessary. Another fault of most of the descriptions and keys hitherto published is that they have been written with a complete specimen in mind, as it might be assembled on the herbarium sheet with both kinds of flowers and leaves. But a collector never has a complete specimen and is sure to be balked by lack of the missing parts. It must be admitted, to be sure, that there are some stages of some species which are almost indeterminable. But they are not so numerous as to make it inadvisable to construct keys for the others.

Any successful treatment of the genus must for the present be local in its scope for Salix is subject to very great geographical variation and a treatment of a given species which would be entirely accurate in a given area might be entirely inadequate for the same species if observed a thousand miles from the first locality. The description of *Salix nigra* given below for example would not cover at all satisfactorily the southern and western plants which go by that name. And yet though the characters which we use in the descriptions vary enormously, one would still recognize without much difficulty that the southern plant was *Salix nigra* in a metamorphosed condition. Consequently, as far as the native species are concerned, at least, though it is hoped that this paper will be of service all over the northeastern portion of the United States, one must expect to find it more and more at fault as one recedes from Columbus. Some day when there is a monograph like the present covering every state in the country, some genius will write a general treatment that will effectively handle all the species.

One reason why it is necessary at present to limit the treatment to a small area is that no one has yet succeeded in describing the qualities by which we recognize a willow. We define the species by external, artificial characters such as the shape and hairness of the leaves, the length of the pedicels and so on; but all such characters may vary enormously and still leave the qualities by which the expert determines the species, constant. We cannot study willows profitably by tables of dimensions and geometrical descriptions of the leaves any more than we can study the faces of our friends by measuring the length of their noses. As there is a certain almost indefinable individuality in a human face, there is in a species of plants an individuality no less indefinable but no less important.

I here desire to extend my thanks to friends who have aided me very greatly in the preparation of this paper: to Dr. W. A. Kellerman of the Ohio State University, who at one time planned to be joint author with me, for innumerable kindnesses done and suggestions given during the whole course of the work; to Prof. John H. Schaffner of the same institution for help especially in verifying and testing the keys and to Mr. Otto E. Jennings of the Carnegie Museum for the loan of the collections of that institution.

The present paper is based on studies and collections of willows begun in the spring of 1898 and carried on as opportunity afforded ever since. During that time the author has been enabled to study the plants in the field in various parts of Ohio, in the vicinity of Washington, D. C., and in the Red River Valley of North Dakota and Minnesota. The herbarium on which he has mostly depended is that of the Ohio State University at Columbus. The United States National Herbarium and the Herbarium of the Carnegie Museum at Pittsburg have also contributed considerably to whatever value the work may possess.

TERMS.

Most of the terms used are those common to Botanical descriptions, but those referring to the venation may be so unfamiliar as to require definition. They are based on a most excellent paper by Dr. Glatfelter (Rep. Mo. Bot. Gard 5:46–60. 1894.) on the venation of the willows.

Primary. A main vein branching directly from the midrib.

Costal. A smaller vein from the midrib, of considerable size but not reaching as far as the primaries.

Secondary. A vein of the second order given off from a primary.

Tertiary. A vein given off from a secondary.

Arch. The joining near the margin of a primary with a fork sent off from the one next above, the two branches together forming the arch which rests upon the two primaries.

Loop. Formed by a primary near the margin curving forward and inward and merging into the next above, similar to an arch but lacking the angle at the apex.

Regular. Veins parallel.

Bract. } In his treatment of the genus in Britton's Manual
Scale. } Mr. P. A. Rydberg applies the term bract to the rudimentary perianth of the flower, a small leaf subtending the essential organs, whereas previous writers have termed this a scale and reserved the former term for the bracts which support the aments. This departure from the accepted usage seems to me almost as confusing and unjustifiable as the departures from the rules of priority in nomenclature which the New York Botanists condemn so strongly. Further the meaning given the terms in the glossary at the end of the book, accords better with the older usage than with Rydberg's application of them. Those definitions are here followed. According to Britton, a "Bract" is "A leaf, usually small, subtending a flower or a flower cluster or a sporange." That is, in this case one of the leaves which appear at the bases of the aments. And a "Scale" is "A minute rudimentary or vestigial leaf."—In this case one of the small leaves in the axils of which the flowers are borne. To make the matter worse, Rydberg uses *bract* in both senses thus introducing ambiguity also.

The Willows of Ohio.

THE GENUS SALIX AND ITS RELATIONSHIPS.

The willow family contains but two genera, Salix and Populus. These, in most cases distinct enough in their leaves are separated by the following floral differences. Populus has fimbriate scales, cup shaped discs, elongated stigmas and many stamens, while Salix has entire or only slightly crenate scales, mostly glandular clavate discs, short stigmas and few stamens, two in the majority of the species. In the polyandrous willows which are treated first in the present paper, there is a distinct approach from the diandrous or prevailing willow type toward the poplars, most conspicuously shown in the increased number of stamens but also evidenced in the disc which becomes compound with several glands and sometimes almost forms a lop-sided cup. It is, too, in the polyandrous willows and in those diandrous species manifestly most closely related to them that we find most of the arborescent species—a habit prevailing among the poplars—while most of the willows are shrubs.

There are recognized in all something like two hundred species of willows. They are mostly natives of the north temperate zone but are not entirely absent from the torrid and south temperate zones.

The willow may be counted one of the most successful of present day plants. In few other genera, so compact and homogeneous in respect to their floral characters, is there shown so great a variety of adaptations to varied conditions of life. Within this one genus may be found plants all the way from large trees to dwarf herbs, affecting habitats from the fertile alluvial plain to the barren mountain peak. They grow almost everywhere but yet there are certain limitations in their habitat. Varying from hydrophytes to xerophytes, they are uniformly lovers of the sun and never found to any extent in deep forests or other shaded situations. In their various habitats their vegetative structures undergo wide modifications to accommodate them to their environments. Some species like *Salix lucida* have broad thick leaves, protected from too severe conditions by the hard glossy surface. In others like *Salix adenophylla* the same protection is gained by a thick coating of wool on one or both surfaces. Or a heavy coat of glaucescence may be developed probably to a degree at least for the same purpose. In other cases the leaves are so small as to enable them to endure the most severe conditions, especially when, as is often the case, there is coupled with the small surface exposed a prostrate habit which shelters them from the wind and allows them any advantage to be gained from warmth radiated from the ground. In great contrast to these dwarf creeping almost herbaceous forms are the tree willows so well known to every one. These, by their rapid growth are enabled to succeed well in their favorite habitat along streams and lakes because they can quickly repair the damage done by floods and storms, while more slowly growing trees would be almost hopelessly beaten down and destroyed before they could rear their trunks to a sufficient size to enable them to withstand the elements. Likewise their well known ability to grow from cuttings and broken branches renders them able to use the very storms which break them in pieces as the means of their further dispersal.

Their well known variability under different conditions is an evidence of plasticity of constitution and adaptability to various environments which is as important a factor in the success of a plant in meeting the competition to which it is subjected as is the same quality in the success of a man. From their adaptability, variability and the large number of intermediates between very divergent forms we may safely infer that we have here a group of species with a very large amount of "Vital Motion" in rapid course of evolution.

ON USING THE KEYS.

To construct a key which will hold for all individual willows is well nigh impossible, because in the first place, there is a greater or less number of hybrids for which no pretense at a key is made; and secondly, there is so much variation in some of the species that even after including them in two or three different places, the writer is not so sanguine as to suppose that he has covered all the variant forms. Bearing this probable defect of the key in mind, it will be understood that the greater the diligence with which each clue given is followed out, the greater will be the probability of a correct determination. If the plant you have seems to fit in both divisions of the key by all means run it through both and after doing so refer to the descriptions and plates as well.

The synoptic table is intended primarily to give some idea of the relationships of the different species and consequently the whole anatomy of the plant is used while all the parts are never present in a single specimen. But in the keys proper everything is subordinated to the end in view, namely the identification of the plant; and only such characters are used as are actually present on a single specimen. In the foot-notes under the keys their especial uses and limitations are discussed.

SYNOPTIC TABLE OF OHIO WILLOWS.

Stamens 3 or more, filaments pubescent at base, catkins appearing on leafy branches. *Polyandrae.*

Trees with rough, flaky, brown bark and brown twigs. *Amygdaleneae.*

Capsules short pedicelled, short globose conic, forming dense thin catkins; leaves green on both sides, glabrous, primaries distant, very fine net veined, with a marginal running nearly to the base of the leaf, linear-lanceolate when mature, often, falcate; of very scragly growth, seldom upright; frequenting streams. *S. nigra.*

Capsules long pedicelled, short conic, in lax aments; leaves sometimes 15 cm. long, typically oblong with straight sides, glaucous beneath, generally hairy, primaries ascending, but scarcely forming a marginal; sprawling shrub or straggling tree; southern, river banks. *S. Longipes.*

Capsules long pedicelled, long conic, forming large loose catkins; leaves glaucous beneath, glabrous, primaries close, reticulation not so fine, marginal seldom running below the middle of the blade, broadly lanceolate, petiole often red; an elegant shapely tree; northern, prefers swamps. *S. amygdaloides.*

Shrub, twigs shining brown, scales often dentate, capsules large and glossy, aments thick; leaves ovate-lanceolate, often very long attenuate, sub-coriaceous, glossy above, light green, glands very prominent, especially on stipules; mostly in rocky wet places, northern. *S. lucida.*

Stamens less than 3.

Stamens 2. *Diandrae.*

Filaments pubescent, catkins appearing with the leaves, on leafy branches, except early flowers of *S. interior*, scales nearly as long as the ovularies at anthesis.

Large trees with bark rough but not flaky, leaves glaucous below, capsules glabrous, short pedicelled. *Fragiles.*

Not weeping, primaries and secondaries close and regular.

Bark greenish, leaves glabrous, rather coarsely serrate, and strongly glandular; capsules long conic, remaining green. *S. fragilis.*

Bark yellowish, leaves pubescent at least when young, fine serrate; capsules short conic, turning yellow in fruit. *S. alba.*

Bark golden yellow, leaves glabrous in age *S. alba vitellina.*

Branches pendent, leaves small, very fine net veined, primaries and secondaries irregular; capsules short globose conic, remaining green in fruit, staminate plants practically unknown. *S. babylonica.*

Shrub, often growing in dense clumps with many slender stems; leaves often very long, linear-oblong, with a strong marginal vein and distant primaries, smaller veins except a few costals vanishing; catkins often in cymose clusters which continue flowering all summer, or the earliest only leafy bracted. *S. interior.*

Leaves short and broad (more than 1 cm.) inclined to be very wooly; cymose clusters of catkins very pronounced, carpellate plant rare. *S. interior wheeleri.*

Filaments glabrous, catkins coming before or with the leaves but not on leafy branches unless in fruit.

Capsules pubescent at least in flower.

Styles short and inconspicuous, less than half as long as ovulary.

Leaves mostly broad, coarsely serrate or entire; capsules long conic, very hairy; upright, many stemmed shrubs preferring lowland swamps. *Capreae.*

Catkins at anthesis seldom 2 cm. long, not very wooly, bracts conspicuous, scales light brown, persistent, pedicel very long, filaments slender; venation prominent below, leaves dirty white tomentose, especially on the veins. *S. bebbiana.*

Catkins seldom less than 2 cm. long, wooly pussies, bracts small, scales almost black, filaments thick, pedicel medium; leaves mostly glabrescent, veins not very prominent below. *S. discolor.*

Leaves narrow.

Leaves undulate-revolute to entire, primaries prominent on the under surface, distant, coming out at right angles and arching or looping regularly to the base of the leaf; aments small short pussies without leafy bracts, capsules long conic, very hairy; upland swamps and hillsides. *S. humilis.*

As above but smaller throughout; leaves up to 5 cm. long, aments less than 1 cm. long, shrub less than 1 m. tall; prairies especially. *S. humilis tristis.*

Leaves sharply serrate, showing a decided tendency to blacken in drying, aments from pussies, bracts small or none, capsules when long conic, thinly pubescent; lowland shrubs. *Sericeae.*

Capsules blunt, short pedicelled, short conic, densely silvery silky; leaves dull above, lustrous sericeate below, at least till old. *S. sericea.*

Capsule long conic, long pedicelled, sparsely pubescent; leaves shining above, glaucous below, glabrous (or rusty sericeate when young); northern. *S. petiolaris.*

Style very long, capsule short conic, silky, white; leaves long and narrow, revolute with veins prominent below and depressed above, not distinctly arching, snowy tomentose below; wet prairie shrub not more than a meter tall; northern. *S. candida.*

Capsules glabrous, styles short, filaments glabrous.

Filaments distinct to the base; leaves sharply serrate, good sized shrubs. *Cordatae.*

Leaves dull on both sides, only a little paler beneath

Leaves thickly pubescent on both sides alike, short and broad, bracts broad, remaining green; northern. *S. adenophylla.*

Leaves thinly pubescent with most of the hair on the veins beneath, or glabrous, green on both sides or slightly glaucous beneath, lanceolate, bracts narrow, remaining green. *S. cordata.*

Leaves glossy above, very glaucous below, glabrous, generally broad, bracts narrow; turning black; northern. *S. glaucophylla*

Filaments frequently united at the base, capsule long pedicelled in fruit, leaves small, entire, purplish green, conspicuously reticulated; low shrub in sphagnum bogs. *S. pedicellaris.*

Stamen 1, formed by the coalescence of 2, anthers 4, scales black, reflexed in staminate flower, capsules rarely seen, short, thick, hairy; leaves oblanceolate, opposite or scattered, purplish; shrub with long slender branches. *Synandrae. S. purpurea.*

Key Based on Carpellate Aments.*

1. Flowers appearing in pussies before the leaves, bracts small or absent. 2.
1. Aments and leaves unfolding together, bracts mostly large. 11.
   2. Capsules glabrous from a wooly rachis, inner membrane of bud scale growing out beyond the outer. 3.
   2. Capsules silky till after breaking open, bud scale not as above. 5.
3. Capsules turning brown when ripe, 10 mm. long, aments lax, bracts glabrous and glaucous in fruit. - *S. glaucophylla.*
3. Capsules remaining green, less than 10 mm. long, bracts green on both sides. 4.
   4. Bracts narrow, obscurely serrate or entire, aments becoming rather lax, leaves becoming glabrous above. *S. cordata.*
   4. Bracts broad, prominently glandular, aments dense, leaves becoming densely tomentose above; northern. *S. adenophylla.*
5. Style very long and slender, rose red at anthesis, conspicuous, capsule snowy white; leaves tomentose; dwarf shrub; northern. *S. candida.*
5. Style less than half as long as ovulary, leaves glabrous above. 6.
   6. Capsules short conic. 7.
   6. Capsules long conic. 8.
7. Aments long, 35 mm. or more, very dense, often opposite, capsules large, strictly sessile, carpellate plant rare. *S. purpurea.*
7. Aments short, 30 mm. or less, moderately dense, not opposite, capsules small, short pedicelled. *S. sericea.*
   8. Capsules short pedicelled. 9.
   8. Capsules long pedicelled; northern. 10.

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*The fruiting aments of our willows are quite distinctive and though the differences between the species are not always easy to describe, they are constant and easily learned, so that with fruiting specimens we should have a minimum difficulty in determination. But in flower they are by no means so easy to determine. The ovularies are all very much alike and seem not to develop character until filled out. In fruit too, the leaves of most specimens are present and help greatly.

The greatest need of caution in using the key is to be sure that the descriptions of capsules are not applied to younger stages which are more slender with shorter pedicels. It will also be found difficult to use the key after the capsules have burst. The leaves referred to are those present at flowering and fruiting time. They may or may not be similar to the mature leaves of the species.

9. Aments long in fruit with many capsules; stigmas greenish white when fresh. *S. discolor.*
9. Aments short and thick, few flowered, stigmas red when fresh. *S. humilis.*
  10. Aments short, scales frequently darkened at the tip, leaves narrow, turning black. *S. petiolaris.*
  10. Aments long, scales yellow, leaves broader, strongly veined, remaining green. *S. bebbiana.*
11. Capsules hairy. 12.
11. Capsules glabrous. 16.
  12. Style more than 1 mm. long. *S. candida.*
  12. Style less than 1 mm. long. 13.
13. Capsule subsessile, blunt pointed, stigmas sessile. *S. interior.*
13. Capsule with a distinct pedicel, acute, narrow conic, stigmas rarely sessile. 14.
  14. Capsule thinly hairy, almost glabrescent, aments short, leaves narrow, silvery, blackening; northern. *S. petiolaris.*
  14. Capsule persistently hairy, aments long. 15.
15. Scales persistent, light colored, leaves broad, wooly below with prominent veins, pedicels very long; northern. *S. bebbiana.*
15. Scales usually deciduous at length, almost black, leaves without prominent veins, pedicel short to medium. *S. discolor.*
  16. Capsules long pedicelled. 17.
  16. Capsules short pedicelled or sessile. 19.
17. Aments short, bracts obtusish, small, capsules generally redening; small shrub in sphagnum bogs only. *S. pedicellaris.*
17. Aments long, bracts large; good-sized shrubs or trees. 18.
  18. Capsules narrow conic; northern. *S. amygdaloides.*
  18. Capsules mostly globose conic; extreme south. *S. longipes.*
19. Capsules short conic, aments nearly glabrous. 20.
19. Capsules rather long conic. 22.
  20. Aments dense, short (25 mm. or less) of small calibre, with a few small bracts. *S. babylonica.*
  20. Aments longer, bracts larger. 21.
21. Scales as long as the ovulary, capsules yellowing in fruit, aments rather lax; leaves pubescent, glaucescent. *S. alba.*
21. Scales shorter than the ovulary at anthesis, capsules green, aments dense; leaves glabrous, green. *S. nigra.*
  22. Bracts, especially stipules, very glandular, coriaceous, bracts and leaves broad, green, capsules when ripe more than 6 mm. long; northern. *S. lucida.*

22. Bracts not especially glandular, stipules seldom present, capsules less than 6 mm. long. 23.
23. Stigmas sessile, capsule blunt, flowers often fascicled on the rhachis with a distinct interval between the fascicles, bracts green; shrub in dense clumps. *S. interior.*
23. Stigmas on a short style, capsules pointed, flowers not fascicled. 24.
24. Sprawling shrub. *S. cordata.*
24. Trees in clumps with few stems or single. 25.
25. Leaves green, reticulate venation very fine, bark brown, undeveloped stages of *S. nigra.*
25. Leaves glaucescent, venation coarse, bark yellow or green. 26.
26. Leaves glabrescent. *S. fragilis.*
26. Leaves pubescent, young stages of *S. alba.*

Field Key Based on Mature Leaves and Habits.*

1. Leaves alternate. 2.
1. Leaves opposite, oblanceolate, nearly sessile, stiff ascending, purplish green; shrub with long slender branches. *S. purpurea.*
2. Secondary and tertiary veins prominent by transmitted light, unless concealed by tomentum. 3.
2. Secondaries and tertiaries almost obliterated with age, primaries distant, running into a strong marginal; leaves narrowly oblong, serrate with distant spinulose teeth or entire; often forming dense slender stemmed clumps. *S. interior.*
3. Leaves persistently pubescent. 4.
3. Leaves glabrous unless very young. 18.
4. Pubescence not concealing the upper surface. 6.
4. Both surfaces hidden, at least till mature, by a thick coat of tomentum; shrubs growing in exposed places. 5.

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* Note. This key is constructed for *mature* well developed leaves. It will not hold for leaves which have not acquired their full size or venation, nor for those of water-shoots and suckers. In immature leaves the primaries are usually more ascending, the other veins not well developed; and the leaf is commonly relatively broader and blunter than when mature. Frequently the two or three terminal leaves of a twig do not assume the character of the species so that one must be careful not to be misled by them when they are different from those lower down on the twig. The leaves of water-shoots are so characterless that it is often difficult for an expert to determine them certainly. They are all thin, green on both sides, lacking both the pubescence and glaucescence which may render the normal leaves distinguishable.

5. Leaves oblong, hair long and straight. *S. interior.*
5. Leaves ovate, hair shorter, matted. *S. adenophylla.*
   6. Pubescence not lustrous. 7.
   6. Leaves clothed below, sometimes only thinly, with silvery short hair having a lustrous appearance almost like changeable silk, glabrous above, narrow, narrowed to both ends, sharply serrate, generally blackening in drying, venation irregular; sprawling shrub. *S. sericea.*
7. Leaves narrow, oblong or spatulate, broadest above the middle, margins mostly revolute, venation very prominent below. 8.
7. Not as above, margins serrate (or rarely entire but not revolute.) 10.
   8. Hair dull red brown, leaves dull above, not revolute. *S. discolor.*
   8. Pubescence not ferruginous, leaves revolute. 9.
9. Secondaries depressed above, leaves very thickly snowy tomentose, especially on the veins, margins mostly entire; dwarf prairie shrub, northern. *S. candida.*
9. Secondaries not depressed above, leaves gray tomentose, margins mostly undulate; growing larger, in hillside swamps and uplands. *S. humilis.*
   10. Leaves coarsely serrate with relatively distant, blunt teeth incurved except when young, or entire; swamp shrubs with ascending stems. 11.
   10. Leaves closely and sharply serrate, rarely entire, teeth not incurved. 12.
11. Veins often depressed above, dirty white tomentose and very prominent on the under surface; northern only. *S. bebbiana.*
11. Veins not depressed above, not very prominent beneath nor especially hairy, frequently ferruginous. *S. discolor.*
   12. Pubescent on both surfaces. 13.
   12. Pubescent only below. 14.
13. Leaves ovate, subcoriaceous, very glandular, rarely entire. tomentose with matted wool, green on both sides; shrub, northern. *S. adenophylla*
13. Leaves lanceolate, thin, not especially glandular, pubescent with parallel hairs, glaucous beneath; tree. *S. alba.*
   14. Pubescence evenly distributed. 15.
   14. Pubescense mostly on the veins, wooly. 16.
15. Venation regular, neither arching nor looping; arborescent. *S. alba.*
15. Venation irregular, arching or looping; sprawling shrub. *S. sericea.*

16. Primaries ascending a long way near the margin, usually not arching; leaves narrow, often auriculate in rank growth. *S. longipes.*

16. Primaries more distant, forming a series of arches or loops near the margin; not auriculate. 17.

17. Leaves ovate; northern. *S. adenophylla.*

17. Leaves lanceolate. *S. cordata.*

18. Leaves green on both sides, only a little paler if at all beneath. 19.

18. Leaves glaucous beneath. 27.

19. Leaves relatively thin, dull. 20.

19. Leaves subcoriaceous, glossy above, strongly glandular especially on the stipules, ovate or broadly lanceolate, often, especially in rank growth, very long attenuate; buds and twigs bright shining brown, buds large; a beautiful shining shrub; northern. *S. lucida.*

20. Marginal vein prominent, extending nearly to the base of the leaf, primaries distant. 21.

20. Marginal not present, primaries closer. 23.

21. Leaves very finely serrate, reticulate venation very fine, long acuminate, frequently falcate; growing into a scraggly tree, along streams. *S. nigra.*

21. Leaves spinulose serrate to entire, teeth rather distant, meshes coarse, acute, not falcate; shrubs tending to form close thickets. 22.

22. Leaves, except those at the bases of the season's twigs, less than 1 cm. wide. *S. interior.*

22. Leaves more than 1 cm. wide. *S. interior wheeleri*

23. Leaves dark purple green, entire or obscurely serrate. 24.

23. Leaves bright green, mostly distinctly serrate. 25.

24. Leaves elliptical; dwarf shrub in sphagnum bogs only. *S. pedicellaris.*

24. Leaves mostly oblanceolate; shrub with many ascending branches, often planted. *S. purpurea.*

25. Venation irregular, primaries mostly arching or looping; shrubs. 26.

25. Venation regular, primaries ascending to near the margin; arborescent; water-shoots of *S. fragilis.*

26. Leaves sharply serrate; shrub with branches lopping over onto the ground. *S. cordata.*

26. Leaves distantly serrate with incurved teeth; shrub with stems ascending. *S. discolor.*

27. Leaves spatulate, elliptical, or oblong-oblanceolate, not sharply serrate. 28.

27. Leaves lanceolate or broader than above, serrate. 31.

28. Leaves distantly serrate with incurved teeth, not revolute. *S. discolor.*
28. Leaves entire or very obscurely serrate, frequently revolute. 29.
29. Margin undulate-revolute, veins very prominent below, bright green, only rarely completely glabrous. *S. humilis.*
29. Margin not undulate, veins not raised below, purplish green. 30.
30. Leaves elliptical, widest near the middle; dwarf shrub in bogs. *S. pedicellaris.*
30. Leaves oblanceolate, widest above the middle; good-sized shrub; often planted. *S. purpurea.*
31. Leaves with a strong marginal vein, smaller veins forming a very fine meshwork, leaves small, narrow, often falcate; tree with pendent branches. *S. babylonica.*
31. Marginal if present not extending much below the middle of the leaf. 32.
32. Leaves bluntly and coarsely or irregularly serrate with incurved teeth or entire; shrubs. 33.
32. Leaves sharply serrate with projecting teeth. 36.
33. Leaves extremely glaucous below, glossy above, broadly lanceolate or ovate; northern. *S. glaucophylla.*
33. Leaves with a thin bloom beneath, not glossy. 34.
34. Leaves lanceolate, long acute, venation regular; bark of branches green, smooth; arborescent. *S. fragilis.*
34. Leaves mostly broadest above the middle, short acute; bark of branches brown, soon roughened. 35.
35. Water shoots, blackening in drying { *S. glaucophylla.* and *S. discolor.* }
35. Well developed leaves, remaining green. *S. discolor.*
36. Leaves held up by the stiff midrib so as to display their white under surfaces, broadly lanceolate or ovate, mostly glossy above and very heavily glaucous below; northern. *S. glaucophylla.*
36. Leaves not held up against the twigs, mostly lanceolate. 37.
37. Primaries mostly forking and arching; sprawling shrubs. 38.
37. Primaries mostly ascending without forking, arching or looping; arborescent, not sprawling except *S. longipes.* 39.
38. Leaves dull above, not very glaucous, almost always with a trace of hair on the veins above or below, quite sharply serrate, petiole stoutish. *S. cordata.*

38. Leaves subglossy, frequently very glaucous, when young sometimes pubescent but with evenly distributed sericeate hairs, inclined to be distantly serrate with prominent glands, petiole slender, leaves hanging down gracefully from the twigs. *S. petiolaris.*

39. Venation mostly regular, reticulations not very fine, no marginal; trees with smooth bark on the branches. 40.

39. Venation mostly irregular, reticulations very fine, with a strong tendency toward a marginal; bark of branches ridgey, brown. 41.

40. Bark of branches yellow to olive; serrations very fine and sharp, not especially glandular. *S. alba.*

40. Bark of branches green; serrations rather distant, glands prominent, glauscescence absent from the veins beneath leaving them contrasted with the rest of the leaf. *S. fragilis.*

41. Northern and western parts of state only, shapely tree, especially in swamps; leaves ovate-lanceolate, twigs smooth. *S. amygdaloides.*

41. Extreme south only, straggling tree or sprawling shrub in river beds; leaves oblong-lanceolate, twigs usually pubescent. *S. longipes.*

AMYGDALENAE, BLACK WILLOWS.

Mostly trees with rough brown bark, leaves long attenuate, often falcate, with a marginal vein at the tips at least, reticulations of the secondaries and tertiaries very fine. Catkins unfolding with the leaves, stamens 5 or more, filaments pubescent, scales one colored, deciduous, capsules glabrous, green, style short or none. Conspicuous inhabitants of the temperate regions of America and extending clear through the tropics to Chili and Peru.

For a key to this section of the genus I feel that I cannot do better than copy the following table in which the characters of the three species are contrasted, from an article by Dr. Glatfelter in Science Nov. 1, 1895, which I have found quite useful. It is constructed for the forms about St. Louis and is particularly servicable on that account; for Missouri is the only region where the ranges of all three species overlap and all can be studied together.

S. nigra	*S. longipes*	*S. amygdaloides*
Range extended north and south	south of 39° lat.	north and west
large tree, branches crooked, ascending	small spreading top	large, branches straight
stems in clumps	single	single
old bark flaky	deeply laticed ridg'y	smooth or roughish
twigs very brittle at base	tenacious	somewhat brittle
hardy	buds winter-killed	hardy
shoots pubescent	hoary pubescent	glabrous
leaves oblong or linear lanceolate	same or broader	ovate-lanceolate
bases acute to truncate	acute to auriculate	acute to cordate
under surface green	whitish glaucous	bluish glaucous
venation very minute, strong marginal	without marginal	coarser more regular
petiole short	short	very long
stipules pointed, persistent, non-glandular	obtuse, persistent, non glandular	obtuse, caducous, always glandular
blossoms about April 25	May 5	April 15
stamens mostly less than 6	4–7 mostly 5–6	6–9
scales short, obtuse	ovate	ovate-oblong, acute
capsules ovoid conical	globose conical	ovoid conical
pedicel short, slender	long, stout	long, stoutish
notched stigmas and style	both poorly developed.	as in nigra.

SALIX NIGRA Marsh. BLACK WILLOW.

A tree occasionally reaching a height of 40 meters and a trunk diameter of 1 meter but generally dying when about 15 meters tall. It most often grows in characteristic straggling clumps with four or five crooked, leaning stems. In the fall it drops off most of the season's twigs leaving the old branches bare, a habit which hinders their elongation and in a few years makes them thick and stubby. This excess of self-pruning together with the straggling clumps in which it grows give it a habit which n typical specimens clearly distinguishes it from any other

Plate I. Salix nigra.

species, especially in winter when it is leafless. In summer the long slender twigs sometimes give it almost the appearance of the Weeping Willow from which, however, it can be easily distinguished by its leaves green, not glaucous. The winter buds are very small, less than 3 mm. long, broadly ovate, acute, commonly but not always without the mark of the leaf base across the back. The leaves commonly are about 10 cm. long by 1 wide, narrowly lanceolate with a very long attenuate-falcate tip, mostly very finely serrate, green and glabrous on both sides. The characteristic venation of the Amygdalenae is at its fullest development in *Salix nigra*. The marginal vein often runs almost to the very base and the secondaries and tertiaries blend into a system of meshes finer than in any other of our species.

Sometimes broad, blunt leaves are found at the bases of lateral twigs but they are still easily recognized by their fine reticulation. The aments appear with the leaves, capsules glabrous, short conic, short pedicelled, forming thin close cylindric catkins which, supported as they are by the characteristic leaves, resemble those of no other species. The staminate resemble very closely those of *S. amygdaloides* (which see), stamens 5 or more, filaments pubescent.

Everywhere throughout the state, *Salix nigra* is our commonest willow. But it assumes a much more important role in plant society along the southern border than further north. There it attains its greatest size and at the same time becomes much more abundant than elsewhere. For long distances along the Ohio River it is almost the only native willow met with and occupies all the territory which in the north is divided up between several species.

So far as Ohio is concerned it is perhaps the most constant and easily recognized of our willows but in the south it is almost identical with *S. humboldtiana* and is rather hard to separate from *S. longipes*. In the west it is represented by several variable varieties which seem to connect it with related forms and render it a very difficult subject indeed.

Its typical habitat is along streams but it may be found in wet places generally though it seems to prefer moving to stagnant water and is much more infrequent in swamps.

The variety "*falcata*" is a form with narrower more falcate leaves. In my opinion it is scarcely worthy of consideration since it is not genetically different but is merely an accidental leaf variation without correlated variation in other characters

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Plate I. *Salix nigra*.

Leaves of ordinary growth and of ranker growth with stipules; flowers and fruit typical; natural size; drawings of the flowers and capsule made with camera lucida and photographed, enlarged seven times.

of the plant. All the leaves are more or less falcate; their falcation varies greatly on the same plant.

A hybrid between *S. nigra* and *S. alba* has been reported from New York.* It is said to have the catkins of *S. alba* and the leaves of *S. nigra* x *amygdaloides*. Such a cross is most surprising in view of the distant relationship of the parents. It has not been reported from Ohio.

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SALIX LONGIPES Shuttlew. WARD'S WILLOW.

This species has not as yet been found in the state; its nearest reported station is at the falls of the Ohio at Louisville. Though this is some distance south of our territory it is possible that it may be found along the Ohio River. I include it here because of that possibility and in order to make the paper more useful outside the state. Its range extends from Missouri to Washington, D. C., and southward to the Gulf. Dr. Glatfelter says that it is not found like *S. nigra* sometimes away from the banks of the streams but is strictly confined to them.

Sometimes it grows into a tree like *S. nigra* but much more bushy. Around Washington it is a low shrub resembling *S. cordata* surprisingly, considering the remoteness of their relationships. The leaves have short stout petioles which with the midribs and larger veins are usually hairy. The blades are extremely variable. Frequently in rank growth they are auriculate at the base; this character when present segregates them at once from any other of our species. Sometimes they are very long, oblong-lanceolate with straight edges narrowing gradually to the tip; and this again is like no other of our species. More often they are lanceolate with upper surfaces varying from shiny and glabrous to dull and hairy. Sometimes they resemble those of *S. nigra* closely except for the glaucous under surface. Or they may be so similar to those of *S. cordata* as to deceive even the expert; often this resemblance is especially well borne out by the under surface which is at times gray glaucous and hairy exactly like that species when grown in a dry place. The two can best be distinguished by the venation which is similar to that of the rest of the Amygdaleneae except that the marginal is hardly perceptible and in its place the primaries ascend a long way near the margin.

From printed descriptions *Salix amygdaloides* might be confused with the present species but they are not very similar. *Salix amygdaloides* is a much cleaner more shapely tree, never shrubby; its leaves are long petioled, decidedly broader, much

* Bebb, Abrorescent Willows of North America 3. Gard. & For. 8:423 1895. Fig. 58.

more sharply pointed and never pubescent. While both have a bloom on the under surfaces, *S. longipes* is gray glaucous and *S. amygdaloides* bluish glaucous. Besides all this their ranges do not overlap in Ohio.

In fruit it is easily distinguishable from either of the other Amygdaleneae. The capsules are similar to those of *S. nigra* but larger and long pedicelled like those of *S. amygdaloides.*

SALIX AMYGDALOIDES Anders. PEACH-LEAVED WILLOW.

Salix amygdaloides grows to medium sized or rarely to a large tree. Its bark and general appearance suggest at once its affinity for the black willow of which it was once considered a variety. Its habit, however, differs very considerably from that of *Salix nigra.* It is generally single-stemmed and very shapely, with clean branches and darker brown, smoother bark. The winter buds are nearly twice as large as those of *Salix nigra*, dark brown above with a much lighter base where they were protected by the petiole of the old leaf in the fall. *Salix amygdaloides* is well-named for when in leaf the tree, at a little distance, often bears a striking resemblance to a peach tree; the twigs and petioles are often reddened and the leaf arrangement is similar to that of a peach tree. Both twigs and leaves are entirely devoid of hairs while young shoots, at least, of the other black willows are pubescent.

The leaves are much broader than in the other members of the *amygdalenae*, often being almost ovate, distinctly broadest below the middle with a rounded base and an attenuate falcate tip, bright green above, glaucous beneath. The venation while of the black willow type begins to approach the regular type, exemplified by *S. alba*; the primaries are close, the marginal vein short, hardly extending as far as the middle of the leaf, and the meshwork, though very fine is much coarser than in *Salix nigra*, while the secondaries are often more or less regular.

The catkins are so similar to those of the black willow that it is difficult to distinguish them in dried specimens. With the carpellate aments the difficulty disappears in fruit but with the staminate it continues in old flowers. The brightening of the bark at flowering time, which is noticeable in all willows renders the twigs in *Salix nigra* very similar to those of the present species and its smaller buds are swollen to about the size o those of the Peach-leaved willow so that they can be used as a diagnostic character no longer. The leaves supporting the catkins are too young to have assumed their characteristic texture and the aments themselves are almost the same. But *Salix amygdaloides* flowers nearly two weeks earlier than *Salix nigra*, which together with the habits should distinguish them in most cases.

Plate II. Salix amygdaloides.

The ripe capsules of *Salix amygdaloides* are narrowly long-conic on long pedicels, contrasting with the short pedicelled capsules of *Salix nigra* and giving the aments a very different appearance.

S. amygdaloides is characteristically a swamp plant though it is not absent from river banks. In Ohio its range is over the northern and western parts of the state. Columbus is near its southern limit in central Ohio; further east it does not extend so far south while further west I suspect it may even reach the river. It is a north-western species of which Ohio is near the eastern limit.

While remaining for the most part recognizable in the west, *Salix amygdaloides* loses the glaucescence of the under surface of the leaf while the upper surface brightens till it is almost like *Salix lucida*. The shape of the leaves also changes and becomes shorter and broader. Southwestward it grades into the varieties of *S. nigra* which occupy the region. About St. Louis there is a great complex of the *amygdalenae* in which pure forms of the three constituent species are uncommon and there are all sorts of interconnecting variations. In Ohio we have only two species together and intermediates are rare though several have been collected.

LUCIDAE.

Trees or shrubs, branches shining; leaves often very long acuminate, broadly lanceolate to ovate, thick, glossy, strongly glandular; catkins leafy peduncled, thick and dense, scales caducous, often dentate, filaments pubescent, capsules glabrous, style short, stigmas thick.

Salix lucida Muhl. Shining Willow.

A bush or very rarely a tree 8 m. tall; bark smooth or nearly so; twigs shining orange brown, glabrous; buds rather narrowly ovate, large, (5-10 mm. long) bright reddish brown in spring, duller earlier in the season. Leaves reaching an extreme length of 18 cm. and a breadth of 8 cm., varying from ovate to lanceolate, rounded or narrowed at the base, prominently glandular-serrate, especially on the deciduous stipules, often covered when young with long tawny scattered hairs, becoming glabrous, coriaceous, very glossy above so as to give the plant a very beautiful appearance different from any other willow. The thickness of the leaf makes the rather regular veining difficult to make out. Stami-

Plate II. *Salix amygdaloides.*

All parts typical, natural size except the capsule which is enlarged three times.

Plate III. Salix lucida

nate catkins borne with the leaves; easily recognizable by their large diameter and fine appearance; scales large, conspicuous, crenate or dentate, stamens mostly 3–5, filaments pubescent at the base. Carpellate catkins also large, dense, 5-8 cm. long in fruit, long persistent, scales obovate, slightly pubescent, pedicel nearly half as long as the capsule, stigmas large thick, deeply notched, style short, capsule narrowly cylindric, about 6 mm. long.

Salix lucida is a northern plant occuring in the northern third of the state but not extending to Columbus.

Salix lucida hybridises with *Salix alba* and *S. fragilis* and when all three come together in one plant it creates very great confusion in a group already very difficult to handle. Though hybrids are mostly individual cases and irreducible to any general type, it may be said that hybrids between *S. lucida* and one of the fragiles are likely to have some of the following characteristics. Nearly always the leaves are dull instead of glossy, sometimes they are pubescent like *S. alba*. They are likely to retain somewhat of the prominently glandular character of *S. lucida*. Though they may be almost typical of one of the other species in other respects, they are almost certain to have the large reddish brown winter buds of *S. lucida*. The stamens are oftenest two but the catkins are likely to be short and thick as in *S. lucida* and dentate scales are frequent.

Salix pentandra L. European Shining Willow.

Salix pentandra, the European species corresponding to our *Salix lucida*, has been detected as an escape in two places in the state.* It is not infrequently cultivated as a basket willow and may be met with anywhere in cultivation.

