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AUTHORS INDEX.

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Vol. XX NOVEMBER, 1919 No. 1

REPORT OF THE TWENTY-NINTH ANNUAL MEETING OF THE OHIO ACADEMY OF SCIENCE

EDWARD L. RICE, *Secretary*.

The Twenty-ninth Annual Meeting of the Ohio Academy of Science was held at Ohio State University, Columbus, Ohio, May 29 to 31, 1919, under the presidency of Professor Maynard M. Metcalf. Seventy-nine members were registered as in attendance; forty new members were elected.

On invitation of the Academy, a meeting of the psychologists of the State was held in connection with the Academy meeting, for the presentation of papers and the consideration of the formation of a Section for Psychology in the Academy. The organization of the section was accomplished, and the titles of papers presented are included in the program of the meeting of the Academy.

At the close of the formal session, the geologists, under the leadership of Professors J. E. Hyde and T. M. Hills, made an excursion to Newark for the study of glacial physiography and the Upper Waverly formation, while Professor W. M. Barrows conducted a zoological and botanical excursion to Sugar Grove

General Program

Thursday, May 29.

2:00 P. M.	Business Meeting.
3:30 P. M.	Reading of Papers, General Session.
6:00 P. M.	Dinner, followed by Address of the President, Professor Maynard M. Metcalf, Oberlin College, "The Scientific Spirit."
8:30 P. M.	Informal Social Gathering.

Friday, May 30.

9:00 A. M.	Reading of Papers, Sectional Session.
12:30 P. M.	Luncheon.
2:00 P. M.	Adjourned Business Meeting.
3:00 P. M.	Reading of Papers, General Session.
4:30 P. M.	Demonstrations.
6:00 P. M.	Supper.
7:30 P. M.	Public Lecture by Mr. David Carroll Churchill, Oberlin, "Airplanes, Present and Future."
8:30 P. M.	Informal Social Gathering and Inspection of Demonstrations.

Saturday, May 31.

Excursions.

Minutes of Business Meetings

The first business session was called to order by President Metcalf at 2:00 P. M., on Thursday, May 29. An adjourned session was held at 2:00 P. M. on the following day.

The appointment of the following committees for the meeting was announced by the chair:

Committee on Membership—F. C. Blake, G. D. Hubbard, L. B. Walton.

Committee on Resolutions—T. C. Mendenhall, C. G. Shatzer, E. L. Fullmer.

Committee on Necrology—C. E. O'Neal, E. L. Rice.

The following Auditing Committee was elected by the Academy: J. H. Schaffner, R. C. Osburn.

The following Nominating Committee was elected by the ballot of the Academy: F. L. Landacre, G. F. Lamb, T. C. Mendenhall.

Report of the Secretary

The following report by the Secretary was received and ordered filed:

DELAWARE, OHIO, May 26, 1919.

To the Ohio Academy of Science:

In addition to the work done in conjunction with the Executive Committee (covered in the report of that Committee) and with the Program Committee, the Secretary has conducted the usual routine work of his office.

A brief report of the Twenty-eighth Annual Meeting was prepared for "Science," and appeared in the number for September 13. The complete report has appeared in the April number of the Ohio Journal of Science and in the Proceedings of the Academy. Announcement of the current meeting was sent to the Ohio State Journal, Columbus Dispatch, and Columbus Citizen.

In connection with the filling out of a questionnaire from another Academy, it became necessary for the Secretary to compile data as to the distribution of our membership in the various sciences. The figures, although only an approximation, are not without significance and may be of interest to the Academy. Probably some members who are classed under Zoology and Botany belong rather in the group of Medical Sciences, not having revised their classification since the foundation of the section of Medical Sciences. The figures are as follows:

Zoology, 79; Botany, 66; Geology, 40; Physics, 29; Medical Sciences, 16; Chemistry, 6; Mathematics, 4; Unclassified, 18.

The Secretary has commenced to collect data for a permanent record of the war activities of the Academy membership. The returns are too incomplete to justify a report at this time. If the undertaking is approved, it is desirable that a special committee be appointed for its completion and that the Academy authorize the publication of the completed roll.

Two years ago the Academy authorized the reprinting of the Constitution and By-Laws and appointed a committee for this purpose. Owing to an unusual number of pending amendments the committee took no action. Does the Academy wish a reprinting in connection with the report of this meeting? Or is it desirable to wait until 1920 (Thirtieth Annual Meeting) and then reprint regularly at five year periods? The last printing of the Constitution was in 1913; about a dozen amendments have been enacted since that date.

The circular of information is now out of print. Does the Academy desire to have it revised and reprinted? If so, are there any suggestions as to changes in form or content?

Respectfully submitted,

EDWARD L. RICE, *Secretary.*

Report of the Treasurer for the Year 1918-19

The report of the Treasurer was received as follows, and referred to the Auditing Committee, whose report is appended.

For the year since our last annual meeting, the receipts, including balance from last year, have amounted to $481.85, and the expenditures to $357.70, leaving a cash balance of $124.15.

RECEIPTS.

Balance from last year	$201.35
Membership dues	280.50
	$481.85

EXPENSES.

Miscellaneous expenses	$ 69.70
190 subscriptions to the Ohio Journal of Science	190.00
Publication of Annual Reports for 1916-17	98.00
Balance, May 30, 1919	124.15
	$481.85

Respectfully submitted,

James. S. Hine, *Treasurer.*

October 15, 1919.

These accounts have been audited and found correct.

Raymond C. Osburn,
John H. Schaffner,
Auditing Committee.

Report of the Executive Committee

The report of the Executive .Committee was received as follows and ordered filed.

May 29, 1919.

To the Ohio Academy of Science:

A meeting of the Executive Committee was held in Columbus, December 7, 1918, with all members in attendance. A second meeting was held this morning, with the following members present: Metcalf, Osburn, Walton and Rice. Aside from these meetings a considerable amount of business has been transacted through correspondence.

After careful consideration of the proposal to restrict the membership of the Academy to those engaged in productive scientific work, presented by Dr. Mendenhall at the last Annual Meeting and referred to the Executive Committee, the Committee makes the following recommendations: (1) That a class, to be known as Fellows, be created from the members who are doing productive scientific work; (2) that the selection of Fellows be made by the Executive Committee and the Vice-Presidents of the various sections; (3) that eligibility to office be limited to Fellows. It is hoped in this way to secure the objects of Dr. Mendenhall's proposition without sacrificing the present popular and democratic character of the Academy. A straw vote of members not expecting to attend the present meeting shows 27 in favor of the change, 1 against it and 14 neutral or in doubt. The substance of these recommendations will be presented in the form of amendments of the Constitution for action later in the meeting.

An invitation to hold the Annual Meeting for 1919 in London was was received last year from Mrs. Katharine Dooris Sharp, seconded by the local Board of Trade. After a somewhat extended correspondence it was decided that it would be difficult, if not impossible, to secure the needful hotel and meeting accommodations in London, and the matter was dropped by mutual consent.

Correspondence was also conducted through the Secretary relative to the possibility of a joint meeting with the Indiana Academy; but this project was given up, at least for the present year, largely because of the fact that the spring meeting of the Indiana Academy is wholly a field meeting. It seemed unwise to omit the only opportunity of the year for the reading of papers in the Ohio Academy. As noted in the preliminary announcement of this meeting, the Indiana Academy extended a very cordial invitation to the members of the Ohio Academy to join them in their field meeting of last week.

The ultimate decision concerning time and place of the meeting is already known to the Academy.

The Executive Committee directed the Secretary to renew correspondence with the psychologists of the state with a view to the establishment of a Section of Psychology. A partial result of this correspondence is seen in the psychological titles listed in the program of the meeting; it is hoped that a further result will be seen tomorrow morning in the organization of the Section of Psychology.

The resignation of Prof. Samuel R. Williams from the Vice-Presidency for Physics, because of sabbatical leave and prospective absence from the state, was presented to the Executive Committee, and Prof. S. J. M. Allen was appointed to fill the vacancy.

Twelve members have been elected by the Executive Committee since the last annual meeting. The names will be presented later for ratification by the Academy.