It is most difficult to distinguish from *S. lucida* and in some forms of the native species they cannot be told apart with certainty. *Salix pentandra*, however, never has the long attenuate leaf tips common in *S. lucida*, not even on watershoots. Its leaves are rather thinner and not quite so glossy as those of *S. lucida*. It does not grow so rank and does not succeed well in this climate. The osier growers around Columbus complain that it winter-kills.

I should not advise a beginner in Salicology to try to distinguish the two forms in the range of *Salix lucida* but any form outside the range, with the less acuminate leaves of *S. pentandra*, may be suspected.

* See O. Nat. 4:12—Nov. 1903.

Plate III. *Salix lucida*.

Large leaf from rank growth; smaller pair from ordinary twigs; the short, broad, blunt one from the base of a branch; flowers and fruit typical; natural size; capsule enlarged three times.

Plate IV. Salix fragilis.

FRAGILES, CRACK WILLOWS.

Trees, originally introduced from Europe and though now freely escaped, still largely planted and often found growing in rows (except the Weeping Willow). The bark of the medium-sized branches is smooth, and yellow or greenish as distinguished from the rough brown bark of the Amygdalenae. The leaves of all the species are glaucous beneath and without stipules unless very young. The catkins are borne with the leaves on lateral branches; the stamens are normally only two; the capsules glabrous and green, in flower at least, like the Amygdalenae but unlike the other diandrous willows.

The Fragiles are clearly intermediate between the polyandrous tree-willows and the diandrous shrubs. But among themselves their relationships are not so clear. By hybridisation and the importation of various horticultural varieties the group is very much confused and consists of many very closely similar forms. It has been the despair of many Botanists and one finds more mistakes in the determination of this group than in any other.

Key.

From habit.

- Growing in clumps.
  - Bark of branches green. *S. fragilis.*
  - Bark of branches yellowish green or yellow *S. alba.*
- Large trees, not in clumps.
  - Branches long, drooping. *S. babylonica.*
  - Branches not pendulous.
    - Large branches and trunk disfigured by many adventitious twigs, a tall tree with a central shaft, branches yellowish. *S. alba.*
    - Without many adventitious twigs, a low broad topped tree without a central shaft, branches green. *S. fragilis.*

From leaves.

- Leaves with a marginal vein, reticulations very fine, venation irregular, leaf narrow, acuminate, often strikingly falcate, sharply serrate. *S. babylonica.*
- Without marginal, reticulations not so fine, venation regular, leaf broader, not acuminate nor falcate.

Plate IV. *Salix fragilis.*

Leafy twig tpyical of our American form; the single broader leaf resembles more closely the European form; natural size; capsule enlarged three times.

Leaves sharply serrate, pubescent at least when young, glaucescence bluish. *S. alba.*
Leaves distantly blunt-serrate, glabrous, glaucescence greenish. *S. fragilis.*

From capsules.
Capsules long conic, short pedicelled, green or black in drying. *S. fragilis.*
Capsules short, ovoid conic, pedicel very short or none.
Capsules yellowing, catkins often long. *S. alba.*
Capsules green, catkins short. *S. babylonica.*

Salix fragilis. L. Crack Willow.

A tree reaching a height of 25 m. and a trunk diameter of 2.1 m. When in clumps it forms a tall slender tree, but a single individual growing alone branches out so that the head is as thick as high. The bark of the trunk is roughish, gray, that of the smaller branches green and of the twigs sometimes red, winter buds large (7 mm.) seldom well filled out. Leaves reaching a length of 17.5 cm. and a breadth of 4 cm.; acute, narrowed to the base, coarsely serrate with prominent glands, glabrous, greenish glaucous beneath, petiole short, stipules early fugacious, venation regular, showing through the glaucescence as a dark net work, primaries ascending, straight, close together, not arching. The aments being accompanied by leaves are easily identified by the leaf characters; stamens 2, with pubescent filaments, ripe capsules long conic, green, with a short but distinct pedicel.

Salix fragilis is a European species planted extensively along streams to hold the earth or to act as a wind-break. It is also pollarded for its twigs which are valuable in basket making. It is one of the most abundant species in our area. It is found both planted and escaped everywhere. Our American plant is different from the typical European form in having narrower leaves but it is in most cases sufficiently distinct from *S. alba.*

Because of its quick rank growth, shapely habit, and beautiful gray green foliage which turns over very prettily with every breeze *Salix fragilis* is the best of the willows to plant for a shade tree. It is difficult to understand why it has not supplanted *Salix alba* and its varieties long ago. But the nurseries nearly always carry a larger stock of the latter sorts which are much inferior because of their habit of sending out suckers all over their trunks.

Salix alba L. White Willow.

A tree attaining a maximum height of 30 m. with a trunk diameter of 2.5 m. Like *Salix fragilis* often growing in clumps but when single-stemmed it is taller and more slender and has the trunk continued as a central shaft to near the top. It is not clean like that species but is covered with a brush of suckers. Bark of the twigs and branches yellowish green varying to yellow; winter buds smaller (4 mm. long) than those of the crack willow, oblong and well filled out. The leaves reach a length of 13 cm. and a breadth of 3 cm., lanceolate, acute, narrowed to the base, closely and finely serrate, sometimes almost entire, grayish or bluish glaucous, pubescent on both surfaces at least till mature, (hair mostly persistent below) with close, fine, appressed, parallel, gray hairs, stipules deciduous; primary veins close (closer than in *S. fragilis*), straight, ascending, regular, extending to the margin without branching, secondaries conspicuously regular but often forking like the letter Y. Catkins on lateral branches or sometimes supported only by bracts, scales hirsute, deciduous, capsules ovate-conic, not more than 4 mm. long, greenish yellow in fruit, obtuse, glabrous, pedicel very short, style short, stigmas thick.

Salix alba is a European species planted in this country for the same purposes as *S. fragilis*. In most parts of the state it does not seem to escape so readily as that species and hence is not quite as common but may be found planted almost anywhere.

As stated above, most observers have considerable difficulty in separating this species from the preceding. The difficulty is often assigned to their hybridising propensities. But in Ohio at least hybrids are rather rare. I have found that the two species are distinct and separable in nearly all cases though it was only after long study that the ability to distinguish them was acquired. The manuals state that the species in the typical form is rare in this country, the majority of the American forms being the golden osier (var. *vitellina*). It is certainly true that few of our plants are the typical hairy plant of Linneus but study of the European material at Washington leads me to the conclusion that in Europe the typical form is about as scarce as here. Further the extremely bright yellow twigs and glabrous, half shiny leaves of the typical varietal form are scarcer in this country than the pure alba forms. It seems to me good practice in a series of intergrading forms to draw the line between species and variety close to the variety and to call all but nearly typical varietal forms the species simply, if for no other reason to avoid the use of a trinomial.

The variety *vitellina* then, of *Salix alba* includes those plants with bright golden yellow twigs and branches, and leaves soon glabrous and bright green.

Plate V. Salix alba.

The blue willow, *Salix alba coerulea*, has not yet been recognized in Ohio. Indeed there are some willow students of high authority who do not distinguish it at all in this country whatever may be its status in the old world.

As hinted above *Salix alba* hybridises with *Salix fragilis* though not so frequently as might be supposed. It also crosses with *S. lucida* as described under that species.

Salix babylonica L. Weeping Willow.

The Weeping Willow grows into a large graceful tree 20—25 m. tall, easily recognized by its very long drooping twigs, which have a habit peculiar to themselves of sending out numerous short branches at a very acute angle with the main stem. Leaves commonly rather small, 7–10 cm. long, about 1 cm. broad, narrowly lanceolate, long acuminate and often falcate at the tip, narrowed to the base, sharply serrate, glabrous unless very young, greenish glaucous or at least paler beneath, petiole short, stipules apparently absent; primary veins forming regular acute loops which run together into a more or less straight marginal; this together with the very fine reticulations caused by the relative prominence of the tertiaries often gives the leaf a more or less close resemblance to that of *S. nigra*, which, however, is never glaucous as in the present species. Aments on rather short few leaved peduncles, rather dense, not more than 3 cm. long; capsule short conic, glabrous, green, all but sessile, style short.

It is a remarkable fact that the staminate plant of this species is unknown in America. It is sometimes stated that it does not occur at all and it is sufficiently rare to warrant such an assertion but yet in the national herbarium is what I believe to be a genuine specimen of the staminate flowers. It was collected by Coville at Ithaca, N. Y., in 1885 (?). The leaves are similar to those commonly appearing with the carpellate catkins. The aments are short, less than 25 mm. long, densely flowered with a rhachis densely covered with short hairs. The stamens are subtended by a very short ovate scale which is much shorter than in any other of the Fragiles.

Doubtless it is with the Weeping Willow as with the Purple Willow that the absence of one kind of flowers prevents the natural spread of the species and is responsible for the fact that so few plants have escaped when conditions for their growth seem so favorable. But whatever the reason it is certain that the species though commonly planted, esceaps very rarely. During the last

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Plate V. *Salix alba.*

Leaves and flowers typical; natural size; capsule enlarged three times, photographed and brightened with pencil.

Plate VI. Salix longipes and Salix babylonica.

seven years I have been continually on the lookout for it but have seen less than half a dozen individuals which were not clearly planted. One of these was on the Hocking River near Sugar Grove; the others were along the lake shore in Ashtabula county.

In Europe *Salix babylonica* hybridises freely with *S. fragilis*. But in this country the manuals have not included such a cross. A single plant was discovered at Sandusky during the season of 1903. * The leaves and habit were so exactly intermediate beween the two that there could be no doubt of its identity.

At Ashtabula was found a plant which from leaf and habit I take to be a hybrid between the present species and *Salix alba*, which is not reported in the manuals.

LONGIFOLIAE, THE LONG-LEAVED WILLOWS.

The longifoliae comprise a very distinct and compact group of American willows. They have no close affinities with any other group and do not intermingle with any. They have two stamens (a specimen in the Ohio herbarium has three) and light one-colored deciduous scales which show their relationship with both the polyandrous and diandrous willows. Within the group the many described species are difficult to recognize; Bebb, himself, said after he had described two or three of them that he did not know but what they were all one species after all. The group is very easily recognized by the venation of the leaves which is different from any other willow and much resembles that of many Onagaraceae, for example the fire weed. There is typically a prominent marginal vein running clear round the leaf, connected with the midrib by a series of distant nearly straight primaries between which there are practically no secondaries and no meshwork, only a few costals running parallel to the primaries. But in young leaves the veins ascend at a much sharper angle and the marginal vein is not so prominent while the secondaries and tertiaries have not yet faded from view so that the above description will not hold. The leaves in some of the species are very long and sometimes so narrow that it is difficult to find any veins at all.

* Ohio Nat. 4:13 Nov. 1903.

Plate VI. *Salix longipes* (left) and *Salix babylonica* (right).
Typical specimens natural size; capsules enlarged three times.

Plate VII. Salix interior and Salix interior wheeleri.

Key.

Leaves narrow, not over 1 cm., sometimes very long, secondary, (auxilliary) aments very much younger than the primary; forming dense clumps of slender stemmed shrubs. *S. interior.*

Leaves often 1.5 cm. broad or more, not long in proportion, secondary aments of about the same age as the primary, forming a cymose cluster; low, bushy, not in close clumps; northern. *S. interior wheeleri.*

Salix interior Rowlee. Long-leaved Willow, Sandbar Willow.

(S. longifolia and S. fluviatilis of the manuals in part.)

The characteristic habit of this plant is to grow in clumps about 4 meters high with a great many slender stems coming up very close together from a common root system. These stems are more slender than those of any other of our willows and when the species assumes this habit it may be recognized from a considerable distance. Unfortunately, however, it does not always do so, but sometimes grows by itself as a bush or small tree and then it can best be distinguished by its leaves. The twigs are very slender, thickly branched and straight ascending so that the stems have a peculiar brush-like appearance which gives a pleasing softness to the landscape. The winter buds are small and the twigs resemble those of the black willow more or less closely as the bark is of about the same color. Many of the buds are defective and drop off early in the autumn. The places of such are taken by small lateral buds which develop one on each side of the old scar. This habit when present is characteristic. It is largely responsible for the large number of small branches which come out for there thus arise two twigs instead of one at each node. The leaves are sometimes very long (to 15 cm.) and not more than 1 cm. wide, of almost the same breadth throughout, straight linear-oblong, serrated, but with shallow distant spinulose teeth. When young they are spatulate. The venation is very characteristic except in young leaves as described above. Sometimes they are very hairy even being covered with matted wool persistent until very old, but often they are glabrous and green as soon as they unfold.

Plate VII. *Salix interior* and *Salix interior wheeleri* (marked W).

Leafy branch of the narrow leaved form of *S. interior*; flowers typical; two fruiting aments shown, one nearly glabrous, the other with densely tomentose capsules; natural size; capsule enlarged three times. Variety *wheeleri* typical cluster of staminate aments; the densely tomentose leaves in the upper corner are from the form which connect with the species; the larger broad glabrous leaves shown below are the extreme form of the variety farthest from the species, natural size.

The flowering season of *Salix interior* is much longer than that of any other of our willows; it begins just after the pussy willows have gone by and continues late into the summer. I have even seen blossoms in October and on Cedar Point they are not uncommon in July and August. The first catkins come out on short peduncles with a few small bracts. Later when the season's twigs have developed, they also bear aments at their tips. Just below these terminal catkins develop other lateral aments which blossom later and so prolong the season. We have no other willow which does this and the presence of these small undeveloped aments is very characteristic. The carpellate aments are generally *but not always* quite lax as they grow older. The flowers have a tendency, sometimes very marked, to appear in fascicles of from three to five on the rachis with a distinct interval between them. This is another characteristic feature present in no other species. The scales are yellow, deciduous, the filaments frequently pubescent. The ovularies at anthesis are scarcely longer than the scales with sessile stigmas on their summits. They vary much in shape being sometimes, especially when very hairy, thick and short with a squarely cut off tip, sometimes nearly rostrate especially when glabrous. The mature capsules are narrowly conic, blunt pointed so as to be almost cylindric if not well fertilised. When well developed they are quite large (1 cm.) sometimes glabrous sometimes tomentose. This variation makes them a puzzling problem and one would suppose there were several species instead of one but there seem to be no lines of cleavage between the different forms.

Salix interior is with the exception of its own variety *wheeleri* and the Texan *S. thurberi* the only representative of the longifoliae east of the Rockies. It extends all oves the Mississippi valley and is occasionally met with east of the Alleghanies. In Ohio it is common everywhere.

Salix interior var. wheeleri Rowlee. Wheeler's Long-leaved Willow.

This variety as I have seen it in Ohio sometimes acquires a slender tree form, but more generally is a low much branched dwarf bush, spreading in the sand by the sprouting of buried stems. These do not as in the species produce a dense clump of stems close together but come up only at distances of a meter or so and the result is a loose clump the members of which appear like independent plants. In extreme forms, the leaves especially the older ones from the axils of which branches come out, are very much broader than in the species (7–10 cm. x 2 cm.), dark green and glabrous with the typical venation of the longifoliae, except that the primaries are rather closer and more ascending. These extreme forms as they intergrade into the narrow glabrescent leaves of the species pass through a series of forms which are somewhat narrower but so extremely wooly that neither surface of the leaf can be seen. It was from these that Prof. Rowlee took the type of the variety. These intermediate leaves shade into narrow tomentose forms which connect with the narrow glabrous leaves of the typical species. One might doubt, if he had not studied the plant in the field, that the broad glabrous leaves were the extreme form, were they not accompanied by an extreme in floral development which is more significant than the leaf characters on which Prof. Rowlee separated the variety. This is in the development of the secondary aments at the base of the terminal. In the variety the aments often form clusters of half a dozen, all opening at nearly the same time—a thing which is rarely seen in *S. interior* itself. The flowering period is also distinctly later in the variety than in the species. On Cedar Point it seems to be at its height the first of July and continues into August. Fully 99 % of the plants on Cedar Point are staminate. To what the dearth of carpellate plants is due it is not possible to say at present.

As yet the variety *wheeleri* has been found in Ohio only at Painesville (H. C. Beardslee no. 67, fide Rowlee) and on Cedar Point where it is abundant. It possibly occurs all along the lake shore and possibly for some distance back into the country. But I was unable to find it in Ashtabula county though the conditions seem favorable. Its author limits its range to the basin of the Great Lakes.

CAPREAE.

Low trees or shrubs with leaves ordinarily broad in proportion to their length, generally glabrescent above, mostly tomentose beneath, catkins appearing very early, oftenest in pussies, capsules, in our species, villous.

Key.

From leaves.

Leaves ordinarily very tomentose below especially on the rugose veins, venation strongly sunken above, northern. *S. bebbiana.*

Leaves often glabrous, veins not strongly raised on the under surface, nor depressed above, when hairy often with red-brown hairs. *S discolor.*

From flowers.

Catkins appearing with the leaves or only a little while before them, small at anthesis; scales yellow or darkened only at the tip, capsules narrowly cylindric, filaments not coarse nor long. *S. bebbiana.*

Catkins appearing much before the leaves in large pussies, scales dark brown, capsules elongate-conic, filaments coarse, long. *S. discolor.*

P'ate VIII. SALIX BEBBIANA.

SALIX BEBBIANA Sarg. BEBB'S WILLOW.

A shrub or small tree occasionally reaching a height of 8 meters, with a habit almost exactly like that of *S. discolor* and conspicuously different from that of all of the other shrub willows in that there is scarcely any tendency to sprawl, but the stems all ascend from the root. Leaves generally elliptical, varying from sharply serrate through undulate-serrate to entire or often slightly revolute, generally glabrescent above, wooly below at least on the veins, primaries and secondaries prominently raised on the under surface making them very conspicuous, primaries rather distant, inclined to be crooked and often forking. The whole system of veins strongly sunken from above. Catkins appearing just before or with the leaves, with leafy bracts or, in fruit, on leafy branches; staminate 3.5 cm. long or less; carpellate sometimes 6 cm. in fruit; scales yellow or slightly darkened at the tip, pubescent, *persistent in fruit;* capsule long pedicelled, villous with white silky hair, cylindric, obtuse, sometimes 11 mm. long in fruit.

Salix bebbiana is found across the northern third of the state.

This species in its normal forms is very distinct from *Salix discolor* and can be separated from it withont the least difficulty but the western forms though most keep their flowers like the type, have leaves resembling those of *S. discolor* more or less closely; sometimes even so closely as to be indistinguishable from it. One of these plants from the middle west almost half way between the eastern and western forms of the species Dr. Rydberg has named *S. perrostrata*. Unfortunately, however, the difficulty in separating the two species, though worst in the west, is not confined to that region. Some specimens from Ohio are so nearly intermediate that they can scarcely be determined, but these are rare. There is no danger of any specimen with mature leaves or in fruit being confused with any other species than *S. discolor* for it resembles none, but both kinds of flowers, while the bracts are yet small, resemble those of *S. petiolaris* and the staminate are similar to those of *S. candida*.

Plate VIII. *Salix bebbiana*.

Typical specimens; two fruiting aments one with and the other without leafy bracts, natural size; capsule enlarged three times.

Plate IX. Salix discolor.

Salix discolor Muhl. Pussy Willow.

The pussy willow is typically a swamp shrub growing in clumps differing from those of *S. sericea* or *S. cordata* in that each plant is usually a close clump, separated from its neighbors by a distinct interval, while those species run over a considerable area in a loose clump. The stems are not ordinarily recumbent but strictly upright and straight. Twigs of swamp plants rank, sometimes almost 10 mm. in thickness varying from glossy to densely tomentose, with very large well filled purple-brown buds. In less luxuriant growth the twigs may be smaller, sometimes wooly, with smaller buds. Leaves varying from ovate to spatulate, coarse serrate with blunt incurved teeth to entire or even slightly revolute, glabrescent above, beneath glabrous and paler to glaucous or sometimes tomentose or pilose. Hair soft and wooly as in *S. bebbiana* or short, straight and ferruginous.

Pussies before anthesis larger than in any other species and consequently this is the favorite species with the children in search of pussies in the spring. At anthesis the staminate with their long coarse filaments are larger than any other of our willows except *S. lucida*; carpellate also very large, sometimes 13 cm. in fruit, scales dark brown, capsules long (8 mm.), rostrate, gray pubescent to glabrate in age, pedicel sometimes nearly as long as the capsule but usually shorter. The flowering time is earlier than any other of our willows and it lasts such a short time that it frequently happens that *Salix discolor* blossoms and goes by before one gets out after it, a difficulty not met with in any other of our willows. When the other pussy willows are found in flower it is generally in fruit so that there is little danger of confusing it with them.

As described above *Salix discolor* includes forms differing from each other very strikingly. But the longer I study them the surer I am that, diverse as they are, all are one *species*. The great differences are all in characters like the shape, surface and pubescence of the leaves, which are subject to considerable variation and are to a great extent the outcome of various environmental conditions. The catkins also vary somewhat but in studying specimens from marked trees taken in flower and leaf I have been able to find no correlation between the separate variations in flower and leaf.

Plate IX. *Salix discolor.*

Leafy twig of the most common form; other leaves shown below from left to right as follows: broad, blunt, tomentose form resembling *S. nigricans* of Europe connecting with *S. bebbiana* (rare); narrow ferruginous form often found on plants which would pass as *S. eriocephala*; long, narrow, nearly entire form (var. *prinoides*); twig with winter bud and young pussies; staminate flowers typical; carpellate ament a little narrower than usual; fruiting ament typical except that it is unusually long; natural size; capsule enlarged three times.

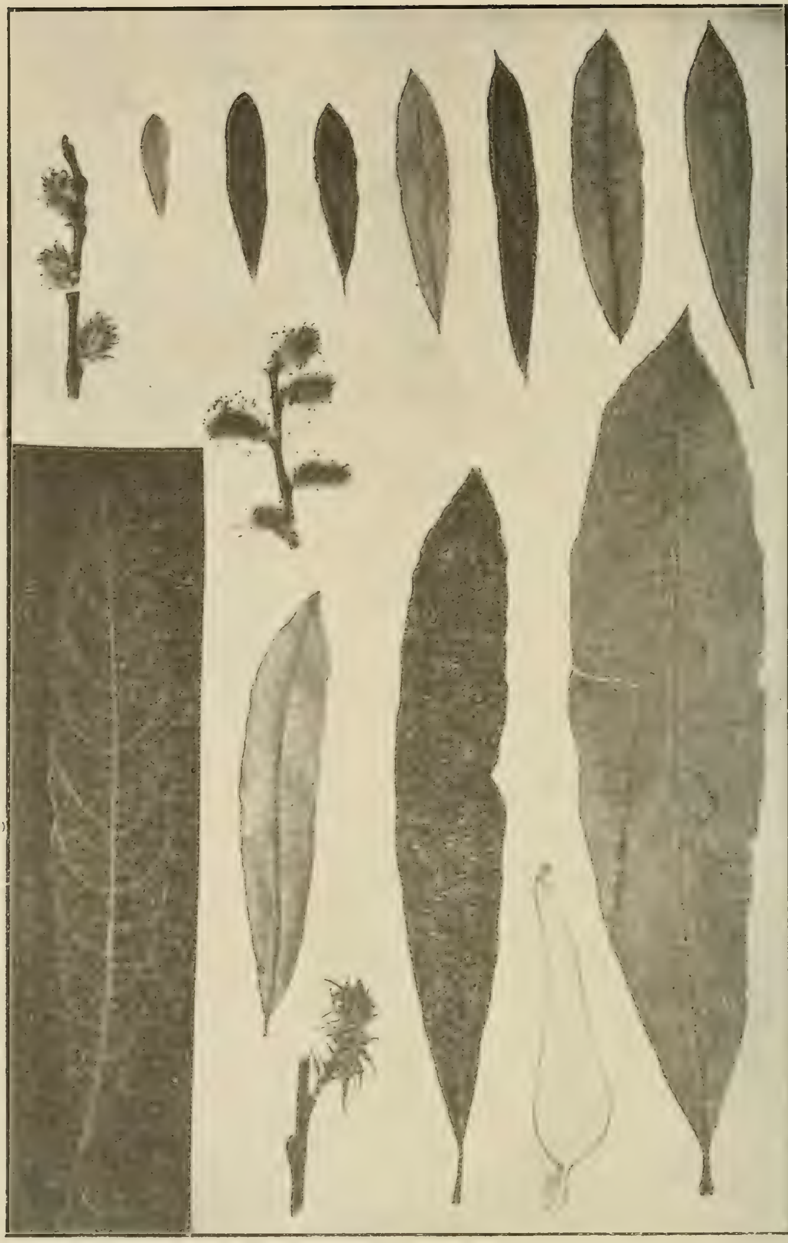

Plate X. Salix humilis and var. tristis.

Salix eriocephala Michx. of Britton's manual includes those forms with ferruginous hair on the leaves and tomentose twigs.

Salix prinoides Pursh, is a narrow leaved form of the type.

It is common in swamps all over the state.

This species is most difficult to separate from *S. cordata* in leaf but its upright habit and the coarse serration as contrasted with the sprawling habit and sharp-toothed leaves of *S. cordata* are sufficient to distinguish them. As described under *Salix bebbiana* it sometimes connects with that species. Narrow revolute-leaved forms are sometimes found which connect this species with *S. humilis*, probably some of them are hybrids.

SALIX HUMILIS Marsh. PRAIRIE WILLOW.

A shrub not more than 3 meters tall with spreading often recumbent branches. Leaves oblong or spatulate, gradually narrowed to the base, abruptly acute and sometimes mucronate at the tip, mostly revolute, entire to undulate-dentate, puberulent or glabrous above, tomentose, especially on the prominently raised veins beneath. or glabrous and glaucous, primary veins rather distant, inclined to be horizontal, looping or oftener branching and arching, with several costals between them, secondaries quite irregular, catkins born very much as those of *S. discolor*, long before the leaves but smaller than in that species, from short stubby pussies, staminate 2 cm. long or shorter, carpellate occasionally 4.5 cm. in fruit, bracts small or none, scales darkened above, long pilose on the back, glabrous in front, capsules elongated, often rostrate-conic in fruit, hirsute at least when young, pedicelled, sometimes almost 1 cm. long when ripe, style distinct, red.

Salix humilis though common nowhere is generally distributed over the state. It will probably be found growing on dry hillsides in nearly every county.

In most forms *Salix humilis* is easily recognizable in leaf because of the long narrow revolute leaves. In flower it is characterized by the short stubby pussies from which the flowers come. The leaves of the ranker shoots take on an appearance very similar to those of *Salix discolor*. It is from such branches that many of the so-called hybrids of our herbaria came but real hybrids undoubtedly do occur. Sometimes also the present species is very similar to *S. candida*, but ordinarily it is a gray plant while *S. candida* has snowy white wool on the under side

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Plate X. *Salix humilis* and variety *tristis*.

Series of leaves from *S. humilis* (lower row) connecting with the variety *tristis* (upper row); flowering aments from var. *tristis*, fruiting from *S. humilis*; natural size; capsule from *S. humilis* drawn in with camera lucida, enlarged five times.

Plate XI. SALIX SERICEA.

of its leaves contrasting strongly with the rich green of the upper surface. In some hybrids, however, most noteworthily *Salix candida* x. *S. petiolaris* the resemblance is so close as to make it all but impossible to separate the two. But such hybrids usually have a distant scolloped serration derived from *S. petiolaris* which is different from any form of *S. humilis*. At flowering time there will be no difficulty in separating them.

Salix humilis var. tristis (Ait.) Dwarf Gray Willow.

A depauperate form of *S. humilis* with which it is connected by many intermediates. It may be described as smaller and hairier throughout. It is quite low (to 6 dm.) with smaller leaves (to 5 cm. long) more strongly gray tomentose, and catkins sometimes scarcely 5 mm. long. This can hardly be regarded as a distinct species. There is not a single constant character by which the two differ and what differences there are, are such as would be likely to be caused by differences in environment. Such forms should be considered as varieties rather than as species.

SERICEAE.

Swamp shrubs, leaves narrowly elliptic-lanceolate, commonly tapering to both ends, serrate with blunt cartilaginous teeth to entire, glabrous to glaucous, sericeate below when young, generally blackening in drying. Aments born before the leaves, sessile or short peduncled, scales darkened at the tip, pilose, capsules pedicelled, silvery sericeate at least when young.

Key.

From leaves.

Leaves dull above, silvery silky beneath at least until very old, scarcely glaucous. *S. sericea.*

Leaves shining above, glabrous on both sides except when young, pubescence on young leaves mostly ferruginous, quite glaucous below. *S. petiolaris.*

From flowers.

Fruiting catkins dense, sessile, capsule ovoid-conic, obtuse, short pedicelled, sericeate even when ripe, hardly 4 mm. long. *S. sericea*

Fruiting caktins, looser, short peduncled, capsule becoming cylindric conic, acutish, long pedicelled, nearly glabrous when mature, more than 4 mm. long. *S. petiolaris.*

Plate XI. *Salix sericea.*

Typical leaves flowers and fruit; natural size; ripe capsule drawn in with camera lucida, enlarged five times.

SALIX SERICEA Marsh. SILKY WILLOW.

A shrub seldom 5 m. tall, with straggling branches generally lopping over onto the ground, forming clumps very similar in appearance to those of *Salix cordata*, buds similar to those of that species but without the loose inner membrane, twigs also similar but very brittle at the base. Leaves narrowly lanceolate, cuneate or rounded at the base, sharply serrate to almost entire, rather dark green and glabrous above, typically dull, below subglaucous, silvery sericeate (rarely somewhat ferruginous or glabrate when old) with lustrous hair which reflects the light irregularly at different angles almost like changeable silk; venation very similar to that of *Salix cordata* but the primaries ascend less rapidly toward the margin than in narrow leaves of that species, the looping is more prominent and blunter or sometimes, even the primaries are quite irregular. Catkins opening before the leaves, supported by a few small green bracts or unbracted, 10–30 mm. long, very dense, scales dark and pilose at the tip, light below, anthers generally red, capsule short conic or ovoid, obtuse, silvery sericeate even when ripe, not more than 4 mm. long, style short but distinct, pedicel about half as long as the ripe capsule.

Salix sericea prefers boggy land and is so common that it may be found in almost any swamp in the state but it seldom grows along river banks with *Salix cordata*.

The greatest difficulty in defining *Salix sericea* is to separate it from *S. petiolaris*, see below, and from *S. cordata*. In both cases the carpellate aments are entirely diagnostic and it is with the leafy specimens that the difficulty occurs. The leaves of *Salix cordata* are ordinarily wider than those of *S. sericea* and broadest below the middle while in this species the greatest width is near the middle; the serrations are sharper and finer in *S. cordata* and the leaves of *S. cordata* do not blacken in drying. But most important of all are the silvery hairs below which differentiate it from everything else. In old specimens, however, they are sometimes almost absent and in such cases it frequently becomes almost impossible to separate them.

Salix sericea subsericea, (*Anders.*) *Rydb.* is the name that has been given to the form of the present species which connects it with *S. petiolaris*. It is characterized by leaves much less pubescent than the typical form and less dull or even subglossy on the upper surface so that from leaf characters alone it cannot be distinguished from that species. It is very common in our area, see under *S. petiolaris*.

SALIX PETIOLARIS Smith. SLENDER WILLOW.

A shrub very similar to *Salix sericea* in habit. But typical leaves are quite different from those of that species in general appearance. Unfortunately, however, in this region connecting forms sometimes render it impossible to distinguish the two from the leaves alone. They are rather narrower, margin (sometimes entire) serrate with more prominent, blunt cartilaginous teeth, subglossy above, quite glaucous beneath, or sericeate when young oftenest with ferruginous hair, venation so similar to that of *S. sericea* that it cannot be distinguished unless by the more ascending primaries and the finer reticulations. Carpellate aments short peduncled, becoming somewhat lax in fruit, scales yellow, mostly darkened above, pilose, capsules long pedicelled, acutish, in fruit cylindric conic, more than 4 mm. long.

The *character* of the leaves in the extreme form is very similar to that of the Broad-leaved Willow with which they might be confused were it not for their narrowness. The difficulty in separating them from *S. sericea* comes especially late in the season when that species begins to lose its pubescence and to become more glossy on the upper surface. The catkins sometimes resemble those of *Salix bebbiana* but can be distinguished by the darkened rather than yellow scales. With these exceptions the present species is not likely to be confused with any other in our area.

Salix petiolaris is the western form of *Salix sericea* or rather since that species was later named, it is the eastern form of *S. petiolaris* of which it was made a variety by Andersson. It almost seems as though that were the proper treatment and that we should be doing well to return to Andersson's view but the carpellate aments seem fairly distinct.

We are near the eastern border of the range of *Salix petiolaris*. It occurs rather rarely in Ohio and has been found only in the north-western portion of the state, though it may extend well eastward along the lake shore.

Salix petiolaris gracilis Anders. Frequently one meets with forms of the Slender Willow with even more slender and graceful twigs than the usual form. This variety has been given the name *gracilis* by Andersson. It is characterized by narrower, more sharply serrate leaves and longer pedicels than the typical form. It may perhaps be taken as the extreme development of the type farthest from *S. sericea*. It is to be expected wherever *S. petiolaris* is found.

Plate XII. SALIX CANDIDA AND SALIX PETIOLARIS.

Salix candida Fluegge. Sage Willow, Hoary Willow.

This little shrub seldom grows more than a meter tall. It may be recognized anywhere by its leaves which are narrowly oblong and revolute, veins deeply depressed on the upper surface and prominent below; under side covered with a thick white tomentum contrasting strongly with the rich dark green of the upper surface, petiole short and stipules lacking. Flowers appearing before the leaves; ovularies densely covered with silvery white wool, nearly sessile, with a very long conspicuous deep rose red style like no other of our species; staminate catkins with few bracts below them and hardly presenting diagnostic characters; small and delicate resembling those of *S. bebbiana* somewhat but easily distinguished from them by the dark colored scales.

Salix candida is quite rare in Ohio. It was first reported by Mr. Moseley from Castalia prairie but has since been found in Wyandot county also. It ranges over the eastern and northern portions of North America. But in the west and north the leaves apparently become broader almost elliptical and not markedly revolute.

Salix candida hybridises with *S. cordata*, with *S. sericea* and with *S. petiolaris*. At Castalia a fine series of hybrids with *S. cordata* and *S. petiolaris* may be found.

CORDATAE.

The cordatae are a group of shrub willows with very variable leaves, characterized by glabrous capsules borne from wooly pussies. A peculiarity of the opening buds is that the inner bud scale grows out beyond the outer, enveloping the base of the ament and looking like the wing of a beetle imperfectly folded under the elytron. This so far as I know occurs in no other group and is therefore an important diagnostic character at a time when the species are particularly hard to separate. In this state the species though variable are fairly well marked but in the west the group is represented by a number of forms whose relationships have not been satisfactorily worked out as yet.

Plate XII. *Salix candida* (left)and *Salix petiolaris* (right.)

S. candida—typical but rather short leaves, other parts typical; natural size; capsule and carpellate flower enlarged three times, photographed and brightened.

S. petiolaris—leafy twig of the extreme type farthest from *S. sericea*, with shiny, glaucous, glabrous leaves; two small leaves belonging to the variety *gracilis* in the lower corner; flowers and fruit typical, natural size; capsule enlarged three times.

Plate XIII. Salix cordata.

Key.

From leaves.

Leaves glossy above, heavily glaucous below, mostly broad, ascending so as to show their white under sides, glabrous, northern. *S. glaucophylla.*

Leaves neither glossy nor very glaucous.

Leaves thick, ovate, with emarginate bases, tomentose on both sides, northern. *S. adenophylla.*

Leaves thin, seldom pubescent above, lanceolate, generally distributed. *S. cordata.*

From flowers.

Bracts strongly glandular, before anthesis very villous, aments dense, capsules green, short pedicelled, medium sized, northern. *S. adenophylla.*

Bracts not glandular, tomentum quickly evanescent, pedicel longer.

Bracts green, obscurely serrate or entire, capsules green, small, medium pedicelled. *S. cordata.*

Bracts blackening, glaucescent, capsules large, rostrate, becoming brown, long pedicelled, aments lax; northern. *S. glaucophylla.*

Salix cordata Muhl. Heart-leaved Willow.

Salix cordata is the botanist's bugbear. It is one of the most common and most variable species with which we have to deal. Its leaves seem to be under no restraint of heredity and may assume almost any form and any character. I have seen them all the way from linear-lanceolate to orbicular, from subglossy to heavily tomentose, from green to glaucous. But various as are the leaf forms they are all united by the flowers and one cannot doubt that they all belong to a single species.

The separation of the bud scales alluded to above is particularly well marked in *Salix cordata* and in the southern portion of the state or anywhere out of the range of the other species at once differentiates this species from *S. sericea* or *S. discolor* which it resembles much in early spring.

Leaves very variable but generally of the lanceolate type, broader or narrower, but widest below the middle, serrations always *sharp* and usually fine. In leaf it is most likely to be confused with *S. discolor* and *S. sercicea.* From the former it can

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Plate XIII. *Salix cordata.*

Leaf showing venation and the two others in the lower portion of the plate typical; large leaf from very vigorous water shoot, perhaps indicating some affinity with *S. adenophylla*; upper narrow leaf from variety *angustata*; flowers and fruit typical; natural size; capsule enlarged three times.

Plate XIV. Salix adenophylla.

be distinguished by its sharp fine serration contrasted with the distant blunt and often coarse teeth of the pussy willow. The habits of the two are sufficiently different to put aside all confusion when the plants are seen together. From *S. sericea* it can generally be distinguished by the absence of the silvery white pubescence on the under surface. The shape of the leaves is also different, in most cases in that species the leaf is widest near the middle; in this it is widest below the middle. *Salix cordata* also lacks the peculiar leaf habit of *Salix sericea*. The flowers come very early from small pussies. As they mature the carpellate aments come to be supported by large leaves and much of the wool of the pussy drops off from the fruiting rachis. The anthers just before the elongation of the filaments are almost as red as those of *Salix sericea*. The capsules are green and glabrous, the stigmas frequently red.

Salix cordata angustata Anders. includes the narrow leaved forms of the species. In Ohio most plants have leaves wider than those of the typical *angustata* but decidedly narrower than the typical specific form. It is therefore difficult to distinguish two forms in our area and since the leaf variation may be considered as accidental and without significance it is perhaps hardly advisable to separate them.

Salix cordata is abundant all over the state. Its usual habitat is along streams while the other species with a similar habit and leaf are typically swamp plants. This is not to say that the present species never grows in swamps nor that *S. sericea* and *S. discolor* never grow along river banks—for they do—but that they attain their best development in the habitats given and are usually found there.

To increase the difficulty of dealing with *Salix cordata* it hybridises very freely. It forms with *S. candida* a fine series of connecting forms. With *S. sericea* hybrids occur though not so frequently as has been supposed. It is also said to mix with *S. discolor* but I have seen no unquestioned specimens from Ohio.

SALIX ADENOPHYLLA Hooker. FURRY WILLOW.

A straggling shrub of about the same size as *S. cordata* which it resembles most closely. It looks like a xerophytic adaptation of that species. The leaves are thicker, shorter and broader, ovate, more or less tomentose on both sides, with an emarginate base, very sharply serrate or entire; ordinarily in rank growth with the leaves closely crowded on the twigs and

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Plate XIV. *Salix adenophylla.*

Typical leaves, flowers and fruit, showing fruiting aments with and without bracts; a bract from a fruiting ament in the upper corner; natural size; capsule enlarged three times.

Plate XV. Salix Glaucophylla.

generally accompanied by large stipules. The flowers differ from those of our other species of cordatae in having broader bracts, much woolier before anthesis; in fruit by the denser catkins with shorter pedicelled capsules which are smaller than those of *S. glaucophylla* and rather larger than the average of *S. cordata*.

In typical forms the wooly broad leaves will distinguish it from everything else in our area. It is sometimes difficult to separate, however, from *S. cordata* in its more tomentose forms, and intermediates seem to occur. In shape the leaves are not so different from *S. bebbiana* but they will be quickly distinguished, among other things, by the sharply serrate margins of the present species.

Salix adenophylla is our rarest willow. It is a plant of the Western Great Lake region and reaches its best development in Michigan, being rare east of that state. Until recently it was not supposed to extend into Ohio but I have seen several specimens collected at Erie, Pennsylvania. It should therefore extend the whole length of the Ohio Lake Shore. But it is very scarce indeed. Though I have hunted for it on Cedar Point and in Ashtabula County I have seen from Ohio but a single undoubted specimen which was taken by A. D. Selby on Cedar Point.

SALIX GLAUCOPHYLLA Bebb. BROAD-LEAVED WILLOW.

A shrub sometimes 5 m. tall, growing in clumps like *S. cordata;* leaves mostly broad, ovate or ovate-lanceolate, shiny above except in rank growth, with very fine irregular venation and stiff midribs which hold them up at an acute angle with the stem so as to display the white under surfaces. In character the leaves resemble much the narrower leaves of *S. petiolaris* and like them, when succulent have a strong tendency to blacken in drying. Flowers appearing before the leaves, bracts mostly narrow, glaucescent; staminate aments generally larger than those of *S. cordata* with smaller bracts; carpellate long, lax in fruit, capsules very long (1 cm. or more) glabrous, sometimes rostrate, long pedicelled, turning brown.

Bebb labelled some of the first material of this species he sent out, *Salix cordata* x *S. lucida*. This determination though very far from correct as he himself soon recognized, is descriptive of the species. Its affinity to *Salix cordata* is evident at once from inspectoin of either leaves or flowers but yet in both there is a strong resmeblance to *Salix lucida*. The large thick catkins with the long capsules and the beautiful glossy leaves cannot but suggest that species.

Plate XV. *Salix glaucophylla.*
Typical leaves and aments, natural size; capsule enlarged three times.

Plate XVI. Salix purpurea and Salix pedicellaris.

The Broad-leaved Willow is a species of the Great Lake basin and in Ohio is confined to the northern part of the state. It is common along the western portion of the Lake Shore but probably does not extend beyond Cleveland.

Salix glaucophylla at times seems to grade into *Salix cordata* by what are probably a series of hybrids. In other cases it is very difficult to separate from *S. discolor* with which it also probably hybridises.

MYRTILLOIDES. BOG WILLOWS.

Low shrubs with mostly elliptical, glaucous, glabrous leaves strongly reticulate veined and purplish green; aments and bracts usually reddened, small, few flowered; filaments often partially united showing their affinity with the following group; a group of three or four species all very similar to the European *Salix myrtilloides*.

Salix pedicellaris (Anders). American Bog Willow.

A low shrub seldom reaching a height of 1 meter, aereal shoots erect, slender, supported in the sphagnum by long creeping stems which run far down into the bog putting out numerous rootlets along their length. Leaves when fully grown sometimes 9 cm. long and 20–25 mm. broad, but ordinarily smaller, elliptical, oblong, spatulate or rarely obovate, pointed at both ends, entire, slightly revolute, dark purplish-green above, slightly glaucous below, not hairy unless when very young, nearly sessile, venation conspicuously reticulate with meshes large and coarse considering the size of the leaf. Catkins appearing with the leaves, loosely flowered, not more than 25 mm. long in flower, but occasionally 5 cm. in fruit, scale short, often no longer than the nectary, as broad as long, filaments often more or less united; capsules long pedicelled, nearly always glabrous, short conic to cylindric-conic, obtuse, sometimes 8 mm. long in fruit, with a decided tendency to turn red or purple.

Salix pedicellaris is a northern species growing in cold peat bogs where it may be easily recognized by its small size and pe-

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Plate XVI. *Salix purpurea* (left) and *Salix pedicellaris* (right.)

S. purpurea. Typical branch with opposite and scattered leaves; flowers and fruit typical, the latter from a European specimen; natural size; staminate flower and capsule enlarged three times, photographed and brightened.

S. pedicellaris. Typical summer branch with small ovate leaf from the base of a twig to its left; staminate and carpellate flowers and fruit typical, the latter not ripe; natural size; staminate flowers and capsules enlarged three times, one of them, marked M, between the leaves of *S. purpurea.*

culiar leaves. It it necessarily quite local in its distribution but probably grows in most of the sphagnum bogs in the state. There are specimens in the state herbarium from Williams and Portage counties and from the Licking Reservoir.

I am informed by Mr. P. A. Rydberg that the typical *S. myrtilloides* of Linneus was a European plant and that it differs slightly but constantly from the American species, hitherto considered as the variety pedicellaris, which should consequently be considered distinct.

As stated above *Salix pedicellaris* is easily distinguished from all the other species with which we have to deal. But more than once I have strongly suspected it of hybridising with *S. discolor* which occupies the same territory. But so far I have not yet been able to satisfy myself of the hybridity and so leave the question in abeyance.

PURPUREAE.

Shrubs, leaves mostly oblong, oblanceolate or linear-oblanceolate, nearly entire, glabrescent, stamens more or less perfectly united into one with 4 anthers, capsules globose-conic, nearly sessile, silky.

Salix Purpurea L. Purple Willow.

A shrub reaching a height of about 3 m. putting forth a dense growth of slender wands from the larger branches. Leaves scattered or opposite, sometimes 10 cm. long and 2 cm. broad, oblong-oblanceolate, oblong or rarely elliptical, mostly broadest above the middle, abruptly acute, generally gradually narrowed to the round base, entire or obscurely serrate, glabrous, dark purplish-green, paler beneath, petioles short, stipules apparently absent. Catkins expanding from pussies, sessile with a few small green bracts, scales more or less pilose on the back, oblong, blunt with conspicuously purpled tips, very concave above and strongly reflexed in the staminate, less so in the carpellate, capsule broadly ovoid, silky, sessile, style very short or none.

Salix purpurea is an Old World species planted in America largely for its twigs which are much used in basket work. It has been long reported in the manuals as escaped in this country but though it is fairly common over the state it is rarely that one sees a clump growing in a place where it would not likely have been planted. It certainly has not esceped to any such degree as have *S. alba* and *S. fragilis*. In America the carpellate plant is very rare and the species is mostly propogated by cuttings. This may account for its inability to spread as in the case of *Salix babylonica*.

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Stockberger, W. W., *Botany*........Dept. Agriculture, Washington, D. C.
Stoner, Minnie A., *Domestic Science*...............O. S. U., Columbus
Surface, F. M., *Zoology, Botany*............................Eaton
Sutton, J. G., *Physics, Geology*.......................*Rushsylvania*
Sweezey, Ottto H.................1019 Olaho Lane, Honolulu, Hawaii
Taylor, Albert ....Bedford
Thompson, Mrs. King...................167 W. Tenth Ave., Columbus
Tillman, Miss Opal I., *Botany*...................O. S. U., Columbus
Tight, W. G. *Geology*...........................Albuquerque, N. M.
Todd, Joseph H., *Geology, Archaeology*........Christmas Knoll, Wooster
Todd, Otto K......................................Vermillion

True, H. L. .... McConnelsville
Tyler, F. J., *Botany* .... Bureau of Plant Industry, Washington, D. C.
Tyler, Harriet Burr, *Botany* .. Bureau of Plant Industry, Washington D. C.
Van Hook, J. M., *Plant Pathology* .... Experiment Station, Wooster
Waite, F. C. .... Western Reserve University, Cleveland
Walton, L. B., *Biology* .... Gambier
Webb, R. J., *Botany* .... Garrettsville
Webster, F. M., *Entomology* ... U. S. Dept. Agriculture, Washington D. C.
Werthner, William, *Botany* .... Steele High School, Dayton
Westgate, Lewis G., *Geology* .... Delaware
Wetzstein, A., *Botany* .... 309 W. 141st St., New York, N. Y.
Whetsel, J. A. G., *Botany, Zoology* .... 193 Jefferson Ave., Brooklyn, N. Y.
Whitney, W. C., *Biology, Geology* .... Westerville
Wieman, Harry L., *Biology* .... Univ. of Cincinnati, Cincinnati
Williams, Stephen R., *Biology* .... Miami University, Oxford
Williamson, E. Bruce, *Ichthiology, Ornithology* .... Bluffton, Ind.
Wolfe, E. E., *Botany* .... Marietta College, Marietta
Wright, G. Frederick, *Geology* .... Oberlin
Yanney, Lula Hock .... Alliance
York, Harlan H., *Botany* .... Dept. of Botany, Columbia Univ., New York

Report of the Fifteenth Annual Meeting
of the
Ohio State Academy of Science

ANNUAL MEETING

The fifteenth annual meeting of the Academy was held in Cincinnati on November 30, December 1 and 2, 1905, the president of the society, Professor Herbert Osborn, presiding. On Thursday evening an informal meeting took place at the Museum of the Society of Natural History.

On Tuesday at 9:30 a. m. the meeting was called to order by the President in Room 27, Cunningham Hall, at the University of Cincinnati. The report of the Secretary was presented and accepted. Reference was made to the Field Meeting at Cedar Point, Sandusky, July 5-8th, in conjunction with the American Microscopical Society. This was attended by about 25 members of the Academy, and excursions were made to Johnson's Island, Kelly's Island, Put-in-Bay, and other places of interest.

The Executive Committee reported the following names elected to membership during the year:

MEMBERS ELECTED BY THE EXECUTIVE COMMITTEE
NOV. 27, 1904, DEC. 1, 1905.

BALLARD, C. E., Biology....................................Gambier
BLACKMAN, M. W., Zoology, Cytology..........................
....................Medical Department Western Reserve, Cleveland
CLEVENGER, J. F., Botany, Zoology........................Cedarville
COTTON, E. C., Entomology, Botany..........Ohio Dept. of Agr., Columbus
COOVER, A. B., Archeology..................1432 Hunter Ave., Columbus
FISCHBACH, H. P., Biology........................Newport, Kentucky
HIXSON, A. H., Zoology...Ada
HOKE, GEO. W., Geography, Biology...........................Oxford
HUBBARD, G. D., Geology, Physiography......................Columbus
HYDE, J. E., Geology......................................Lancaster
JACKSON, C. F., Zoology....................................Columbus
JONES, F. T., Physics, Chemistry, Mathematics..35 Adelbert St., Cleveland
JONES, ROBT. RALSTON, Geology........U. S. Engineer's Office, Cincinnati
KOCK, H. E., Zoology, Physics........Park and McMillan Sts., Cincinnati
NELSON, JAMES, Zoology, Embryology....................Ithaca, N. Y.
SCHULTZ, O. T., Protozoa.......................................
....................Med. Dept. Western Reserve Univ., Cleveland
SMITH, G. D., Botany, Zoology...................450 Spicer St., Akron
STAUFFER, C. R., Geology.....................390 King Ave., Columbus
VAN HOOK, J. M., Plant Pathology...........Experiment Sta., Wooster

The report of the Treasurer was presented and after reference to the Auditing Committee was accepted. The following is a brief summary:

REPORT OF THE TREASURER FOR THE YEAR 1905.

For the year since our last annual meeting the receipts, including balance from last year, have amounted to $246.14, and the expenditures to $245.67, leaving a cash balance of 47 cents.

RECEIPTS.

Balance from last year	$64 85	
Membership dues	158 00	
From sale of publications	23 29	
Total		$246 14

EXPENDITURES.

For printing the Annual Report	$98 56	
152 subscriptions to the Ohio Naturalist	76 00	
Miscellaneous	70 64	
Balance December 1, 1905	47	
Total		$246 14

Respectfully submitted,

JAMES S. HINE.

The report of the Librarian was read and adopted. It was moved and carried that the report be published.

LIBRARIAN'S REPORT.

Members of the Ohio Academy of Science:

I herewith take pleasure in presenting to the Academy my report upon the receipts from the sale of the publications of the Academy.

Amount on hand December 1, 1904		$0 13
Cash received for Annual Reports and Special Papers		21 43
Total cash		$21 56

REPORT OF EXPENDITURES FOR YEAR ENDING DEC. 1, 1905.

Paid for postage on letters and publications	$1 55	
Paid for express	62	
Paid for postage 13th Annual Report	6 74	
Paid for printing and paper	1 28	
		10 19
Cash paid treasurer, May 4, 1905	$5 40	
Cash paid treasurer, October 30, 1905	2 50	
Cash paid treasurer, November 1, 1905	1 20	
		9 10
		$19 29
Cash on hand December 1, 1905		$2 27
Total number of pub. sold during the year		$21 43
Total number of pub. sold last year		7 96
Increase		$13 47

I call the attention of the members to the fact that the early numbers of the Academy publications are about exhausted and advise those having an interest in science to avail themselves of the opportunity to secure a complete set of the publications for their library.

Our exchange list has also increased during the year and we now have the publication of twenty-six scientific societies and colleges available for reference by members of the Academy.

I urge upon the members the necessity of a correct mailing list and should they change their address to notify, at once, the Treasurer or Librarian.

Respectfully submitted,
Wm. C. Mills, Librarian.

REPORT OF THE BOARD OF TRUSTEES.

The appropriations made during 1905 were somewhat less than usual, it being deemed wise to reserve the balance for publication.

The Board of Trustees feel that excellent work has been done by the Academy, and realizes that not a little of this has been accomplished by the aid of the "McMillin research fund". If the work so well begun is continued it will not be long until the "Natural History of Ohio" is quite as complete and more up to date than that of any other.

RECEIPTS.

Balance on hand November 16, 1904	$114 89	
Check — Emerson McMillin — Nov. 29, 1904	250 00	
Total		$364 89

EXPENDITURES.

Special Paper No. 10	$30 00	
Herbert Osborn, expenses for travel in research work on "Insects"	22 00	
R. F. Griggs, expenses for travel in research work on "Willows"	20 92	
Cuts for paper on "Willows"	47 49	
Herbert Osborn, expenses for reasearch work on "Insects"	25 00	
		$148 41
Balance on hand November 20, 1905		$216 48

The Board has again received the annual contribution of Mr. Emerson McMillin of $250.00 to the research fund.

Wm. R. Lazenby, Chairman.
John H. Schaffner.

A Membership Committee, consisting of Mr. Dury, Dr. Guyer and the Secretary, was appointed by the President. They subsequently reported on the following names. These were duly elected.

MEMBERS ELECTED BY THE MEMBERSHIP COMMITTEE. DEC. 1-2, 1905.

Benedict, Stanley M., Physiology........Univ. of Cincinnati, Cincinnati
Braam, Maximilian, Biology............Hughes High School, Cincinnati
Branson, E. B., Geology..Oberlin
Breese, B. B., Psychology.................Univ. of Cincinnati, Cincinnati
Carney, Frank, Geology......................................Granville
Hansen, Hermine J., Biology..........Hughes High School, Cincinnati
Martzoff, C. L., Archaeology..........................New Lexington
McDaniel, J. E., Biology......................................Athens
Wieman, Harry, Biology.................Univ. of Cincinnati, Cincinnati

Reading of papers commenced at 10:15 and continued until 12:05 p. m., when, after the appointment of a committee consisting of the Secretary, Prof. Landacre and Prof. Rice, to consider a revision of the Constitution and report at the next meeting, the Society adjourned to luncheon provided by the local committee.

At 1:15 p. m. the Society listened to the address of the President on "The Origin of the Wings of Insects." This was illustrated by an excellent series of lantern slides.

At 2:15 p. m. the reading of papers commenced and continued until 4:30 p. m. when a brief recess of ten minutes occurred. This was followed by Prof. Herrick's paper, "On the Present Status of Comparative Psychology."

At 5:30 p. m. the Society adjourned to partake of a dinner served by the University.

At 7:30 p. m. President Dabney of the University of Cincinnati, delivered an address entitled, "Our Modern Universities." This was followed by an informal reception in the parlors of the University.

On Saturday the meeting was called to order at 9:10 a. m. Attention was called to the death of two members during the year, Prof. A. A. Wright of Oberlin, and Rev. F. D. Kelsey of Toledo.

A resolution urging the necessity for a biological survey of the Panama Canal Zone before the cutting of the canal was unanimously adopted and the secretary was instructed to transmit the resolution to the proper authorities at Washington.

A committee, consisting of the retiring President, Prof. Herbert Osborn; the incoming President, Prof. E. L. Rice; and the Secretary, was appointed for the purpose of bringing the matter of a State Natural History Survey before the next session of the General Assemmly.

The Committee on Nomination of Officers, Prof. C. J. Herrick, Prof. W. C. Mills, and the Secretary, which had previously been elected by ballot, reported and the following were elected for the coming year:

President — Dr. E. L. Rice, Delaware, Ohio.

Vice-Presidents — Mr. Chas. Dury of Cincinnati, Ohio, and Professor Lynds Jones, of Oberlin, Ohio.

Secretary — Dr. L. B. Walton, Gambier, Ohio.

Treasurer — Professor J. S. Hine, Columbus, Ohio.

Librarian — Professor W. C. Mills, Columbus, Ohio.

Executive Committee (ex-officio) — Dr. E. L. Rice, Delaware; Dr. L. B. Walton, Gambier; Professor J. S. Hine, Columbus (elective); Dr. M. F. Guyer, Cincinnati; Dr. L. G. Westgate, Delaware.

Board of Trustees — Dr. G. B. Halsted (in place of retiring trustee).

Publication Committee — John H. Schaffner.

A committee was also appointed for the purpose of securing the co-operation of the libraries in the state to the end that scientific papers be rendered more available for members of the Society. This committee consisted of Prof. Mercer, Prof. Durrant, and Prof. Westgate.

Invitations to the Society to meet at Columbus in November, 1906, were read from President W. O. Thompson, and from the Secretary of the Biological Club of the State University. No definite action was taken, the matter being left to the Executive Committee.

After resolutions were passed expressing the appreciation of the Society for the courtesies extended by the people of Cincinnati, the faculty of the University of Cincinnati, and the officers of the Museum of Natural History, and, furthermore, thanking Mr. Emerson McMillin, of New York, for his continued interest in the welfare of the Academy, the Society adjourned.

The following is the complete program of the meeting.

Robert F. Griggs — "Report on the Willows of Ohio"

J. H. Todd — "The Relation of Medicine to Anthropology."

Henry F. Kock — "Observations on *Euglena viridis* and *Euglena sanguinea*."

E. W. Berger — "Habits of the Pseudoscorpionidæ principally (*Chelanops oblongus* Say)."

H. P. Fischbach — 'Some Notes on a Myxobolus Occuring in a Diseased Fish (*Abramis chrysoleucas*)."

H. J. Hillig — 'A New Case of Mutation (*Commelina nudiflora*)."

F. Carney — "The Geology of Perry Township, Licking Co.," illustrated by lantern slides.

Charles Dury — "How to Collect and Breed Xenos."

L. B. Walton — "A New Species of Japyx (*J. macgillvrayi*) with some Notes on the Morphology of the Hexapoda and Chilopoda."

J. S. Hine — "Notes on some Ohio Mammals."

W. A. Kellerman — "Corn Rust Cultures."

W. F. Mercer — "The Relation of the Motor Nerve-Endings to the Voluntary Muscle in Amphibia."

J. H. Schaffner — "The Reduction of the Chromosomes in Microsporocytes."

A. D. Cole — "Optical Experiments with Electric Radiation."

M. F. Guyer — "Guinea-chicken Hybrids."

L. G. Westgate — "Glacial Erosion in the Finger Lakes Region, New York.

L. B. Walton — "The Naididæ of Cedar Point, Ohio."

Harris Handcock — "The Present State in the Development of the Elliptic Functions."

W. C. Mills — "Mammalia of the Baum Village Site."

W. R. Lazenby — "Foreign Trees Naturalized in Ohio."

E. W. Berger — "Notes on the Fall Webworm (*Hyphantria cunea*) in Ohio."

J. S. Hine — "Life-History Notes on Three Species of Mosquitoes."

A. M. Miller — "Recent Classification and Mapping of Lower Ordovician in Kentucky." Illustrated by lantern slides.

S. R. Williams — "The Anatomy of *Boophilus annulatus* Say."

C. J. Herrick — "On the Present Status of Comparative Psychology."

W. A. Kellerman — "A Botanical Trip Through Gautemala." Illustrated with lantern slides.

Herbert Osborn — "Further Report on the Hemiptera of Ohio."

J. M. VanHook — "*Ascochyta pisi*, a Fungus Disease of Seed Peas."

Lynds Jones — "Additions to the Birds of Ohio."

W. A. Kellerman — "Exhibition of Selected Gautemalan Plants."

J. H. Todd — "The Garden of the Titans — Its Geology."

Chas. Brookover — "The Prosencephalon of *Amia calva*."

E. L. Moseley — "The Cause of Trembles in Cattle, Sheep and Horses, and of Milk-sickness in Man."

G. D. Hubbard — "Physiography and Geography."

W. C. Mills — "Description of a Teepe Site, Baum Village Site."

C. E. Ballard — "A New Gregarine from the Grasshopper (*Melonoplus atlanis*)."

W. R. Lazenby — "Habits of Introduced Weeds."

G. B. Halsted — "An Application of Non-Euclidean Geometry."

W. F. Mercer — "Development of the Respiratory System in Amphibians."

Gerard Fowke — 'Superficial Geology between St. Louis and Cairo."

W. C. Mills — "Human Jaws as Ornaments."

L. B. Walton — "Some Laboratory Methods."

W. R. Lazenby — "Notes on the Germination of Seeds."

F. Carney — "Glacial Studies in the Vicinity of Newark."

A. F. Burgess — "A Preliminary Report on the Mosquitoes of Ohio."

W. A. Kellerman, H. H. York and H. A. Gleason — "Annual Report of the State Herbarium."

Lynds Jones — "A Contribution to the Life History of the Common Tern (*Sterna hirundo*)."

F. O. Grover — "Notes on Some Ohio Spermatophytes."

W. B. Hermes — "Studies on Insects that Act as Scavengers of the Organic Beach Debris."

Albert Wetzstein — "A List of the Plants of Auglaize Co., O."

R. E. Brockett — "Some Plants on the Campus and in the Vicinity of Rio Grande College."

Lumina C. Riddle — "Bembicidæ of Ohio and Notes on Life History of *Microbembex monodonta* Say, and *Bembex texana* Cress."

C. F. Jackson — "A Key to the Families and Genera of Thrysanura with a Preliminary List of Ohio Species."

Jas. A. Nelson — "A Note on the Occurrence of Sex Organs in Aelosoma."

Joshua Lindahl — "Barite in a New Form (Pisolitic) from a 1,400 Foot Boring for Oil at Saratoga, Texas."

Victor Sterki — "Preliminary List of Land and Fresh Water Mollusca of Ohio."

Victor Sterki — "A Suggestion with Respect to Local Fauna Lists."

Victor Sterki — "Some General Notes on the Land and Fresh-water Mollusca."

On December 28th an informal meeting of the Academy was held in connection with the Allied Educational Societies at Columbus, Prof. Herbert Osborn acting as chairman, and Prof. J. H.

Schaffner as secretary in the absence of the regular president and secretary. The following program was given.

Edward Orton, Jr. — "Report on the Economic Work of the Ohio Geological Survey."

Charles S. Prosser — "Status of Stratigraphical Work in Ohio."

C. E. Sherman — "Progress of the Topographical Survey of Ohio."

Miss S. S. Wilson — "Elementary Science in the High School."

E. P. Durrant — "Amount, Time, and Purpose in View, in High School Biology.

B. F. Thomas — "Lecture and Demonstration in Light and Color."

L. B. Walton, Secretary.

Gambier, O., February 14, 1906

PRESIDENT'S ADDRESS

SUGGESTIONS.

Preliminary to the address proper which will be of a scientific nature, I desire to call attention to a few matters of concern to the Academy, matters which seem to me to be of importance in connection with its further growth and usefulness, and to offer a few suggestions.

In the fifteen years of the Academy's existence it has accomplished many laudable undertakings and has been the means of stimulating and furthering investigations in a number of different lines. Among the most important of its functions is the means it has given for co-operation and acquaintanceship among scientific workers of the state. Numerous papers on geology and the natural history of the state which have appeared from time to time in its publications are the tangible results of the efforts of its members. The use of the McMillin Research Fund has been, perhaps one of the most important influences in its work in recent years, and the amount of scientific investigations and the number of creditable papers which have been published as a result of the encouragement derived from this fund is, it seems to me, a remarkable and creditable showing for the money used. Among the important contributions which may be found listed among the papers credited to this fund are, Studies of Preglacial Drainage in Ohio, The Fishes of Ohio, The Ecology of Big Spring Prairie, The Tabanidae of Ohio, An Annotated List of the Birds of Ohio, The Coccidae of Ohio, Reptiles and Batrachians of Ohio, and other studies are in an advanced stage of progress and reports of these will soon be forthcoming. When we consider that this has been the result of a contribution of $250 per annum through a series of eight years we may flatter ourselves and congratulate the donor as to the showing made. Another matter in which the Academy was influential was the establishment of the Topographical Survey which has been progressing steadily and which when completed will furnish a basis of knowledge for many other lines. Our proceedings and special papers form a creditable series and are yearly growing more valuable.

In taking note of various lines of organized science in the state it will be an easy matter to see what lines are being most thoroughly pushed and where the Academy may best exert its efforts. The State Geological Survey is ably conducted and receives such support from the state as to make steady progress in this important line of investigation.. The Studies of the Archeology and History of the State, supported by the state in the Archeological and Historical Society are constantly increasing in value and justifying the expenditure of state funds which are appropriated for the purpose. In the State Board of Health much work of a scientific character is being accomplished and while bearing directly upon the public health at the same time contributes important additions to general science. Still other agencies accomplish excellent results.

The scientific workers of the state are, I presume, all seriously hampered for the want of extensive library facilities and it seems that it would be desirable, if possible, to inaugurate some system of co-operation between the different scientific workers of the state and the libraries, especially the State Library, in order to better this condition. The librarians fortunately co-operate in publishing lists of periodicals which are available in each library so that for this particular feature we can hardly ask an improvement. The plan, however, might be extended to cover exchange and further purchase of scientific books of an expensive character or publications of societies which are from their nature available in but few libraries and which from the fact that they are seldom in demand could readily be used at different institutions or by different workers with very little danger or inconvenience. The State Library has a few important serial publications, but I understand that its policy with reference to scientific publications has been to leave them for the State University, a policy which I hope may be modified, especially with reference to certain sets of journals which are practically inaccessible to all scientific workers of Ohio. The librarian has very cordially received a suggestion regarding some co-operation, and I feel assured that any resolution passed by the Academy would receive his cordial attention.

The plan which strikes me as possible would be for the Society to appoint a committee of three, representing different institutions, which might take the matter in hand, determining how far it would be possible to publish lists of serial journals available in the libraries of different institutions, including the State Library; to receive from members of the Academy suggestions as to publications that are especially desirable in their lines of work and to present lists of such as would be recommended to the State Library with the request that so far as possible such sets should be completed or provided for in the State Library. The arrangements by which books may be obtained from the State Library are already so admirable that probably no change would be necessary to make such journals accessible to all established scientific workers of the state.

Another matter which seems to me to be of particular importance and which may properly claim the efforts of the Society is that of greater support for the investigations upon the natural history of the state. Information upon the plants and animals existing in the state is so evidently desirable that the arguments for it seem hardly necessary. It may be briefly mentioned, however, that aside from the scientific questions as to distribution, abundance, increase, decrease, and extinction of species in the state all of which should be investigated before further changes occur, there is a great need of investigation in connection with various interests. They would form a sound foundation for the more exact teaching of science in our schools, a branch which is becoming more and more of fundamental importance in education. They have a very direct and important bearing upon the public health. Their service to the medical profession, represented by the Board of Health would no doubt be fully appreciated. The aquatic resources of the state, especially the fisheries interests, dependent upon the aquatic life of various forms would be enormously helped by an exhaustive study of the aquatic life of the different rivers and lakes.

While the Academy can through its individual members contribute considerably to the desired end, in such investigation the progress must of necessity be slow and there would seem to be every reason why investigations in this line as in Geology and Archeology should be directly supported by assistance from the state. Natural History Surveys are in progress in a number of different states and their results have proved of the utmost importance both as aids in education and as a foundation for economic applications. If the suggestion meets your approval it would seem to me well worth while to appoint a committee to take this matter into consideration and to suggest legislation to provide for such a survey.

Another item which has occurred to me at different times is the representation of different branches of science in the Academy. The work during recent years has been very largely in the line of Geology and Natural History, a fact which is very easily accounted for on the basis of the local interest in these subjects, but it seems to me very desirable that the Academy have a strong representation in other branches as well and there are, I feel certain, many questions which lie in other fields of science which might be studied with advantage in connection with this organization. The chemical problems connected with our water supply, coals, soils, etc., have certainly local interest and reports upon such problems would be particularly welcome in our meetings. The only suggestion in this connection I would offer now would be that our members as individuals exert their influence with their associates and friends in other branches of science, urge them to take part in our proceedings and in any way possible encourage their affiliation with our Society. The valuable work done by the Cincinnati Society of Natural History is a good illustration of the usefulness of local societies. I wish we had such a society in each of the large cities of the state. But such societies come only from the self-sacrificing effort of some individual or group of individuals. They cannot be forced into activity at will.

The topic to which I wish to ask your attention and which I present as the annual address provided for at each annual meeting may be entitled:

THE ORIGIN OF THE WINGS OF INSECTS.

Insects were evidently the first of all animals to acquire the power of flight. Except, perhaps, the birds, they have remained to the present time the most successful aerial navigators and they present certainly the greatest variety of wing structure. They are the only creatures among the invertebrate groups that have succeeded in developing the power of independent flight.

From an economic point of view the wings of insects constitute a most important fact since it is by this means that they are rapidly distributed from point to point and their destructive effects greatly enhanced. To the systematist the wings are of the utmost importance since they furnish the basis of classification for all divisions of the class. They have been plastic structures easily molded by adaptation and changes both by elaboration and reduction are numerous.

It becomes, therefore, a matter of special interest to inquire into the structure of these organs and to trace, if possible, the mode of their origin.

While such a study may not add anything to the solution of the practical problem of aerial navigation for man it will certainly instruct us to learn what we can as to how a problem so difficult for man was solved by such apparently insignificant animals.

Insects began to fly, that is, insects were provided with wings and we assume that they could fly, away back in the paleozoic age probably millions of years before any such locomotion was possible to birds or even the more ancient flying reptiles.

The most ancient of the fossil remains referred to as a winged insect are the Protocimex Silurica of the Ordovician of Sweden and next is a primitive orthopteran species formerly thought to be closely related to cockroach and called Paleoblattina douvallia taken from the middle Silurian.* It may seem to those unfamiliar with the methods of biology that inference as to the character of these forms from fragmentary fossils is of doubtful value yet so firm is our conviction as to the certainty of the association of certain types of structure that we build up around these little fragments, depicting the structure of an insect wing, though separ-

* Dr. E. H. Sellards (Am. Jour. Sci. Vol. XVI. p. 324) states the doubt existing as to the accuracy of the reference of these fossils to insects. Later appearance of first winged insects does not, however, alter the sequence of habit and structure for which this paper argues.

ated by immense gaps in geological time, all of the mechanism of a tracheated flying arthropod. .

That they were insects, that they had a tracheal respiration and that they were capable of flight must be accepted else we may as well call in question the whole mass of knowledge based on fossil remains and which we so confidently accept as indubitable history of the forms of life which peopled the earth in past ages.

So much for the antiquity of the organ which we have in discussion and we may perhaps give pause for a moment to think how long since and by what lowly creatures was the problem of aerial navigation solved, a problem so attractive yet so elusive to the powers of man. How then was the problem solved, what were the factors conspiring to provide for flight?

It is hardly necessary to remark that the wing of an insect is a totally different structure from the wing of a bird. The most superficial observation as well as the most elementary knowledge of anatomy is sufficient for this. Their minute structure and the process of their growth are, however, less familiar and in order to secure a firm foundation for the discussion of the mode of origin we must show something of this fundamental structure and its agreement in different kinds of insects — a bit of dry anatomy, a skeleton on which we may hang our threads of theory.

The insect wing is fundamentally a sack the membranous walls of which are supported by a series of stiff rodlike "nerves" or "veins". A sacklike structure is easily seen in the expanding wings of a moth or butterfly. As the rodlike supports fit to each other above and below the fluid not used in the formation of the wing is withdrawn into the body and the membrane hardens so no separation between the upper and lower layer is noticeable. So much may easily be accepted as common to all insects. Is there any similar uniformity with regard to the number and arrangement of the veins?

In the different orders of insects we have quite diverse apparent arrangement so that comparison of a mature cockroach, dragon fly, Cicada, house fly, beetle, butterfly and bee would show what appear to be very different patterns of veins. So different indeed that entomologists have applied very different sets of names to the various nerves and while various attempts have been made to establish uniform systems, such attempts have been largely unsuccessful. Quite recently through elaborate studies of Professors Comstock and Needham this uniformity has been much better established and we can say with very great assurance that the wing structure of all insects is reducible to a common plan or, to carry out the logical conclusion from this, that the wings of all insects are derived from one ancestral form.

I need not here burden you with the technical names of these structures or of the detailed statement of their homology. Reference to the beautiful figures and descriptions in the work of Comstock and Needham just mentioned will suffice.

Granting, however, a common origin for the wings of all insects the problem of their original appearance, the factors in development become all the more interesting. In order to show the position taken by different students of the subject I beg to quote a few paragraphs from various sources. Gegenbaur presents the following: "The wings must be regarded as homologous with the lamellar tracheal gills, for they do not only agree with them in origin, but also in their connection with the body and in structure. In being limited to the second and third thoracic segments they point to a reduction in the number of the tracheal gills. It is quite clear that we must suppose that the wings did not arise as such, but were developed from organs which had another function, such as the tracheal gills; I mean to say that such a supposition is necessary, for we cannot imagine that the wings functioned as such in the lower stages of their development, and that they could have been developed by having such a function."

This general view is stated a little more in detail by Lang: "The problem of the phylogenetic origin of the wings of insects is extremely difficult and as yet by no means solved. The rise of such organs is not explained by saying that they are integumental folds, which gradually increased in size, stood out from and eventually articulated with the body. The wings must in all stages of their phylogenetic development have performed definite functions. It is impossible that they were originally organs of flight. What function it was that they performed before they became exclusively organs of flight, is, however, entirely a matter of conjecture. The following view is at present the most acceptable. (1) The ancestors of the Hexapoda were, like the now living Apterygota, wingless land animals breathing through tracheae. (2) The Apterygota-like ancestors of the Pterygotan racial group became adapted to living in the water. Dorsal integumental folds served for breathing in the water. The rise of such respiratory folds offers no difficulty, since every increase of surface, small or large, is of service. (3) The respiratory appendages (into which the trachea were continued) became movable and may perhaps have assisted in locomotion (swimming). This assumption also offers no difficulty, since the gills of many aquatic animals are movable, and their power of moving is an advantage on account of the exchange of water thus caused. (4) In a new gradual change to land life the respiratory function became less important and the locomotory function came to the front. Here, however, lies the greatest difficulty. It may, however, be assumed that the animals, while still living in water were capable of gliding over the surface of the water by the swinging of their branchial leaves, just as flying fish do by means of their thoracic fins.

The limitation of the wings to the two pairs of meso — and metathorax must be explained mechanically as more suited for the propulsion of the body in flight. We still see among living insects an undoubted tendency to the stronger development of one of the pairs of wings.

Opposed to this view is McMurrich: "Granting a descent of the Pterygota from wingless ancestors, it becomes an interesting problem to discover the origin of the wings. Attempts have been made to show that they are modified tracheal branchiae, a theory which necessitates the derivation of the Pterygota from aquatic ancestors. Such a derivation, however, is unsupported by any evidence at present at our disposal, it being much more probable that the immediate ancestors of the Pterygota were terrestrial, just as Campodea is today. The wings arise in the embryo as dorsal outpouchings of the meso- and meta-thorax, tracheae later pushing out into them and transient indications of outpouchings of the prothorax also occur in some embryos. It has been suggested that primarily the wings were plate-like outgrowths on the thoracic segments which served to break the fall and increased the distance traversed by jumping insects, and in support of this view the fact may be mentioned that many Apterygota are saltatorial. The limitation of the wings to the meso- and meta-thorax may stand in some relation to the center of gravity of the body."

Aside from the lack of any indication of plate-like growths for respiration as here necessitated, it is only necessary to mention the fact so well known to all students of insect structure that the saltatorial Apterygota are a much specialized group, the saltatorial organ a bent-under appendage of the abdomen and never associated in living forms with any structure or habit leaning toward tracheal outgrowths to appreciate the difficulties of this suggestion.

A very full statement of this position was given by Dr. Packard in 1883 and since this was repeated quite fully in his recent text-book in 1898 it may be considered as the position held until his death.

"Now, speculating on the primary origin of the wings, we need not suppose that they originated in any aquatic form, but in some ancestral land insect related to existing cockroaches and Termes. We may imagine that the tergites (or notum) of the two hinder segments of the thorax grew out laterally in some leaping and running insect; that the expansion became of use in aiding to support the body in its longer leaps, somewhat as the lateral expansions of the body aid the flying squirrel or certain lizards in supporting the body during their leaps. By natural selection these structures would be transmitted in an improved condition until they became flexible, i. e., attached by a rude hinge joint to the tergal plates of the meso- and meta-thorax. Then by continued use and attempts at flight they would grow larger, until they would become permanent organs, though still rudimentary, as in many existing Orthoptera, such as certain Blattariae and Pezotettix. By this time a fold or hinge having been established, small chitinous pieces enclosed in membrane would appear, until we should have a hinge flexible enough to allow the wing to be folded on the back, and also to have a flapping motion. A stray tracheal twig would naturally press or grow into the base of the new structure. After the trachea running towards the base of the wing had begun to send off branches into the rudimentary structure, the number and direction of the future veins would become determined on simple mechanical principles. The rudimentary structures beating the air would need to be strengthened on the front or costal edge. Here, then, would be developed the larger number of main veins, two or three close together, and parallel. These would be the costal, subcostal and median veins. They would throw out branches to strengthen the costal edge, while the branches sent out to the outer and hinder edges of the wings might be less numerous and farther apart. The net-veined wings of Orthoptera and Pseudoneuroptera, as compared with the wings of Hymenoptera, show that the wings of net-veined insects were largely used for respiration as well as for flight, while in beetles and bees the leading function is flight, that of respiration being quite subordinate. The blood would then supply the parts, and thus respiration or aeration of the blood would be demanded. As soon as such expansions would be of even slight use to the insect as breathing organs, the question as to their permanency would be settled. Organs so useful both for flight and for aeration of the blood would be still further developed, until they would become permanent structures, genuine wings. They would thus be readily transmitted, and being of more use in adult life during the season of reproduction, they would be still further developed, and thus those insects which could fly best, i. e., which had the strongest wings, would be most successful in the struggle for existence. Thus also, not being so much needed in larval life before the reproductive organs are developed, they would not be transmitted except in a very rudimentary way, as perhaps a mass of internal indifferent cells (imaginal discs), to the larva, being rather destined to develop late in larval and in pupal life. Thus the development of the wings and of the generative organs would go hand in hand, and become organs of adult life."

That there are insuperable objections to this view will be evident if we weigh carefully the significance of the wing structure, especially its tracheation and musculature and we have absolutely no evidence in parallel structure or otherwise of such actual history.