The Executive Committee unites in recommending two changes in the financial plan of the Academy—the amendment of the By-Laws to increase the annual dues from $1.50 to $2.00, and the authorization by the Academy of the payment of traveling expenses of officers and committee members attending regularly authorized committee meetings not held in connection with the Annual Meeting of the Academy.

The Committee also unites in recommending the rescinding of the By-Law requiring the Nominating Committee to present a double slate of nominations for officers.

At the meeting held this morning the President of the Academy presented correspondence with Professor J. McKean Cattell relative to an affiliation of the Ohio Academy with the American Association for the Advancement of Science, the affiliation to permit the representation of the Academy on the Council and Sectional Committees of the American Association for the Advancement of Science, but to commit the Academy to no financial obligations. The Executive Committee recommends that the Academy approve the general plan of affiliation and refer the matter with power to the Executive Committee for 1919-20. Respectfully submitted,

EDWARD L. RICE,
Secretary, for the Committee.

Report of the Publication Committee

The following report of the Publication Committee was received and ordered filed.

May 29, 1919.

The Chairman of the Publication Committee reports the publication of the "Proceedings" mailed to members of the Academy several weeks prior to the date of the present meeting.

L. B. WALTON.

Report of the Trustees of the Emerson McMillin Research Fund

The following report of the Trustees of the Research Fund was received and ordered filed. The financial portion of the report was referred to the Auditing Committee, whose report is appended.

The Trustees of the McMillin Research Fund submit the following report for the year ending May 30, 1919.

RECEIPTS.

Balance on hand May 30, 1918, as per last report	$913.52	
May 23, 1919, Received from Mr. McMillin	250.00	
		$1,163.52

EXPENDITURES.

June 3, 1918, Liberty Bond, par value $500.00 (held for safe keeping by the Capital City Bank, Columbus, Ohio)	484.95
Cash balance in bank, May 30, 1919	678.57
Total assets (Liberty Bond at par)	1,178.57

GRANTS DURING THE YEAR.

May 31, 1918, Professor J. S. Hine	$ 50.00	
February 3, 1919, Professor Walter H. Bucher	100.00	
		$ 150.00
Liabilities from previous grants		137.60
Total liabilities		287.60
Cash in bank in excess of liabilities		390.97

The Trustees announce that grants concerning which no reports of progress have been received will be cancelled at the end of the year.

Regarding the grant of $100.00 to Professor Bucher, it may be desirable to explain that it was made for the purpose of relabelling a valuable and extensive collection of Naiades made by the late George W. Harper, of Cincinnati, and by him donated to the University of Cincinnati. All had been carefully labelled as to locality, but the labels were old, faded and many of them loose, so that there was great danger of their being hopelessly disarranged and permanently lost.

The grant of a portion of the research fund to secure the preservation of the collection is something of a departure from the usual practice, but the object to be attained seemed to justify it. It was agreed on the part of the Cincinnati authorities that the collection should forever be available for study by any member of the Academy whose qualifications for such work were properly attested by its officers.

T. C. Mendenhall, *Chairman*,
Herbert Osborn.

May 30, 1919.

The financial portion of the report of the Trustees of the Research Fund has been audited and found correct.

Raymond C. Osburn,
John H. Schaffner,
Auditing Committee.

Report of the Library Committee

For the Library Committee, Mr. Reeder, of the Ohio State University Library, presented the following report, which was received and ordered filed.

May 29, 1919.

To the Ohio Academy of Science:

The Library Committee begs leave to submit the following report:

(1) The sales of publications during the year amounted to $13.90. This sum has been turned over to the Treasurer.

(2) Printed copies of the Annual Report of the Twenty-eighth Meeting, 1918, were received about two weeks ago, and copies have been mailed to all persons on the membership list as printed in that report, and to all institutions, societies and libraries on the exchange list.

(3) War conditions affected the exchange situation of the Academy as it did of all scientific organizations. Fewer publications were issued and transportation difficulties hindered their distribution. However, since the resumption of near-peace conditions, the foreign societies are informing us that they are now ready to resume exchange relations. Institutions in this country are active in completing files and more parts of the Academy's Proceedings have been sent out for this purpose than usual. Several of these libraries have been restored to the exchange mailing list.

(4) The status of the Union Catalog of Scientific Periodicals is about the same as outlined in the last report. Additional shipments of cards have been received from Oberlin College Library and the Western Reserve University College for Women. On account of the difficulties experienced by libraries in maintaining and meeting the extra demands for service during the war, no pressure has been brought to bear for additional contributions to the Union Catalog. However, it is known that several libraries have partially completed records ready for shipment, and are only waiting the completion of their periodical listing before depositing the cards with the Academy.

(5) The University Library desires to call attention again to its desire and willingness to serve the members of the Ohio Academy with scientific literature. Through the exchanges and regular purchases, there is maintained a library equipment which can serve in a very satisfactory way the scientists of this state, if they only will make use of the facilities offered to them, either directly through study in the library itself, or through the system of inter-library loan.

Respectfully submitted,

C. W. Reeder.

Report of the Committee on Legislation

The following report of the Committee on Legislation was received and ordered filed.

Your committee appointed to consider the matter of Legislation begs to report as follows:

We find that a number of State Academies receive state support either in the form of publication funds, or support of secretaries or other activities. In all states where such support is in force there seems to be agreement as to the advantage of such support and the only argument opposed to the plan is the possible interference with the entirely independent attitude of the academies as to matters affecting state activity.

The committee recommends that legislation to provide the following lines of support be requested at the hands of the next session of the general assembly and that the Committee on Legislation be authorized to arrange for the introduction of the necessary bills and to meet any necessary expenses incurred in the proper attention to their consideration.

First—A provision for the publication of the Proceedings of the Academy, preferably by the direct appropriation of an adequate sum for a creditable publication of not more than 500 pages per year, or, if necessary, as a part of the State printing.

Second—A provision for the compensation of a permanent secretary whose duty shall be to edit the proceedings, look after the activities of the society, the arrangement of details for scientific service to the State under the plan proposed in No. 3, and other matters of society interest.

Third—A provision that in consideration of the support provided as above, the academy agree to act in an advisory capacity in all matters of scientific concern in which the officers of the state may desire their services, such relation to be arranged through the officers and such committees as they or the Executive Committee may appoint, such services to include advice in matters of policy concerning state service of a scientific character and the recommendation of a special expert scientific assistance where needed.

HERBERT OSBORN,
MAYNARD M. METCALF,
EDWARD L. RICE,
T. C. MENDENHALL,
L. B. WALTON.

Election of Officers

The following officers and committee members for 1919-20 were elected by the ballot of the Academy:

President—Professor F. C. BLAKE, Ohio State University, Columbus.

Vice-Presidents:

Zoology—Professor F. H. HERRICK, Western Reserve University, Cleveland.

Botany—Professor A. B. PLOWMAN, Municipal University of Akron, Akron.

Geology—Professor J. E. HYDE, Western Reserve University, Cleveland.

Physics—Professor M. E. GRABER, Heidelberg University, Tiffin. (Owing to removal from the state, Professor Graber was unable to accept his election and the Executive Committee appointed Professor J. A. CULLER, Miami University, Oxford to fill the vacancy).

Medical Sciences—Professor R. J. SEYMOUR, Ohio State University, Columbus.

Psychology—Professor G. R. WELLS, Ohio Wesleyan University, Delaware.

Secretary—Professor E. L. RICE, Ohio Wesleyan University, Delaware.

Treasurer—Professor W. J. KOSTIR, Ohio State University, Columbus.

Elective Members of Executive Committee—Professor WILLIAM McPHERSON, Ohio State University, Columbus; Professor L. G. WESTGATE, Ohio Wesleyan University, Delaware.

Member of Publication Committee—Professor J. H. SCHAFFNER, Ohio State University, Columbus.

Trustee of Research Fund—Professor G. D. HUBBARD, Oberlin College, Oberlin.

Member of Library Committee—Mr. C. W. REEDER, Ohio State University, Columbus.