On the other hand the chief difficulty in the theory of aquatic origin, the difficulty which for a long time seemed to me to invalidate this view, was in the absence of any primitive aquatic form, all aquatic groups showing most positive evidence of being so by secondary adaptation. The great majority of insects and practically all members of some orders have no aquatic stages nor do they show any trace of aquatic elements in their ancestry. Moreover, the most ancient fossil forms known have been distinctly terrestrial in character, nor do we have any trace of appearance of forms that can be referred to modern groups aquatic in character until considerably later in the geological record.

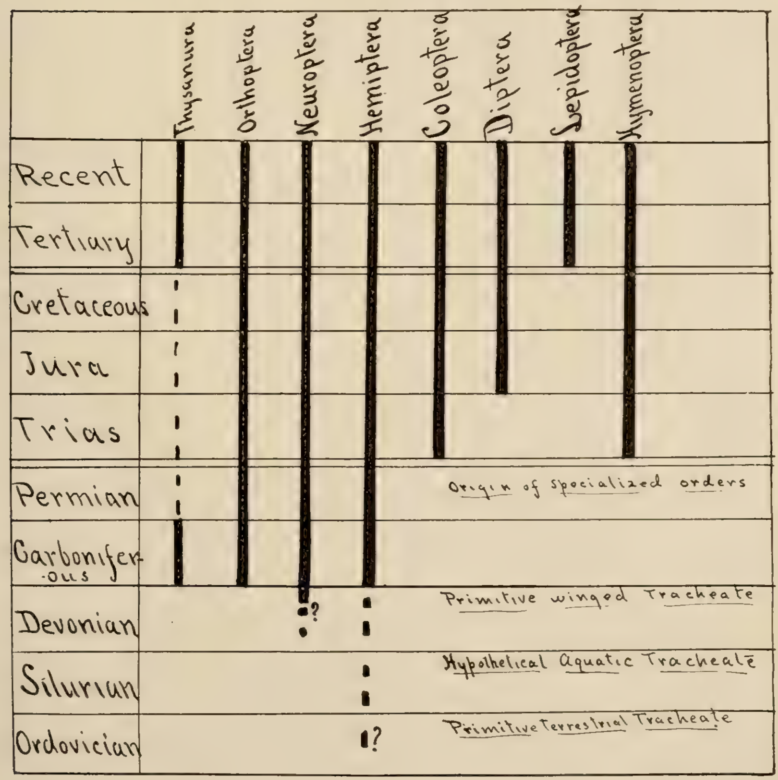
The generalized and very ancient orthoptera, for example, have nowhere aquatic stages or indication of any such habit. All the aquatic insects of the present time, moreover, have best of evidences of being primarily terrestrial, their aquatic habit an adaptation and in most cases the evidence of adaptation indicating fairly recent resort to that habit. Practically all aquatic forms retain tracheal respiration showing indisputable evidence of adaptation from aerial life, the few cases of blood gills — as in Simulidae — resulting evidendy from extreme specialization in recent time.

It seems very difficult, however, to conceive of any condition outside of water which could furnish the basis for development of a tracheated membranous expansion from the body wall, the origin of such organs direct for the purposes of flight being excluded from consideration on the ground that no such organ could be of any functional service till sufficiently developed to serve some purpose in locomotion. Further the manner of articulation of wings to body, the fact that their movement is secured by movements of the body wall, not by direct muscular action, is excellent proof that they were first developed for some other function than flight. Moreover, such structures are paralleled by the tracheal gills of some modern aquatic forms.

We are forced then to the ground that the development of the tracheal membrane was in water, and we are shut out from considering any of the existing aquatic groups as furnishing a basis as the ancestral aquatic form.

We are left then with one other alternative and this on careful examination seems to offer a really satisfactory solution for the problem. That is, that back of the earliest fossil winged insect such as Protocimex, Paleoblattina, or the first of the Paleoblattidae there must have been an aquatic form which in its adaptation to aquatic life developed tracheal gills in the form of membranous tracheal expansions on the two hinder thoracic segments; that this hypothetical form changed its habitat to land and the membranous structures instead of being lost were modified into wings. Then from this primitive winged form we have by divergence the various groups of orders of modern insects established and in some of these by adaptation again to aquatic existence we have in many instances a well developed aquatic stage with many resulting respiratory structures — these in some instances resembling in some degree the primitive form but not occupying position previously pre-empted by wings.

The bearing of these conclusions on the early phylogeny of the group of insects is evident and we are practically forced to carry the origin of the group back more remotely in time to connect it as seems necessary with a primitive, wingless, tracheate ancestor. The elaboration of such a phylogeny in so far as the evidence may justify is beyond the scope of this address but its general bearing may be indicated in graphic form by adaptation of the diagram showing the distribution of different groups of insects in time. The diagram adapted from latest edition and translations of Zittel's Paleontology is of course poorly adapted to show the present views of direct affinity but will serve our purpose to indicate time of appearance of different orders.



STRATIGRAPHIC GEOLOGY.*

(By Charles S. Prosser.)

The science of Stratigraphic Geology was founded by William Smith, an English surveyor and civil engineer, who was born in 1769 in Oxfordshire, a county in which the rocks contain abundant fossils which as a boy he observed and collected. Later as an assistant to a land surveyor he became intimately acquainted with a considerable portion of southern England. For twenty-five years he continued his investigations in that country, making colored geological maps, determining the stratigraphy and arranging a collection of fossils in the chronological order of the succession of the strata. In the course of this long investigation he was able to trace certain strata across England, and he discovered that each horizon could be identified by its characteristic fossils. His famous geological map of England and Wales on which the various divisions were represented by different colors was published in 1815 and this was the first representation on a large scale of the geological formations of any considerable part of Europe. Accompanying the map was an explanatory text of some fifty pages in which the stratigraphic divisions received names adopted from local ones in use where the rocks had been studied. In 1816 he published what is usually considered his greatest work, entitled "Strata identified by organized fossils, containing prints of the most characteristic specimens in each stratum." Thus was stratigraphic geology founded through the unceasing efforts of an investigator of his own country who, for a long time without even the encouragement of other students of the subject still remained true to his ideal. In considering his rank among other pioneers of the science the eminent German geologist, von Zittel has written that "His greatness is based upon this wise restraint and the steady adherence to his definite purpose; to these qualities, the modest, self-sacrificing, and open-hearted student of nature owes his well-deserved reputation as the 'Father of English Geology'."[1]

In this connection it is specially important to note the prominence of the study of fossils in the organization and development of stratigraphic geology.

Apparently one of the first geological reports relating to any

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* The following address on *Stratigraphic Geology* was prepared at the request of Professors Edward Orton, Jr., and Herbert Osborn and read at the meeting of the Ohio Academy of Science, December 28, 1905.

1 History of Geology and Palaeontology to the end of the Nineteenth Century. Ogilvie-Gordon translation, 1901, p. 112.

portion of the United States was written by Dr. Samuel L. Mitchill of New York concerning the rocks of that state and published in the Medical Repository in 1798 and 1799.[1] At the close of the eighteenth century scarcely half a dozen men in this country understood the elements of geology. One of these was Professor Benjamin Silliman, who graduated at Yale College in 1796, and in 1818 founded the American Journal of Science, which was the first distinctly scientific periodical published on this continent that has continued to the present time. An idea of the equipment for the study of this science in the leading scientific educational institutions of this country at the beginning of the nineteenth century may be gained from the statement that Professor Silliman carried the whole mineral collection "at Yale for examination and study to Philadelphia, in a candle box."[2]

Prominent among these early students of geology were William Maclure, who published the first geological map of the United States in 1809, and Amos Eaton, a graduate of Williams College, who later attended lectures in Yale College and in 1817 became a lecturer on chemistry, botany, mineralogy and geology in his *alma mater*. Eaton and Theodore R. Beck were selected by the wealthy Patroon the Hon. Stephen Van Rensselaer, in 1820, to conduct the first geological survey of any district in this country, viz: Albany county, New York. Two years later he was appointed to survey that portion of New York state adjacent to the Erie Canal, which was then in process of construction. The expense of this pioneer work was borne by Van Rensselaer, this country's first patron of the science. Eaton classified the rocks to a certain extent and to one of the divisions he gave the name of Corniferous limestone, a name that for many years has been well known in this state. Later Van Rensselaer made Eaton senior professor in Rensselaer school in the city of Troy, now known as the Rensselaer Polytechnic Institute, which became under his instruction for a time the most noted school in geology in this country.

To the west of Albany county lies the rugged one of Schoharie, crossed by the northern escarpment of the Helderberg plateau, or mountains, and deeply trenched by the Schoharie creek, a southern tributary of the Mohawk river. In the Schoharie valley near the village of that name lived the Gebhards, a prominent and well-to-do family of gentlemen farmers, father and son, who between 1820 and 1835 worked out the succession of Silurian and Devonian

1 The statement of Professor Chester Dewey is that "The Society for Promoting Agriculture, Arts and Manufactures," incorporated in 1793, afterwards merged in the Albany Institute, appointed Dr. Mitchill Commissioner to examine and report on the "Minerals of the State;" but his report treated chiefly of the rocks. (Tenth An. Rept. Regents of the University of the State of New York, 1857, p. 14, f. n.)

2 Ibid., p. 14.

"strata in that remarkable section, collected their fossils and proposed their own stratigraphic terms,"[1] some of which as for example, Pentamerus limestone and Tentaculite limestone are still familiar names to geologists.

This work of Eaton and the Gebhards marked the beginning of stratigraphic geology in America which in eighty-five years has extended to every state and territory of this country and to every province of Canada.

It is claimed that North Carolina was the first state to order a geological survey. In 1824 Professor Olmstead was appointed State Geologist and in that year and the following one he published a report of one hundred odd pages. Her sister state of South Carolina followed in 1825 with the appointment of Professor Vanuxem; but as his results were not published by the state they were consequently lost, except what appeared in the periodicals. In 1830 Massachusetts ordered a trigonometrical and geological survey of the state with Professor Edward Hitchcock of Amherst College as State Geologist. The thirties were prolific years in the organization of state surveys and during this period such surveys were established by Maryland, Tennessee, Arkansas, New York, New Jersey, Pennsylvania, Virginia, Georgia, Maine, Connecticut, Ohio, Michigan, Delaware, Indiana, Kentucky, Missouri, the David Dale Owen Survey of Illinois, Iowa and Wisconsin, and in Canada by New Brunswick and Newfoundland.

The Geological and Natural History Survey of New York was not authorized until twelve years later than the first one of North Carolina. Still it must be conceded by any one conversant with the history of geology that none of the other surveys exerted so great an influence in the development of American geology; nay, I will go further and state that the combined influence of *all* the other states was not equal to that of New York. This may seem like a strong statement but permit me to read from an address by McGee delivered at the celebration in honor of the sixtieth anniversary of Professor James Hall's public service as a geologist of New York. Let us remember in passing that McGee is a native of Iowa, was never a resident of New York nor a member of its survey and was not a paleontologist. Among other things he said: "Other systems of nomenclature have come and gone; the brilliant and attractive * * * system proposed by the Rogers brothers for a time competed with the system devised in New York; but no other system has endured the test of time * * * The New York formations were defined by fossil contents, as were those of England and the Continent, while the nature and genesis of deposits were given greater weight than before; and this method has been followed more or less closely by the geologists of the world

1 Dr. John M. Clarke in High School Bul. 25, 1903, p. 497.

engaged in researches among the clastic rocks. Most of the New York formations were named from geographic features so chosen as to indicate type localities and to permit endless rearrangement of the duly labeled rock divisions as research progressed and other divisions were recognized; and this system of nomenclature which was practically original in the New York survey as applied to minor divisions in [the] geologic column, stopped not at the boundaries of the state, but has spread over the country and the world, and is today the accepted system of civilized lands."[1]

The New York survey was organized in July, 1836, and the state was divided into four districts with a Chief Geologist for each one; but with no one as State Geologist or chief in authority, save the Governor. The first year the geologists of the four districts were Lieut. William W. Mather of the First, Dr. Ebenezer Emmons of the Second, Timothy A. Conrad of the Third, and Lardner Vanuxem of the Fourth, while James Hall, a young man of twenty-four, who had been a student of Eaton in the Rensselaer School, graduating in 1832, was an assistant geologist of Dr. Emmons in the Second District. The following year the boundaries of the districts were changed considerably. Conrad became the Paleontologist, Vanuxem was transferred to the Third, and Hall placed in charge of the Fourth District. The law provided for the continuance of this survey for four years with an annual appropriation of $36,000 and at its expiration was continued for an additional two years. At the conclusion of this work a quarto volume was prepared by each geologist for his district, while Professor Hall remained to describe the fossils and continued as State Geologist or Paleontologist until his death in his eighty-seventh year in 1898. He has appropriately been termed the Nestor of American Geologists. The magnificent series of volumes devoted to the geology and paleontology of New York are known to every geologist throughout the world and have cost that state over a million and a half dollars. In New York there are three formations of bituminous shales with extended outcrop, which are lithologically similar to shales often found in association with coal, and on account of the early determination of the greater age of these shales than coal-bearing rocks it has been estimated that the amount of money saved from useless exploration fully equals the sum the state has expended for its Geological Survey. The work, however, is considered as far from finished and under Dr. John M. Clarke, the worthy successor of Professor Hall, the survey is energetically continued.

Now let us consider the history of geological work in Ohio, and in the time allowed me, this will of necessity be a very brief review. Perhaps the earliest papers relating to the geology of

1 Science, N. S., Vol. IV, Nov. 13, 1896, p. 702.

Ohio were two published by Caleb Atwater of Circleville in volume I. of the American Journal of Science, the first entitled "On the Prairies and Barrens of the West," and the second, "Notice of the Scenery, Geology, Mineralogy, Botany, etc., of Belmont County." The first state geological survey was created under the authority of an act passed by the Legislature in March, 1837, providing for "a complete and detailed geological survey of the State," which also included the construction of a geological map of the state and the collection of the fossils of the various formations. The Legislative Committee recommended an annual appropriation of $12,000 for four years, the appointment of "a skilled geologist," with not more than four assistants and in addition a topographical engineer. The Governor appointed as Principal Geologist, Lieut. Wm. W. Mather, at that time Geologist of the First District of New York; Drs. S. P. Hildreth and John Locke and Professors J. P. Kirkland and C. Briggs, Jr., as assistants, with Col. Charles Whittlesey as topographical engineer. The field work was begun late in 1837 but was actively prosecuted during the field season of 1838 and at the close of that year the survey had cost the state $16,000, when it was abruptly terminated. Two annual reports were published by Mather and his assistants, which were quite similar in plan to those of New York, Pennsylvania and Virginia, and a beginning was made toward a description of the geology of the state. How elementary most of this was, however, may be seen from the section of central Ohio in the second report in which the Devonian limestones on the Scioto at Columbus are given as "Mountain limestone," which belongs in the Subcarboniferous; while what is now known as the drift was referred to the Tertiary. Still the survey, brief as was its life, was of great value and Dr. Orton has made the statement that "The state never received larger returns from any other equal expenditure than from the $16,000 used" for its maintenance, and that the increase of wealth in a single county due to "the development of mining industries, largely based on the work of the survey, was * * * many times more than the entire expenditure which the state had made in its support."[1]

From the termination of the first survey at the close of 1838 until the passage of the bill in March, 1869, "providing for a Geological Survey of Ohio" the state did absolutely nothing toward furthering the knowledge of its geology and geological resources. This was a formative period in American geology in which nearly all the northern states and part of the southern had supported state surveys for a longer or shorter period and published fairly accurate reports. Even the first tier of states beyond the Missisippi had published quite elaborate reports of large octavo or quarto

1 Jour. Geol., Vol. II, 1894, p. 507.

size. The backwardness of Ohio had long been a source of humiliation to some of her more intelligent citizens and it is safe to say that at the beginning of 1869 less was known concerning the Natural History and Geology of Ohio than of any other northern state.

The Second Geological Survey of Ohio, as it is generally termed, was organized by Governor Hayes in 1869 with Dr. J. S. Newberry, chief Geologist; Professors E. B. Andrews, Edward Orton, and Mr. John H. Klippart, assistant geologists. In the list of local assistants that served on this survey are the names of men who afterward became famous geologists, as for example, R. D. Irving, Henry Newton, G. K. Gilbert, J. J. Stevenson and N. H. Winchell. Dr. Newberry was a native of Ohio and his interest in geology was first aroused by the visit of James Hall at his father's house in Cuyahoga Falls on Hall's famous geological trip to the Mississippi Valley in 1841 and "Newberry used to say that Hall came as an angel, but before he went away he had become almost divine."[1] At the time of Dr. Newberry's appointment he was professor of geology in the School of Mines of Columbia College, New York city, a position which he did not deem it expedient to resign. Newberry's plan for the survey was a wise one and the first really comprehensive one that had been formulated concerning a Geological and Natural History Survey of the state. His broad grasp of the problem may be seen from the following statement in his first Report of Progress:

"During the many years that had passed since the former board was disbanded, geological surveys had been maintained, with more or less thoroughness, in New York, Pennsylvania, Kentucky, Indiana, Illinois, Missouri, Arkansas, Kansas, Iowa, Wisconsin, Michigan and Canada, and the observations made by the geologists of those states in different and widely separated localities, had presented discrepancies that had given rise to long, earnest, and sometimes bitter discussions. Before the diverse conclusions of these various observers could be harmonized, and the succession and distribution of the rocks represented in our geology be fully made out, it was necessary that these views should be compared in Ohio; that observations made east, west, north and south should here be connected. Ohio thus, in some sort, formed the keystone in the geological arch reaching from the Alleghenies to the Mississippi; and for many years geologists in our own country and abroad had been looking forward with interest to the time when the geological survey in Ohio should supply this keystone, and render our whole geological system complete and symmetrical. It was also necessary that our work should be, first of all, blocked out in its generalities; that we should learn precisely what forma-

1 Professor J. J. Stevenson in Science, N. S., Vol., IV, p. 716.

tions were represented in the state, their order of superposition, their mineral character and contents, their thickness and the geographical areas occupied by their outcrops."[1]

I have said that the above plan is a comprehensive one and I believe it will be so conceded when it is once understood that all the details of it as enumerated in the last sentence of the above quotation are as necessary for the guidance of the Geological Survey today as when they were published thirty-five years ago. Furthermore, some idea of the magnitude of the work outlined may be gained when it is stated that probably not more than one-half of it has as yet been accomplished, in spite of the valuable and extensive contributions made by the Newberry Survey and that of his worthy successor, Dr. Orton. Time does not permit of an analysis of the results of these surveys; but suffice it to say that the Annual Reports of 1869 and 1870 and Volumes I, II and III of the Newberry Survey were devoted quite largely to stratigraphic geology and that some progress was made in describing the geology of eighty-five of the eighty-eight counties of the state. The county reports were in the main accompanied by a geological map on which some of the larger divisions were represented; but in very few instances was this areal work carried to a sufficient degree of refinement for the representation of units or formations. A list of the geological formations as at present recognized in this state has recently been published by the Geological Survey of Ohio.[2] Each survey also published a Geological Map of Ohio. Newberry's is on the larger scale and also shows the distribution of a larger number of geological divisions. Take for example the oldest division represented on this map, which covers the southwestern part of the state and is given as the "Cincinnati Group, Trenton and Hudson." This terrain is composed of four distinct formations, viz.: the Trenton limestone (or whatever part of the Mohawkian series the Point Pleasant beds of Ohio may represent), the Eden shale and the Lorraine or Maysville and Richmond formations. These formations have never been differentiated and mapped in Ohio, although this has been done in Indiana by its Geological Survey. The next large division, the "Niagara Group," in southwestern Ohio, is composed of the Osgood beds, the West Union, Springfield and Cedarville limestones and the Hillsboro sandstone. No attempt has been made to map these divisions or even correlate them with the Niagara area of the northern part of the state and such correlation with the more eastern representatives in Ontaio and New York is very indefinite. The two divisions of the "Salina" and "Water Lime" in the northern part of the state which belong to what is now called the Monroe formation were badly confused and in general the supposed age quite

1 Geological Survey of Ohio, Report of progress in 1869, pp. 9, 10.
2 Fourth series, Bul. No. 7, Nov., 1905.

remote from the real one. The recent report on Monroe county, the southeastern one of Michigan, by the Geological Survey of that state, has added greatly to our exact knowledge of this formation. The writer has also collected considerable data in this state, Michigan, Ontario, and New York for a bulletin upon this formation. The "Corniferous limestone" is composed of the two distinct formations of the Columbus and Delaware limestones which have never been separately mapped. It may be mentioned in passing that Dr. Charles K. Swartz of Johns Hopkins University has in preparation a valuable monograph describing the stratigraphy and paleontology of these formations and the writer and his students have done something in this same line. The next large division, the "Waverly Group," in central Ohio, is composed of six clearly defined formations, viz.: the Bedford shale, Berea sandstone, Sunbury shale, Cuyahoga, Black Hand and Logan formations, no one of which has ever been mapped separately. It is also probable that there will be some change in the units of this series in the northern part of the state and perhaps in the southern as compared with those of central Ohio. The writer and his students have given considerable attention to the problem of the classification and description of the Waverly series. Finally, the area colored as the "Coal Measures" includes the upper portion of the Pottsville, the Allegheny, Connemaugh and Monongahela formations together with the Dunkard formation, the latter probably of Permian age. Although these formations are not mapped separately, still something has been done toward furnishing the data for such representation in tracing the various coal seams of the state. Certain ones, as for example the Upper Freeport, Pittsburg and Waynesburg coals indicate formation limits and the recent work of Dr. Bownocker and his assistant in tracing the Pittsburg coal will be of value in separating the Conemaugh and Monongahela formations. There also remain the subjects of glacial and physiographic geology which have become of great importance and interest in these later years. Concerning glacial geology much has been accomplished by the United States Geological Survey in this state as is shown in Leverett's Monograph entitled "Glacial formations and drainage features of the Erie and Ohio basins."

It is not the writer's intention to criticise in any way the work of the earlier members of the Ohio Geological Survey, and if any have formed that opinion they have missed entirely the aim of this paper. Indeed, on the contrary, he often wonders at the large amount of correct and valuable information which they brought together, hampered as they were financially, pressed for time, and often laboring under most discouraging conditions. The fidelity, perseverence and faithfulness of those men merit all honor.

Neither has the writer any criticism to make of the present survey. Its efficient chief has invariably furthered all the work which I have been able to undertake and patiently awaited results, which on account of numerous other duties are long delayed, and the relations with all the other members of the staff have always been pleasant. Nor has the writer any plan which he wishes to launch and so is availing himself of this opportunity for that purpose. He is simply attempting to state in a fair and impartial manner, as it appears to him, what stage has been reached in the description of the stratigraphic geology of this state.

There is, however, a very general misapprehension concerning the accuracy and degree of refinement reached in the stratigraphic geology of Ohio. The frequent question, "Well, have you finished your work for the survey?" is very tiresome, or the remark, "Why, I thought the geology of Ohio was finished." If I have any standing as a geologist, let me say once for all that $25,000, nay $50,000, wisely and economically administered will not then furnish Ohio with a similar wealth of accurate stratigraphic knowledge as that upon which the last geological map of New York or Pennsylvania is based.

Ladies and Gentlemen: The time has not yet arrived when we can consider that our knowledge of the geology of Ohio is about complete. It is still a far cry before she overtakes some of her sister states. Moreover, those same states at present are by no means idle. Look at New York! After almost seventy years of state investigation still appropriating $30,000 annually for geological work, with a permanent force of fourteen men and ten additional temporary assistants. Her magnificent set of geological reports is a source of pride to all her intelligent citizens and has made the name of New York familiar wherever geology is known. Nor is New York alone. The appropriation for geological work during the current year in Maryland is $10,000, in West Virginia $12,000, in Kentucky $10,000, in Indiana $7,000, in Michigan $8,000, in Illinois $15,000, in Iowa $5,000 and in Missouri $20,000. Probably in no state is the entire amount devoted to stratigraphic geology; but in each case a large proportion of the appropriation is alloted to that part of the subject.

I have attempted to show very briefly in these few minutes how the science of stratigraphic geology originated and developed. Likewise the attempt has been made to indicate in a general way what has been accomplished in Ohio in this science and *most of all* to emphasize the fact that it is not finished. If this last point has been made clear, in my judgment, this paper will not have been written in vain.

SUPERFICIAL DEPOSITS ALONG THE MISSISSIPPI

Gerard Fowke.

For the most part geologists, and others, who have studied the loess formation in the states bordering on the Missouri and Mississippi rivers, concur in attributing the deposit to glacial floods which attained their maximum when the ice was melting along the front more rapidly than it could advance from the north. The material is clay and sand, in varying proportions, modified more or less by local detritus. Considering the ease with which it is excavated, its power to withstand pressure or erosion is something remarkable. This quality is especially noticeable along the Missouri bluffs; below that river it becomes less resistant. On the upper portions of the two great rivers, the loess is heavy, forming high bluffs and spreading far inland; southward, it progressively diminishes in extent and thickness. This fact, reinforced by similar conditions observable along tributary streams, have enabled students to determine that coincident with the greatest extension of the glacier, and lasting until the present time, there was a marked subsidence of land, relative to sea-level, in the Mississippi Valley; the subsidence being more pronounced toward the north. The current of southward flowing streams was retarded, and the sediment-laden waters began to free themselves from silt, by precipitation, almost at once upon their emergence from the ice. There was still sufficient movement, however, to carry the finer suspended matter until sea-level was reached.

The limit of the ice-sheet, in southern Illinois, was along the hills bordering Big Muddy on the north, almost to the mouth of that stream, as it passed into the Mississippi at Grand Tower; thence northward, closely following the line of the larger stream, nearly to Alton; thence, crossing into Missouri, it skirted the north side of the Missouri river nearly to the middle of the state. On the bluffs at the mouth of the Missouri, on the south side, is considerable glacial drift; until very recently it has been uncertain whether it marked an extension of the glacier, or whether it is due to floating ice. Within the past year, the excessive rainfall has enabled two little streams to carry away enough overlying gravel to reveal two small areas of typical till; so it is now certain that the main body of ice shut off the Missouri and consequently acted as a temporary dam. Further, Brodhead records the occurrence of gravel, which he supposed to be of glacial origin, on the highest point in St. Louis county, about 350 feet above the Mississippi. It seemed possible, from these facts, that the ice had attained sufficient height to back the water up the Missouri a long distance and form a temporary lake. But Brodhead's gravel beds prove to be of local origin, while the first-mentioned drift reaches but little, if any, more than 100 feet above the stream, and the ice-dam did not hold for a period that allowed any channel to be made to the south of it; so another cause must be sought for the loess deposits in the vicinity.

In and around St. Louis the loess forms a cap, covering nearly all the early formations. While it is thin on hilltops and thicker in valleys by reason of erosion and re-deposition on uneven ground, yet it is singularly regular over many square miles. Reports of railway cuttings, wells, and other excavations, contain numerous references to "loess 12 or 14 feet thick." It is from 6 to 8 feet thick on a plateau nearly 350 feet high; and is not more than 20 feet in most of the county unless near the foot of a slope. This means a depth of water that would submerge hills at the level indicated, and lowering so rapidly in the end as to uncover all the territory within a comparatively short time.

Worthen says that in Jackson county (Illinois), the loess occupies only a narrow belt on the top of the river bluffs; and in Union county, next south of Jackson it was found at only one point and that below the top of the bluff.

Shumard notes the presence at Wittenberg, Missouri, of a mass of granite weighing several tons; and thinks this is evidence of a ledge of eruptive rock in the neighborhood.

It should be stated that Big Muddy separates Jackson from Union county, and that Wittenberg lies opposite to the old mouth; being about eighty miles south of St. Louis. Between these two points are Rock Creek, twenty miles south of the city, in whose valley the loess (modified by local drift) is one hundred feet high; and Plattin creek, forty miles south, where it covers a slope of an elevation of eighty feet.

It seemed plausible to suppose that a prolongation or spur of the glacier might have reached from the Big Muddy to the Missouri side, thus choking the Mississippi and allowing the water to stand at a level sufficient to drown most of the country above. Additional color was given to this supposition by the gorge at Grand Tower, just below Wittenberg. Here, the river flows in a narraw, rock-bound channel, over a solid rock bottom, while on the Illinois side is a valley fully three miles wide, of alluvial silt subject to overflow in great freshets. But the granite proves to be only a boulder, lying in a small ravine a few feet above the river's ordinary level, and it may have come in with an ice floe at any time. And there is not a trace of evidence on either side of the river, that the glacier had even reached the lowland. This was an additional problem, instead of an explanation; for there was St. Louis and Cairo only sand and silt are found along the valley, a feature that apparently indicates a drainage no more vigorous also to be sought, a reason why a stream should be turned from a wide, deep channel, into a narrow gorge which lay higher than the stream itself.

At Thebes, near Cairo, is a similar gorge; for fifteen miles there are bluffs along both sides of the river which is bordered only by narrow strips of alluvial land, while at one place, "The Grand Chain," masses of rock projecting above the surface compel pilots to hold their boats in a very narrow channel. At Cape Girardeau, a few miles above, the loess caps a hill fully 170 feet above the level of the river bank. Here, again was an obstructed ancient channel; and the question of a solid ice-dam was answered in the negative at once, for the greatest southern extension of the glacier was many miles above. It was deemed possible, though not at all probable, that icebergs or floes may have found some obstacle to hold them at this point until they had formed a hard pack. Beginning near Cape Girardeau is a swamp fully three miles in width and terminating more than fifteen miles below, which was the former course of the Mississippi. Bluffs border it on both sides, in most places precipices of solid limestone. As at Grand Tower, no trace of glacial drift could be found above high-water mark; besides, the valley of the swamp is too wide and too deep for ice to have jammed. Below here, are reached the extensive swamps that fill the former prolongation northward of the Gulf of Mexico; and farther research was useless.

It thus was evident that by no possibility could loess deposits south of the Missouri river be due to a dam of either earth or ice; and some other explanation must be worked out and investigated.

Wright has calculated, and brought forward proof of his figures, that at its greatest discharge during the melting of the continental glacier, the Missouri reached a flood height of at least two hundred feet.

On the Illinois river, sixty miles above its mouth, are bluffs of loess fully one hundred feet high, proving this stream also subject to great floods.

At the same time the Mississippi was draining a large area of ice-covered country.

The border of the ice-sheet being in this region along a line approximately east and west, these rivers would discharge their immense volumes of summer water at practically the same time, and not with intervals between flood height, as is now the case. It is quite probable that the rise in the Mississippi, when reinforced by that from the Illinois, fully equalled that in the Missouri. When all these waters united, in a channel not much wider in many places than in one of the three, it follows that, either the current must flow with great velocity or the water must rise to a level greater below the junction than it would naturally. Bearing upon this point is an observation by Leverett, who says that "between than at the present day. Yet it seems probable that at times the volume of water greatly exceeded that now discharged through the valley."

We have seen why the volume of water should be greater than at present; but as yet have given no reason why the flow should not be correspondingly vigorous. That it was greater, is evident from the loess at Cape Girardeau; and as this is near the wide flood plain on which the water could rush out as into a sea, the obstruction that would hold it back must be close at hand.

Leverett says, again, "The Ohio at one time discharged either wholly or in part through the 'Cache Valley,' which crosses southern Illinois a few miles north of the present course of the Ohio." The "clay deposit stands only about seventy-five feet above the present stream. [It] has sufficient depth to extend to river level, and it may extend much lower." The "Grand Chain of the Ohio," crosses the river below the point of divergence of the old channel from the one now occupied by the river.

Clearly, we have here a condition similar to that at Thebes. At the time under consideration the Ohio received all the glacial discharge east of that flowing into the Illinois and Mississippi, in addition to the floods from its southern tributaries swollen by rainfall greater than we now know. These torrents flowed through Cache valley, over a bottom which is now seventy-five feet above river level. The water thus discharged would equal or perhaps exceed that coming from the north; each great river would retard the flow of the other, and in the comparatively sluggish currents above their junction sediment would come to rest. This condition prevailed until the ancient beds, excavated in geological ages antedating the glacial period, were filled up. At Grand Tower and at Thebes, the Mississippi when it was once more free to flow southward without hindrance found the clefts through which it now flows, lower than the silt in its old channel. So the Ohio Cache valley was filled to a level higher than the crevices in "Grand Chain," and the water made its way through these. Probably the Tennessee had discharged directly into the Mississippi; but this region has not been fully studied.

The sharp peaks, bluffs, and ridges of loess on the upper rivers are the counterparts of the broad bottom lands along the lower Ohio. In the one case, the land is high enough above sea-level to permit aerial sculpturing; in the other, erosion can not act because the gradient is almost at the base line. All, alike, are due to sediments carried by glacial floods; the components being the various earthy materials which ice and water have ground from rocks, picked up from soils, mingled by ceaseless grinding and washing, and finally carried in suspension until in quiet waters behind projecting hills, or in lake-like expanses of over-flowing back-water, they settle to the bottom to form picturesque landscapes where carved by winds and frost, or stretch out in plains of wonderful fertility where these agencies do not erode them.

Pteridophyta and Spermatophyta found in Auglaize County, Ohio

A. Wetzstein

In the following list c after a species name indicates common; l, local; r, rare; s, sporadic.

SUBKINGDOM PTERIDOPHYTA

1. OPHIOGLOSSACEAE.

Botrychium dissectum Spreng., s.
ternatum Sw., not c.
virginianum Sw., c.
Ophioglossum vulgatum L., found only in three places.

2. OSMUNDACEAE.

Osmunda cinnamomea L., I obtained one specimen from Prof. Young as found in a woods northeast of St. Marys. Doubt its presence in Auglaize county.
Osmunda regalis L., r.

3. POLYPODIACEAE.

Adiantum pedatum L., c.
Asplenium acrostichoides Sw., r.
angustifolium Michx., not c.
filix-foemina Bernh., not r.
Cystopteris fragilis Bern., c.
Dryopteris acrostichoides Kuntze.,c
noveboracensis A. Gray, l.
spinulosa Kuntze., s.
Dryopteris spinulosa dilatata Underw., r.
spinulosa intermedia Underw.,c
thelipteris A. Gray., not c.
Onoclea sensibilis L., c.
Phegopteris dryopteris robertiana, very r.
hexagonoptera Fee, c.
phegopteris Underw., c.
Pteris aquilina L., l.

4. EQUISETACAE.

Equisetum arvense L., c.
hyemale L., c.
laevigatum A. Br., not c.
Equisetum pratense Ehrh., not c.
robustum A. Br., r.
silvaticum L., not c.

SUBKINGDOM SPERMATOPHYTA

I CLASS GYMNOSPERMAE

5. PINACEAE.

Juniperus communis L., s.
virginiana L., l.
sabina L., a few shrubs in a garden at St. Marys, O., now destroyed a few years ago, in spite of my endeavor to save them.
Larix laricina Koch. r.
Pinus echinata Mill.,r. Elmgrove cemetery, St. Marys, O.
resinosa Ait., one tree, Elmgrove cemetery.
Picea canadensis B. S. P., not c.
Thuja occidentalis L., not r.
Tsuga canadensis Carr, c.

II CLASS ANGIOSPERMAE

a Monocotyledones

6. TYPHACEAE.

Typha angustifolia L., not very c.
Typha latifolia L., c.

7. SPARGANIACEAE.

Sparganium androcladum Morong., c.
Sparganium eurycarpum Engelm., not c.

8. NAJADACEAE.

Najas flexilis Rost and Schmidt, c.
Potamogeton amplifolius Tuckerm., r.
crispus L., r. St. Marys Reservoir.
foliosus Raf., c.
foliosus niagarensis Morong., c.
Potamogenton Hillii, one plant, St. Marys Reservoir.
lonchites Tuckerm., r.
natans L., c.
pectinatus L., c.
pusillus L., not c.

9. ALISMACEAE.

Alisma plantago-aquatica L., c.
Lophotocarpus calycinus J. G. Smith., c.
Sagittaria latifolia Willd., c.
longiloba Englem., c.
longirostra J. G. Smith., not c

10. GRAMINEAE.

Agrostis alba L., very c.
exarata Trin., l.
intermedia Scribn., not c.
perennans Tuckerm., c.
Alopecurus geniculatus L., l.
Andropogon furcatus Muhl., c.
scoparius Michx., r.
Avena sativa L., escaped, s.
Bromus asper Murr., c.
ciliatus purgans L., not c.
breviaristatus Buckl., r.
racemosus L., c.
secalinus L., c.
tectorum L., l.
Calamagrostis canadensis Beauv., l
Dactylis glomerata L., c.
Danthonia spicata Beauv., very c.
Cinna arundinacea L., c.
Chrysopogon avenaceus Benth., l.
Eatonia obtusata A. Gray., r.
pennsylvanica A. Gray., locally c.
Eleusine indica Gaertn., c.
Elymus canadensis L., c., locally.
striatus Willd., c.
virginicus L., c.
glaucus., r.
Festuca elatior L., not c.
gigantea Vill., l.
nutans Willd., c.
Homalocenchrus oryzoides Poll., c.
virginicus Britton., c.
Hystrix hystrix Millsp., very c.
Ixophorus glaucus Nash., c.
italicus Nash., l.
Ixophorus viridis Nash., not c.
Korycarpus diandrus Kuntze., l., woods near St. Mary's Reservoir, north.
Milium effusum L c.
Muhlenbergia diffusa Schreb., c.
mexicana Trin., c.
Panicularia americana,MacM.,not c
nervata Kuntze., not c.
fluitans Kuntze., c. locally.
Panicum capillare L., c.
capillare Gattingeri Nash., c.
crus-galli L., very c.
dichotomum, r.
macrocarpon., not c.
proliferum Lam., c.
pubescens Lam., c.
virgatum L., r.
Walteri Pursh., l.
Phalaris arundinacea L., l.
Phleum pratense L., very c.
Poa alsodes A. Gray., l.
annua L., not c.
buckleyana Nash., r.
brevifolia Muhl., r.
compressa L., c.
pratensis L., c.
silvestris A. Gray, not c.
trivialis L., l.
Secale cerele L., escaped, s.
Spartina cynosuroides Willd., not c
Sporobolus neglectus Nash not c.
vaginaeflorus Wood., c.
Syntherisma linearis Nash., not c.
sanguinalis Nash., very c.

11. CYPERACEAE.

Carex albursina Sheldon, l.
aquatilis Wahl., c.
arenaria L., not c.
aristata R. Br.
Asa-Grayi Bailey., l.
cephaloidea Dewey, r.
cephalophora Muhl., c.
comosa Boott., l.
conjuncta Boott., not c.
crinita Lam.
cristatella Britton., c.
crus-corvi Shuttlw., l.
Davisii Schwein & Torr., r.
deweyana Schwein., c.
digitalis Willd., not c.
Frankii Kunth., c.
gracillima Schwein., c.
glaucodea Tuckerm., r.
granularis Muhl., c.
granularis Shriveri Britton., l.
grisea Wahl., c.
hitchcockiana Dewey., r.
hystricina Muhl., very c.
Jamesii Schwein., c.
lanuginosa Michx., l.
laxiflora Lam., c.
laxiflora blanda Boott., c.
laxiflora patulifolia Carey, l.
lupulina Muhl., l.
muhlenbergii Schk., r.
muskin gumensis Schwein., c.
pennsylvanica Lam., very c.
plantaginea Lam., l.
platyphylla Carey, r.
pubescens Muhl., c.
retroflexa Muhl., c.

riparia Curtis, l.
rosea Schk., not c.
scoparia Schk., r.
setacea Dewey, not c.
shortiana Dewey, locally c.
sparganioides Muhl., not c.
squarrosa L., l.
stipata Muhl., r.
stricta Lam., l.
styloflexa Buckley., not c.
tribuloides Wahl., c.
tribuloides Bebbii Bailey, s.
tribuloides moniliformis Britton., not r.
triceps Michx., c.
Tuckermani Dewey, l.
varia Muhl., not c.
virescens Muhl., c.
vulpinoidea Michx., c.
walteriana Bailey, not c.
xanthocarpa Bicknell, not c.
xanthocarpa annectens Bicknell, r.
Cyperus diandrus Torr., not c.
erythrorhizos Muhl., c.
esculentus L., c.
ferox, r.
Engelmanni Steud., not c.
refractus Engelm., r.
rivularis Kunth., c.
speciosus Vahl., not r.
strigosus L., c.
strigosus robustior, s.
Nuttallii, only a few specimens.
Dulichium arundinaceum Britton, r
Eleocharis acicularis Br., l.
acuminata Nees., not c.
Engelmanni, r.
intermedia Schult., not c.
microcarpa, r.
melanocarpa Torr., not c.
ovata R. & S., c.
palustris Br., common l.
tenuis Schultes, not c.
tuberculosa Br., not c.
Kyllinga pumila Michx., l.
Scirpus atrovirens Muhl., not r.
cyperinus Kunth., l.
lacustris L., c.
lineatus Michx., very c.
robustus Pursh., s.

12. ARACEAE.

Acorus calamus L., l.
Arisaema dracontium Schott, not r
Arisaema tripyllum Torr., c.
Spathyema foetida Raf., l.

13. LEMNACEAE.

Lemna minor L., not c.
trisculca L., c.
Spirodela polyrhiza Schleid., c.

14. COMMELINACEAE.

Tradescantia reflexa Raf., found only in one place, along a ditch near St. Mary's Reservoir.
Tradescantia virginiana L., c.

15. PONTEDERIACEAE.

Heteranthera dubia MacM., not c.

16. JUNCACEAE.

Juncus canadensis Gay., c.
tenuis Wild., very c.
Juncoides campestre Kuntze., c.

17. MELANTHACEAE.

Uvularia grandiflora J. E. Smith., c.

18. LILIACEAE.

Allium canadense L., c.
cepa L., escaped, along canal.
cernuum Roth., l.
tricoccum Ait., not r.
Erythronium albidum Nutt., c.
americanum Ker., l.
Hemerocallis fulva L., locally c.
Lilium canadence L., not r.
Ornithogalum umbellatum L., r.
Quamasia hyacinthina Britton., c.
hyacinthina alba Wetzstein., 2 specimens.

19. CONVALLARIACEAE.

Asparagus officinalis L., s.
Polygonatum biflorum Ell., c.
commutatum Dietr., l.
Trillium erectum L., c.
grandiflorum Salisb., c.
Trillium recurvatum Beck., c.
sessile L., c.
Unifolium canadense Green., r., Wapakoneta, O.
Vagnera racemosa Morong., c.
stellata Morong., l.

20. SMILACEAE.

Smilax ecirrhata L. Wats., c.
glauca Walt., not c.
herbacea L., c.
Smilax rotundifolia L., c.
spinulosa J. E. Smith., r.
tamnifolia Michx.
pseudo-china L., r.

21. AMARYLLIDACEAE.

Hypoxis hirsuta Coville. l.

22. DIOSCOREACEAE.

Dioscorea villosa L., c.

23. IRIDACEAE.

Iris hexagona Walt., only one place: wet meadow east of St. Marys.
versicolor L., c.
Sisyrinchium angustifolium Mill., c
graminoides Bicknell, not r.

24. ORCHIDACEAE.

Aplectrum spicatum B. S. P., very r
Cypripedium hirsutum Mill., r., l.
Habenaria bracteata R. Br., not r.
Habenaria leucophaea A. Gray., l.
psycodes A. Gray, l.
Orchis spectabilis L., r.

b Dicotyledones

1 Series: Choripetalae

25. SAURURACEAE.

Saururus cernuus L., c.

26. JUGLANDACEAE.

Hicoria laciniosa Sarg., not c., l.
microcarpa Britton, c.
minima Britton, not r.
Hicoria ovata Britton, not r.
Juglans nigra L., c.

27. SALICACEAE.

Populus alba L., s.
balsamifera L., not r.
deltoides Marsh., c.
dilatata L., l.
grandidentata Michx., l.
heterophylla L., s.
tremuloides Michx., c.
Salix alba L., c.
coerulea Koch., r.
vitellina Koch., c.
Salix amydaloides Anders, not r.
cordata Muhl., c.
cordata angustata Anders, l.
discolor Muhl., very c.
humiles Marsh., one shrub only.
lucida Muhl., l.
nigra Marsh., c.
fluviatilis Nutt. (interior), c.

28. BETULACEAE.

Carpinus caroliniana Walt., c.
Corylus americana Walt., c.
Ostrya virginiana Willd., c.

29. FAGACEAE.

Fagus americana Sweet., c.
Quescus alba L., c.
acuminata Sarg., s.
coccinea Wang., not c.
digitata Sudw., s.
imbricaria Michx., not r.
macrocarpa Michx., c.
Quercus marylandica Muench., s.
Michauxii Nutt., not c.
platanoides Sudw., s.
prinoides Willd., only one shrub now destroyed.
prinus L., s.
palustrus DuRoi., s.
rubra L., c.
velutina Lam., s.

30. ULMACEAE.

Celtis occidentalis L., c.
Ulmus americana L., c.
Ulmus fulva Michx., c.

31. MORACEAE.

Humulus lupulus L., not c.
Morus rubra L., not r.
Morus alba L., a few trees only, cultivated.
Toxylon pomiferum Raf., not r.

32. URTICACEAE.

Adicea pumila Raf., c.
Boehmeria cylindrica Willd., c.
Parietaria pennsylvanica Muhl., c.
Urtica dioica L., l
gracilis Ait., not c.
Urticastrum divaricatum Kuntze., c

33. SANTALACEAE.

Comandra umbelata Nutt., l.

34. ARISTOLOCHIACEAE.

Aristolochia serpentaria L., c.
Asarum canadense, l.
reflexum ambiguum Bicknell., c.

35. POLYGONACEAE.

Fagopyrum fagopyrum Karst., escaped.
Polygonum aviculare L., very c.
arifolium L., l.
emersum Britton, c.
erectum L., l.
convolulus L., c.
hydropiper L., l.
hydropiperoides Michx., c.
hydropiperoides Macouni Small, r.
incarnatum Ell., c.
lapathifolium L., c.
lapathifolium nodosum Small, found few plants 1902 along the Canal south of St. Marys, O. In 1903 the whole canal north of town was filled with it, but in 1904 it had almost disappeared.
Polyonum pennsylvanicum L., not c
persicaria L., c.
punctatum Ell., c.
punctatum robustior Small, s.
ramosissimum Michx., s.
sagittatum L., l.
scandens L., not r.
virginianum L., c.
Rumex acetosella L., l.
altissimum Wood, l.
crispus L., very c.
obtusifolius L., c.
verticillatus L., l.

36. CHENOPODIACEAE.

Atriplex hastata L., very c.
patula L., c.
Chenopodium album L., very c.
album viride Moq., s.
leptophyllum Nutt., r.
Chenopodium urbicum L., not r.
Salsola tragus L., found only in one place.

37. AMARANTHACEAE.

Acnida tamariscina tuberculata Uline and Bray, c.
Amaranthus graecizans L., c.
Amaranthus hybridus L., c.
hybridus paniculatus Uline & Bray, c.
retroflexus L., very c.

38. PHYTOLACCACEAE.

Phytolacca decandra L., c.

39. AIZOACEAE.

Mollugo verticillata L., l.

40. PORTULACACEAE.

Claytonia virginica L., very c.
Portulaca grandiflora Tourn., escaped, r.
oleracea L., very c.

41. CARYOPHYLLACEAE.

Agrostemma githago L., s.
Alsine longifolia Britton, c.
graminea Britton, l.
media L., very c.
Arenaria serpyllifolia L., s.
Cerastium longipedunculatum Muhl., c.
Cerastium viscosum L., c.
vulgatum L., s.
Moehringia lateriflora Fenzl., c.
Saponaria officinalis L., escaped.
Silene antirrhina L., l.
noctiflora L., r.
virginica L., c.

42. NYMPHAEACEAE.

Castalia adorata Wood & Wood, not rare.
Nymphaea advena Soland., l.
Nelumbo lutea Pers., in a pond near canal St. Marys, O.

43. CERATOPHYLLACEAE.

Ceratophyllum demersum L., c.

44. MAGNOLIACEAE.

Liriodendron tulipifera L.
Magnolia acuminata L.

45. ANONACEAE.

Asimina triloba Dunal., c.

46. RANUNCULACEAE.

Actaea alba Mill., not r.
Anemona canadensis L., c.
quinquefolia L., l.
virginiana L., c.
Aquilegia canadensis L., l.
Batrachium divaricatum Wimm., l.
Caltha palustris L., s.
Clematis viorna L., r.
virginiana L., not r.
Delphinium Ajacis L., escaped, s.
consolida L., s.
Hepatica acuta Britton, l., r.
hepatica Karst., c.
Hydrastis canadensis L., not c.
Ranunculus abortivus L., c.
acris L., s.
delphinifolius Torr., l.
hispidus Michx., c.
Purshii Richards, very r.
recurvatus Poir., c.
repens L., c.
sceleratus L., l.
septentrionalis Poir., s.
Syndesmon thalictroides Hoffmg., s
thalictroides petiolata Kellerman, s.
Thalictrum dioicum L., c.
purpurascens L., c.

47. BERBERIDACEAE.

Berberis vulgaris L., s.
Caulophyllum thalictroides Michx., l.
Jeffersonia diphylla Pers., c.
Podophyllum peltatum L., c.

48. MENISPERMACEAE.

Menispermum canadense L., c.

49. LAURACEAE.

Benzoin benzoin Coulter, c.
Sassafras officinale Nees., very r.

50. PAPAVERACEAE.

Bicuculla cucullaria Millsp., c.
Papaver rhoeum L., very r.
Sanguinaria canadensis L., c.
Argemone alba, 2 plants.

51. CRUCIFERAE.

Arabis dentate T. & G., l.
glabra Bernh., r.
laevigata Poir., c.
Barbarea barbarea MacM., c.
Brassica arvensis B. S. P., c.
campestris L., c.
napus L., s.
nigra Koch, very r.
Bursa bursa-pastoris Britton, very c
Camelina sativa Crantz, s.
Cardamine bulbosa B. S. P., l.
pennsylvanica Muhl., l.
purpurea Britton, c.
Dentaria heterophylla Nutt., r.
laciniata Muhl., c.
Lepidium apetalum., not r.
campestre R. Br., l.
virginicum L., very c.
Roripa armoracia A. S. Hitchcock, locally c.
hispida Britton, not c.
palustris Bess., c.
Raphanus sativus L., sporadically escaped.
Sisymbrium officinale Scop., very c.

52. CRASSULACEAE.

Penthorum sedoides L., c.
Sedum acre L., sporadically escaped.
Sedum telephioides Michx., l.
ternatum Michx., locally c.

53. SAXIFRAGACEAE.

Heuchera americana L., c.
Mitella diphylla L., locally c.
Philadelphus coronarius L., spordically.
Philadelphus inodorus L., one shrub near railroad to New Bremen.
Saxifraga pennsylvanica L., l.

54. GROSSULARIACEAE.

Ribes aureum Pursh., c. in gardens
cynosbati L., c.
Ribes floridum L'Her., c.

55. PLATANACEAE.

Platanus occidentalis L., not r.

56. ROSACEAE.

Agrimonia mollis Britton, not c.
parviflora Soland., c.
striata Michx., c.
Fragaria americana Britton, l.
virginiana Duchesne, c.
Geum canadense Jacq., c.
vernum T. & G., c.
virginianum L., c.
Rosa carolina L., c.
humilis Marsh., c.
humilis lucida Best., l.
humilis villosa Best., l.
setigera Michx., c.
Rubus canadensis L., c.
laciniatus Willd., very r.; found only two specimens in woods about two miles N. E. of St. Marys.
occidentalis L., c.
villosus Ait., c.

57. POMACEAE.

Amelanchier canadensis Medic., s.
Crataegus coccinea L., c.
crus-galli L., c.
macracantha Lodd., s.
mollis Scheele., c.
punctata Jacq., not r.
punctata canescens Britton, l.
Crataegus rotundifolia Borck., s.
tomentosa L., c.
Malus coronaria Mill., c.
angustifolia Ait., l.
malus Britton, s.

58. DRUPACEAE.

Amygdalus persicaria L., s.
Prunus americana Marsh., c.
cerasus L., s.
Prunus serotina Ehrh., c.
virginiana L., l.

59. CAESALPINACEAE.

Cassia marylandica L., l.
Cercis canadensis L., c.
Gleditsia triacanthos L., c.
Gymnocladus dioica Koch, locally c.

60. PAPILIONACEAE.

Apios apios MacM., l.
Falcata comosa Kuntze, c
Lathyrus myrtifolius Muhl., l.
palustris L., not r.
Lespedeza frutescens Britton, l.
violacea Pers., c.
Medicago lupulina L., c.
sativa L., l.
Meibomia canadensis Kuntze, c.
canescens Kuntze, s.
bracteosa Kuntze, c.
Dillenii Kuntze, l.
glabella Kuntze, not c.
Meibomia grandiflora Kuntze, c.
nudiflora Kuntze, c.
paniculata Kuntze, c.
pauciflora Kuntze, r.
Melilotus alba Desv., c.
officinalis Lam., locally c.
Robinia pseudacacia L., c.
Trifolium hybridum L., c.
pratense L., c.
repens L., very c.

61. GERANIACEAE.

Erodium cicutarium L'Her., r.
Geranium maculatum L., c.

62. OXALIDACEAE.

Oxalis cymosa Small, l.
stricta L., c.
Oxalis violacea L., l.

63. LINACEAE.

Linum usitatissimum L., s.

64. RUTACEAE.

Ptelea trifoliata L., not r.
Xanthoxylum americanum Mill., c.

65. POLYGALACEAE.

Polygala verticillata L., locally c.
ambigua, with the type.

66. EUPHORBIACEAE.

Acalypha virginica L., c.
Euphorbia corollata L., c.
cyparissias L., l.
maculata L., localy very c.
Euphorbia marginata Pursh., locally abundant.
nutans Lag., c.
obtusata Pursh., l.

67. CALLITRICHACEAE.

Callitriche palustris L., s.

68. LIMNANTHACEAE.

Floerkea proserpinacoides Willd., c.

69. ANACARDIACEAE.

Rhus glabra L., c.
Rhus radicans L., c.

70. ILICACEAE.

Ilex verticillata tenuifolia A. Gray., r.

71. CELASTRACEAE.

Celastrus scandens L., c.
Euonymus atropurpureus Jacq., c.
obovatus Nutt., l.

72. PYROLACEAE.

Pyrola rotundifolia L., l.

73. STAPHYLEACEAE.

Staphylea trifolia L., c.

74. ACERACEAE.

Acer negundo L., s.
rubrum L., c.
Acer saccharinum L., c.
saccharum Marsh, l.

75. HIPPOCASTANACEAE.

Aesculus glabra Willd., c.

76. BALSAMINACEAE.

Impatiens aurea Muhl., l.
Impatiens biflora Walt., c.

77. VITACEAE.

Parthenocissus quinquefolia Planch., c.
Vitis aestivalis Michx., c.
Vitis bicolor Le Conte., s.
vulpina L., c.

78. TILIACEAE.

Tilia americana L., c.

79. MALVACEAE.

Abutilon abutilon Rusby., c.
Althaea rosea Cav., locally abundant.
Hibiscus militaris Cav., l.
trionum L., locally c.
Malva rotundifolia L., c.
sylvestris L., l.
Sida spinosa L., c.

80. HYPERICACEAE.

Hypericum maculatum Walt., c.
mutilum L., l.
Hypericum perforatum L., c.
Triadenum petiolatum Britton, r.

81. VIOLACEAE.

Cubelium concolor Raf., c.
Viola cucullata Ait., s.
labradorica Schrank, l.
obliqua Hill, c.
obliqua alba Wetzstein, one place only at canal north of St. Marys.
Viola palmata L., c.
pedatifida Don., one place only east of St. Marys.
pubescens Ait., c.
rostrata Pursh., l.
Viola sagittata Ait., s.
scabriuscula Schwein, l.
Viola sororia Willd., l.
striata Ait., c.

82. THYMELACEAE.

Dirca palustris L., l, not r.

83. LYTHRACEAE.

Decodon verticillatus Ell., l.
Lythrum alatum Pursh., c.
Lythrum alatum albidum Wetzstein, one place only along railroad to Celina, O.

84. ONAGRACEAE.

Chamaenerion angustifolium Scop., s.
Circaea lutetiana L., c.
Epilobium adenocaulon Haussk., s.
coloratum Muhl., c.
Gaura biennis L., l.
Isnardia palustris L., c.
Ludwigia polycarpa Short and Peter, c.
Onagra biennis Scop., c.

85. HALORAGIDACEAE.

Myriophyllum spicatum L., l.

86. ARALIACEAE.

Aralia racemosa L., localy abundant.
Panax quinquefolium L., s.

87. UMBELLIFERAE.

Angelica atropurpurea L., l.
Chaerophyllum procumbens Crantz, c.
Cicuta bulbifera L., c.
maculata L., l.
Conium maculatum L., s.
Daucus carota L., c.
Deringa canadensis Kuntze, c.
Erigenia bulbosa Nutt, locally c.
Foeniculum foeniculum Karst, s.
Heracleum lanatum Michx., l.
Pastinaca sativa L., c.
Pimpinella integerrima A. Gray, c.
Sanicula canadensis L., c.
gregaria Bicknell, locally c.
marylandica L., c.
Thaspium barbinode Nutt, c.
barbinode angustifolium Coult. and Rose, l.
trifoliatum aureum Britton, c.
Aegopodium podagraria L., r.

88. CORNACEAE.

Cornus amonum Mill., c.
asperifolia Michx., l.
candidissima Marsh, c.
Cornus florida L., not r.
stolonifera Michx., l.

2 Series: Gamopetalae

89. MONOTROPACEAE.

Monotropa uniflora L., r.

90. PRIMULACEAE.

Naumburgia thyrsiflora Duby., l.
Lysimachia nummularia L., c.
Samolus floribundus H. B. K., c.
Steironema ciliatum Raf., c.
lanceolatum A. Gray, c.
quadriflorum Hitchc., l.

91. OLEACEAE.

Chionanthus virginica L., s.
Fraxinus americana L., c.
Fraxinus quadrangulata Michx., s.
Ligustrum vulgare L., l.

92. GENTIANACEAE.

Gentiana Andrewsii Griseb., c.
Gentiana crinita Froel., one place only; meadow at east side of Reservoir.

93. APOCYNACEAE.

Apocynum androsaemifolium L., c.
cannabinum L., c.
pubescens R. Br., very rare; only one place at foot of high bank of canal north of St. Marys, O.
Vinca minor L., c. locally.

94. ASCLEPIADACEAE.

Asclepias exaltata Muhl., s.
incarnata L., c.
quadrifolia Jacq., l.
Asclepias purpurascens L., l.
syriaca L., c.
tuberosa L., c.

95. CONVOLULACEAE.

Convolvulus arvensis L., locally c.
japonicus Thunb., l.
sepium L., c.
spithamaeus L., s.
Convolvulus repens, l.
Ipomoea hederacea Jacq., locally c.
pandurata Meyer, c.
purpurea Roth, l.

96. CUSCUTACEAE.

Cuscuta cephalanthi Engelm, l.
compacta Juss., l.
Cuscuta Gronovii Willd., l.

97. POLEMONIACEAE.

Phlox divaricata L., c.
divaricata candida Wetz., s.
maculata L., l.
Phlox paniculata L., l.
Polemonium reptans L., c.
reptans album Wetzstein, s.

98. HYDROPHYLLACEAE.

Hydrophyllum appendiculatum Michx., c.
macrophyllum Nutt, l.
Hydrophyllum virginicum L., c.
Phacelia Purshii Buckl., l.

99. BORAGINACEAE.

Cynoglossum officinale L., l.
Lappula lappula Karst, c.
virginiana Greene, c.
Lithospermum arvense L., c.
latifolium Michx., l.
Mertensia virginica DC., c.
Myosotis palustris Lam., s.
Symphytum officinale L., l.
Onosmodium virginianum DC., s.

100. VERBENACEAE.

Lippia lanceolate Michx., c.
Verbena angustifolia Michx., s.
hastata L., c.
Verbena urtifolia L., c.
urticifolia riparia Britton, s.

101. LABIATAE.

Agastache nepetoides Kuntze, l.
scrophulariaefolia Kuntze, l.
Blephilia hirsuta Torr, c.
Colinsonia canadensis L., c.
Glecoma hederacea L., c.
Hedeoma pulegioides Pers., c.
Koellia pilosa N., r.
virginiana MacM., locally c.
Lamium amplexicaule L., l.
maculatum L., locally c.
Leonurus cardiaca L., c.
Lycopus americanus Muhl., c.
rubellus Moench., l.
virginicus L., not r.
Mentha alopecuroides Hull, s.
citrata Ehrh., l.
sativa L., not c.
spicata L., c.
canadensis L., c.
Monarda clinopodia L., l.
fistulosa L., c.
Nepeta cataria L., c.
Physostegia virgeniana Benth., l.
Prunella vulgaris L., c.
Salvia officinalis L., sporadically escaped.
Scutellaria cordifolia Muhl., c.
galericulata L., c.
lateriflora L., c.
lateriflora albida Wetzstein, s.
nervosa Pursh., not c.
Stachys aspera Michx., l.
cordata Riddell, l.
palustris L., not c.
tenuifolia Willd., l.
Teucrium canadense L., c.
occidentale A. Gray, l.

102. SOLANACEAE.

Datura tatula L., l.
Lycium vulgare Dunal, c.
Lycopersicon lycopersicon Karst, escaped.
Physalis heterophylla Nees., l.
philadelphica Lam., c.
pruinosa L., l.
Physalis virginiana Mill, l.
pubescens L., c.
Physalodes physalodes Britton, l.
Solanum carolinense L., local, not c.
dulcamara L., l.
nigrum L., c.
tuberosum L., escaped.

103. SCROPHULARICEAE.

Afzelia macrophylla Kuntze, l.
Collinsia verna Nutt, locally c.
Chelone glabra L., not c.
Gerardia besseyana Britton, only one place, at N. E. shore of Reservoir.
tenuifolia Vahl., localy c.
tenuifolia asperula A. Gray, with the type.
Gratiola virginiana L., c.
Ilysanthes gratioloides Benth., l.
Leptandra virginica Nutt, l.
Linaria linaria Karst, c.
Mimulus alatus Soland, l.
ringens L., l.
Pedicularis canadensis L., l.
lanceolate Michx., l.
Pentstemon canescens Britton, r.
Verbascum blattaria L., c.
thapsus L., c.
Veronica arvensis L., c.
officinalis L., c.
peregrina L., l.
scutellata L., c. locally.
serpyllifolia L., c.
Scrophularia marylandica L., c.

104. LENTIBULARIACEAE.

Utricularia vulgaris L l.

105. ORABANCHACEAE.

Conopholis americana Wallr., l.
Leptamnium virginianum Raf., c.

106. BIGNONIACEAE.

Catalpa catalpa Karst, not r.
Tecoma radicans DC., c.

107. ACANTHACEAE.

Ruellia strepens L., c.
Dianthera americana L., c.

108. PHRYMACEAE.

Phryma leptostachya L., c.

109. PLANTAGINACEAE.

Plantago aristata Michx., l., r.
cordata Lam., l.
lanceolata L., c.
Plantago major L., c.
Rugelii Dec., l.

110. RUBIACEAE.

Cephtlanthus occidentalis L., c.
Galium aparine L., c.
circaezans Michx., c.
concinnum Torr & Gray, c.
tinctorium L., locally c.
Galium trifidum L., l.
triflorum Michx., c.
triflorum luteum Wetzstein, s.
triflorum purpureum Wetz., s.

111. CAPRIFOLIACEAE.

Lonicera caprifolium L., s.
dioica L., l.
glaucesens Rydb., not c.
japonica Thunb., escaped.
sempervirens L., s.
tartarica L., s.
Sambucus canadensis L., c.
Symphoricarpus racemosus Michx., l.
Triosteum perfoliatum L., c.
Viburnum acerifolium L., l.
dentatum L., not c.
opulus L., s.
prunifolium L., c.
pubescens Pursh., l.

112. VALERIANACEAE.

Valeriana pauciflora Michx., l.
Valerianella radiata Dufr., c.

113. DIPSACACEAE.

Dipsacus sylvestris Huds., c.

114. CUCURBITACEAE.

Citrullus vulgaris Schrad., escaped
Micrampelis lobata Greene, c.
Sicyos angulatus L., l.

115. CAMPANULACEAE.

Campanula americana L., c.
rapunculoides L., one place at N. W. end of St. Marys, O
Lobelia cardinalis L., l.
inflata L., l.
syphilitica L., c.

116. CICHORIACEAE.

Adopogon virginicum Kuntze, l.
Cichorium intybus L., c.
intybus divaricatum D C., s.
Hieracium scabrum Michx., l.
Lactuca canadensis L., c.
floridana Gaertn., l.
sagittifolia Ell., c.
villosa Jacq., l.
scariola L., c.
Nabalus altissimus Hook, c.
Sonchus asper All., c.
oleraceus L., c.
arvensis L., s.
Taraxacum taraxacum Karst., c.
erythrospermum., l.
Tragopogon porrifolius L., l.
pratensis L., s.

117. AMBROSIACEAE.

Ambrosia artemisiaefolia L., c.
trifida L., c.
trifida integrifolia T. & G., l.
Xanthium canadense Mill, c.

118. COMPOSITAE.

Achillea millefolium L., very c.
Antennaria neodioica Greene, l.
plantaginifolia Richards, l.
Anthemis cotula L., very c.
Arctium minus Schk., c.
Artemisia annua L., locally c.
biennis Willd., l.
Aster cordifolus L., c.
cordifolius alveariusBurgess, l.
cordifolius candidus Wetz., r.
Drummondii Lindl., not c.
hirsuticaulis Lindl., l.
laevis L., r.
lowrieanus Porter, c.
lowrieanus lancifolius Porter, with type.
multiflorus Ait., l.
Novae-Angliae L., c.
Novae-Angliae candidus Wetzstein, s.
Novae-Angliae roseus Wetzstein, s.
paniculatus acutidens Burgess, l.
paniculatus bellidiflorus Burgess, l.
paniculatus simplex Burgess,c
puniceus L., locally c.
puniceus lucidulus A. Gray, l.
salicifolius Lam., l.
Tradescanti L., c.
Tradescanti X lateriflorus Wetzstein, 1 specimen.
ericoides pilosus Porter, l., r.
ericoides platyphyllusT.&G., r.
Bidens cernua L., locally c.

comosa Wiegand, c.
connata Muhl., l.
connata involucrata Wetzst., a few specimens.
frondosa L., c.
trichosperma Britton, c.
trichosperma tenuiloba Britton, on an island in reservoir.
Boltonia asteroides L'Her., localy-c
Carduus altissimus L., l.
arvensis Robs., l. not c.
discolor Nutt, not r.
lanceolatus L., l.
muticus Pers., l.
Centaurea cyanus L., s.
Chrysanthemum leucanthemum L., c.
parthenium Pers., s.
Coreopsis tinctoria Nutt, sporadically escaped.
Doellingeria umbellata Nees, r.
Eclipta alba Haussk., c.
Erechtites hieracifolia Raf., c. locally.
Erigeron annuus Pers., c.
philadelphicus L., c.
ramosus B. S. P., l.
Eupatorium ageratoides L. f., c.
maculatum L., l.
perfoliatum L., c.
perfoliatum truncatum A. Gray, s.
purpureum L., l.
Euthamia graminifolia Nutt, c.
Gnaphalium obtusifolium L., l.
purpureum L., l.
Helenium autumnale L., l.
Helianthus annuus L., s.
decapetalus L., c.
divaricatus L., l.
doronicoides Lam., not c.
grosse-serratus Martens, c.
laetiflorus Pers., local not c.
tuberosus L., l.
Heliopsis heleanthoides B. S. P., c.
scabra Dunal, l.
Inula helenium L., l.
Leptilon canadense Britton, very c.
Polymnia canadensis L., l.
Ratibida pinnata Barnhart, locally c.
Rudbeckia hirta L., l.
laciniata L., locally c.
triloba L., c.
triloba indivisa Wetzstein, s.
Senecio aureus L., c.
obovatus Muhl., l.
Silphium perfoliatum L., c.
Solidago caesia L., c.
caesia axillaris A. Gray, l.
canadensis L., c.
canadensis procera T. & G., l.
canadensis scabriuscula Porter, l.
flexicaulis L., l.
juncea Ait., local, not c.
rigida L., abundant, east bank of Reservoir.
ulmifolia Muhl., locally c.
Tanacetum vulgare L., l.
Verbesina alternifolia Britton, l.
Vernonia fasciculata Michx., c.

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G. B. Halsted,
Trustees.

INTRODUCTION

The following catalogue of Ohio Mollusca, an abstract of my hand list, is published at the request of conchologists, and of members of the Ohio Academy. As indicated by the title, it is a preliminary one, imperfect, and not complete either as to the species and forms occurring in the state or as to their distribution. It is based partly on earlier lists, especially those of the vicinity of Cincinnati, by Shaffer, Byrnes, "O. G. B." Harper and Wetherby, and partly on recent collecting in several counties by other conchologists, and my own collecting of over twenty years, in various parts of the State. The only vicinities worked up fairly well, and of which approximately complete lists have been published, are those of Cincinnati, a classical collecting ground for nearly a century, and New Philadelphia, Tuscarawas County. Much careful collecting has been done also in the vicinity of Columbus, since the forties of the last century, by Moores, Higgins, Surface and others, but only a very incomplete catalogue of the land mollusca has been published. The late Geo. W. Dean and his friend, Geo. J. Streator (now in California), have collected principally in Portage County, A. Pettingell in Summit Co., John A. Allen in the vicinity of Cleveland and on the lake islands, and E. L. Mosely at Sandusky.

It is expected that more students of nature, in all parts of the state, will direct their attention to, and collect our land and fresh-water mollusca, recent as well as fossil, wherever such can be found. Very much work is yet to be done, and these animals are of great interest, especially with respect to zoogeography. Then the time will come when it is possible to work up a more complete and elaborate "fauna" of the state, with more data on the distribution over the main drainages, and the various kinds of soil and surface formation, with tables, charts, etc. Also closer comparison with the faunas of neighboring states will then be in place. Earlier work and earlier lists will be reviewed, and literature cited.

During recent years, mollusk lists have been published of the States of New York, Michigan, Indiana, Illinois and Wisconsin, and local lists of Pennsylvania. None of them pretends to be complete; yet, with Ohio added, they facilitate a fair conception of the fauna of this part of the continent.

Ohio, being in the Interior Region of the Eastern Subprovince (W. G. Binney) of the Nearctic Province, has that characteristic fauna, in a general way. Yet there are some features of special interest. The northern part of the state is in the drainage of the upper St. Lawrence River, which has fresh-water forms of the Atlantic Sub-province mixed with some of the Mississippi drainage. Also there are a number of boreal and circumboreal species. The Northeast, the so-called Appalachian Corner, seems to be inhabited by some specifically Appalachian snails also, *e. g. Gastrodonta lasmodon* and *collisella*, *Hyalina lamellidens* and an unidentified *Hyalina;* and more may be found. The southern part of the state has some southern forms, outside of the Strepomatidæ and Unionidæ of the Ohio River, such as *Gastrodonta gularis*, *Omphalina lævigata* and *friabilis*, *Polygyra appressa*, *obstricta* and *stenotrema*, and probably others. Western species extending as far eastward as Ohio, are *Zonitoides læviusculus*, *Vallonia parvula*, *Bifidaria holzingeri*. The distribution of all of these species, and eventually others, should be ascertained more exactly.

But it must be understood that our mollusca are rapidly and considerably decreasing in numbers, by deforestation and cultivation of the land, draining of lakes, ponds and swamps, and consequent disappearance of springs, brooks and smaller creeks, or their being dry during a large part of the year, resulting in the disappearance of mollusca. In the rivers and larger creeks, the water comes to its lowest stages, with sudden floods rapidly receding. Shade, as a protection from insolation, is taken off by cutting down the trees on the banks of water courses. The canals, which were great routes for mollusca, are more and more neglected, and partly abandoned. To this comes the contamination of waters by city sewage and factory refuse, and already a number of rivers are barren of life or rapidly approaching that stage. These factors certainly affect all groups of fresh water animals, not only the mollusca. And of late years, the Unionidæ are destroyed in wholesale slaughter, by the shell and pearl hunters. Thus, not only the number of individuals is rapidly reduced, but many species are threatened with extinction over large tracts of the territory. Therefore it is imperative that we take a careful inventory of our fauna as rapidly as possible.

To the main catalogue of recent mollusca are added a few supplements: a list of species not or little known up to recent years, mistaken for or mixed up with others; a list of species not yet known to occur in the state, but probably to be found; lists of fossils collected.

With respect to the general catalogue, a few remarks may be in place. Of common, and widely distributed species, of which Ohio is within the area of general distribution, it was thought unnecessary to cite numerous localities, except of such as are comparatively little known. "Over the state" seemed sufficient, even if such a species has actually been seen from few places. I am well aware of the fact that some widely distributed, and even generally common species, may be absent over stretches of many miles, or in whole river systems,—if not simply overlooked. To ascertain and register such gaps of distribution*, and also their causes, may be possible when the whole territory is worked up better than it is at the present time. On the other hand, it seemed to be in place to add some notes on such species and forms which are of special interest with respect to either their systematic position, variation or distribution, things which constitute the characteristic features of a local or state fauna.

The list was intended to contain the species and varieties known to occur in Ohio, and recognized as such, seen by myself or cited on good authority. There are, however, a few exceptions, much to my regret. I am not familiar with many of the *Pleurocera* and *Goniobasis*, and also with some *Anodonta* of the St. Lawrence drainage. More material from all over the state, and special study, will be necessary in order to ascertain which of them represent valid species, varieties or local forms, and their distribution.

As varieties, I regard only such forms which, although connected with the typical, somewhere, by intermediate specimens (otherwise they would represent distinct species), maintain their characteristic features over a larger or smaller territory; in short, propagate as such. Individual variations, such as albinos†, reversed (usually sinistrorse) specimens, and shells with imperfectly or abnormally formed apertures, as occasionally found with the normal forms, cannot be regarded as varieties, in the accepted sense of the term.

In regard to classification and nomenclature, I have followed, for the most part, our leading conchologists, in some instances contrary to my own views. A faunal list is not the place for controversies on these topics. Where yet dissenting, I believe to have good reasons, *e. g.*, in adhering to *Hyalina* instead of *Vitrea*, *Patula* instead of *Pyramidula*. *Pisidium* versus *Corneocyclas* has been vindicated by higher authority than myself. For recognizing *Proptera* as a genus, I have given

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* As an example of this kind, the fact may be cited that none of the four species of Proptera has been found in the Tuscarawas River (with its thirty-six species of Unionidæ, and possibly more), while at least two or three of them are widely distributed over the state.

† Such are found especially of many species of Polygyra and Patula; but I know of no instance where any of them are constant and consequently constitute varieties.

sufficient reasons, and more might be cited. The reasons for my arrangement of the *Unionidæ* are stated elsewhere. As to the terms NEPHROPNEUSTA and BRANCHIOPNEUSTA: Von Ihering has found that the pulmonal cavity of the former has developed in connection with the nephridium, and they are related with the Nudibranchiata, that of the latter from the branchial cavity of the Tectibranchiata. Consequently, Stylommatophora and Basommatophora cannot be ranged, collectively, under one group, Pulmonata, as in contrast to the Prosobranchiata.

Synonyms are added where it seemed necessary or advisable with respect to earlier lists and books to be consulted.

Species introduced from other continents, are not an integral part of the Nearctic fauna, however interesting they may be, in several respects, and in order to mark this, their names are printed in different type (capitals). Certainly they swell the number of species recorded, but the number in itself is not of principal importance. It has been said that species and forms not identified, or of which descriptions have not yet been published, should not be included in faunal lists. In my opinion, they must be there, being parts of that fauna, and their systematic position and characteristic features should be pointed out.

A few words may be in place with respect to the mollusca of Lake Erie Almost all Unionidæ (I have seen about thirty species, and there are probably more), are represented by forms more or less different from those of the rivers, generally being smaller, of different shapes, and often colors. Some of them have been described as species, *e. g.*, *Unio rosaceus* De Kay, *leibei* Lea, *hippopæus* Lea; in fact they are varieties, lake forms, of *Lampsilis luteola*, *Obovaria circulus*, *Quadrula plicata*, respectively. Corresponding forms of other species might, or should, be named and described. Of Sphæriidæ and Gastropoda, a few lake forms are also known, and more will be found. All mollusca of the lake should be systematically collected, and compared with the inland forms as well as with those of the other great lakes.

It has been suggested that keys for identification be added. I am sorry to say that this could not be done. Simpson states that it is impossible for the Unionidæ. After repeated attempts to work up keys for the Sphæriidæ, I had to give it up, mainly on account of the almost endless variation of a large part of our species. For most of the Prosobranchiata, it would be equally impossible. For identifying the "land mollusca" of Ohio, keys have been published by the Academy*. A few species were added since, but they do not materially affect the keys.

* In the fifth annual report, 1896, (by the writer); I have a number of copies, with additions, on hand, for distribution.

For identification and registration, specimens may be sent to me, and I am also willing to give directions for collecting and preparing such.

To several conchologists, I am under obligation for much valuable information, especially to Mr. Bryant Walker, of Detroit, Michigan.

As it is customary to give the numbers of species listed, the same is done here. The numbers are only approximately correct, *e. g.*, the species of *Pleurocera* and *Goniobasis* may be reduced, those of the Sphæriidæ will be added to.

	NEARCTIC	INTRODUCED	TOTALS
Nephropneusta........	92	5	97
Branchiopneusta......	47		47
Prosobranchiata......	44	1	45
Gastropoda.......	—182		—189
Unionidæ............	83		83
Sphæriidæ............	39		39
Pelecypoda........	—122		—122
Totals........	303	6	311

MARKS AND ABBREVIATIONS:

A † (dagger) in front of a name, means: recent addition over earlier lists (except mine, of Tuscarawas Co., 1894 and 1900).

An × after a name: should be looked for especially.

An ! after a locality: I have seen and verified, or identified specimens.

t = teste.

A personal name in parenthesis after a locality, is that of the collector, or sponsor.

"Pal." after a name: the species is also distributed over the Palæarctic province.

New Philadelphia, O., January, 1907.

Catalogue of Recent Mollusca.

GASTROPODA.

NEPHROPNEUSTA.

ZONITIDÆ.

Gastrodonta gularis (Say, Helix). ×
Cited by several conchologists; I have seen no specimens from Ohio.

†**Gastrodonta collisella** Pilsbry. ×
New Philadelphia (St., one specimen of the same form as from eastern Tennessee.

Gastrodonta suppressa (Say, Helix).
Cincinnati; Portage and Tuscarawas Counties (St.); probably over most of the state.

†**Gastrodonta lasmodon** (Phillips, Helix). ×
Rootstown, Portage Co. (St.).