Election of Members

The Membership Committee reported twenty-eight names for election to membership; twelve additional names, previously approved by the Executive Committee and marked with * in the following list, were presented for ratification. All were elected as follows:

Aikins, H. Austin, Psychology, Western Reserve University, Cleveland.
Alexander, William H., Meteorology, Weather Bureau, Columbus.
*Ballin, E., Chemistry, 320 Burns Ave., Wyoming.
*Birch, T. Bruce, Psychology, 1115 N. Fountain Ave., Springfield.
*Bliss, Chester I., Entomology, Psychology, General Biology, Museum Technique, 316 W. Eighth Ave., Columbus.
*Breitenbecher, J. K., Zoology, Western Reserve University, Cleveland.
Bridges, James W., Psychology, Ohio State University, Columbus.
Campbell, Eva Galbraith, Biology, 141 N. Franklin Street, Delaware.
Churchill, D. C., Physics, Oberlin.
Courtright, Emma L., Biology, 1493 E. Long St., Columbus.
Coy, Genevieve L., Psychology, 317 W. Tenth Ave., Columbus.
Crane, Harry W., Psychology, 1827 Summit Street, Columbus.
Culler, Elmer A., Psychology, Ohio State University, Columbus.
Evans, J. E., Educational and Child Psychology, 31 Seventeenth Avenue, Columbus.
*Fox, Rolland D., Biology, 395 Doyle Street, Akron.
Gatewood, Esther L., Psychology, Biology, 440 E. North Broadway, Columbus.
Goudge, Mabel Ensworth, Psychology, 1827 Summit Street, Columbus.
Jones, C. Thompson, Psychology, Bureau of Juvenile Research, Columbus.
*Kindred, James Ernest, Zoology, 1353 E. Ninth Street, Cleveland.
Lampe, Lois, Botany, Washington C. H.
Mateer, Florence, Psychology, Bureau of Juvenile Research, Columbus.
Mitra, Swarna Kumer, Botany, 189 W. Eleventh Avenue, Columbus.
Morrey, C. B., Bacteriology, Ohio State University, Columbus.
Mosher, Edna, Entomology, Botany and Zoology Building, Ohio State University, Columbus.

*Otis, Charles H., Botany, Adelbert College, Western Reserve University, Cleveland.
Pintner, Rudolf, Psychology, Ohio State University, Columbus.
Reamer, Jeannette, Psychology, 1751 Franklin Park, So., Columbus.
Ridenour, Alice Louise, General Science, London.
Rogers, A. Sophie, Psychology, Dept. of Psychology, Ohio State University, Columbus.
*Shollenberger, F. J., Physics, Mount Union College, Alliance.
*Skinner, Charles H., Physics, 102 University Avenue, Delaware.
Taylor, Mrs. Bayard, Botany, Ornithology, West Jefferson.
*Thomas, Edward S., Ornithology, 81 Ruggery Bldg., Columbus.
Toops, Herbert A., Psychology, Harrisburg.
*Trettien, A. W., Psychology, Toledo University, Toledo.
*Wagner, M. Channing, Physics, 941 Harriett St., N. W., Canton.
Weiss, Albert P., Psychology, Biology, Ohio State University, Columbus.
Wells, G. R., Psychology, Delaware.
Wood, Louise, Psychology, Bureau of Juvenile Research, Columbus.
Wright, Ivan G., Psychology, Lenox Hotel, Columbus.

The Report of the Committee on Necrology

The following report was presented by the Committee on Necrology:

But a single death in the Academy membership has been reported this year.

Eugene Ray Burton joined the Academy in 1915. He was born in Hamilton, Iowa, May 10, 1891. When he was about five years old, his family moved to Findlay, Ohio, where he spent his boyhood and prepared for college. In the fall of 1911 he entered Ohio Wesleyan University, where he received the degrees of B. A. and M. S. in 1915 and 1916 respectively. Before his graduation he served as assistant in Zoology, and remained as teaching fellow, 1915-16, and instructor, 1916-17. In the latter year he and his wife (Dorothy Walters Burton, also a member of the Academy) were in joint charge of the zoological work of the college during the absence of the head of the department.

The year 1917-18 was spent in a successful experiment as superintendent of schools in Felicity, Ohio; but Mr. Burton felt that Biology was his real field, and resigned his position to accept an instructorship in Marquette University Medical School, Milwaukee, Wisconsin. This work he was destined never to take up. Early in the summer of 1918 he moved to Milwaukee, where he died suddenly on August 14, following an operation for appendicitis.

And thus, at its very beginning, a life was suddenly cut off which gave promise of the highest success and usefulness. Mr. Burton was devotedly interested in Zoology and absolutely loyal to scientific truth. Instinctive powers of observation and a passionate love of the out-of-doors gave him exceptional ability as a field naturalist. His death is a real scientific loss to the Academy; to those of us who were intimately associated with him the personal loss is even more keenly felt. Mr. Burton was and original stimulating an student, a generous colleague, and a true friend, whom we can ill spare and never forget.

CLAUDE E. O'NEAL,
EDWARD L. RICE,
Committee.

Report of Committee on Resolutions

The following resolutions were presented by the Committee on Resolutions and adopted by the Academy:

1. The Academy wishes to thank the Local Committee and the professors and officers of Ohio State University for their aid in making the Twenty-ninth Annual Meeting a most successful one.

2. The Academy expresses its thanks to Mr. Emerson McMillin for his generous gifts in support of research work in Ohio.

3. The Academy thanks Mr. David Carroll Churchill for his interesting and instructive lecture on Airplanes.

4. The members of the Academy desire to express their appreciation of the work of our Secretary, which has so materially contributed to the success of this meeting.

T. C. MENDENHALL,
E. L. FULLMER,
Committee.

Amendment of Constitution

The following amendments of the Constitution, relative to the establishment of a class of Fellows, were unanimously adopted, notice having been given at the preceding Annual Meeting.

Article III, Section 1, amended to read:

The Academy shall be composed of Resident Members, Fellows, Corresponding Members, Honorary Members, and Patrons.

Article III, Section 2a, new section (to be renumbered when Constitution is reprinted), to read as follows:

Fellows shall be persons who are engaged in productive and scientific work.

Article III, Section 6, amended to read:

Only Resident Members, Fellows, and Patrons shall be entitled to vote in the Academy; only Fellows and Patrons shall be eligible to office and to membership in the Executive Committee.

Article V, Section 1, Paragraph (a^1), new paragraph (to be renumbered when Constitution is reprinted), to read as follows:

Fellows shall be elected by joint action of the Executive Committee and the Vice-Presidents; approval by three-fourths of the members of this joint committee shall be necessary to election.

Amendment of By-Laws

The following amendments of the By-Laws were adopted, changing the annual dues from one dollar and a half to two dollars, and rescinding the obligation upon the Nominating Committee to nominate two candidates for each office.

Chapter I, Section 1, amended to read:

> No person shall be accepted as a Resident Member or as a Corresponding Member unless dues for the year are paid within three months after notification of election. The annual dues shall be two dollars, payable in advance. A single payment of twenty-five dollars, however, shall be accepted as commutation for life.

Chapter IV, Section 2, amended to read:

> The Academy shall select by ballot a Nominating Committee, consisting of three members who shall nominate a candidate for each office, including elective members of the Executive Committee, the Publication Committee, and the Trustees of the Research Fund. Additional nominations may be made by any member of the Academy.

Committee on Legislation

The Committee on Legislation was continued, with power to add to its own membership if desired. The Committee was authorized to take such steps as may seem advisable, with the approval of the Executive Committee, to secure legislative support for the work of the Academy.

Section for Psychology

On request of the psychologists attending the meeting, the Academy authorized the formation of a Section for Psychology; and the Section was formally organized, with an initial membership of about twenty.

National Department of Public Works

An invitation was received from Mr. E. G. Bradbury, President of the Columbus Engineers' Club, to send a representative to the Annual Meeting of the Engineers' Club, Thursday evening, May 29, to report back to the Academy on the discussion of the proposed National Department of Public Works. The invitation was accepted; and Professor James R. Withrow was appointed to represent the Academy. At the adjourned business meeting on Friday, Professor Withrow presented the following resolution, which was adopted by the Academy:

Resolved, That the Ohio Academy of Science expresses its interest in any legitimate effort to render more effective the scientific and engineering work of the national government, and stands ready to approve and aid in any way within its power efforts at co-ordination of the public works of the national government which may be shown, to the Executive Committee of the Academy or to the Academy itself, to be an increase in scientific engineering effectiveness.