Gastrodonta demissa (Binney, Helix.) ×
"Ohio" (Wetherby).

Gastrodonta ligera (Say, Helix).
Over the state, common.

Gastrodonta intertexta (Binney, Helix).
Over the state, not as common as the preceding.

Gastrodonta interna (Say, Helix).
Columbus, Cincinnati.

Zonitoides nitidus (Müller, Helix). Pal.
Over the state, at wet and damp localities.

Zonitoides arboreus (Say, Helix).
Over the state, common everywhere; colorless, or greenish, specimens are occasionally found.

Zonitoides limatulus (Ward, Helix).
Columbus; Cincinnati; (not e. g. in Tuscarawas Co.).

Zonitoides minusculus (Binney, Helix).
Over the state, common. A reversed (sinistrorse) specimen was found near New Philadelphia (St.).

†**Zonitoides læviusculus** (Sterki, Hyalina). ×
Troy! (Shepherd); Tuscarawas Co. (St.).

Zonitoides exiguus (Stimpson, Helix).
Over the state.

Zonitoides milium (Morse, Helix).
Over the state.

Omphalina friabilis (W. G. Binney, Helix). ×
Cincinnati.

Omphalina lævigata (Pfeiffer, Helix). ×
Cincinnati.

Omphalina fuliginosa (Griffith, Helix).
Over the state.

Omphalina inornata (Say, Helix).
Cincinnati; Columbus; Portage Co.! (Streator); Cuyahoga Co.! (Allen); Akron (Walker); probably over most parts the of state, but e. g. not found in Tuscarawas Co.

Omphalina subplana (Binney, Helix), cited from Cincinnati (O. G. B.), has not been found by other conchologists.

†**HYALINA [VITREA] DRAPARNALDI** (Beck, Helix).
Nursery east of Painesville (St.). Introduced from Europe.

†**HYALINA CELLARIA** (Müller, Helix).
Greenhouse at Kent, Portage Co.! (Dean). Introduced from Europe.

†**HYALINA ALLIARIA** (Müller, Helix).
Greenhouse at Painesville (St.). Introduced from Europe.

†**Hyalina wheatleyi** (Bland, Zonites).
Portage Co.! (Streator); Cuyahoga Co.! (Allen); Tuscarawas Co. (St.); probably over the state.

Hyalina radiatula (Alder, Helix), *hammonis* Ström? *electrina* Gould. Pal.
Over the state, common; colorless specimens are found occasionally.

Hyalina binneyana Morse.
Cincinnati; Midvale, Tuscarawas Co. (St.).

†**Hyalina**—sp. ×
Midvale, Tuscarawas Co. (St.). [Umbilicate, spire flat, almost concave, radial striæ very fine, regular and crowded; the same has been seen from the southern Appalachians].

Hyalina indentata (Say, Helix).
Over the state.

†**Hyalina ferrea** (Morse, Striatura).
Portage Co.! (Streator); Summit Co.! (Petingell); Tuscarawas Co. (St.).

Hyalina multidentata (Binney, Helix).
Cincinnati; Portage Co.! (Streator); Summit Co.! (Pettingell); Tuscarawas Co. (St.); probably all over the state.

†**Hyalina lamellidens** Pilsbry. ×
Garrettsville, Portage Co., t. Pilsbry.

Euconulus fulvus (Müller, Helix). Pal.
Over the state, common.

†**Euconulus chersinus** (Say, Helix).

Over the state, common; in some sections more common than fulvus, e. g. in Tuscarawas Co. In earlier descriptive works, and lists, these two species were understood as one, under one name or the other.

†**Euconulus sterkii** (Dall., Hyalina). ×

Summit Co.! (Pettingell); Tuscarawas Co., where the types were collected (St.). Probably over the state, but overlooked for its small size, like some other minute mollusca.

LIMACIDÆ.

†**LIMAX MAXIMUS** Linné.

Cincinnati (Lindahl); Wooster, Agricultural Station! (Webster); Nursery east of Painesville (St.). Introduced from Europe.

LIMAX FLAVUS Linné, introduced from Europe; probably in greenhouses and nurseries; I have seen no specimens.

AGRIOLIMAX AGRESTIS (Linné, Limax).

Cincinnati; I have found it at Cleveland, Garrettsville, Ravenna, Navarre, Tiffin, Defiance. Introduced from Europe.*

Agriolimax campestris (Binney, Limax).

Over the state, common everywhere. A bluish gray form, or eventually a variety (*plumbeus*) was found at Scio, Harrison Co. (St.), adult and young specimens, side by side with the typical, brownish form, in striking contrast. [Mr. Geo. H. Clapp has found the same at Pittsburg, Pa.]

CIRCINARIIDÆ.

Circinaria concava (Say, Helix), *Selenites*, *Macrocylis concava*.

Over the state, common. Appears to be absent from Put-in Bay, t. Allen.

HELICIDÆ—POLYGYRINÆ.

Polygyra profunda (Say, Helix), *Mesodon profunda*.

Over the state. Albino specimens (without reddish bands) are occasionally found.

Polygyra sayana Pilsbry, *Helix diodonta* Say, *sayi* Binney.

Cincinnati (Shaffer).

Polygyra multilineata (Say, Helix).

Over the state, especially in river bottoms, swamps, etc. Decidedly variable, with respect to size, shape and color. Specimens without red bands (form alba), and reddish all over (form rubra) are occasionally found.

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*Some conchologists, however, believe it to be native of North America, being so widely distributed.

Polygyra albolabris (Say, Helix).
Over the state, common and variable. On the lake islands (Put-in Bay, Kelley's) Allen found a reddish form, constant, in the marshy lowlands; **minor** Sterki, form or var., at New Philadelphia (St.).

Polygyra zaleta (Binney, Helix), *exoleta*.
Columbus; Cincinnati; Medina and Defiance Counties (St.); Put-in Bay and Kelley's Islands, uplands (Allen); probably over most of the state, yet wanting over wide stretches, e. g. not found in Tuscarawas Co.

Polygyra thyroides (Say, Helix).
Over the state, common in most parts.

Polygyra clausa (Say, Helix).
Cincinnati; Columbus; Lorain Co., cited as rare, by Dr. Hubbard, in litt., 1858.

Polygyra mitchelliana (Lea, Helix).
Cincinnati; Columbus; Portage Co. (Dean, Streator); Harrison and Tuscarawas Counties (St.); Defiance (St.)

Polygyra pennsylvanica (Green, Helix).
Cincinnati; Columbus; Cuyahoga Co. (Allen); Tuscarawas Co. (St.); probably over the state.

Polygyra elevata (Say, Helix).
Cincinnati; Columbus; Defiance (St.); probably over at least the southern and western parts of the state.

Polygyra dentifera (Say, Helix). ×
Cincinnati (Byrnes); "Ohio," t. W. G. Binney.

Polygyra appressa (Say, Helix).
Cincinnati.

Polygyra obstricta (Say, Helix). ×
Cited from the state (W. G. Binney); I have seen no specimens.

Polygyra palliata (Say, Helix).
Over the state; albinos are found occasionally.

Polygyra inflecta (Say, Helix).
Over the state.

Polygyra fraudulenta Pilsbry, *Helix*, *Triodopsis fallax* auctt.
Over the state, common.

Polygyra tridentata (Say, Helix).
Over the state, common and variable. Specimens ,from various places have the peristome without teeth, or with mere traces of such, but do not constitute a variety.

Polygyra tridentata discoidea Pilsbry.
Cincinnati.

Polygra stenotrema (Say, Helix.).
Cincinnati.

Polygyra hirsuta (Say, Helix.).

Over the state, common. Albinos are not infrequent.

Polygyra fraterna (Say, Helix).

Over the state, common, albinos are occasionally found. This is what has been taken for *monodon* Rackett, plus var. *fraterna* in earlier descriptions and lists.

Polygyra monodon (Rackett, Helix), *leai* Ward.

Cincinnati; Columbus; lake islands! (Allen); Defiance (St.). Not found e. g. in Tuscarawas Co. This is the *Helix leai*, or *monodon* var. *leai* of descriptive works and lists. At least in Ohio, the two species appear to be distinct, and have always been so regarded by the Cincinnati and Columbus conchologists; at Defiance, I have found the two side by side, without any intermediate specimens.

PHILOMYCIDÆ.

Philomycus caroliniensis (Bosc, Limax), *Tebennophorus caroliniensis* G. W. Binney.

Over the state, common, but becoming rare in many sections. Variable, and its color variations are said to indicate varieties and even distinct species, by some conchologists. These slugs should be carefully collected and studied.

†**Philomycus** sp.—pennsylvanicus Pilsbry? ×

Near Chippewa Lake (St.). Decidedly distinct from the two other species. About 30 mill. long, slender, light colored, the sole tinged with blood-red; the jaw has a number of somewhat rib-like, irregular ridges. The animal is as active as a Limax.

†**Philomycus dorsalis** Binney, *Pallifera dorsalis* Morse. ×

Tuscarawas and Defiance Counties (St.); probably over the state, but overlooked. (It is in none of the Cincinnati catalogues.)

ENDODONTIDÆ.

Patula [Pyramidula] solitaria (Say, Helix).

Over the state, less common than the following.

Patula alternata (Say, Helix).

Over the state, common, at some places abundant. Albinos are found occasionally, also reversed (sinistrorse) specimens, e. g. at New Philadelphia (St.).

Patula perspectiva (Say, Helix.)

Over the state, common, preferably in the forests, on and in decaying wood. Albinos are found occasionally.

Patula striatella (Anthony, Helix).

Over the state, common, preferably in the open.

Helicodiscus parallelus (Say, Planorbis), *H. lineata* Say.
Over the state, common.

Punctum pygmæum (Draparnaud, Helix), *minutissima* Lea. Pal.
Over the state, common.

Sphyradium edentulum (Daparnaud, Pupa), *Pupa simplex* Gould. Pal.
Cincinnati; Husdon, Summit Co.! (Pettingell); Tuscarawas Co. (St.); probably over the state.
Listed as *Pupa*, *Vertigo* and *Isthmia edentula*, but does not range under the Pupidæ (as swown by the writer).

VALLONIIDÆ.

Vallonia pulchella (Müller, Helix). Pal.
Over the state, common, somewhat variable.

†**Vallonia excentrica** Sterki. Pal.
Lake, Tuscarawas, Guernsey, Hamilton and Defiance Counties (St.); East Cleveland!, in lawns, by tens of thousands (Allen.); probably over the state. This seems to be one of the few species which have rather increased in numbers, in consequence of deforestation and cultivation of the land.

Vallonia costata (Müller, Helix). Pal.
Over the state. It has been listed as *pulchella var. costata*, but is quite distinct; the ribs are not the only distinguishing feature, but also the shape of the whorls and of the aperture.

†**Vallonia parvula** Sterki. ×
Sandusky (St.); Put-in Bay! (Allen), Walker.

FAM. ——.*

Strobilops labyrinthica (Say Helix), *Strobila labyrinthica*.
Over the state, preferably at damp places.

†**Strobilops affinis** Pilsbry. ×
Summit Co.; probably over the state.

†**Strobilops virgo** (Pilsbry, *Strobila labyrinthica virgo*). ×
New Philadelphia (St.); seems to prefer elevated and dry places.

PUPIDÆ.

Pupoides marginata (Say, Odostomia, Pupa), *Pupa fallax* of authors.
Over the state.

Bifidaria procera (Gould, Pupa).
Cincinnati; Columbus; Hamilton (St.); probably over most of the state, but e. g. not found in Tuscarawas Co. Listed as "*Pupa rupicola*" Say, for which (southern species) it has been mistaken.

*Some years ago, I ranged Strobilops under the Pupidæ, but believe that it was a mistake.

Bifidaria armifera (Say, Pupa).
Over the state, common; oftener found at dry places than any other species.

Bifidaria contracta (Say, Pupa).
Over the state, common.

†**Bifidaria holzingeri** (Sterki, Pupa). ×
Cincinnati! (Billups); Troy! (Shepherd); Put-in Bay! (Walker); Kelley's Island! (Allen).

Bifidaria pentodon (Say, Vertigo), *Pupa curvidens* Gould, *Pupa cincinnatiensis* Judge.
Over the state, common and variable. This species has been mistaken for and mixed up with B. *tappaniana* ("*pentodon*"), later known as *curvidens* Gould, recently changed to *pentodon*, by Vanatta and Pilsbry.

Bifidaria pentodon gracilis Sterki.
New Philadelphia (St.). This form is widely distributed outside of Ohio, e. g. in Alabama, and has been regarded as a species by some conchologists.

Bifidaria tappaniana (Adams, Pupa).
Over the state, common. The form **curta** Sterki at wet places. This has been known as *Pupa* and *Bifidaria pentodon* Say; the name was recently changed to the above, by Vanatta and Pilsbry.

Bifidaria corticaria (Say, Odostomia, Pupa).
Over the state.

Pupa (Pupilla) muscorum Müller (nec Linné). ×
Cited from Ohio (and no doubt to be found, being known from New York, Michigan and Illinois).

Vertigo milium (Gould, Pupa).
Over the state.

†**Vertigo morsei** Sterki. ×
Castalia, Erie Co. (St.), and probably over the north-western part of the state, being known from north-east Indiana, and Michigan.

Vertigo ovata Say.
Over the state, common and rather variable.

Vertigo ventricosa (Morse, Isthmia).
Over the state.

†**Vertigo ventricosa elatior** Sterki.
Summit Co.! (Pettingell); Stark and Tuscarawas Counties (St.). Probably over the state. (Has rather the significance of a species.)

(†) **Vertigo pygmæa** (Draparnaud, Pupa), *callosa* Sterki. × Pal.
Columbus! (Hy. Moores a. os.). The most western station known. Rather different from European and North American *pygmæa* seen, and probably a variety, (but

the name, *callosa*, being preoccupied, would have to be changed).

Vertigo decora (Gould, Pupa). Columbus, cited by Surface. The place seems to be outside of the range of its distribution, and probably *pygmæa* was mistaken for it, which I received, as "*modesta*," from the late Hy. Moores.

†**Vertigo tridentata** Wolf.

Summit Co.! (Pettingell); Cincinnati! (Billups); Troy! (Shepherd); Tuscarawas Co., Columbus, Hamilton (St.). Probably all over the state.

†**Vertigo parvula** Sterki. ×

Summit Co.! (Pettingell).

Vertigo gouldii (Binney, Pupa).

Summit Co.! (Pettingell); Portage and Tuscarawas Co.s (St.). Probably over the state.

COCHLICOPIDÆ

Cionella lubrica (Muller, Helix), *Cochlicopa lubrica*, *Ferussacia subcylindrica* auctt, not Linné.

Over the state.

SUCCINEIDÆ.

Succinea ovalis Say, obliqua Say.

Cincinnati; Medina and Tuscarawas Counties. (rare, St.).

Succinea retusa Lea, *ovalis* Gould.

Over the state, common and variable.

Succinea retusa higginsi Bland.

Sandusky; Put-in Bay; South Bass Id. (Walker). Seems to be a form of *retusa*.

Succinea aurea Lea. ×

Cincinnati. The Cincinnati conchologists have regarded it as a distinct species; others regard it as a form, or variety of *retusa*. Not being familiar with it, I am unable to judge on its merits.

Succinea avara Say.

Over the state, common everywhere.

Succinea avara vermeta Say. ×

Tuscarawas Co. (St.).

It seems that this form is not simply an incidental form of *avara*, being absent at many places where that sp. is common, but more or less prevalent, or common at some stations, and consequently a variety.

BRANCHIOPNEUSTA.

AURICULIDÆ.

Carychium exiguum (Say, Pupa).
Over the state, common and variable.

†**Carychium exile** H. C. Lea.
Over the state; seems to be more on elevated and dry places than *exiguum*, although the two are found associated.

PHYSIDÆ.

Physa ancillaria Say. ×
Summit Co.

†**Physa ancillaria magnalacustris** Walker.
Lake Erie (St.,), t. Walker.

Physa sayi Tappan.
Meyer's Lake, Canton (St.); "Pippin Lake, Portage Co.," from where the species was originally described.

Physa heterostropha Say.
Cincinnati; Cleveland (Allen); Tuscarawas Co.(St.); probably over the state.

Physa gyrina Say.
Over the state, common and very variable.

Physa gyrina elliptica Lea.
Tuscarawas and Medina Counties (St.).

Physa gyrina hildrethiana Lea.
La Grange, Lorain Co. (Walker).

Physa integra Say.
Over the state, preferably in rivers and creeks.

Physa anatina Lea.
Tuscarawas river, and Nimishillen Creek, at Canton (St., t. Walker). May be a variety of *integra*.

†**Physa aplectoides** Sterki. ×
Portage Co.! (Streator); Tuscarawas Co. (St.). Very small and slender; distinct, t. Walker.

Aplexa hypnorum (Linneé, Bulla).
Over the state; at some places out of water, on damp ground, e. g. Tuscarawas Co. (St.).

LYMNÆIDÆ.

Lymnæa stagnalis Linné. Pal.
Kent, Portage Co. (Dean).

†**Lymnæa megasoma** Say. ×
Mahoning River at Alliance (St.)

Lymnæa palustris Müller, *elodes* Say. Pal.
Over the state.

Lymnæa reflexa Say.
Cincinnati; Lockland, Hamilton Co.; Sandusky; La Grange, Lorain Co. (Walker); Cleveland (Allen); Garrettsville.

Lymnæa reflexa kirtlandiana Lea, *exilis* Lea?
Cincinnati; Cuyahoga Co.! (Allen); pond near Congress Lake (Walker); Poland (Walker); Tuscarawas Co. (St.). Regarded as distinct by some conchologists.

Lymnæa columella Say.
Over the state, common.

Lymnæa columella chalybea Gould.
Kent, Portage Co. (Walker).

Lymnæa catascopium Say.
Cincinnati; Lake Erie.

Lymnæa desidiosa Say, *obrussa* Say, t. Baker.
Over the state, common and very variable.

†**Lymnæa desidiosa modicella** Say.
Summit, Stark and Tuscarawas Counties (St.); Hiram, Portage Co. (Streater, Walker); Circleville (Walker). Probably over the state.

Lymnæa humilis Say.
Over the state, common and variable; often out of water, on damp ground. Probably this Lymnæa was found, common, on flower pots, in a greenhouse at Painesville (St.).

Lymnæa humilis var ——, t. Baker (unnamed).
New Philadelphia (St.), with strongly malleate surface and open umbilicus.

†**Lymnæa sterkii** Baker ×
Near Dover, Cuyahoga Co. (St.).

†**Lymnæa parva** Lea.
Summit, Tuscarawas, Franklin, Butler, Auglaize and Defiance Counties (St.). Probably all over the state, but overlooked until recently.

Lymnæa caperta Say.
Cuyahoga Co.! (Allen); Elyria (Walker); common in Portage, Summit and Stark Counties, rare in Tuscarawas Co. (St.). It is listed in none of the Cincinnati catalogues.

Lymnæa haldemani Deshayes, *gracilis* Jay. ×
Sandusky Bay (Walker); cited from Congress Lake.

Planorbis glabratus Say. ×
Cincinnati (Harper and Wetherby).

Planorbis trivolvis Say.
Over the state, common and variable. A specimen of 26 mill. diam. was found in the Nimishillen Creek, at Canton (St.).

Planorbis trivolvis lentus Say.
Cincinanti; Columbus (Walker).
Planorbis campanulatus Say.
Summit, Stark and Tuscarawas Counties (St.).
Planorbis bicarinatus Say.
Over the state, common.
Planorbis dilatatus Gould.
Over the state.
†**Planorbis dilatatus buchanensis** Lea (t. Walker).
New Philadelphia (St.).
†**Planorbis opercularis multilineatus** Vanatta, *opercularis oregonensis* Vanatta. ×
Geauga Lake, east of Cleveland (Allen, t. Vanatta).
Planorbis excacuous Say, *exacutus*.
Over the state.
†**Planorbis rubellus** Sterki, *exacutus var. rubellus*.
Portage Co.! (Streator); Summit, Stark and Tuscarawas Counties (St.).
†**Planorbis umbilicatellus** Cockerell. ×
Summit and Tuscarawas Counties (St.).
Planorbis deflectus Say. ×
Garretssville, Portage Co. (Streator, t. Walker); Tuscarawas Co. (St.). This needs careful revision, since specimens of several other species have been identified as *deflectus*.
Planorbis albus Müller, *hirsutus* Gould. Pal.
Stark and Tuscarawas Counties (St.); probably over the state.
Planorbis parvus Say.
Over the state, common and variable.
†**Planorbis circumlineatus** Tryon.
Summit and Tuscarawas Counties (St.). Some conchologists regard it as a variety of *parvus;* so far as my materials show, it appears to be distinct; at any rate not simply a synonym of *parvus*.
Segmentina armigera (Say, Planorbis).
Over the state, common, preferably in quiet water.

ANCYLIDÆ.

Ancylus diaphanus Haldeman.
Cincinnati; Tuscarawas Co. (St.).
Ancylus fuscus Adams.
Cincinnati; Tuscarawas Co. (St.).
†**Ancylus Kirklandi** Walker.
Summit Co. (Walker); Tuscarawas Co., e. g. common in the Tuscarawas River (St.).
Ancylus parallellus Haldeman. ×
Ohio Canal at Navarre, Stark Co. (St.).

Ancylus tardus Say.
Cincinnati; Tuscarawas Co. (St.). Probably over the state.
Ancylus rivularis Say.
Cincinnati; Cuyahoga River (Allen); Tuscarawas Co. (St.).
†**Ancylus sterkii** Walker, MS.
Tuscarawas River, common; Maumee River (St.). [Shell rather small, slender, with the apex decidedly posterior, near the right margin, and markedly oblique.]
Ancylus shimeki Pilsbry. ×
Tuscarawas Co. (St.).
†**Ancylus pumilus** Sterki.
Tuscarawas River (types), Miami Canal at Hamilton (St.).
†**Gundlachia** ——? **meekiana** Stimpson. ×
Pools near New Philadelphia (St.). Thornburg, Cuyahoga Co., on Nuphar leaves in a slough on the Cuyahoga River (Allen), may be of another species.
†**Gundlachia** ? sp. ×
Tuscarawas Rixer at New Philadelphia (St.). [The same has been seen from Indiana; very small, 2 mill. long, and of a shape quite different from other Gundalchia; may represent a distinct genus.]

PROSOBRANCHIATA.

HELICINIDÆ.

Helicina occulta (Say, Helix), has been cited, but I have seen no specimens.

VIVIPARIDÆ.

Campeloma ponderosum (Say, Paludina).
Ohio River.
Campeloma subsolidum (Anthony, Paludina.)
"Ohio, northern part;" Ohio Canal near Cleveland (Allen).
Campeloma integrum (Say, Paludina).
Over the state, common. Regarded as a variety of *decisum*, by some conchologists.
Campeloma integrum obesum Lewis.
Cincinnati; Miami Canal at Middletown, Ohio Canal at Columbus; Hudson, Summit Co. (Walker).
Campeloma decisum (Say, Lymnæa, Paludina).
Lake Erie and tributaries; Mahoning River, Miami River, Miami Canal (Walker).
Campeloma decisum fecundum Lewis.
Ohio Canal at Columbus, Miami Canal at Cincinnati (Walker)

Campeloma rufum (Haldeman, Paludina).
Canal at Columbus (Call); Summit and Tuscarawas Counties (St.). Sandusky River (St.). Possibly not distinct from *integrum*.

Lioplax subcarinatus (Say, Paludina).
Ohio River; Lake Erie,—tributaries?

STREPOMATIDÆ (Pleuroceridæ).

Pleurocera canaliculatum (Say, Melania).
Ohio River; Tuscarawas River, rare (St.).

Pleurocera elevatum (Say, Melania).
"Ohio."

Pleurocera undulatum (Say, Melania), = *monilijerum* Lea?
Ohio River.

Pleurocera neglectum, Anthony.
Ohio River at Cincinnati; Great Miami River, Ohio Canal at Circleville (Walker).

Pleurocera labiatum Lea (= var. of *neglectum*?).
Cincinnati; Scioto River.

Pleurocera conicum (Say, Melania).
Cincinnati.

Pleurocera subulare (Lea, Melania).
Lake Erie, common.
Other psecies listed from Ohio:
Pleurocera ellipticum Anthony.
Pleurocera pallidum Lea.
Pleurocera simplex Say.
Pleurocera troostii Lea.

Goniobasis livescens (Menke, Melania).
Over the state, common and variable.

Goniobasis livescens depygis Say.
Over the state. Seems inseparably connected with *livescens*, although extreme forms of the two are very different; e. g. in the Tuscarawas River all possible intermediate forms are found together -abundant.

Goniobasis semicarinata (Say, Melania).
Cincinnati; Rocky River (Allen).

Goniobasis vicina Anthony.
"Ohio" (Walker.)

Goniobasis pulchella Anthony.
Cincinnati; Little Miami River (Walker).

Goniobasis gracilior Anthony.
Kent, Portage Co., Springfield Lake (Walker); Ohio Canal and Tuscarawas River at New Philadelphia (St., t. Simpson).

Goniobasis elata Anthony.
Elyria, Vermilion River (Walker).

Goniobasis brevispira Anthony.
Gambier, Knox Co. (Walker).
Goniobasis exilis Haldeman.
Scioto River (Walker).
Goniobasis laqueata Say.
"Ohio" (Walker).
Other species (?) listed from Ohio:
Goniobasis gibbosa Lea.
Goniobasis haldemani Tryon.
Goniobasis infantula Lea.
Goniobasis lithasioides Lea (=var. of *livescens*?).
Goniobasis ohioensis Lea.
Lithasia obovata Say. ×
Ohio River, up to Marietta (Call.)
Angitrema verrucosum Rafinesque.
Ohio River at Cincinnati.
Anculosa costata Lea (=*carinata* Bruguière?).
Ohio River.
Anculosa prærosa Say.
Ohio River.
Anculosa trilineata Say (=*viridis* Lea, syn. or var.?).
Ohio River.

RISSOIDÆ (s. lat., AMNICOLIDÆ etc.).

BITHYNIA TENTACULATA (Linné, Turbo).
Lake Erie! (Streator); Ohio Canal in Stark Co. (St.). Introduced from Europe, and now widely distributed over various states. The central part of the operculum is distinctly spiral, not concentric!
Somatogyrus subglobosus (Say, Paludina), *isogonus* Say.*
Over the state. A form from the Ohio River, at Cincinnati (St.), is rather different and may represent a variety.
Somatogyrus integer (Say, Melania).
Over the state, common.
Pomatiopsis lapidaria (Say, Cyclostoma).
Over the state, common; often far away from water.
Pomatiopsis cincinnatiensis (Anthony, Cyclostoma).
Cincinnati; Columbus.
Amnicola limosa (Say, Paludina).
Over the state, common and variable.
Amnicola limosa porata Say.
Meyer's Lake at Canton (St.).
Amnicola limosa parva Lea.
New Philadelphia.

*Some conchologists, e. g. F. C. Baker, regard S. isogonus as distinct from subglobosus.

†**Amnicola lustrica** Pilsbry.
Cuyahoga River; Springfield Lake; Ohio Canal at New Philadelphia (St.). Probably over the state.

Amnicola cincinnatiensis (Lea, Cyclostoma).
Over the state, common in rivers and creeks.

†**Amnicola walkeri** Pilsbry.
Geauga Lake, east of Cleveland! (Allen).

†**Amnicola pilsbryi** Walker. ×
Meyer's Lake at Canton, Ohio Canal at New Philadelphia (St.).

†**Amnicola nickliniana** Lea. ×
Springfield Lake.

†**Amnicola emarginata** Küster, *obtusa* Lea.
Lake Erie and tributaries; Ohio canal at Navarre and New Philadelphia (St.).

†**Amnicola** —— sp., undescribed, t. Walker. ×
Lake Erie and Ohio Canal in Stark Co. (St.). [The shell is small and very slender, very different from all other Ohio Amnicolæ.]

†**Lyogyrus pupoides** (Gould, Valvata). ×
Springfield Lake (St.).

VALVATIDÆ.

Valvata tricarinata Say.
Over the state, common in all kinds of waters. Forms with one or two keels more or less obsolete are found with typical specimens.

Valvata tricarinata simplex Gould.
Lake Erie at Sandusky (Walker).
Valvata bicarinata Lea. ×
I have seen no specimens of the typical form from Ohio.

Valvata bicarinata depressa Walker.
Lake Erie at Sandusky and Vermilion (St.).

Valvata sincera Say. ×
"Ohio."

†**Valvata lewisi** Currier, *striata* Lewis. ×
Springfield Lake (St.).

PELECYPODA.

UNIONIDÆ.

Truncilla triquetra Rafinesque.
Both drainages, Lake Erie.

Truncilla sulcata (Lea, Unio), *U. ridibundus* Say = female. ×
Ohio River.

Truncilla sulcata delicata Simpson. ×
Lake Erie drainage—?

Truncilla foliata (Hildreth, Unio). ×
Ohio River, Cincinnati.

Truncilla personata (Say, Unio), *U. pileus* Lea. ×
Ohio River — and tributaries?

Trincilla perplexa (Lea, Unio).
Ohio River; Scioto River.

Truncilla perplexa rangiana Lea.
Ohio, Scioto, Tuscarawas, Mahoning Rivers.

Truncilla perplexa cincinnatiensis Lea.
Ohio River at Cincinnati.

Micromya fabials (Lea, Unio), *U. lapillus* Say.
Both drainages; in nearly all rivers.

Lampsilis ventricosa (Barnes, Unio), *U. subovatus* Lea is the male form, *occidens* Lea, the female.
Over the state, decidedly variable; common in Lake Erie, very small to medium sized, of somewhat peculiar shape and appearance, representing a variety.

Lampsilis capax (Green, Unio). ×
Ohio River.

Lampsilis ovata (Say, Unio).
Ohio River; Great Miami River (Walker).

Lampsilis multiradiata (Lea, Unio).
Both drainages, over the state.

Lampsilis luteola (Lamarck, Unio).
Over the state, common and variable; common in Lake Erie and decidedly variable, some forms being very small.

Lampsilis luteola rosacea DeKay.
Lake Erie.

Lampsilis radiata (Gmelin, Mya). ×
St. Lawrence drainage; Portage River! (Oberlin collection).

Lampsilis ligamentina (Lamarck, Unio).
Both drainages, generally common; abundant e. g. in the Tuscarawas River, large and much inflated. Not in the Mahoning River, t. Dean ——?

Lampsilis ligamentina gibbus Simpson.
Ohio River.

Lampsilis orbiculata (Hildreth, Unio). ×
Ohio River and probably some of its tributaries.
Lampsilis higginsii (Lea, Unio) is considered a variety of orbiculata, by some conchologists; I have not seen it from Ohio. ×

Lampsilis anodontoides (Lea, Unio).
Ohio River; Great Miami River (large).

†**Lampsilis fallaciosa** (Smith) Simpson. ×
Ohio River at Cincinnati (St.), and probably at other places.

Lampsilis recta (Lamarck, Unio).
Both drainages; Lake Erie (small); not in the Mahoning River, t. Dean.

Lampsilis nasuta (Say, Unio).
St. Lawrence drainage, Lake Erie; probably also in the Ohio drainage, at least along the divide. In Muzzy Pond, near Rootstown, Portage Co., specimens were found (St.), to 118 mill. long, the largest of any known, t. Simpson.

Lampsilis subrostrata (Say, Unio). ×
"Ohio;" I have seen no sepcimens (although it is doubtless at least in the north-western part of the state).

Lampsilis iris (Lea, Unio). *L. Novi Eboraci* Lea = syn. or var.?
Both drainages; Lake Erie (St.).

Lampsilis ellipsiformis (Conrad, Unio), *U. spatulatus* Lea.
Ohio River.

Lampsilis glans (Lea, Unio).
Both drainages; Ohio River; Maumee and Auglaize Rivers (St.); not in the Tuscarawas River.

Lampsilis parva (Barnes, Unio).
Over the state (both drainages, Lake Erie); rivers, creeks and canals.

Plagiola securis (Lea, Unio); *Obovaria lineolata* Rafinesque?)
Ohio River.

Plagiola elegans (Lea, Unio).
Both drainages; Ohio and Little Miami Rivers; Maumee and Tiffin Rivers (St.); Lake Erie (Prof. Moseley, St.); not in the Tuscarawas River.

Plagiola donaciformis (Lea, Unio), *U. zigzag* Lea.
Both drainages, Lake Erie.

Obovaria circulus (Lea, Unio).
Over the state. So far as evidence goes, U. *lens* Lea is the female form, *circulus* the male, the latter generally much the larger.*

* These male and female forms are much more different from each other in shape, than those of *ellipsis*, and of *retusa*.

Obovaria circulus leibei (Lea, *U. leibei*).
Lake Erie.
"*Obovaria lens var. depygis*, Conrad."
"Ohio," in check list, is unknown to me.

Obovaria ellipsis (Lea, Unio).
Ohio River, common.

Obovaria retusa (Lamarck, Unio).
Ohio River.

Cyprogenia irrorata (Lea, Unio).
Ohio drainage: Ohio, Great Miami, Scioto, Tuscarawas, Mahoning Rivers.

Obliquaria reflexa Rafinesque, *U. cornutus* Barnes.
Both drainages, but not everywhere; Ohio, Scioto, and Mahoning Rivers, not in the Tuscarawas; Lake Erie (St.)

Pytchobranchus phaseolus (Hildreth, Unio).
Both drainages, Lake Erie.

Tritogonia tuberculata (Barnes, Unio).
Ohio drainage, generally.

Quadrula plicata (Say, Unio).
Ohio and Little Miami Rivers.

Quadrula plicata hippopœa Lea. ×
Lake Erie.

Quadrula undulata (Barnes, Unio).
Both drainages, generally common.

Quadrula heros (Say, Unio), *U. mulliplicatus* Lea.
Ohio River, Little Miami River.

Quadrula cylindrica (Say, Unio).
Ohio River and most or all of its tributaries. Some specimens have none of the nodose projections, e. g. from the Tuscarawas River.

Quadrula metanevra (Rafinesque, Obliquaria).
Ohio River, common.

Quadrula metanevra wardii Lea.
Ohio River; Sugar Creek, tributary to the Tuscarawas River (St.), but not a trace of it was found in the River, nor of typical *metanevra* in the river or creek.

Quadrula tuberculata (Rafinesque, Obliquaria).
Ohio River; Little Miami River; Tuscarawas River (St.), large and heavy, often with regular transverse undulations above the posterior umbonal ridge; Maumee and Tiffin Rivers, near Defiance (St.).

Quadrula granifera (Lea, Unio).
Ohio River; tributaries?

Quadrula lachrymosa (Lea, Unio), *U. asperrimus* Lea.
Both drainages, decidedly variable. The Lake Erie form is little inflated and has few tubercles; a simliar form in the Ohio Canal near Cleveland (Allen); not in the Tuscarawas River.

Quadrula fragosa (Conrad, Unio).

Ohio River at Cincinnati, seems rare; Scioto River.

Quadrula pustulosa (Lea, Unio).

Ohio River and most of its tributaries; decidedly variable in regard to size, shape, and surface sculpture: from smooth to covered with tubercles all over.—A form from the lake drainage, e. g. the Tiffin River (St.), is considerably different from the high, *cooperiana*-like form of the Ohio River and tributaries: more elongate, "quadrate," approaching *lachrymosa* in outlines; the same is known from Michigan, Indiana (Kankakee River, St.), Illinois and Iowa (t. Walker), and seems to represent a variety, may be = *schoolcraftensis* Lea. ×

Quadrula pustulosa kleineriana Lea.

"Entire Mississippi drainage; Lake Erie," t. Simpson.

Quadrula cooperiana (Lea, Unio).

Ohio River; tributaries?

Quadrula pustulata (Lea, Unio).

Ohio River at Cincinnati; Mahoning River (Dean, Streator); cited from the Tuscarawas River, by Dean; I was not able to find a trace of it and suppose some form of *pustulosa* was mistaken for it.

Quadrula subrotunda (Lea, Unio).

Ohio River; Scioto River; Tuscarawas River, a form with very heavy shell, the beaks quite anterior, the shape of the mussel being much like that of *Pl. clava*, the lines of growth coarse and markedly regular; a very small, slight form seems to be in Lake Erie.

Quadrula kirtlandiana (Lea, Unio).

Ohio River and some tributaries: Mahoning River, from which Lea had his types; Tuscarawas River, common and very variable, from the *subrotunda* form to much elongate, and some specimens much resembling (old) *æsopus*; one large and heavy specimen has numerous small muscle scars scattered all over the inner surface within the pallial line. It seems that *kirtlandiana* is doubtfully distinct from *subrotunda*, and half grown specimens agree with Lea's description and figure of the last named species.

Quadrula æsopus (Green, Unio).

Ohio River and tributaries, Scioto, Mahoning, Tuscarawas.

NOTE.—*æsopus* certainly ranges nearer the Quadrula of this group than with *Pleurobema*; it closely resembles *kirtlandiana* in features of the shell and soft parts. [Simpson himself was in doubt where to range this and the following species.]

Quadrula cicatricosa (Say, Unio), *varicosa* Lea.
Ohio River.
Quadrula pilaris (Lea, Unio).
Ohio River at Cincinnati.
Quadrula ebena (Lea, Unio).
Ohio River.
Quadrula pyramidata (Lea, Unio).
Ohio River and tributaries; large and heavy specimens in the Tuscarawas River.
Quadrula plena (Lea, Unio).
Ohio River.
Quadrula obliqua (Lamarck, Unio).
Ohio River, and some tributaries.
Quadrula solida (Lea, Unio).
Ohio River; Scioto River.
These last four species are closely related to each other, and should be revised.
Quadrula trigona (Lea, Unio).
Both drainages, not common.
Quadrula rubiginosa (Lea, Unio).
Over the state, generally common.—In some specimens from various rivers (Ohio, Tuscarawas, Tiffin), where the gonad was for the most part a testis ("males"), a few acini were found to be ovarian, containing ova.
Quadrula coccinea (Conrad, Unio).
Over the state, variable. In the Tuscarawas River is a form higher than the "typical" one, resembling *kirtlandiana* in shape, but with the soft parts quite different, and usually with a few undulations in the middle of the disks; it may represent a variety.
Quadrula coccinea paupercula Simpson.
St. Lawrence drainage; probably in the state.
Pleurobema clava (Lamarck, Unio).
Both drainages; e. g. in the Maumee; not in the Cuyahoga River, t. Dean.
Pleurobema bournianum (Lea, Unio). ×
Scioto River; Ohio River at Cincinnati (Byrnes).
Unio crassidens Lamarck.
Ohio River, common; Scioto River.
Unio gibbosus Barnes.
Over the state, common and variable in regard to size, shape and color of the nacre: dark purple to salmon to white (the latter = arctior Lea); a very small form, with the beaks more anterior, is in Lake Erie.
Unio tetralasmus camptodon Say.
Ohio River at Cincinnati; Great and Little Miami Rivers.

Unio tetralasmus sayi Ward.
Scioto River, e. g. at Circleville (type locality).

Unio complanatus (Solander) Dillwyn. ×
St. Lawrence drainage; (among numerous Unionidæ collected from Lake Erie, at Sandusky and Vermilion, at various times, no specimens were seen, St.). One was found in a race on the Tuscarawas River, at New Philadelphia; evidently the mussels have migrated from Lake Erie, over the divide, probably by way of the Ohio canal.

Margaritana monodonta (Say, Unio).
Ohio River at Cincinnati (still!), but not common.

Proptera alata (Say Unio).
Both drainages; large e. g. in the Great Miami River; common in Lake Erie, rather small.

Proptera lævissima (Lea, Symphynota), *U. ohioensis* Say.
Ohio River, and tributaries—?

Proptera gracilis (Barnes, Unio).
Both drainages; common in Lake Erie.

Proptera leptodon (Rafinesque, Unio), *Symphynota tenuissima* Lea.
Both drainages, not common; a specimen from "Cleveland" is in the Oberlin collection.
None of the four Proptera species have been found in the Tuscarawas River.

Symphynota compressa Lea (known as *Unio pressus* Lea).
Over the state.

Symphynota costata (Rafinesque, Alasmidonta), *Al. rugosa* Barnes.
Over the state; the Lake Erie form is quite small and of somewhat different shape.

Symphynota complanata (Barnes, Alasmodonta).
Over the state, in rivers, creeks, canals, lakes.

Alasmidonta marginata Say, *Al. marginata* var. *truncata* B. H. Wright, *Al. truncata* Simpson, Synopsis.
Over the state, both drainages; a small, slight form in Lake Erie.
Alasmidonta ——— (the eastern, or Atlantic drainage form, or species): Lake Erie and tributaries (?). ×

Alasmidonta calceolus (Lea, Unio), *Margaritana deltoidea* Lea.
Over the state, common.

Arcidens confragosus (Say, Alasmodonta.)
Ohio River at Cincinnati.

Lastena lata (Rafinesque, Anodonta—Lastena), *U. dehiscens* Say.
Ohio drainage, not common.

Hemilastena ambigua (Say, Alasmodonta), *U. hildrethianus* Lea.
Ohio drainage; Lake Erie (St.).

Strophitus edentulus (Lea, Anodonta).
Over the state, common and very variable. A very small, slight form, much inflated, in Lake Erie, seems to represent a variety.

Strophitus edentulus pavonius Lea.
Over the state; very small e. g. in a run in Portage Co. (St.–t. Simpson); very large in the Mahoning River, at Alliance (St.); Tuscarawas River, with the common form of *edentulus*, and merging into it (St.).

Anodontoides ferussacianus (Lea, Anodonta).
Over the state.

Anodontoides ferussacianus subcylindraceus Lea.
Pymatuning River in Ashtabula County, Grand River, Silver Creek in Portage Co.; Olentangy River at Delaware (Walker); Burton City, Wayne Co. (St.).

Anodontoides ferussacianus modestus Lea.
St. Lawrence drainage, Lake Erie.

Anodonta grandis Say.
Over the state, very variable.

Anodonta grandis plana Lea.
Scioto River, Columbus; Miami Canal; Ohio Canal at Canal Winchester (Walker); Sandusky River (St.).

Anodonta grandis decora Lea.
Mahoning River; Silas Creek, Portage Co.; Columbus; Little Miami River; Miami Canal; Little Stillwater Creek near Denison (St.).

Anodonta grandis salmonia Lea.
Tuscarawas River and Ohio Canal (St.); Upper Cuyahoga River, at Hiram (Streator, St.); Pymatuning River, Ashtabula Co. (Walker); Silver Lake, Clark Co.; Olentangy River (Walker).

Anodonta grandis benedictensis Lea.
St. Lawrence drainage; Rocky River (Allen); Lake Erie (St.).

Anodonta grandis footiana Lea.
St. Lawrence drainage; Springfield Lake, Summit Co. (St.); cited from Cincinnati.

For citing localities for these varieties, and identifying specimens, I am largely indebted to Mr. Bryant Walker.

Anodonta marginata Say. ×
St. Lawrence drainage; Hudson, Summit Co.

Anodonta imbecillis Say.

Over the state, common, in all kinds of waters. The animal is hermaphrodite.

Of the following three species, of the St. Lawrence drainage, I have seen no specimens:

Anodonta implicata Say. ×

Anodonta pepiniana Lea. ×

Anodonta kennicottii Lea. ×

SPHÆRIIDÆ.

Sphærium simile (Say, Cyclas), *Cyclas sulcata* Lamarck, *Sphærium sulcatum* Prime, Mon. Corb.

Over the state, in various kinds of waters.

Sphærium striatinum (Lamarck, Cyclas).

Over the state; very variable in size, shape, striation, color, etc. Some Sphæria provisorily ranged under *striatinum*, may prove distinct species, e. g. a form from Geauga Co. (Streator), seems identical with a Potomac River Sphærium.

Sphærium solidulum (Prime, Cyclas).

Over the state, variable. The typical form, as it seems, especially in the western part of the state.

Sphærium stamineum (Conrad, Cyclas).

Over the state, very variable, and there are, probably, a number of varieties.

†**Sphærium flavum** (Prime, Cyclas). ×

Lake Erie (St.), and probably some of its tributaries.

Sphærium fabale (Prime, Cyclas).

Hamilton Co. (Walker; the species is in none of the Cincinnati lists); Portage Co. (Streator, St,); Summit and Stark Counties (St.). Probably over most of the state.

Sphærium rhomboideum (Say, Cyclas).

Portage Co.! (Streator); Summit, Stark and Tuscarawas Counties (St.); Columbus; Cincinnati.

Sphærium occidentale Prime.

Over the state, common in quiet waters, ponds, ditches, swamps.

Sphærium occidentale amphibium Sterki.

Living on damp ground, under dead leaves, etc.; smaller than the typical form, and of somewhat different shape and appearance. Garrettsville! (Streator); Tuscarawas Co., various places (St.).

Musculium transversum (Say, Cyclas), *Sphærium*, *Calyculina transversa*.

Over the state, common in all kinds of waters, even in rivers with rocky bottom, e. g. the Sandusky at Tiffin (St.).

Musculium contractum? (Prime, Sphærium), was seen among a mixed lot supposed to be from Ohio (Cincinnati museum).

Musculium partumeium (Say, Cyclas), *Sphærium*, *Calyculina part.*

Over the state, in quiet waters; variable.

A form: more rounded in outlines, more regularly inflated, with broad, low beaks, smaller than typical *partumeia*, seems to represent a variety. Garrettsville! (Streator); New Philadelphia (St.); a simliar form from Mentor (Allen).

†**Musculium jayense** (Prime, Cyclas), *Sphærium jayanum* Prime, Mon. Corb.

Cincinnati; probably over western Ohio.

†**Musculium truncatum** (Linsley, Cyclas), *Sphærium*, *Calyculina tr.*

Portage Co. (Streator, St.); Geauga and Cuyahoga Counties! (Allen); Stark and Tuscarawas Counties (St.); probably all over the state.

Musculium securis (Prime, Cyclas), *Sphærium*, *Calyculina securis.*

Over the state, common in ponds, pools, ditches, variable. Several forms seen are considerably different and may represent varieties or even distinct species.

Musculium sphæricum (Anthony, Cyclas), described from the Black River, Lorain Co., is beliveed to be a form of securis; I have seen no authentic specimens.

†**Musculium** sp. — ×

Geauga Lake, east of Cleveland (Allen). [Quite distinct from all other species, and probably underscribed; the same has been seen from Michigan, Indiana and Illinois].

Pisidium virginicum (Gmelin, Tellina, *Cyclas dubia* Say.

Cuyahoga River and Breakneck Creek, Portage Co., Nimishillen Creek, Stark Co.; Auglaize River (all: St.); Cincinnati.

Pisidium compressum Prime. (The "river form," regarded as typical).

Over the state, common in rivers and creeks, rarely in springs.

Pisidium compressum lævigatum Sterki.

Springfield Lake, Meyer's Lake (St.); in quiet waters.

Pisidum compressum opacum Sterki.

Sloughs on the Tuscarawas River (St.).

†**Pisidium kirklandi** Sterki. ×

Auglaize River at Wapakoneta (St.).

†**Pisidium cruciatum** Sterki. ×

Tuscarawas River, Miami Canal at Hamilton (St.).

†**Pisidium fallax** Sterki.

Rivers, creeks and races in Portage, Summit, Stark and Tuscarawas Counties; Miami Canal at Hamilton; Sandusky and Maumee Rivers (all: St.).

Pisidium fallax mite Sterki.
Nimishillen Creek at Canton (St.).

†**Pisidium punctatum** Sterki.
Portage, Summit, Stark and Tuscarawas Counties, various places; Ohio River at Cincinnati; Miami Canal at Hamilton (all: St.); doubtless all over the state, in running water.

Pisidium variabile Prime.
Summit, Stark and Tuscarawas Counties (St.). Probably all over the state.

†**Pisidium affine** Sterki.
Springfield Lake, Meyer's Lake (St.).

†**Pisidium sargenti** Sterki.
Portage, Stark and Tuscarawas Counties, various places (St.); Cuyahoga Co.! (Allen).

†**Pisidium noveboracense** Prime.
Summit, Stark. Tuscarawas, Erie Counties (St.); Geauga Co.! (Streator); Puritas springs, Cuyahoga Co.! not typical (Allen). Decidedly variable.

Pisidium noveboracense elevatum Sterki.
Sandusky (St.).

Pisidium noveboracense quadrulum Sterki, and form *proclive* St.
Tuscarawas Co., various places (St.).

†**Pisidium succineum** Sterki.
Tuscarawas Co., various places (St.).

†**Pisidium walkeri** Sterki.
Portage, Stark, Tuscarawas Counties (St.); Hamilton Co.! (Cincinnati Museum).

†**Pisidium mainense** Sterki.
Navarre, Stark Co. (St.).

†**Pisidium neglectum Sterki.**
Krumroy, Summit Co., Canal Dover, Tuscarawas Co. (St.); Dover, Cuyahoga Co.! (Allen).

†**Pisidium trapezoideum** Sterki.
Summit, Tuscarawas and Auglaize Counties (St.).

†**Pisidium roperi** Sterki.
Hudson, Summit Co.! (Pettingell).

†**Pisidium streatori** Sterki.
Garrettsville! (Streator); Justus, Stark Co. (St.); Columbus! (Moores); Geauga Lake, east of Cleveland! (Allen).

Pisidium abitum Haldeman.
Over the state; very variable. Under this name, most of our Pisidia, even of widely different groups, are listed and in collections. All of them should be revised.

†**Pisidium strengii** Sterki.
Garrettsville (St.); Dover, Cuyahoga Co.! (Allen).

†**Pisidium politum** Sterki.
Tuscarawas Co., various places (St.).

†**Pisidium politum decorum** Sterki.
Dover, Cuyahoga Co.! (Allen); Meyer's Lake, Canton (St.); Tuscarawas Co., various places (St.).

†**Pisidium splendidulum** Sterki.
Cuyahoga River at Hiram, Sandusky, various places in Tuscarawas Co. (St.); decidedly variable.

†**Pisidium rotundatum** Prime.
Garrettsville! (Streator); Justus, Stark Co. (St.).

†**Pisidium ohioense** Sterki.
Garrettsville! (Streator).

†**Pisidium medianum** Sterki.
Springfield Lake (St.); probably at least over the northern part of Ohio.

†**Pisidium pauperculum** Sterki.
Springfield Lake (St.).

Pisidium pauperculum crystalense Sterki.
Cuyahoga River, Nimishillen Creek at Canton (St.).

Note: All of these Pisidia are widely distributed, outside of Ohio, and most of them will be found over the state.

SUPPLEMENTARY LISTS.

In the following list, some Ohio species are enumerated, which were not known when earlier lists and descriptive works were published, or misunderstood. Specimens are probably mixed in among other similar forms, and all such lots in collections should be looked over carefully.

Gastrodonta collisella Pilsbry may be among *gularis*, and *ligera*; (from the latter it is at once distinguished by its lamellæ).

Zonitoides læviusculus Sterki, among *minusculus*.

Hyalina wheatleyi Bland, and others, among *H. radiatula*, *Zonitoides arboreus*, etc.

Hyalina lamellidens Pilsbry, among *multidentata*.

Euconulus chersinus Say, among *fulvus*, and vice versa!

Vallonia excentrica Sterki, among *pulchella*.

Vallonia parvula Sterki, among *costata*, and all of these species among "*pulchella*."

Strobilops affinis Pilsbry and *virgo* Pilsbry, among *labyrinthica*.

Bifidaria procera Gould, as *Pupa rupicola* Say, and among *Vertigo*.

Bifidaria holzingeri Sterki, among *pentodon*.

Bifidaria pentodon Say, among *tappaniana*; notice the change of names.

Vertigo tridentata Wolf, *pygmæa*-Drap., *morsei* Sterki, among *ovata*.

Vertigo parvula Sterki, *bollesiana* Morse, among *milium*, *gouldii*, and others.

Carychium exile H. C. Lea, among *exiguum*, and both species among small Pupidæ.

Physa aplectoides Sterki, among *gyrina* etc., and *Aplexa hypnorum*.

Lymnæa parva Lea, *sterkii* Baker, among any of the smaller, and young, Lymnææ.

Planorbis umbilicatellus Cockerell, among *parvus*.

Planorbis opercularis multilineatus Vanatta, among *dilatatus*.

Planorbis rubellus Sterki, among *exacuous*.

Gundlachia species among *Ancylus*!

Ancylus, various species, among any in collections.

Amnicola pilsbryi Walker, and other small forms, among *limosa*, *cincinnatiensis*, etc.

Valvata bicarinata Lea, among *tricarinata*.

Lampsilis fallaciosa Simpson, among *anodontoides*.

Sphærium flavum Prime, and probably others, among *striatinum*.

Musculium, various species, among any in collections.

Pisidium, many species, among any lots on hand, especially "*abditum* Hald."

A Few Species Not Recorded from Ohio, Probably or Possibly to be Found.

Hyalina rhoadsi Pilsbry; in various states.

Hyalina capsella Gould; Kentucky and southern Indiana.

Philomycus (Pallifera) hemphilli W. G. Binney; Kentucky and northern Michigan.

Vallonia perspectiva Sterki; Indiana, close to the Ohio line.

Vertigo bollesiana Morse; New York, Michigan, etc.

Planorbis crista Linné (v. **cristatus** Drap.); several states.

Ancylus elatior Haldeman; Kentucky.

Vivipara sp.; Indiana, etc.

Lampsilis fatua Lea; Beaver River, Pa.

Lampsilis obscura Lea; Lower Ohio River.

Sphærium walkeri Sterki; Indiana, Michigan, Canada.

Pisidium, numerous species known from Indiana, Michigan, etc.

FOSSILS.

Fossil land and fresh-water mollusca have been collected only at few places in Ohio. Younger and older deposits should be carefully searched for them.

In the "preglacial deposits" near Middletown, first bottoms on the Miami River, examples of the following species have been collected.*

Helix elevata Say.
" **concava** Say.
" **alternata** Say.
" **hirsuta** Say.
" **monodon** Rackett.
" **thyroides.**
" **profunda** Say.
Helix solitaria.
" **tridentata.**
Goniobasis depygis.
Planorbis trivolvis.
Amnicola lapidaria Say.
Succinea sp.

In the "Old Forest Bed" of the Ohio River, a layer of yellow clay, Mr. A. C. Billups† has collected the following species:

Vallonia pulchella Müller. Traces.

Polygyra tridentata Say. Scarce.
" " **var.** Region of the mouth much depressed. and very deeply striated.
" **inflecta** Say. Few.
" **profunda** Say. Very large, heavy.
" **albolabris** Say. Very scarce.
" **exoleta** Binney. Very common, but not found alive within twenty miles of this deposit.
" **multilineata** Say. Most common. (Same note as of preceding.)
" **palliata** Say.
" **appressa** Say.
" **elevata** Say. Fairly common.
" **pennsylvanica** Green. Common; rare in the vicinity alive.
" **thyroides** Say. Rather common.
" **mitchelliana** Lea. Common, rare alive.
" **stenotrema** Fer.
" **monodon** Rackett. Very rare.

Pupoides marginatus Say.
Bifidaria contracta Say.
" **armifera** Say. Common.
Cochlicopa lubrica Müller.
Circinaria concava Say. Common.
Vitrea hammonis Ström. Several examples.

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* See Geological Survey of Ohio, Vol. III, Warren and Butler Counties

† The Nautilus XVI, p. 50. (Sept., 1902).

Gastrodonta ligera Say. Common.
Pyramidula alternata Say. Very large.
" **solitaria** Say. Plentiful, large.
" **perspectiva** Say. Rare.
" **striatella** Anth. Rare.
Helicodiscus lineatus Say. Rare.
Succinea sp. Very large.
Pomatiopsis lapidaria. Common.

Four miles east of Defiance, in a sandy deposit (loess?), forming the north bank of the Maumee River, at the state dam, I have collected ,Oct. 27, 1906, the following 27 species:*

Gastrodonta ligera Say.
Zonitoides arboreus Say.
" **læviusculus** Sterki.
Hyalina radiatula Alder.
" **indentata** Say.
Circinaria concava Say.
Polygyra profunda Say. Common.
" **multilineata** Say. Common.
" **albolabris** Say.
" **zaleta** Binney.
" **clausa** Say.
" **mitchelliana** Lea.
" **thyroides** Say.
" **elevata** Say. The commonest of the Polygyra.
" **fraudulenta** Pilsbry.
" **inflecta** Say.
" **hirsuta** Say.
Patula solitaria Say, common.
" **alternata** Say.
" **striatella** Anthony.
Bifidaria contracta Say.
Succinea avara Say.
" **retusa** Lea, or near.
Physa sp. (one specimen, broken to fragments).
Pomatiopsis lapidaria Say. Abundant.
Pisidium compressum Prime.
" **fallax** Sterki.

Of Unionidæ, fragments were common, but all too small to be identified.

* Since I had chance to collect there only once, and during a short time, notes with respect to frequency and scarcity are insufficient. There is no doubt that many other species will be found in that deposit, which probably has a wide extension.

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Snyder, F. D., *Zoology, Ethnology*..........................Ashtabula
Soule, William ....1804 S. Union Ave., Alliance

Stair, L. D. .... 92 Wadena St., Cleveland
Stauffer, Clinton R., *Geology* .... 390 King Ave., Columbus
Sterki, Victor, *Conchology, Botany* .... New Philadelphia
Stickney, M. E., *Botany* .... Granville
Stockberger, W. W., *Botany* ...... Dept. Agriculture, Washington, D. C.
Stoner, Minnie A., *Domestic Science* .... O. S. U., Columbus
Surface, F. M., *Zoology, Botany* .... Eaton
Sweezey, Otto H. .... 1019 Olaho Lane, Honolulu, Hawaii
Taylor, Albert .... Bedford
Thompson, Mrs. King .... 167 W. Tenth Ave., Columbus
Tillman, Miss Opal I., *Botany* .... Tucson, Arizona
Tight, W. G., *Geology* .... Albuquerque, N. M.
Todd, Joseph H., *Geology, Archaeology* .... Christmas Knoll, Wooster
Todd, Otto K. .... Vermillion
True, H. L. .... McConnelsville
Tyler, F. J., *Botany* ...... Bureau of Plant Industry, Washington, D. C.
Tyler, Harriet Burr, *Botany* ..
..Bureau of Plant Industry, Washington, D. C.
Van Hook, J. M., *Plant Pathology* .... Experiment Station, Wooster
Waite, F. C. .... Western Reserve University, Cleveland
Walton, L. B., *Biology* .... Gambier
Webb, R. J., *Botany* .... Garrettsville
Webster, F. M., *Entomology* .. U. S. Dept. Agriculture, Washington, D. C.
Wells, Jessie, *Botany* .... McConnelsville
Werthner, William, *Botany* .... Steele High School, Dayton
Westgate, Lewis G., *Geology* .... Delaware
Wetzstein, A., *Botany* .... 309 W. 141st St. ,New York, N. Y.
Whitney, W. C., *Biology, Geology* .... Westerville
Wieman, Harry L., *Biology* .... Univ. of Cincinnati, Cincinnati
Williams, Stephen R., *Biology* .... Miami University, Oxford
Williamson, E. Bruce, *Ichthiology, Ornithology* .... Bluffton, Ind.
Wolfe, E. E., *Botany* .... Marietta College, Marietta
Wright, G. Frederick, *Geology* .... Oberlin
Yanney, Lula Hock .... Alliance
York, Harlan H., *Botany* .... Univ. of Texas, Austin, Texas
Young, R. A., *Botany* ..
..Div. Seed and Plant Introduction Washington, D. C.

Report of the Fifteenth Annual Meeting

of the

Ohio State Academy of Science

ANNUAL MEETING

The sixteenth annual meeting of the Academy was held in Columbus on November 29 and 30, and December 1, 1906, the First Vice President of the Society, Mr. Charles Dury, of Cincinnati, presiding, owing to the unavoidable absence of Prof. E. L. Rice, the President.

On Thursday evening an informal reception was held at the residence of Prof. and Mrs. Herbert Osborn, 485 King avenue.

Thursday morning at 9:45 the meeting was called to order by the Vice President in room 46 of Physics Hall, of the State University. A committee on membership consisting of Prof. Hine, Prof. Lynds Jones and the secretary, together with a committee on resolutions consisting of Prof. Guyer, Prof. Stickney, and Prof. Waite, was appointed by the chair. The report of the secretary was presented and accepted. The report of the treasurer, Prof. J. S. Hine, was presented and after reference to an auditing committee consisting of Messrs. Burgess and Adams was accepted. The following is a brief summary:

Report of the Treasurer for the Year 1906.

For the year since our last annual meeting the receipts, including balance from last year, have amounted to \$209.05, and the expenditures to \$207.75, leaving a cash balance of \$1.30.

RECEIPTS.

Balance from last year	\$0 47	
Membership dues	188 00	
From sale of publications	20 58	
Total		\$209 05

DISBURSEMENTS.

For printing the annual report................	$60 00
183 subscriptions to the Ohio Naturalist.....	91 50
Miscellaneous	56 25
Balance December 1, 1906....................	1 30
Total	$209 05

Respectfully submitted,

JAMES S. HINE.

Prof. Lazenby, chairman of the trustees, presented the following report, which was approved and accepted. Mention was made of the continued interest in the Society manifested by Mr. Emerson McMillin in his gift of $250.

REPORT OF THE BOARD OF TRUSTEES.

The annual appropriations from the "Emerson McMillin Research Fund" have been continued the past year, and the total amount assigned for research has been somewhat larger than usual.

The Board of Trustees feel that excellent work has been done by the Academy through the aid of this fund, and express the hope that this work will be continued with unabated energy and enthusiasm until the "Natural History of Ohio" is more complete and up-to-date than that of any other state.

We again have the satisfaction of acknowledging the contribution of $250 by Mr. Emerson McMillin for the year 1907. We present the following financial statement for the past year.

WILLIAM R. LAZENBY,
C. J. HERRICK.

FINANCIAL STATEMENT OF THE EMERSON McMILLIN RESEARCH FUND, OHIO ACADEMY OF SCIENCE.

1905–1906.

RECEIPTS.

1905.	Balance on hand Nov. 20, 1905......................	$216 48
	Check from Emerson McMillin, Nov. 26, 1905.........	250 00
		$466 48

EXPENDITURES.

1906.			
Mar.	13.	Spahr & Glenn, printing 500 copies "Willows of Ohio"	$67 00
Sept.	20.	Dr. V. Sterki, research work on Ohio Mollusca	11 45
	24.	Prof. W. B. Herms, research work in Zoology	40 00
	25.	Jesse E. Hyde, research work in Geology	21 40
Oct.	8.	Prof. F. Carney, research work in Geology	40 00
	8.	Dr. V. Sterki, research work on Ohio Mollusca	15 75
Nov.	3.	Dr. V. Sterki, research, Mollusca	10 05
	19.	Prof. Chas. Brookover, special study of neurenes in dog-fish	35 00
			$240 75

Balance on hand, $225.73.

Of this balance $53.60 have been appropriated, but not expended, leaving unappropriated balance of $170.13.

William R. Lazenby,
for Trustees.

Nov. 30, 1906. We have examined this report and have found it correct.

A. F. Burgess,
Chas. C. Adams,
Auditing Committee.

The report of the publication committee was presented, approved and accepted.

Prof. Osborn, chairman of the committee on the Natural History Survey, presented a report. It was moved and seconded that the report be accepted, the committee be enlarged, and that an appropriation not to exceed $50 be made to meet the expenses incurred by the committee in the efforts to establish the survey. The librarian presented a report which was approved and accepted.

LIBRARIAN'S REPORT.

I herewith take pleasure in presenting to the Treasurer of the Ohio State Academy of Science my report upon the sales of the publications of the Academy:

Amount on hand November 29th, 1905	$2 27
Cash received from Annual Reports and Special Papers	18 09
Total	$20 36

REPORT OF EXPENDITURES FOR THE YEAR 1906.

Paid out for postage on letters and publications sold	$1 59
For express	30
For postage on Special Paper No. 11	6 36
Postage on Fourteenth Annual Report	4 38
Large envelopes for sending out reports and printing	3 75
Money turned over to the Treasurer	4 20
Total expenditures and cash paid Treasurer	$20 58

WM. C. MILLS.

The report of the committee on the revision of the constitution was presented. Moved and seconded that the report be accepted, the committee be enlarged by the addition of the executive committee, and continued, and that a revision of the constitution and by-laws be printed and submitted to members of the society for approval at the next annual meeting. It was the sense of the meeting that the preliminary revision be published in the Ohio Naturalist. At the request of the chairman of the committee on libraries, the report was deferred to the last business meeting.

After an address of welcome from the chairman of the local committee, the Society proceeded to the reading of papers.

At 12:05 P. M. the Society adjourned to a luncheon provided by the University.

The Society met at 1:30 P. M. and listened to an interesting address by Mr. Dury, First Vice President, on the Natural History of the lower Rio Grande. After an election of a nominating committee consisting of Prof. Osborn, Prof. Landacre and the secretary, the Society again proceeded to the reading of the special papers, and adjourned at 5:30 P. M.

At 7:30 P. M. the members of the Society and their friends listened to an address by Prof. J. A. Bownocker on "Earthquake and Volcanic Phenomena." This was followed by an informal reception.

The Society reassembled at 9:20 Saturday morning. The nominating committee reported and the following officers were elected for the coming year:

President — Mr. Charles Dury, Cincinnati, Ohio.
Vice-Presidents — Prof. W. F. Mercer, Athens, Ohio, and Prof. Frank Carney, Granville, Ohio.
Secretary — Professor L. B. Walton, Gambier, Ohio.
Treasurer — Professor J. S. Hine, Columbus, Ohio.
Librarian — Professor W. C. Mills, Columbus, Ohio.
Executive Committee (ex-officio) Mr. Charles Dury, Cincinnati; Prof. L. B. Walton, Gambier; Prof. J. S. Hine, Columbus, (elective); Prof. F. C. Waite, Cleveland;; Prof. A. D. Cole, Columbus. œ
Board of Trustees — Professor W. R. Lazenby (re-elected).
Publication Committee — Professor J. C. Hambleton.

The membership committee reported on the following, who were duly elected:

Hawkins, L. A., Botany, O. S. U., Columbus, Ohio.
Sanders, E. A., Botany, Geology Chillicothe Ohio.
Hawk J. F. Biology, Athens, Ohio.
Foltz, H. L., Biology, Gambier, Ohio.
Foote, E. H., Biology, Granville.
Bolin, W. C., Newark.

The following names were elected by the Executive Committee during the year:

Darling, C. A., Zoology and Botany........Portland, Chaut. Co., N. Y.
Wells, Jessie, Botany..................................McConnelsville
Houser, J. S., Entomology.................Ohio Exp. Station, Wooster
Pumphrey, J. H., Ornithology..................................Clayton
McCaughey, Vaughan, Biology and Geology..Cornell Univ., Ithaca, N. Y.
Box, Cora May, Zoology (Protozoa in particular)................
..............................University of Cincinnati, Cincinnati
Smith, Ethel M., Biology, (Ornithology in particular),............
....Rame, Ashtabula Co.
Gilbert, Harriet A., Biology, Physiography and Physiology.....Painesville
Smead, Annie E., Biology........................634 Nessle St., Toledo
Morris, C. H., Biology (Ornithology in particular)......McConnellsville

McCampbell, E. F.................................O. S. U., Columbus
McKean, T. L...Berea
Matheney, W. A...Sardis
Young, R. A...................................O. S. U., Columbus
Porterfield, J. C...................................Columbus, Ohio
Adams, C. C., Ecology......Cincinnati Society, Nat. Hist., Cincinnati, O.
Sauer, L. W., Botany.................Univ. of Cincinnati Cincinnati, O.
McCall, A. G., Horticulture.......................O. S. U., Columbus, O.
Morse, W. C. Geology, Zoology, and Botany..1950 High St., Columbus, O.
Fink, Bruce, Botany...Oxford, O.

Under new business it was moved and seconded that the dues be increased from $1.00 to $1.50 a year. This was referred to the Executive Committee. It was moved and seconded that the By-Laws be amended to the effect that the dues of the Librarian be omitted. Carried. It was further moved and seconded that it be the sense of the Academy that no formal session be held at the Christmas meeting of the Allied Educational Associations. Carrid.

The following resolutions were passed:

Be it Resolved, That we, the members of the Ohio State Academy of Science extend our heartiest thanks to the authorities and staff of the Ohio State University for their numerous courtesies in connection with the Sixteenth Annual Meeting of the Academy, and we that further signify our appreciation to Professors Osborn and Cole individually of their special favors to the Academy.

Be it Further Resolved, That we express our sense of obligation to Representative C. V. Trott for his efforts in behalf of the interests of the Academy.

Furthermore, be it Resolved, That we signify to Mr. Emerson McMillin our great appreciation of his continued interest in the efforts of the Academy and for his substantial contributions to the suppor of the projects of the same, and that we extend to him our sincere thanks for his numerous favors.

M. F. Guyer, *Chairman.*
F. C. Waite,
M. E. Stickney.

After this the Academy adjourned.

The complete program of the meeting was as follows:

1	A study of *Pilacre petersii* B. & C. 5 min.	R. A. Young
2	A Preliminary List of the Land and Fresh water Mollusca of Ohio. 5 min.	V. Sterki
3	Better Results in Science Photography. 10 min.	G. D. Smith
4	Notes on a Sandusky Bay Shrimp *Palæmonetes exilipes*. 12 min.	W. B. Herms
5	Platycnemic Man in Ashtabula Co. 5 min.	F. D. Snyder
6	Cell Division in *Euglena oxyuris* Schmarda. 5 min.	L. B. Walton
7	A small agaric with a disputed name. 6 min.	W. A. Kellerman
8	Occurrence of Rare Birds in Ohio in 19066. 5 min.	Lynds Jones
9	Some Physical Properties of Wood. 10 min.	W. R. Lazenby
10	Ohio Archæological Atlas. 5 min.	W. C. Mills
11	On the Occurrence of *Phytophthora infestans* and *Plasmopara cubensis* in Ohio. 8 min.	A. D. Selby
12	Experiments to test the difference of Hydrocyanic Acid Gas in the Fumigation of Houses. 8 min.	A. F. Burgess
13	The Specific Name of Necturus. 8 min.	F. C. Waite
	Address by the Vice-President, Chas. Dury: "The Natural History of the Lower Rio Grande."	
14	Weather and Crop Yield. 15 min.	J. W. Smith
15	An Ecological Survey of Isle Royale, Lake Superior (Illustrated with lantern slides). 18 min.	C. C. Adams
16	A Successful Mutant of Verbena Without External Isolation. 10 min.	J. H. Schaffner
17	A Lantern Talk on Lichenists. 20 min.	Bruce Fink
18	The Vicissitudes of the Cincinnati Ice Dam. 20 min.	G. F. Wright
19	A Botanist's Second Trip to a Tropical Country (Illustrated with lantern slides.) 20 min.	W. A. Kellerman
20	Notes on Guatemalan Hemiptera with description of a few new species. 10 min.	Herbert Osborn
21	A Spear Point containing a nugget of gold. 3 min.	W. C. Mills
22	"Esperanto," a Universal Language for Science, 8 min.	Ivy Kellerman
23	The Public Drinking Cup. A report on the Species of Bacteria found in ten Examinations. 5 min.	E. F. McCampbell
24	Interesting Foreign Seeds Disseminated in Alfalfa. 5 min.	A. D. Selby
	Address: "Earthquake and Volcanic Phenomena," with special reference to the San Francisco earthquake and the volcanoes of the Hawaiian Islands (illustrated with lantern slides.)	J. A. Bownocker.
25	Notes on some Interesting Protoza from Cedar Point. 5 min.	Cora M. Box

26	Juvenile Kelps and the Recapitulation Theory (illustrated with lantern slides) 15 min.	R. F. Griggs
27	An Ecological and Experimental Study of Sarcophagidæ with relation to organic beach debris. 15 min.	W. B. Herms
28	Critical Notes on some Ohio Agarics and Polypores with exhibitions of specimens. 15 min.	J. C. Hambleton
29	Further Observations on the Naididæ of Cedar Point. 5 min.	L. B. Walton
30	*Auerswaldia ohionis* Kellerm. nov. sp. 5 min.	W. A. Kellerman
31	Notes on the Myriapod Polydesmus sp. 3 min.	S. R. Williams
32	The Development of the Sporangium in *Equisetum hyemale* L. 8 min.	L. A. Hawkins
33	A Simple Cultural Method for Procuring Protoza for Class-room Study.5 min.	Lynds Jones
34	The Correllation between the method of distribution of Taste Buds and their Nerve Supply in Amerius.	F. L. Landacre
35	Development of the Pineal Region in Ophidia. 15 min.	J. E. McDaniel
36	Histogenesis of Heart Muscle of Chick. 10 min.	H. L. Wieman
37	On the Dipterous Fauna of Ohio. 5 min.	J. S. Hine
38	Observations on the Habits of *Senotania rubroventris* Mac. 3 min.	Herbert Osborn
39	On the Commissures of the Medulla Oblonganta of Fishes (read by title).	C. J. Herrick
40	Collecting Mollusca in 1906. 5 min.	V. Sterki
41	A Southern Wolfiella indigenous in Central Ohio. 8 min.	W. A. Kellerman
42	Shading of Plants with Colored Cloth. 10 min.	W. R. Lazenby
43	New Species of Ohio Hemiptera. 5 min.	Herbert Osborn
44	Fossil Land and Fresh Water Mollusca (in loess?) found at Defiance, Ohio. 5 min.	V. Sterki
45	Note on a Method of Collecting Scutigerella, Scolopendrella, Japyx, Campodea and other minute forms. 3 min.	L. B. Walton
	Annual Report on the State Herbarium. 4 min.	Freda Detmers
46	Footprints of Prehistoric Man in Perry Co. 10 min.	C.. L. Martzolff
47	The Glacial Dam at Hanover, Ohio (illustrated with lantern slides). 25 min.	Frank Carney
48	Preglacial Erosion in Ohio. 15 min.	G. D. Hubbard
49	Corrosion by Ribers, Glaciers and Waves (illustrated with lantern slides). 10 min.	L. G. Westgate
50	Boundary of the oldest Drift Sheet in Licking county, Ohio. [Slides.] 5 min.	Frank Carney
51	Harness Mound Explorations. 15 min.	W. C. Mills

52	Glacial Folding of Subjacent Strata near Huron, Ohio. 5 min.	E. B. Branson
53	The Radnor Esker System. [Slides.] 10 min.	L. G. Westgate
54	Aboriginal Manufacture of Bone and Stone Implements. 10 min.	A. B. Coover
55	A Buried Valley along the Rocky Fork east of Gahana, Ohio. [Slides.] 5 min.	G. D. Hubbard
56	Pre-Wisconsin Drift in the Finger Lake Region of New York. [Slides.] 10 min.	Frank Carney
57	A Fauna from the Cleveland Shale of Lorain Co. 5 min.	E. B. Branson
58	The Pottsville Formation of Eastern Licking County. [Slides.] 10 min.	Frank Carney

Gambier, O., March 30, 1907.

L. B. Walton, *Secretary.*

PROCEEDINGS

OF THE

Ohio State Academy of Science

VOL. IV. PART 10

Special Paper No. 13

The Protozoa of Sandusky Bay and Vicinity

BY

F. L. LANDACRE

PUBLISHED BY THE ACADEMY

COLUMBUS, OHIO

PROCEEDINGS

OF THE

Ohio State Academy of Science

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By F. L. LANDACRE

PUBLISHING COMMITTEE

John H. Shaffner E. L. Rice J. C. Hambleton

DATE OF PUBLICATION FEBRUARY 18, 1908

Published by the Society
COLUMBUS, OHIO

The Protozoa of Sandusky Bay and Vicinity.

F. L. LANDACRE.

The collection of fresh-water Protozoa of Sandusky Bay exclusive of the Sporozoa was begun as a preliminary survey of the Protozoan fauna of that region. The faunal work was meant to precede a more extended study of the Protozoa with a view to determining the life history and relationships of many doubtful forms, and their value as a food supply of fresh-water fishes.

No attempt has been made to describe new species in the present paper although many have been found which are apparently new. The large number of intermediate forms found probably indicate a greater degree of variability of known species rather than a large number of new forms.

The region about Sandusky seemed to be paticularly favorable for a large Protozoan fauna and the work there has shown this to be true. It is particularly rich in Infusoria and Mastigophora, but contains a smaller representation of Sarcodina than one would be led to expect. The region is poorest perhaps in Rhizopods. This is due probably to the fact that the swamps there contain no sphagnum.

When the collections were first begun it seemed probable that the plankton of Sandusky Bay and the Lake would be particularly rich. This expectation, however, has not been fulfilled but the marshes and stagnant pools, on the other hand, have been found to be unusually rich. Owing to the peculiar conditions present in Sandusky Bay the attempt to study the vertical distribution was not productive of good results. Neither is the study of the surface towings at all satisfactory. The work was begun with the expectation that faunal regions could be mapped out, but the results here are also largely negative.

The probable reason that the plankton of Sandusky Bay is small both in quantity and number of species, is, that the water is shallow; this causes an unusual amount of sediment in the water when agitated by the wind. Sandusky Bay is rarely clear.

The lake itself while furnishing a large number of Crustacea has given, at least near the shore, a very small number of Protozoa, even though they do occur with such frequency in the coves mentioned. A great majority of the species of Protozoa, in this region at least, can be found in localities where duck-weed thrives abundantly. Almost any condition of temperature, light, or varying amounts of vegetation will furnish a good Protozoan fauna, especially of Mastigophora and Infusoria and Suctoria if the common duck-weed, *Lemna minor,* can be found in abundance.

The collections are confined to Sandusky Bay and vicinity with the exception of a few species from a small pond in Columbus, and a few Rhizopods from sphagnum taken from Licking Reservoir.

The work was done during the summers of 1902, 1903, and 1904. The original plan involved a study of the seasonal distribution of the Protozoa in this region, but owing to the fact that work was confined each year to the months of June, July and August no serious study of the seasonal distribution could be made. This has not been attempted since 1881-2, when C. M. Vorce made such a study in the vicinity of Cleveland.

A great majority of the species catalogued are found in three localities. A brief description of the topography of Sandusky Bay will make this clear. Sandusky Bay is a shallow, almost land-locked harbor averaging about twelve feet in depth, some fourteen or fifteen miles in length, with a width of something like two miles. The portion of the Bay lying next to the main land contains numerous marshes and a number of sluggish streams enter it. The shore of the Bay lying toward the north is separated from the lake by a long sand spit known as Cedar Point, which throughout the greater portion has a sandy shore. At the western portion of Cedar Point there is a large marsh known as Biemiller's Cove. This marsh, with a well-defined channel kept open by the rise and fall of the lake due to the action of the wind, has an average depth of about three feet. It is a typical marsh with dense vegetation along the shore, a good deal of decaying vegetation in the bottom. On the southern side of the Bay near the city is the cove which I have designated as the Water Works cove. This is separated from the lake by a railroad embankment, but is open to the bay. In this cove is a smaller cove which I have designated as the Basket Factory cove, where a great deal of timber is allowed to remain before being manufactured into baskets. There is a bare possibility that the large number of species ascribed to this locality may be due to the fact that they were imported with the timber. I am inclined to think, however, that this if true would furnish conditions favorable to the development of the Rhizopods. The basket factory cove was not unusually rich in Rhizopods as one would expect it to be if the species had been imported.