The Secretary was instructed to communicate the action to Mr. Bradbury, the Ohio representative of the national organizations which are backing this program.

Affiliation With A. A. A. S.

The general plan of affiliation, as reported by the Executive Committee, was approved by the Academy; and the incoming Executive Committee was authorized to proceed with the affiliation if found feasible.

Affiliation With Ohio Association of Technical Societies

The Executive Committee was instructed to investigate the desirability of an affiliation with the Ohio Association of Technical Societies, and to present a report at the next Annual Meeting.

War Roll

The President was instructed to appoint a committee of three to collect data concerning war activities of the membership of the Academy. The President appointed E. L. Rice, Chairman; J. S. Hine, W. J. Kostir.

Reprinting of Constitution, By-Laws and Circular of Information

The Secretary was instructed to have the revised Constitution and By-Laws reprinted in connection with the Report of the Thirtieth Annual Meeting, 1920, and regularly thereafter at five year intervals unless otherwise directed.

The Secretary was authorized to proceed at once with the revision and reprinting of the Circular of Information.

Expenses of Officers, etc.

The Treasurer was authorized to pay necessary expenses incurred by officers and committee members in attending regularly authorized committee meetings not held in connection with the Annual Meeting of the Academy.

The Treasurer was also authorized to pay the expenses of Mr. D. C. Churchill in connection with his lecture before the current Annual Meeting.

SCIENTIFIC SESSIONS

The complete scientific program of the meeting follows:

Presidential Address

"The Scientific Spirit" . . . . M. M. METCALF

Public Lecture

"Airplanes, Present and Future" . . DAVID CARROLL CHURCHILL

Papers

1. The Theory of Chance Applied to the Bacon-Shakespeare Controversy. 30 min. (Lantern) . . . . T. C. MENDENHALL
2. Teleology in the Teaching of Zoology. 15 min . . . . W. M. BARROWS
3. Dynamics and Evolution as illustrated in the Euglenoids. 15 min. (Lantern) . . . . L. B. WALTON
4. Notes on a Technique for the Study of Euglenidae. 5 min . . . . . . W. J. KOSTIR
5. The Comparative Resistance of Different Species of Euglenidae to Acids. 5 min . . . . W. J. KOSTIR
6. Notes on a Tingid Destructive to Beans. 5 min . . . . HERBERT OSBORN
7. The European Corn Borer (Pyrausta nubialis, Hubn.) a Menace to American Agriculture. 10 min . . . . E. C. COTTON
8. The Stratification of Spiders in Meadows. 15 min . . . . W. M. BARROWS
9. Concerning the Attachment of Larval Colonies of Pectinatella and Plumatella. 10 min . . . . STEPHEN R. WILLIAMS
10. Remarks on the Phylum Prosopygia. 10 min . . . . RAYMOND C. OSBURN
11. The Bryozoan Fauna of Greenland. 5 min . . . . RAYMOND C. OSBURN
12. Classification of the Salpidae. 15 min. (Opaque projection), MAYNARD M. MATCALF
13. The Remarkable Fauna of a Drop of Pond Water. 3 min . . . . . . W. J. KOSTIR
14. Polymorphism and Allelomorphism in Bruchus quadrimaculatus. 25 min. J. K. BREITENBECHER
15. Circulation of Coelomic Fluid in a Nematode. 15 min . . . . . . F. H. KRECKER
16. Egg Laying of a Leech, Piscicola. 10 min . . . . F. H. KRECKER
17. The Columella Auris of the Reptiles. 10 min . . . . EDWARD L. RICE
18. Information wanted in Zoological and Botanical Cases to be Cited. 5 min . . . . KATHARINE D. SHARP
19. Use of Airplane in Studying Vegetation. 15 min. (Lantern) . . PAUL B. SEARS
20. A Map of Ohio Prairies. 10 min . . . . P. B. SEARS
21. Brief Notes on Some Ohio Plants. 10 min . . . . L. S. HOPKINS
22. A Remarkable Bud Sport of Pandanus. 6 min . . . . JOHN H. SCHAFFNER
23. The Nature of Dieciousness in the Hemp. 10 min . . . . . . JOHN H. SCHAFFNER
24. Xenia in Maize and Rye. 15 min . . . . A. E. WALLER
25. Some Biological Relations of the Hysteriales. 10 min . . . . BRUCE FINK
26. A Hitherto Undescribed Ascomycete. 10 min. (Lantern) . . . . FREDA DETMERS
27. Witches Broom of Bald Cypress. 5 min. (Lantern) . . . . FREDA DETMERS
28. Abscission of Populus deltoides (common cottonwood). 10 min. (Lantern) . . . . LOIS LAMPE, introduced by FREDA DETMERS
29. Toxic and Antagonistic Effects of Salts on Yeast (Saccharomyces ellipsoideus). 30 min . . . . SWARNA K. MITRA, introduced by E. N. TRANSEAU
30. Two Serious Diseases of Wheat New to America . . . . W. G. STOVER
31. Some Future Industrial Centers in America as Seen by a Geographer. 30 min . . . . GEO. D. HUBBARD
32. Estimates on the Thickness of the Sedimentary Rocks of Ohio. 10 min. T. M. HILLS
33. Some Geological Features in the Akron Region. 15 min . . . . . . G. F. LAMB
34. The Location of the Barrier Between the Ohio and Mississippi Valley Basins in Richmond Times . . . . AUGUST FOERSTE
35. Some Aspects of the Waverly . . . . J. E. HYDE
36. The Pyrite Deposits in the Ohio Coals . . . . W. M. TUCKER

37. The Correlation of Ohio Silurian Strata with those of Indiana, AUGUST FOERSTE
38. Elongation of Nickel in Transverse Magnetic Fields. 10 min. H. A. BENDER
39. The Nature of the Lyophilic Colloids and Their Importance in Theoretical and Applied Science. 30 min. (Lantern)............ MARTIN H. FISCHER
40. The Prevention and Treatment of Pneumonia 5 min...E. F. MCCAMPBELL
41. Recent Advances in the Auditory Method of Measuring Blood Pressure. 15 min...CLYDE BROOKS
42. Vaccines and Serums in Coccus Infections. 10 min............C. B. MORREY
43. Five Years of Progress in Medical Entomology. 20 min. (Lantern), EDNA MOSHER
44. A Note on the Technic of Smear Preparations. 6 min.....F. L. LANDACRE
45. Differentiation of Mucous and Serous Cells. 6 min., EVA CAMPBELL, introduced by F. L. LANDACRE
46. Note on the Effect of Dry Heat Upon the Blood of Guinea Pigs. 5 min. JONATHAN FORMAN
47. Observations upon the Complement Content of the Blood of Guinea Pigs which have been Subjected to Dry Heat. 5 min...........CARL H. SPOHR
48. Observations on the Death of Guinea Pigs Induced by Dry Heat. 5 min., ERNEST SCOTT
49. A Model Illustrating Some Features of Urinary Secretion. 10 min. (Lantern)...MARTIN H. FISCHER
50. The Muscle-Twitch Curve. 6 min.........................E. P. DURRANT
51. Vitamine Tests With Chicks. 5 min .R. J. SEYMOUR and E. P. DURRANT
52. An Anomalous Frog Heart. 3 min...............................E. P. DURRANT
53. A Modified Waterhouse Test for Pure Butter. 5 min........CHAS. P. FOX
54. Demonstration of Mendel's Law. 15 min ....W. M. BARROWS
55. Observations on the Diagnosis of Contagious Abortion by Guinea Pig Inoculation. 5 min ....W. A. STARIN
56. Fat Absorption in Earthworm, Salamander and Frog. 15 min. (Lantern), CHAS. G. ROGERS
57. The Normality vs. the Psychopathy of the Precocious Child. 20 min., FLORENCE MATEER
58. The Clinical Function of Psychology. 15 min.........FLORENCE MATEER
59. Short Methods of Individual Examination Used by Psychologists in the Army. 25 min.......................................JAMES W. BRIDGES
60. Psychological Study of a Delinquent. 15 min.............LOUISE WOOD
61. The Very Bright Child. 5 min........................C. THOMPSON JONES
62. The Moral and Religious Psychology of Late Senescence. 5 min., T. BRUCE BIRCH
63. Psychology Applied to the Problems of Everyday Life. 15 min.A. W. TRETTIEN
64. The Vocality of Fork, Violin and Piano Tones. 20 min..ESTHER GATEWOOD
65. Relations of Images in Recall to Directly Aroused Sensations. 15 min. A. SOPHIE ROGERS