These three localities, Biemiller's cove, the Water Works cove ,and the Basket Factory cove, furnish by far the larger part of the fauna of this region. All three of these localities contain enormous numbers of small fish and are densely packed except in the channels with vegetation.

One can not help being impressed even on superficial observation of the importance of the Protozoan fauna as a means of food supply for small fish, although no attempt has been made as yet to determine just what species and to what extent they are used as a source of food supply. The work was undertaken with a view of determining first just how extensive and in what manner the species were distributed in this region. The list is not offered as a complete survey of the Protozoa of this region. Undoubtedly many more species could be added if the time were taken to make the survey more complete.

The system used in classification is largely that of Bütschli, although the large number of new species and genera by American authors makes the interpolation of genera necessary, which may sometimes not fit perfectly into the original description. It is a very striking fact that of all the species of Protozoa recorded in America almost one-half are new; but of those found in Sandusky approximately only one-fifth have been described by American authors. In arranging the bibliography a special effort has been made to collect all those papers which would be of any valúe systematically, and especially those written by American workers. No attempt has been made to include papers dealing with the morphology or physiology of Protozoa. The European papers aside from monographs have not been listed. It seems important to get these American papers together and find out just what has been done by American workers and what our fauna contains. An attempt to establish a synonomy may be made later. The task of arriving at any scientific classification of Protozoa is exceedingly difficult owing to the fact that no type specimens are preserved and many papers have been published not only with inadequate descriptions but with poor drawings and no bibliographies. One can sometimes overcome the difficulty presented by a poor description provided the drawing is fair, and he may even form some conception of what the author had in hand with poor descriptions and drawings if he knows what papers he was describing from. Bibliographies heretofore have been very rarely given with American papers. While there are undoubtedly many good species described, the difficulty of determining just what has been done is very great. While this bibliography may omit a few papers it is practically complete for American authors up to 1904.

A portion of this work was done while acting as field assistant for the United States Fish Commission. The writer is under obligations to the trustees of the Emerson McMillan Fund of the Ohio Academy for assistance in securing literature, especially some of the more expensive papers.

The author desires to express his obligations to Prof. Herbert Osborn, Director of the Lake Laboratory at Sandusky.

O. S. U. Lake Laboratory,
Cedar Point, Sandusky, Ohio.

The Protozoa of Sandusky Bay and Vicinity.

Class Sarcodina
- Subclass Rhizopoda
  - Order Amoebida
    - Family Amoebidae
      - Genus Amoeba Ehrbg.
        - Amoeba proteus Leidy; on aquatic plants from Water Works cove.
        - Amoeba verrucosa Ehrbg.; on aquatic plants from logs in Basket Factory cove.
        - Amoeba radiosa Ehrbg.; on aquatic plants from Water Works cove.
      - Genus Pelomyxa Greeff
        - Pelomyxa villosa Leidy; in ooze in towings from Biemiller's cove.
      - Genus Hyalodiscus Hertwig & Lesser
        - Hyalodiscus rubicundus H. & L.; on roots of duckweed from Water Works cove, common.
    - Family Arcellidae
      - Genus Arcella Ehrbg.
        - Arcella vulgaris Ehrbg.; common in all collections of vegetation and towings at Sandusky.
        - Arcella vulgaris var. angulosa Leidy; on vegetation from basket factory cove.
        - Arcella discoides Ehrbg.; in sediment from basket factory cove.
        - Arcella mitrata Leidy; in towings from Biemiller's cove.
        - Arcella dentata Ehrbg.; in vegetation of Basket Factory cove.
        - Arcella artocrea Leidy; in towings from Biemiller's cove.

Class Sarcodina — Continued.

Genus Hyalosphenia Stein

Hyalosphenia papilio Leidy; on sphagnum from Licking County Reservoir.

Hyalosphenia tincta Leidy; on sphagnum from Licking Reservoir.

Genus Pamphagus Bailey

Pamphagus hyalinus (Ehr.) Leidy; vegetation from Biemiller's cove.

Genus Difflugia Leclerc

Difflugia spiralis Ehrbg.; in towings from Biemiller's cove; in sphagnum from Licking County Reservoir.

Difflugia constricta (Ehrbg.) Leidy; in sediment from Water Works cove.

Difflugia pyriformis Perty; in sediment from Water Works cove.

Difflugia pyriformis *var.* vas Leidy; in sediment from Biemiller's cove.

Difflugia urceolata Carter; in towings from Biemiller's cove.

Difflugia corona Wall.; in vegetation from Basket Factory cove.

Difflugia lobostoma Leidy; in plankton of Biemiller's cove.

Difflugia crateria Leidy; in plankton of Water Works cove.

Genus Nebela Leidy

Nebela collaris (Ehr.) Leidy; in sphagnum from Licking County Reservoir; also from Biemiller's cove, disk like form pronounced.

Nebela caudata Leidy; on decaying floating vegetation from Biemiller's cove, the spined rarer form, see Leidy (161) above.

Class Sarcodina — Continued.

Genus Heleopera Leidy

Heleopera petricola Leidy; among sphagnum in Licking County Reservoir.

Heleopera picta Leidy; common in sphagnum in Licking County Reservoir.

Genus Centropyxis Stein

Centropyxis aculeata Stein; on decaying floating vegetation from Biemiller's cove.

Centropyxis aculeata var ecornis Leidy; on vegetation from Water Works cove; on sphagnum from Licking County Reservoir.

Genus Assulina Ehrbg.

Assulina seminulum Ehr.; on sphagnum from Licking County Reservoir.

Family Euglyphidae

Genus Euglypha Duj.

Euglypha alveolata Duj.; on plants from floating island on southeast side of bay, a spineless variety; on sphagnum from Licking County Reservoir.

Euglypha ciliata (Ehrbg.); Leidy; among algae from college lake (east), Columbus.

Genus Trinema Duj.

Trinema enchelys (Ehrbg.) Leady; in towings from Biemiller's cove.

Subclass Heliozoa

Order Aphrothoracida

Genus Vampyrella Ceink.

Vampyrella lateritia Fres.; among algae from basket factory cove, abundant.

Genus Actinophrys Ehrbg.

Actinophrys sol Ehrbg.; on vegetation from Basket Factory cove.

Class Sarcodina — Continued.

Genus Actinosphaerium Stein

Actinosphaerium eichornii, Stern.; on walls of fish tank, San. Hatch. abundant.

Order Chlamydophorida

Genus Heterophrys Archer

Heterophrys myriapoda Archer; in vegetation from stagnant pool.

Order Chalarathoracida

Genus Raphidiophrys Archer

Raphidiophrys elegans Hertwig & Lesser; among duckweed roots from Biemiller's cove, rather common.

Raphidiophrys viridis Archer; in floating decaying vegetation from Biemiller's cove.

Raphidiophrys pallida Schulze; on algae from basket factory cove. Closely resembling "viridis" except granules are pale and diameter 1/800 in.

Genus Acanthocystis Carter

Acanthocystis chaetophora (Schrank) Leidy; among roots of duckweed from Water Works cove.

Acanthocystis pertyana? Archer; numerous among algae, duckweed and willow roots from college lake and run at Columbus.

Order Desmothoracida

Genus Clathrulina Cienk.

Clathrulina elegans Cienk; on duckweed roots from basket factory cove, three individuals; on sphagnum from Licking County Reservoir.

Class Sarcodina — Concluded.

Genus Biomyxa Leidy

Biomyxa vagans Leidy; in decaying vegetation from Biemiller's cove. A form answering the description of the above given by Dr. Leidy was found several times in August, 1903. It is placed after the Heliozoa with no attempt at classification.

Class Mastigophora

Subclass Flagellidia

Order Monadida

Family Bikoecidae

Genus Stylobryon De From. (Poterrodendron?) Stein.

Stylobryon petiolatum (Duj.) S. K.; on duckweed from basket factory cove.

Family Heteromonadidae

Genus Cladonema S. K.

Cladonema laxa S. K.; on duckweed roots, much more branched than figured by Kent and stalks much more difficult to see; in constant motion.

Genus Deltomonas S. K.

Deltomonas cyclopum S. K.; on Cyclops from creek near Sandusky.

Genus Anthophysa Bory d. St. Vincent.

Anthophysa vegetans (Müll.) S. K.; common.

Order Choanoflagellida

Family Craspedomonadidae

Genus Monosiga S. Kent.

Monosiga steinii S. K.; on duckweed from basket factory cove and on stalk of Epistylis plicatilis.

Monosiga brevipes S. K.; on Vorticelli campanula from Biemiller's cove.

Class Mastigophora — Continued.

Monosiga consocialtum S. K.; on the pedicel of Carchesium polyporum from ice house cove.

Monosiga globosa S. K.; on roots of smart weed, Polygonum emersum, from Biemiller's cove.

Monosiga woodiae Stokes; on algae from Biemiller's cove.

Genus Codosiga James-Clark

Codosiga grossularia S. K.; on algae from Biemiller's cove, rare.

Codosiga utriculus Stokes; on Lemna from Biemiller's cove.

Codosiga umbellatum (Tatem) S. K.; species on Cyclops from Biemillers cove. See Stokes, pl. III, fig. 22.

Codosiga botrytis (Ehr.) S. K.; on duckweed roots from basket factory pond.

Codosiga candelabrum S. K.; on Cyclops from Biemillers cove.

Codosiga assimilis S. K.; on algae from Biemillers cove, rare.

Genus Salpingoeca James-Clark

Salpingoeca boltoni S. K.; attached to algae from Biemillers cove, rare.

Salpingoeca oblonga Stein; in vegetation (algae) from Biemillers cove.

Salpingoeca gracilis J. Clk.; on algae from Biemillers cove, one among duckweed.

Salpingoeca amphoridium J. Clk.; on duckweed from basket factory cove.

Salpingoeca amphoridium J. Clk.; on pedicel of Epistylis plicatilis, var. with short pedicel.

Salpingoeca fusiformis S. K.; on algae from Biemillers cove.

Class Mastigophora — Continued.

Salpingoeca cylindrica S. K.; on algae from Biemillers cove, rare.

Salpingoeca carteri S. K.; found on Cladophyra from basket factory cove, one specimen found.

Order Polymastigida

Tribe Distomea

Genus Hexamitus Duj.

Hexamitus intestinalis Duj.; in small intestine of common toad from Cedar Point.

Order Euglenida

Family Euglenidae

Genus Amblyophis Ehr.

Amblyophis viridis Ehr.; on vegetation from basket factory cove.

Genus Euglena Ehr.

Euglena sanguinea Ehr.; in stone quarry near Sandusky, very abundant.

Euglena oxyurus Schmarda; on Ceratophyllum and duckweed from basket factory cove.

Euglena spirogyra Ehr.; on vegetation of basket factory cove.

Euglena deses Ehr.; on vegetation of basket factory cove.

Euglena acus Ehr.; on vegetation from basket factory cove.

Genus Colacium Ehr.

Colacium vesiculosum Ehr.; parasitic on Cyclops; length 100 μ, width 65 μ, sessile of pedicle 10 μ, base of pedicle brown 50 μ, in diameter circular or horseshoe shaped, chloroplasts arranged around border, three or four showing on each side, eye spot nearly central slightly nearer anterior end. Solitary, sometimes two together.

Class Mastigophora — Continued.

Colacium steinii S. K.; boat landing, Cedar Point.

Colacium arbuscula St.; on Rotifer (colony bearing unidentified on algae parasite), from Biemillers cove.

Colacium calvum Stein; on algae and duckweed roots from Biemillers cove, common.

Genus Trachelomonas Ehr.

Trachelomonas piscatoris (Fisher) Stokes; in towings from Biemillers cove and on decaying vegetation.

Trachelomonas hispida (Perty) Stein; on vegetation of basket factory cove; also another form similar to the above but with spines on the ends and smooth in the middle.

Trachelomonas armata (Ehr.) Stein; on vegetation of basket factory cove; a form with many short spines on posterior end.

Trachelomonas cylindrica Ehr.; in decaying vegetation from Biemiller's cove.

Trachelomonas volvocina Ehr; in decaying vegetation from Biemiller's cove.

Genus Phacus Nitzsch.

Phacus pleuronectes (O. F. Müll.) Duj.; in vegetation of basket factory cove; chlorophyll arranged in rectangular masses on ventral border.

Phacus triqueter Ehr.; on vegetation of basket factory cove.

Phacus pyrum (Ehr.) S. K.; on vegetation of basket factory cove.

Phacus longicaudus (Ehr.) Stein; on vegetation of basket factory cove;

Class Mastigophora — Continued.

Genus Cryptoglena Ehr.

Cryptoglena conica Ehr.; on vegetation from Biemiller's cove.

Genus Chloromonas S. K.

Chloromonas pigra (Ehr.) S. K.; in infusion from decaying vegetation from Biemiller's cove.

Genus Chloropeltis Stein

Chloropeltis hispida (Eichwald) Stein; in decaying vegetation from Biemiller's cove.

Chloropeltis ovum (Ehr.) S. K.; in decaying vegetation from Biemiller's cove.

Family Astasiidae

Genus Astasia Ehr.

Astasia trichophora (Ehr.) Clap.; on Ceratophyllum and duckweed from basket factory cove.

Genus Distigma Ehr.

Distigma proteus Ehr.; among decayed vegetation from Biemiller's cove.

Genus Atractonema Stein

Atractonema teres Stein; in decaying vegetation from Biemiller's cove.

Family Peranemidae

Genus Urceolus Meresch.

Urceolus cyclostomata (Stein) Meresch.; in decaying vegetation from Biemiller's cove. Synonym, Phialonema cyclostomum (Stein) Kent.

Genus Paramonas S. K.

Paramonas ovum (From) S. K.; in towings from Biemiller's cove.

Class Mastigophora — Continued.

Genus Anisonema Duj.

Anisonema grande (Ehr.) S. K.; in towings from Biemiller's cove. Syn. A. acinus Duj.

Genus Entosiphon Stein

Entosiphon sulcatus (Duj.) S. K.; on algae from logs of basket factory; on algae from college lake, east, Columbus, rare.

Order Phytoflagellida

Suborder Chromomonadina

Family Chrysomonadidae

Genus Dinobryon Ehr.

Dinobryon stipitatum Stein; in plankton of in vegetation.

Dinobryon sertularia Ehr.; quite common vegetation.

Genus Mallomonas Perty.

Mallomonas plosseii Perty; among algae from basket factory cove.

Genus Synura Ehr.

Synura uvella Ehr.; in basket factory cove.

Genus Uroglena Ehr.

Uroglena volvox Ehrbg.; taken in tow net at boat landing in Biemiller's cove, one specimen.

Family Cryptomonadidae

Genus Cryptomonas Ehr.

Cryptomonas ovata Ehr.; in decaying vegetation from basket factory cove.

Genus Chilomonas Ehr.

Chilomonas paramaecium Ehr.; in vegetation infusions from basket factory cove.

Chilomonas cylindrica (Ehr.) S. K.; on Ceratophyllum and duckweed from logs near basket factory.

Class Mastigophora — Continued.

Suborder Chlamydomonadina

Family Chlamydomonadidae

Genus Chlamydomonas Ehr.

Chlamydomonas monadina Stein; occurring in the septic tanks of the experimental sewage disposal plant at Columbus, Ohio, and in connection with the diatom Navicula, completely obstructing the sand filters used there. The clogging seems to be due to both these forms, although either seems capable of doing it alone. The resting vegetative stage seems to form the mat causing the trouble.

Chlamydomonas pulvisculus Ehr.; in pools left on beach by high surf at Cedar Point, abundant.

Genus Chlorangium Stein.

Chlorangium stentorinum Ehr.; attached to Entomostraca from Biemiller's cove.

Suborder Volvocina.

Family volvocidae.

Genus Gonium O. F. Müller.

Gonium pectorale Müll.; taken in tow net at boat landing near Big Nat's cove, occasional.

Genus Pandorina Bory de St. Vincent.

Pandorina morum Ehrbg.; in Big Nat's cove at point of boat landing in tow net, numerous.

Genus Eudorina Ehr.

Eudorina stagnata; in tow net in Big Nat's cove at point of boat landing, common.

Eudorina elegans Ehrbg.; in plankton of cove, common everywhere.

Class Mastigophora — Concluded.

Genus Volvox (Leeuw.) Ehr.

Volvox globator Ehrbg.; in tow net at boat landing in Big Nat's cove.

Subclass Dinoflagellidia.

Order Diniferida.

Family Peridinidae.

Genus Peridinium.

Peridinium tabulatum (Ehr.) S. K.; towing near shore at landing near Biemiller's cove; also a blue form resembling the above in every respect (young?).

Genus Ceratium Schrank.

Ceratium hirudinella O. F. Müller; in plankton of Biemiller's cove, common.

Class Infusoria.

Subclass Ciliata.

Order Holotrichida.

Family Enchelinidae.

Genus Holophrya Ehr.

Holophrya ovum Ehr.; among duckweed roots from Biemiller's cove, one specimen.

Genus Trachelophyllum C. & L.

Trachelophyllum vestitum Stokes; from towings taken in Biemiller's cove.

Trachelophyllum apiculatum (Perty) S. K.; in towings from Biemiller's cove.

Genus Prorodon Ehr. (Euchelyodon C. & L.)

Prorodon farctus C. & L.; in floating decaying vegetation.

Genus Lacrymaria Ehr.

Lacrymaria truncata Stokes; body not markedly striate except at anterior end.

Class Infusoria — Continued.

Lacrymaria lagenula C. & L.; in towings from Biemiller's cove, one specimen seen.

Genus Lagynus Quennerstedt.

Lagynus elegans Eng.; in towings from Biemiller's cove.

Genus Trachelocerca Ehr.

Trachelocerca versatilis Müll.; in vegetation and towings from Biemiller's cove.

Trachelocerca olor (Müll.); Ehr. among duckweed roots.

Genus Coleps Nitsch.

Coleps uncinatus C. & L.; in vegetation from basket factory cove.

Coleps hirtus Ehrbg., in vegetation of basket factory cove.

Genus Didinium Stein.

Didinium nastutum Müll.; in decaying vegetation from basket factory cove.

Family Enchelyidae S. K.

Genus Tillina Gruber.

Tillina flavicans Stokes; in infusion of dead leaves, very common and all stages represented.

Family Trachelinidae.

Genus Amphileptus Ehr.

Amphileptus anser Ehr.; in vegetation from basket factory cove.

Amphileptus gigas C. & L.; in vegetation kept in jars, basket factory cove.

Amphileptus margaritifer Ehr.; among algae and duckweed from basket factory cove.

Genus Lionotus Wrzes.

Lionotus diaphanus Wrz.; in towings from Biemiller's cove, common in vegetation.

Class Infusoria — Continued.

Lionotus fasciola (Ehr.) Wrzes.; on walls of fish-tank, rare.

Lionotus wrzesniowskii S. K.; on algae from basket factory cove, in process of fission.

Genus Loxophyllum Duj.

Loxophyllum meleagris Duj. (Ehr.); in vegetable infusion.

Genus Trachelius Schrank.

Trachelius ovum Ehr.; among Lemna from College run, Columbus, (one specimen).

Genus Loxodes Ehr.

Loxodes rostrum Ehrbg.; in sediment and vegetation from Biemiller's cove, rather rare.

Family Chlamydodontidae.

Subfamily Nassulinae.

Genus Nassula Ehr.

Nassula rubens C. & L.; on algae from logs at basket factory cove.

Nassula ornata (Ehr.); on Ceratophyllum from basket factory cove.

Nassula ornata var. conica Ehr.; on Ceratophyllum from basket factory cove, common.

Nassula flava C. & L.; in towings from Biemiller's cove, common.

Subfamily Chilodontinae.

Genus Chilodon Ehr.

Chilodon megalotrochae Stokes; a form answering this description was found on the gills of a crayfish from creek near Infirmary. General form correct, abundant, possibly only a young stage of C. cucullulus as a larger one was seen later.

Class Infusoria — Continued.

Chilodon cucullulus (Müll.) Ehr.; in decaying vegetation from Biemiller's cove.

Suborder Trichostomina.

Family Chiliferidae.

Genus Leucophrys Ehr.

Leucophrys patula Ehr.; in Licking Reservoir, among sphagnum, common.

Genus Frontonia (Ehr.) C. & L. (Cyrtostomum Stein).

Frontonia acuminata Ehr.; dark pigmented variety, pigment-spot.

Genus Colpidium Stein.

Colpidium colpoda Ehr. Schrank sp.; associated with colonies of the bryozoan Plumatella.

Genus Loxocephalus Kent.

Loxocephalus luridus Eberhaud; in towings from Biemiller's cove.

Genus Colpoda O. F. Müller

Colpoda cucullus O. F. Müll.; in towings from Biemiller's cove.

Family Urocentridae

Genus Urocentrum Nitsch.

Urocentrum turbo O. F. Müller; on Lemna from Biemiller's cove.

Family Microthoracidae

Genus Microthorax Eng.

Microthorax sulcatus Eng.; in towings from Biemiller's cove, common.

Family Paramoecidae

Genus Paramoecium Stein.

Paramoecium aurelia Müll.; common.

Paramoecium caudatum Ehr.; in Biemiller's cove.

Paramoecium bursaria Ehr.; from duckweed roots from basket factory cove and Big Nat's cove.

Class Infusoria — Continued.

Family Pleuronemidae

Genus Lembadion Perty.

Lembadion bullinum Perty; in towings from Biemiller's cove.

Genus Cyclidium Ehr.

Cyclidium glaucoma Ehr.; in infusion of weeds from basket factory cove.

Family Opalinidae.

Genus Anoplophrya Stein.

Anoplohrya striata Duj.; in alimentary canal of large earthworm from Sandusky.

Anoplophrya branchiarum Stein; in respiratory appendage of Gammarus pulex from Biemiller's cove.

Genus Hoplitophrya Stein

Hoplitophrya falcifera Stein; in alimentary canal of earthworm from Sandusky.

Genus Opalina Purkinjie and Valentin.

Opalina dimidiata Stein; in rectum of common toad, Cedar Point, larval stage.

Opalina ranarum Purk.; in rectum of common frog.

Order Heterotrichida

Suborder Polytrichina.

Family Plagiotomidae

Genus Conchopthirus Stein

Conchopthirus anadontae Ehr. sp.; in body fluid of Unio from Sandusky Bay.

Conchopthirus curtus Eng.; in body fluid of Unio from Sandusky Bay.

Genus Plagiotoma Duj.

Plagiotoma lumbrici Duj.; in intestine of earthworm.

Genus Metopus C. & L.

Metopus sigmoides Müll.; in towings from Biemiller's cove.

Class Infusoria — Continued.

Genus Spirostomum Ehr.

Spirostomum ambiguum Ehr.; in floating decayed vegetation from Biemiller's cove.

Family Stentoridae

Genus Stentor Oken

Stentor igneus Ehr.; on algae (Cladophora) from basket factory cove near ice house, one specimen.

Stentor caeruleus Ehr.; in vegetation of basket factory cove.

Stentor roeselii Ehr.; on algae from college lake (east), Columbus.

Stentor polymorphus Müll.; among duckweed roots from basket factory cove.

Genus Chaetospira Lachmann

Chaetospira müelleri Lach.; on willow roots.

Suborder Oligotrichina

Family Halteriidae

Genus Strombidium C. & L.

Strombidium claperedi S. K.; among algae from basket factory cove, occasional.

Genus Arachnidium S. K.

Arachnidium globosum S. K.; on duckweed from basket factory cove.

Family Tintinnidae

Genus Calceolus Diesing

Calceolus cypripedium (J. Clk.) S. K.; in fish tank in Laboratory building, Sandusky.

Order Hypotrichida

Family Oxytrichidae

Genus Urostyla Ehr.

Urostyla grandis Ehr.; seen on Hydra fusca first, but afterwards in water,

Class Infusoria — Continued.

Genus Kerona Ehr.

Kerona polyporum Ehr.; parasitic on Hydra fusca.

Genus Stichotricha Perty

Stichotricha cornuta C. & L.; on decaying vegetation from Biemiller's cove.

Genus Uroleptus Stein.

Uroleptus rattulus Stein; on floating decaying vegetation from Biemiller's cove.

Uroleptus piscis (Müll. sp.); on Ceratophyllum and duckweed of basket factory cove.

Genus Opisthortricha S. K.

Opisthotricha parallela (Eng.); S. K.; on duckweed roots from Biemiller's cove.

Genus Oxytricha Ehr.

Oxytricha acuminata Stokes; on decaying vegetation from Biemiller's cove.

Oxytricha caudata Stokes; in decaying vegetation from Biemiller's cove.

Genus Stylonychia Stein

Stylonychia mytilis Ehr.; in decaying infusions.

Family Euplotidae

Genus Euplotes Stein

Euplotes patella Ehr.; in vegetation of basket factory cove.

Euplotes charon Müll.; in vegetation of basket factory cove.

Genus Aspedisca Ehr.

Aspedisca costata Duj.; in vegetation of basket factory cove.

Class Infusoria — Continued.

Order Peritrichida

Family Vorticellidae

Subfamily Urceolarinae

Genus Trichodina Stein

Trichodina pediculus Ehr.; parasitic on Hydra fusca.

Subfamily Vorticellidinae

Genus Scyphidia Lachmann

Scyphidia fromentellii S. K.; on Carchesium polypinum from Water Works cove.

Scyphidia inclinans D'Udek.; on Nais from basket factory cove.

Scyphidia physarum C. & L.; attached to Physa in material from basket factory cove.

Scyphidia limacina Lach.; in respiratory cavity of Planorbis. The form observed answered the above description except that the body was packed full of chloroplasts and striations were visible only under most favorable conditions. Found in great abundance.

Scyphidia constricta Stokes; on foot and tentacles of Planorbis, numerous. May this form not be the same as S. limacina and differences being due to chloroplasts.

Genus Spirochona Stein

Spirochona gemmipara Stein; on Gammarus from Castalia, common on all appendages.

Genus Gerda C. & L.

Gerda fixa D'Udk.; attached to debris from Biemiller's cove.

Class Infusoria — Continued.

Genus Vorticella Linn.

Vorticella hamata Ehr.; on duckweed roots from Biemiller's cove. Agreeing with the above except that it is shorter and thicker.

Vorticella nebulifera Ehr.; on roots of duckweed from basket factory cove.

Vorticella microstoma Ehr.; on algae from college lake, Columbus.

Vorticella campanula Ehr.; in vegetation of basket factory cove.

Vorticella citrina Ehr.; in vegetation from basket factory cove.

Vorticella nutans Müll.; on roots of Lemna from basket factory cove.

Vorticella lockwoodii Stokes; on willow roots from college lake, Columbus.

Vorticella alba From.; found attached to bristles of Gammarus.

Vorticella rhabdostyloides Kell.; on Cyclops agreeing in every detail obtainable; also on worm.

Vorticella conosoma Stokes; attached to Conochilus volvox.

Vorticella aquae dulcis Stokes; attached to various crustaceans, faintly striated.

Vorticella chlorostigma Ehr.; on duckweed roots, variable in shape, ciliary disc depressed, transverse striations quite fine.

Vorticella fasciculata Müll.; on Lemna.

Vorticella vestita Stokes; on willow roots from cove near basket factory, common.

Vorticella parasita Stokes; attached to dragon fly larvae.

Class Infusoria — Continued.

Vorticella appuncta From.; among roots of duckweed from basket factory cove.

Vorticella telescopica S. K.; on duckweed from basket factory cove.

Vorticella monilata Tatem.; on roots of duckweed from basket factory cove.

Vorticella cratera S. K.; on duckweed from basket factory cove, not common.

Vorticella lemnae Stokes; on duckweed from Biemiller's cove.

Vorticella aperta From.; on moss (Bryales) from Licking Reservoir.

Vorticella smaragdina Stokes; on duckweed roots from Biemiller's cove.

Vorticella floridensis Stokes; on duckweed from Biemiller's cove.

Vorticella convallaria Linn.; on duckweed from Biemiller's cove, occasional.

Vorticella elongata From.; on sphagnum from Licking County Reservoir.

Vorticella similis Stokes; on duckweed roots from Biemillers cove.

Vorticella crassicaulis S. K.; on Cyclops from Biemiller's cove, quite variable in shape and sometimes showing transverse, striations, also on setae of worm.

Vorticella communis From.; on duckweed from Biemillers' cove (several), a few individuals showing faint transverse striations, colony of 25.

Genus Carchesium Ehr.

Carchesium polypinum (L.) S. K.; on Lemnaceae from college run, Columbus; in duckweed from Biemiller's cove.

Class Infusoria — Continued.

Genus Zoothamnium Stein.

Zoothamnium adamsi Stokes; on Cladophora from the government docks at Cedar Point, agrees with the above except that I cannot find striations on stem or body.

Genus Epistylis Ehr.

Epistylis cambari Kell.; on Cyclops from Biemiller's cove; on gills of Cambarus from Pipe creek.

Epistylis vaginula? Stokes; on willow roots from east college lake, Columbus.

Epistylis nympharum Eng.; in Water Works cove.

Epistylis tubificis D'Udk.; on dragon fly larva from basket factory cove, also on Gammarus and Tubifex, on snail and dragon fly larva. Individual colonies found on dragon fly larva containing 30 individuals. Stalk profusely branched. Whole colony five times length of one zooid. Primary stem equals one zooid. Irregularly dichotomously branched.

Epistylis articulata From.; in vegetation from basket factory cove.

Epistylis leucoa Ehr.; in decaying vegetation from Biemiller's cove.

Epistylis anastatica Linn.; on algae from government docks.

Epistylis steinii Wrz.; on Gammarus pulex from Biemiller's cove.

Epistylis pyriformis D'Udek.; on insect larvae, an unidentified Ephemerid from Biemiller's cove.

Class Infusoria — Continued.

Epistylis umblicata C. & L.; on Cypris from basket factory cove.

Epistylis plicatilis Ehr.; in vegetation of basket factory cove; on Ceratophyllum; stalk shorter and stouter, secondary branches short, primary long, zooids curved somewhat full of green granules.

Epistylis flavicans Ehr.; on root of duckweed from basket factory cove, both single and branched colonies found.

Epistylis invaginata C. & L.; on Cyclops, very numerous on one individual from basket factory cove.

Epistylis digitalis Ehr.; on Cyclops from screenings in Biemiller's cove.

Genus Rhabdostyla Kent

Rhabdostyla ovum S. K.; on Cladophora from Biemiller's cove.

Rhabdostyla brevipes C. & L.; on dragon fly larvae from Biemiller's cove; on duckweed roots.

Rhabdostyla chaeticola Stokes; on setae of Nais from basket factory cove.

Rhabdostyla vernalis Stokes; attached to Cyclops from Biemiller's cove.

Rhabdostyla invaginata Stokes; on Cypris and Cyclops from screenings in Biemiller's cove.

Genus Opisthostyla Stokes.

Opisthostyla pusilla Stokes; on duckweed from Biemiller's cove.

Genus Opercularia Stein

Opercularia allensi Stokes; on species of Clepsine, a number of parasitized individuals were found all at the same place.

Class Infusoria — Continued.

Opercularia nutans Ehr.; on roots of Lemna from college run, Columbus; on duckweed roots at Sandusky.

Opercularia humilis Kell.; on the leech Clepsine from Biemiller's cove.

Opercularia lichtensteinii Stein; on duckweed roots from Biemiller's cove.

Opercularia berberina Linn.; attached to dragon fly larva from Biemiller's cove, rare.

Opercularia articulata Ehr.; on willow roots from cove at ice house.

Opercularia stenostoma Stein; on willow roots from college lake, Columbus; on gills of cray fish from creek at Infirmary.

Opercularia elongata Kell.; on duckweed roots from Biemiller's cove.

Opercularia rugosa Kell.; on duckweed roots, Biemiller's cove.

Genus Thuricolopsis Stokes

Thuricolopsis kellicottiana Stokes; attached to algae and willow roots from basket factory cove.

Thuricolopsis innixa Stokes; on willow roots from college lake, Columbus.

Genus Cothurnia C. & L.

Cothurnia annulata Stokes; among algae from Biemiller's cove.

Cothurnia imberbis Ehr.; attached to algae from the willow roots from college lake (east), Columbus.

Cothurnia elongata From.; attached to algae and willow roots from Biemilmiller's cove.

Cothurnia spissa From.; on duckweed roots from basket factory cove; in college lake, Columbus.

Class Infusoria — Continued.

Cothurnia variabilis Kell.; attached to gills of Cambarus from creek near Sandusky, never attached to each other; from Columbus also.

Genus Stylocola De From.

Stylocola ampulla From.; from algae in basket factory cove.

Genus Vaginicola C. & L.

Vaginicola tincta Ehr.; on roots of duckweed from basket factory cove.

Vaginicola leptosoma Stokes; on Lemna roots from basket factory cove.

Vaginicola grandis Perty; on willow roots from college lake, Columbus, agrees with above except that there are few or no green granules.

Vaginicola inclinata De From.; on Cladophora from college lake (east), Columbus, body extruded about $\frac{1}{3}$ its length from lorica.

Vaginicola ingenita (From.) S. K.; on Zygnum from basket factory cove.

Vaginicola gigantea D'Udk.; on willow roots from college lake, Columbus, agreeing with above but body extruded $\frac{1}{3}$ its length from lorica.

Vaginicola crystallina Ehr.; on Lemna from basket factory cove.

Vaginicola vestita From.; on roots of Polygonum emersum from Biemiller's cove.

Genus Platycola S. K.

Platycola coelochila Stokes; on Lemna roots from near basket factory cove.

Platycola regularis De From.; on discarded skin of Culex larva.

Class Infusoria — Continued.

Platycola decumbens (Ehr.) S. K.; attached to willow roots, Columbus; in basket factory cove, Sandusky.

Platycola gracilis From. sp.; on duckweed roots from Biemiller's cove.

Platycola truncata From. sp.; on duckweed roots from Biemiller's cove.

Genus Pyxicola S. K.

Pyxicola carteri S. K.; on algae from Biemiller's cove.

Pyxicola annulata Leidy; on willow roots from college lake, Columbus, body has boss like prominence at point of attachment. Syn. P. striata Kell. A. S. M. 84.

Pyxicola pusilla S. K.; on algae from basket factory cove.

Pyxicola constricta Stokes; on willow roots from college lake, Columbus, also common at Sandusky.

Pyxicola affinis S. K.; attached to algae from college lake, Columbus.

Genus Pyxidium S. K.

Pyxidium inclinans (Müll.) S. K.; on duckweed from Biemiller's cove.

Pyxidium cothurnoides S. K.; on decaying vegetation from Biemiller's cove, and on Entomostraca.

Genus Thuricola S. K.

Thuricola operculata Gruber; attached to willow roots, Columbus.

Thuricola valvata (Wright) S. K.; on roots of duckweed from basket factory cove.

Genus Lagenophrys Stein.

Lagenophrys ampulla Stein; on Gammarus pulex from Biemiller's cove.

Class Infusoria — Continued.

Lagenophrys nassa Stein; on Gammarus pulex from Biemiller's cove.

Subclass Suctoria.

Family Podophryidae.

Genus Sphaerophrya C. & L.

Sphaerophrya hydrostatica Eng.; on decaying vegetation from Biemiller's cove.

Sphaerophrya magna Maupas; in Chlamydomonas culture from moist sand on beach at Cedar Point.

Genus Podophrya Ehr.

Podophrya brachypoda Stokes; on algae from ice house cove, also on Opercularia stenostoma from basket factory cove.

Podophrya diaptomi Kell.; found on Cladophora from basket factory cove, Sandusky, one individual.

Podophrya quadripartita C. & L:; attached to algae from lake, Columbus, and on Epistylis flavicens.

Podophrya fixa Müll.; on Cyclops from Biemiller's cove.

Podophrya cyclopum C. & L.; on Cyclops sp., common; also on Gammarus.

Podophrya lichtensteinii C. & L.; attached to thorax of Gammarus pulex from Biemiller's cove, one specimen.

Podophrya infundibulifera Hartog.; on Cyclops from Biemiller's cove.

Family Acinetidae.

Genus Acineta Ehr.

Acineta stellata S. K.; on algae from Biemiller's cove, also among duckweed roots.

Class Infusoria — Concluded.

Acineta mystacina Ehr.; on algae from basket factory cove, especially on algae among duckweed roots, long and short forms both common.

Acineta lacustris Stokes; on algae (Cladophora) from basket factory cove near ice house; also from college lake, Columbus, common.

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INDEX.

GENUS.	PAGE.
Acanthocystis	430
Acineta	453
Actinosphaerium	430
Actinophrys	429
Amblyophis	133
Amoeba	427
Amphileptis	439
Anisonema	436
Anoplophrya	442
Anthophysa	431
Arachindium	443
Arcella	427
Aspedisca	444
Assulina	429
Astasia	435
Atractonema	435
Biomyxa	431
Calceolus	443
Carchesium	447
Centropixis	429
Ceratium	438
Chaetospira	443
Chilomonas	436
Chilodon	440
Chlamydomonas	437
Chlorangium	437
Chloromonas	435
Chloropeltis	435
Cladonema	431
Clathrulina	430
Codosiga	433
Colacium	433
Coleps	439
Colpidium	441
Colpoda	441
Concopthirus	442
Cothurnia	450
Cryptoglena	435
Cryptomonas	436
Cyclidium	442
Deltomonas	431
Didinium	439
Difflugia	428
Dinobryon	436
Distigma	435
Entosiphon	436
Epistylis	448
Eudorina	437
Euglena	433
Euglypha	429
Euplotes	444
Frontonia	441
Gonium	437
Gerda	445
Heleopera	429
Heterophrys	430
Hexamitus	433
Holophrya	438
Hoplitophrya	442
Hyalodiscus	427
Hyalosphenia	428
Kerona	444
Lacrymaria	438
Lagenophrys	452
Lagynus	439

GENUS.	PAGE.
Lembadion	442
Leucophrys	441
Lionotus	439
Loxocephalus	441
Loxodes	440
Loxophyllum	440
Mallomonas	436
Metopus	442
Microthorax	441
Monosiga	431
Nassula	440
Nebela	428
Opalina	442
Opercularia	449
Opisthostyla	449
Opisthotricha	444
Oxytricha	444
Pamphagus	428
Pandorina	437
Paramaecium	441
Paramonas	435
Pelomyxa	427
Peridinium	438
Phacus	434
Plagiotoma	442
Platycola	451
Podophrya	453
Porodon	438
Pyxicola	452
Pyxidium	452
Raphidiophrys	430
Rhabdostyla	449
Salpingoeca	432
Scyphidia	445
Sphaerophrya	453
Spirochona	445
Spirostomum	443
Stentor	443
Stichotricha	444
Strombidium	443
Stylobryon	431
Stylocola	451
Stylonychia	444
Synura	436
Tillina	439
Thuricola	452
Thuricolopsis	450
Trachelomonas	434
Trachelophyllum	438
Trachelocerca	439
Trachelius	440
Trichodina	445
Trinema	429
Urceolus	435
Urocentrum	441
Uroglena	436
Uroleptus	444
Urostyla	443
Vaginicola	451
Vampyrella	429
Volvox	438
Vorticelli	446
Zoothamnium	448