Demonstrations

1. A Case of Apparent Triple Superfetation in the Cat .... R. A. BUDINGTON
2. Growths on Glass Slides Submerged in Open Sea Water Ten Days, R. A. BUDINGTON
3. Exhibit of Ohio Cicadellidae.............................HERBERT OSBORN
4. Indications of Circulation of Coelomic Fluid Shown by Preserved Nematodes...F. H. KRECKER
5. Model of Nasal Region of the Lizard, Eumeces, ELVA PUMPHREY, introduced by EDWARD L. RICE
6. Sections of Columella Auris of the Lizard, Eumeces........EDWARD L. RICE
7. A Hitherto Undescribed Ascomycete.....................FREDA DETMERS
8. Auditory Method of Measuring Blood Pressure...........CLYDE BROOKS
9. Technic of Smear Preparations............................F. L. LANDACRE
10. Model Illustrating Some Features of Urinary Secretion..MARTIN H. FISCHER
11. A New Muscle Lever...E. P. DURRANT
12. An Adjustable Spring-myograph.............................E. P. DURRANT
13. An Anomalous Frog Heart...................................E. P. DURRANT

NOTES ON CORYTHUCA BULBOSA O. & D.

Harry B. Weiss

The following notes are the results of observations made at Uhlerstown, Pa., during the first half of the summer of 1919 at which time and place, *Corythucha bulbosa* was noted on the bladder nut tree *Staphylea trifolia*.

On June 11 eggs and adults were present. The blackish eggs were found in groups of from ten to two hundred and fifty, each egg being inserted in the tissue of the lower leaf surface usually more or less at right angles to the leaf. Groups of eggs were noted at various places on the lower surfaces, but in most cases they seemed to be near the edges. The adult feeding was scattered and showed as light spots on the upper surfaces. On June 24 many eggs were found, a few adults and first, second and third stage nymphs. The nymphs were feeding in colonies on the under leaf surfaces. The individuals of a colony tend to scatter out somewhat and the groups are not as compact as those of *Gargaphia tiliæ*.

On July 8 adults were missing, but all stages of the nymphs were present with fourth and fifth stages most plentiful. These were shining brownish-black or black in color. A very few eggs still remained unhatched. The leaflets bearing the fourth and fifth stages were badly injured, many of them being perfectly white and some from which the nymphs had moved were dried and curled. On July 12 the first adults appeared. While an opportunity for visiting this locality again was not afforded, it is extremely probable that this insect is two brooded as in this latitude most species of *Corythucha* are and as adults collected in Ohio and received from Mr. C. J. Drake bear the date September 30.

EGG.

Length 0.65 mm. Width 0.18 mm. Subelliptical, slightly curved, one side almost straight; basal portion with rounded tip; extremity of apical and truncate with rim-like collar and central projecting cone-shaped nipple; sides of apical third almost parallel; widest across middle third. Entire surface covered with black or brownish black varnish-like material, which sometimes hides the contour and makes the shape somewhat irregular; when material is removed, egg is translucent.

FIRST NYMPHAL STAGE.

Length 0.51 mm. Greatest width 0.12 mm. Elongate-elliptical; whitish or brownish white; eyes red, consisting of five, distinct ommatidia; antennæ white, hairy, more than one third length of body; legs long, white; rostrum white, extending beyond bases of last pair of legs; tubercles on head, thorax and abdomen minute and bearing comparatively long hairs.

SECOND NYMPHAL STAGE.

Length 0.82 mm. Greatest width 0.32 mm. Brownish-white; last antennal segment club-like; antennæ almost one-half length of body; tubercles somewhat more developed; otherwise similar in shape, color, armature, etc., to first nymphal stage.

THIRD NYMPHAL STAGE.

Length 1.05 mm. Greatest width 0.55 mm. Subelliptical or oval; brownish to brownish-black; sides of abdomen flattened in this and remaining stages; rostrum extending considerably beyond bases of third pair of legs; armature similar to that of fourth stage, except that in addition the metathorax bears a minute, lateral, dorsal tubercle on each side.

FOURTH NYMPHAL STAGE.

Length 1.65 mm. Greatest width 0.79 mm. Subelliptical or oval; brownish-black or black; antennæ white, almost one-half as long as body; lobes of mesothorax rounded, quite pronounced, extending posteriorly to second abdominal segment; ventral surface and legs white, sparsely hairy; rostrum extending to beyond bases of second pair legs; spines on thoracic and abdominal tubercles light; armature similar to that of fifth stage nymph, except for following: Lateral edge of prothorax anterior to lateral tubercle bears only two spines; lateral edge of mesothorax anterior to lateral tubercle bears only two spines; swelling in centre of mesothoracic wing pad missing.

FIFTH NYMPHAL STAGE.

Length 2.2 mm. Greatest width 1.3 mm. Suboval; prothoracic lobes rounded extending laterally, slightly more than half the width of the mesothoracic lobes; anterior lateral angle of mesothoracic lobe obtuse; wing pads extending posteriorly to lateral tubercles on fourth abdominal segment; sides of abdomen flattened; color brownish-black or black, except for light area on posterior surface of mesothoracic wing pads and a light median area posterior to the prothorax and extending as far as and including median, dorsal portion of the second abdominal segment and its pair of spines; fine, median, light, dorsal line on prothorax; eyes lateral, consisting of numerous distinct, red ommatidia; antennæ white, sparsely hairy, almost one-half as long as body. Legs white, sparsely hairy, hairs short, claws slightly brownish; ventral surface brownish-black or black, except median portion of thorax, rostrum and first two abdominal segments, which are whitish; rostrum extending to between bases of third pair legs. Head bears a pair of spines just above the antennæ, posterior to this pair is a median tubercle bearing two spines, posterior to this tubercle and close to anterior margin of prothorax are two large tubercles, each bearing three prominent spines and several spine-like hairs. Prothorax bears large, median tubercle tipped with several spines and spine-like hairs and a pair of minute, median spines posterior to this tubercle. Posterior lateral angle of prothoracic lobe bears large tubercle with three large spines and several spine-like hairs, on the lateral edge anterior to this tubercle are five minute to medium sized spines. Mesothorax bears pair median, dorsal tubercles, each bearing several small spines; on the lateral edge of the mesothoracic lobe midway between anterior and posterior lateral angles is a large tubercle bearing two prominent and several smaller spines, anterior to this on the lateral edge are five smaller spines. Centre of mesothoracic wing-pad bears a tubercle-like elevation. Second abdominal segment bears a median, dorsal pair of spines. Fifth, sixth and eighth abdominal segments each bear pair median, dorsal tubercles, each tubercle bearing a spine and several spine-like hairs, median spines on eighth abdominal segment close together. Posterior lateral edges of abdominal segments beginning with the fourth each bear a prominent tubercle, each tubercle bearing one large and several smaller spines. Each spine on this and previous stages bears a hair. All spines and hairs arise from tuberculate bases.

ADULT.

Corythucha bulbosa Osborn and Drake (Ohio Biol. Sur. ii, No. 4, p. 232, 1916). This is the largest of the species of *Corythucha* and easily recognized by the brown costal margins of the elytra. According to Gibson it was known by the manuscript names, *carbonata* of Uhler and Heidemann and *staphlea* of Heidemann before being described by Osborn and Drake. It occurrs on *Staphylea trifolia*, American bladder-nut, and Gibson gives its known range as from Maryland and Virginia west to Ohio.

REFERENCES TO THE SPECIES.

Osborn and Drake, Ohio Biol. Sur. II, No. 4, p. 232.
Van Duzee, Cat. Hem. p. 215.
Osborn and Drake, Ohio Jour. Sci., Vol. XVII, No. 8, p. 304.
McAtee, Bull. Brook. Ent. Soc., Vol. XII, No. 4, p. 79
Gibson, Tr. Am. Ent. Soc., XIIV, p. 77:

NOTE ON PROLIFERATIVE POWER OF PINUS sp.

N. M. Grier, Ph. D.

Near Lakehurst, N. J. is the proving ground of the Chemical Warfare Service, U. S. A. It consists of a large tract of exceptionally sandy loam covered mostly with a growth of conifers (*pinus rigida*, principally *echinata*, *sylvestris*), but with occasional oaks, chestnuts, sassafras, etc., intermingled. Most of this tract has been re-forested within 40-50 years, while in this part of New Jersey, forest fires are by no means infrequent.

Judged by the age of oak saplings, a fire had occurred in one part of this tract within the last 4 years. Its effect had been to completely destroy the undergrowth and residual humus and to kill all other kinds of trees but the conifers, whose charred bark indicated the severe heat. A succeeding flora, principally of huckelberry, bracken, commoner grasses had obtained a thriving footing, while the stumps of the destroyed trees supported luxuriant outgrowths. Examination of the trunks of the conifers showed, that previous to the fire, extensive self-pruning had taken place, indicating the density of shade in the woods at one time, the trees branching about 10 feet from the ground. A large number of these branches had been burned quite short, while many of the higher ones had been killed.

It will be remembered that the branching habit of conifers is a radial one—the trunk might be compared to the hub of a wheel, the whorls of branches to the spokes. Also in old trees these whorls are usually some distance apart from each other. The fire, however, had elicited an elaborate response from the trunks—something which seemed unusual to the writer in view of the common impression of the conservative habits of conifers. While thickest at the top of the trees (in fact, very thick), there appeared between the older whorls, in regions of the trunk never branched before and as near the ground as 3 feet, new and healthy whorls of branches. This proliferation also occurred around the stumps of burnt off branches in all directions above, below, and to the sides.

The writer is not familiar with any literature dealing with the localization of branch forming elements in the conifers, although their highly symmetrical habit of branching had often impressed him. While this proliferation was thickest in the younger part of the stem where material might be considered more condensed, the fact that it was found also on the older portions of the stem seemed to indicate that these branch forming elements are by no means limited in locality. They appear to exist everywhere on the stem, and apparently need only the proper stimulus to cause them to grow out. Moreover the full history of the secondary branches shows that where each primary branch emerges from the trunk it is apparently surrounded by the branch forming elements of the secondary branches—the primary branch then becoming comparable to the hub of the wheel. The writer's observation has been that these secondary branch elements rarely develop under normal conditions into branches at this basal position, but undoubtedly portions of them are carried along in the lateral growth of the primary branches, and under appropriate conditions develop the secondary ones.

The hardy character of the trunk and such a distribution of branch forming material under the circumstances described, may be granted a distinct advantage. While many of the older branches were destroyed, yet the younger proliferating elements were rapidly filling their place, *at their base*, as well as between nodes. Ordinarly, an angiospermous tree sufficiently resistant to fire could supply one or two branches in any given region of the trunk where the conifer could produce a larger number. In the former, it would mean that so far as reproduction and maturity are concerned, a tree burned to the ground has to start over; an injury sufficient to destroy an angiospermous tree leaves unharmed the trunk of the conifer, and the young branches of the conifer find their lines of supply still highly organized. The high pitch and other organic content in the conifer is also of advantage, for such under influence of high temperatures readily carbonizes, and forms a protective layer readily resisting the encroach of the destroying heat. These facts seem to have a direct relation to what we believe to be the conditions under which conifers evolved, and to their persistence in geologic time.

Some opportunity was afforded to observe in the vicinity the effect of the various poison gases, (phosgene, chlorine, "mustard," etc.), on the two types of trees, angiosperms and gymnosperms, in a portion of the proving ground where there had been extensive artillery firing. Here the former seemed more in luck, proliferation seemed to be reduced in the conifers and these trees, although scarcely damaged by shell fragments, apparently were scarcely living and had a comparatively greater number of dead branches. A possible reason is the greater ease of aeration of leaves in the angiosperm, which the thick bushy leaves of the conifers seems to inhibit. The fact that the whole tree seemed to suffer when under such conditions, would seem to indicate that the effects of these substances is by no means localized, but would seem to exist throughout the tree. While dead branches in the other type of tree were not uncommon, yet the impression was gained that on the whole they had suffered less.

Dr. O. E. Jennings, Curator of Botany, Carnegie Museum, has been kind enough to make certain comments on this data, which I have combined in the above.

Hollins College.

A NEW GENUS ALLIED TO INCURVARIA (MICROLEPIDOPTERA).

Annette F. Braun.

The genus described below includes several species hitherto placed under *Incurvaria*, to which it is allied, but from which it differs in several particulars.

Cyanauges new genus.

Head and face rough-haired. Antennæ $^2/_3$, thickened throughout in both sexes with closely appressed scales; microscopically pubescent. Tongue short; labial palpi moderately long, porrected, second segment with spreading bristles below and at apex, terminal segment pointed, with a few bristles; maxillary palpi minute. Posterior tibiæ hairy. Ovipositor of female long, heavily chitinized. Wing membrane with fixed hairs or "aculei" throughout; the normal broad scales overlaid more or less densely with elongate metallic scales.

Fore Wing: All veins present, R_4 and R_5 short stalked, R_5 to costa; accessory cell defined, base of media obsolescent, forked at extreme end of cell, posterior arculus distinguishable, but obsolescent; Cu and 1st A coalescent at extreme base; Cu_1 and Cu_2 widely separate in male, connate in female; 2d A forked at base.

Hind Wing: Male with single-spined frenulum, female with rudimentary frenulum and series of costal spines beyond; $Sc+R_1$ forked at base, R_s obsolescent toward base; M_1 and M_2 separate, approximate, or short stalked; base of media and posterior arculus distinct; 2d A forked at base.

Genotype: *Cyanauges cyanella* Busck (Proc. Ent. Soc. Wash. XVII, 92, 1915).

In this genus should also be placed *dietziella* Kearfott (Jn. N. Y. Ent. Soc., XVI, 187, 1908), which agrees with *C. cyanella* in all respects, except that M_1 and M_2 of hind wing are short stalked. *Incurvaria itoniella* Busck, which I have not examined, probably also belongs here.

The wings of *Cyanauges cyanella* are figured in a forthcoming paper, where the presence of certain persistent primitive characters, such as the posterior arculus and the basal coalescence of Cu and 1st A, is noted and their significance discussed.

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DIECIOUSNESS IN THALICTRUM DASYCARPUM.*

JOHN H. SCHAFFNER.

In the search for further light on the nature of dieciousness, the writer made some observations on Thalictrum, as representing a genus of plants quite low in the evolutionary scale yet showing considerable specialization. The Ranunculaceæ, among which the meadow-rues are included, are normally bisporangiate plants and the lower species of Thalictrum are also bisporangiate, as for example, Thalictrum clavatum DC. and Thalictrum alpinum L. Thalictrum clavatum shows plainly that the ancestral type of the genus had the normal lateral stamens and terminal carpels so characteristic of Anthophyta, altho in the specialized species as will appear below there is no definite position for either stamens or carpels in the intermediate type of flowers. Thalictrum dsycarpum Fisch. and Lall. and Thalictrum revolutum DC. are among the diecious species with many intermediate individuals, while Thalictrum dioicum L. and other species are normally strictly diecious.

In Thalictrum dasycarpum there is no apparent sexual dimorphism between the staminate and carpellate plants except in the sporophylls themselves and even the stamens and carpels have an unusual similarity of appearance before the filaments elongate.

A considerable per cent of the individuals are apparently strictly staminate or carpellate and from these extremes, intermediates grade through all degrees up to individuals which produce nearly an equal number of stamens and carpels. Next to a pure staminate plant may be one completely staminate except that one flower has one normal carpel. A single sporophyll with female expression among thousands with male expression! Or there may be an individual having all carpellate flowers but one of these flowers has a single stamen. The stamens and

* Papers from the Department of Botany, The Ohio State University, No. 118.

carpels are not distributed in any definite way on the bisporangiate flowers of intermediate individuals. In a staminate flower, for example, a single carpel mayappear in the outermost part next the sepals. The same is true of flowers that have a larger number of carpels. The carpels may occupy any chance position on the floral axis. The same conditions apply to stamens in carpellate flowers. A study of the bisporangiate species of Thalictrum shows that the ancestral type had the normal central or terminal carpels and lateral stamens as intimated above.

Below is a record of a few plants showing the number and character of the opposite kinds of sporophylls in staminate and carpellate individuals which show some degree of intermediateness. As stated, any degree of staminateness or carpellateness from either extreme to typical intermediate can be found among the plants growing in the field.

PLANT

No. 1. An individual with pure staminate flowers only.

No. 2. A staminate plant having numerous staminate flowers and 1 flower with numerous stamens and a single carpel.

No. 3. A staminate plant with 2 bisporangiate flowers, each with a single carpel.

No. 4. A staminate individual having 1 bisporangiate flower with 4 carpels.

No. 5. A staminate plant with 3 bisporangiate flowers; 1 flower with 5 carpels and 2 flowers with 2 carpels each.

No. 6. A staminate plant having 1 bisporangiate flower with 2 carpels and 1 with 5 carpels.

No. 7. A staminate plant with 3 bisporangiate flowers; 1 with 1 carpel, 1 with 2 carpels, and 1 with 4 carpels.

No. 8. A staminate plant with 3 bisporangiate flowers; 1 flower with 1 carpel, 1 flower with 2 carpels, and 1 flower with 5 carpels.

No. 9. A staminate plant with 12 main branches of the inflorescence; 9 branches had all pure staminate flowers; 1 branch had 1 bisporangiate flower with a single carpel, 1 branch had 1 bisporangiate flower with 3 carpels, and 1 branch had 1 bisporangiate flower with 7 carpels.

No. 10. A staminate plant with 7 bisporangiate flowers; 3 flowers with 1 carpel each, 1 flower with 2 carpels, and 3 flowers with 5 carpels each.

No. 11. A staminate plant with 17 bisporangiate flowers, each of those flowers having from 1 to 5 carpels.

No. 12. A staminate plant having 33 bisporangiate flowers, the carpels in each flower ranging from 1 to 13.

No. 13. A staminate plant with 37 bisporangiate flowers, the number of carpels in a flower ranging from 1 to 12.

No. 14. A plant having about an equal number of staminate and pure carpellate or bisporangiate flowers. Some bisporangiate flowers had but one stamen and some but one carpel, others ranged in degree from such a condition to flowers with about an equal number of stamens and carpels.

No. 15. A carpellate plant with 9 bisporangiate flowers; 4 flowers with 1 stamen each, 3 flowers with 2 stamens each; and 2 flowers with 3 stamens each.

No. 16. A carpellate plant with 8 bisporangiate flowers; 6 flowers with 1 stamen each and 2 flowers with 2 stamens each.

No. 17. A carpellate plant with 5 bisporangiate flowers; 3 flowers with 1 stamen each, 1 flower with 2 stamens and 1 flower with 3 stamens.

No. 18. A carpellate plant with 4 bisporangiate flowers; 3 flowers with 1 stamen each, and 1 flower with 2 stamens.
No. 19. A carpellate plant with 4 bisporangiate flowers, each flower with 1 stamen.
No. 20. A carpellate plant with 2 bisporangiate flowers, each with 1 stamen.
No. 21. A carpellate plant having among its numerous carpellate flowers 1 bisporangiate flower with 1 stamen.
No. 22. A pure carpellate plant.

If one were inclined to take the time, there is no doubt but that intermediates of almost any conceivable degree of expression of maleness or femaleness could be found. The careful study of individual plants is, however, very tedious, since the larger individuals have great inflorescences with flowers running into the many hundreds. Apparently intermediates are everywhere common in Thalictrum dasycarpum. Around Columbus, Ohio, they are abundant.

According to Overton* Thalictrum purpurascens has 24 chromosomes in the gametophyte and 48 in the sporophyte. The species studied was probably either Thalictrum dasycarpum Fisch. & Lall. or Thalictrum revolutum DC., or both. Now one might consider that the complex sexual expression of Thalictrum dasycarpum was due to the presence of multiple sex factors distributed in a large number of the chromosomes. If there were a half dozen or so allelomorphic pairs of sexual factors and if the number of allelomorphs of one nature or the other determined the degree of intensity and the constancy of sexual expression in some such way as multiple color factors or multiple size factors, the resulting diversity of sexual expression might be something like what actually takes place. But such an hypothesis would after all not explain the facts in the case. For one can find the same diversity of distribution among the various branches of certain bisporangiate individuals as exists among the individuals themselves.

The following examples will indicate the complexity of sexual expression as found in intermediate individuals studied. In the tabulations the main lateral branches coming from the central axis of the inflorescence are roughly considered as equivalent parts and the terminus above the larger branches is considered as one branch. The plants listed were mainly staminate in nature but showed considerable carpellate expression. All the branches had large numbers of pure staminate flowers.

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* Overton, J. B. On the Organization of the Nuclei in Pollen Mother cells of certain Plants with Especial Reference to Permanence of Chromosomes. Ann. of Bot. 23 : 19-61, 1909.

First Plant.

BRANCH

No. 1 had 1 bisporangiate flower with 1 carpel and 1 flower with 2 carpels.
No. 2 had 1 bisporangiate flower with 2 carpels and 2 flowers with 3 carpels each.
No. 3 had all pure staminate flowers.
No. 4 had 4 bisporangiate flowers with 1 carpel each, 2 flowers with 2 carpels each, 2 flowers with 3 carpels each, 2 flowers with 5 carpels each, and 1 flower with 10 carpels.
No. 5 had all pure staminate flowers.
No. 6 had all pure staminate flowers.
No. 7 had all pure staminate flowers.
No. 8 had 1 bisporangiate flower with 7 carpels and 1 flower with 8 carpels.
No. 9 had all pure staminate flowers.
No. 10 had 1 bisporangiate flower with 3 carpels, and 1 flower with 6 carpels.
No. 11 had 2 bisporangiate flowers, each with 3 carpels.
No. 12 had all the flowers pure staminate.
No. 13 had 1 bisporangiate flower with 1 carpel, and 1 flower with 2 carpels.
No. 14 had all the flowers pure staminate.
No. 15 had 1 bisporangiate flower with 6 carpels.
No. 16, the terminal branch, had 1 bisporangiate flower with 1 carpel, 1 flower with 3 carpels, and 1 flower with 5 carpels.

Second Plant.

BRANCH

No. 1 had 1 bisporangiate flower with 1 carpel, 2 flowers with 2 carpels each, and 1 flower with 9 carpels.
No. 2 had 1 bisporangiate flower with 1 carpel, 3 flowers with 2 carpels each, and 1 flower with 3 carpels.
No. 3 had 1 bisporangiate flower with 1 carpel.
No. 4 had 1 bisporangiate flower with 4 carpels.
No. 5 had 1 bisporangiate flower with 1 carpel, 1 flower with 2 carpels, and 1 flower with 3 carpels.
No. 6 had 1 bisporangiate flower with 7 carpels.
No. 7 had all pure staminate flowers.
No. 8 had 1 bisporangiate flower with 7 carpels.
No. 9 had 1 bisporangiate flower with 5 carpels.
No. 10 had 1 bisporangiate flower with 6 carpels.
No. 11, the terminal branch, had 2 bisporangiate flowers with 1 carpel each.

This diversity of sexual expression on different branches of the same inflorescence cannot be due to a diversity of hereditary constitutions, but we must assume that the different degrees of staminate or carpellate expression all come from the operation of a single hereditary complex; maleness or femaleness in any cell or group of cells being determined by some physiological state of the cell or tissue at the inception of the sporophylls of the flower, the physiological state causing the one set or the other of morphological factors involved in the development of sexual structures to become latent or active. We know, for example, that two species of gall-forming insects can, from the same hereditary complex, cause two entirely different galls to appear side by side on a hackberry leaf. The same group of factors can produce any number of forms of morphological expression because of the different physiological states somehow set up in the protoplasts by the presence of the different gall-forming insects. So sexuality appears to be a differential condition or state of greater or lesser degree of intensity and not a set of discreet male and female determiners. In the living tissue we have a positive or negative state set up which we call femaleness and maleness mainly because the characters expressed show a dimorphism. It may even be assumed that for the greater part of sexual characters there are no separate factors for the male and female characters, but that the factors present are merely modified in their activity thru the influence of the male or female state established at the time. The maleness or femaleness or neutral condition of a cell or tissue suggests, in a vague way, some analogy to positive and negative electricity in physics or acid and alkaline substances in chemistry. The dimorphism which appears is probably due to the hereditary mechanism or factors acting under the influence of a male or female condition. If growth is taking place while the given state is set up male characters or female characters of a permanent type appear. In the lowest sexual forms sexuality is commonly developed in the cell when growth is completed and so no dimorphism of structure can appear. In such plants as the more specialized Spirogyras, altho no sexual dimorphism is apparent in the cells until shortly before conjugation, because the cells and filaments are apparently in a neutral state while growth is going on, the conjugation tubes nevertheless do show a dimorphism apparently because the cells are plainly in a male or female state at the time. It is well known that in certain Spirogyras lateral conjugation frequently takes place between adjacent cells of the same filament. In such cases sexuality cannot be determined until near the end of the vegetative period, or if it is determined it is reversed again in certain cells. The sexual state, either male or female is set up in neutral cells without any reference, apparently, as to the presence of a male or female determining factor in a special chromosome. We may compare such cells to a delicately poised balance in which a slight internal physiological difference will tip the beam in one direction or the other. In the case of extreme diecious sporophytes it is possible that the sex is thus determined in the egg even before fertilization takes place. But in such species as

Thalictrum dasycarpum maleness or femaleness frequently is not expressed until a late stage of the vegetative growth of the annual shoot. The only other alternative explanation is to assume that the sex has been determined at an early stage and is later reversed in the vegetative tissues of the incipient inflorescence.

A General Survey of the Origin and Nature of Dieciousness in Sporophytes.

The evidence from comparative morphology indicates very strongly that the first seed plants coming from the great fern phylum, Ptenophyta, had bisporangiate sporophytes. The living heterosporous ferns are bisporangiate, having, as in Marsilea and other genera, microsporangia and megasporangia developed on the same individual and even closely associated on the same leaf. The fossil forerunners, the Bennettitales, of the lowest living seed plants, had bisporangiate strobili, and there is at present little question but that the bisporangiate Magnolias represent the most primitive group of the Anthophyta. Even a superficial study of monecious and diecious species must convince any one that monosporangiate flowers are modifications of bisporangiate flowers.

Another fact that stands out prominently is that dieciousness and moneciousness have been independently derived in many distinct groups all along the evolutionary series from the lowest to the highest heterosporous sporophytes. The development of dieciousness, altho it must be regarded as a decided specialization in hereditary ability, does not then depend on advanced or specialized spermatophyte morphology but seems to be a condition that can be readily established in a low type as well as in an advanced one. This may be due to the fact that the maleness and femaleness is established in an extreme degree in spermatophyte gametophytes and can thus be thrown over, so to speak, into the developing sporophyte which, of course, contains all the hereditary factors of both parent gametophytes with all their evolved complexity.

When compared with its more primitive relatives, like Magnolia, Ranunculus, or Anemone, Thalictrum dasycarpum represents a type of flowering plant which has been directly specialized in a low stage of evolution. The flowers have been reduced and multiplied in the inflorescence until the cluster is very complex when compared with a species having single flowers terminating leafy branches. Thalictrum has progressed far toward the complete segregation of the sporophylls, some species, as mentioned above, being diecious with few if any intermediates. Overton found true parthenogenesis in T. purpurascens both when growing in an artificial environment and also in the field. There is probably no question as to the presence of parthenogenesis in the species; nevertheless, investigators along these lines should make a careful study of the plants employed, otherwise self-pollination may be taking place in individuals which were assumed to be monosporangiate simply because the manuals describe them in general terms as being diecious.

Among the Cycadophyta, the more primitive Bennettitales contain species with bisporangiate flowers while the specialized modern Cycadales, which appear to have been derived from the same primitive stock if not directly from them, have monosporangiate flowers and are diecious.

The living conifers are mostly monecious as for example, the Pinaceæ and the lower Juniperaceæ, like Thuja and Chamæcyparis, while the extremely specialized genus, Juniperus, with its remarkably modified carpellate cone, is usually diecious.

Monocotyls.

Among the lower Helobiæ, Echinodorus cordifolius (L.) has bisporangiate flowers while its near relatives of the genus Sagittaria are monecious or sometimes apparently diecious. The extremely specialized species, Vallisneria spiralis L., plainly belonging to the same group, is diecious.

Some of the lower apocarpous palms have bisporangiate flowers, while other species, like Phœnix dactylifera L., have advanced to a diecious condition but show prominent vestiges of the opposite set of organs in both the staminate and carpellate flowers.

Among the grasses, Atheropogon and Bouteloua have bisporangiate flowers while the related Bulbilis dactyloides (Nutt.) is diecious.

The lower lilies are bisporangiate while among the specialized forms diecious species occur, like Smilax sp. and Chamælirium luteum (L.)

The higher relatives of the lilies show few monosporangiate flowers, probably because of the very general reduction of the stamens, commonly having but one fertile stamen present.

Dicotyls.

The Thalamifloræ are typically bisporangiate, but diecious species and genera appear at various levels. Magnolia is bisporangiate, and certain Thalictrums, as already described are diecious. The common Mallows are bisporangiate like the genera, Malva and Althæa, while their near relative Napæa dioica L., is diecious. Carica papaya L. one of the most advanced members of the group, is also diecious.

Among the Centrospermæ, some species of Lychnis are bisporangiate and some, like L. alba Mill. and L. dioica L., are diecious. The same relationship can be found among the higher types. For instance, Chenopodium has bisporangiate flowers while the species of Amaranthus grade from the monecious condition to extreme dieciousness.

Among the lower Calycifloræ, Opulaster and Spiræa are bisporangiate and Aruncus aruncus (L) Karst. is diecious with prominent vestiges of the opposite sets of organs. Farther along the evolutionary scale we find Cercis and Cassia bisporangiate while the related Gymnocladus dioica (L) Koch, is diecious with prominent vestiges. As we pass to the advanced members of the group, such genera as Acer become conspicuous which not only show their close relationship to bisporangiate genera but the various species present a close gradation of degrees of intensity of the monosporangiate condition up to complete dieciousness in Acer negundo L.

The Amentiferæ have bisporangiate flowers in the less specialized groups, but a large per cent of the species are monecious or diecious. Extreme examples of diecious species are Cannabis sativa L., Myreca gale L., and Populus deltoides Marsh.

Among the Myrtifloræ, the evening primroses are bisporangiate while the related Haloragidaceæ have bisporangiate, monecious, and diecious species.

The lower families of the Heteromeræ, like the Ericaceæ, are usually bisporangiate while the more advanced Ebenaceæ rarely have bisporangiate flowers but are usually completely diecious, or imperfectly diecious like Diospyros virginiana L.

The Tubifloræ present the same remarkable conditions as other groups, having closely related bisporangiate and diecious species. In the Olive family, many of the genera are bisporangiate while Fraxinus has all gradations from bisporangiate to completely diecious species. In the Tubifloræ, just as in the higher Monocotyls, the zygomorphic condition seems to interfere with the development of monosporangiate flowers. Perhaps the reduction of stamens in the extreme zygomorphic flowers is the direct cause; for a further mutation to the monosporangiate condition would probably subject the species to too severe a struggle for life. In such forms cleistogamy and self-pollination are more apt to arise, although only sporadically. The extreme Plantaginaceæ are usually considered to be related to the Tubifloræ, but if so they are an isolated group long separated from the main branch. They have bisporangiate, imperfectly bisporangiate, or monecious flowers with various intergradations.

Finally, the Inferæ are no exception and show the same evolutionary gradations from the bisporangiate to the monosporangiate condition as the lower subclasses. Among the Compositales, the lower species are bisporangiate or imperfectly bisporangiate while various, related specialized species are monecious or diecious. For example, the Solidagos and Asters have bisporangiate disk flowers while the related Baccharis is a genus of diecious plants. Gnaphalium has at least part of the flowers bisporangiate while its near relatives, Anaphalis and Antennaria are diecious, some species of Antennaria showing considerable sexual dimorphism. In general, the distribution of bisporangiate and monosporangiate flowers on the heads of the Composites is exceedingly interesting and instructive and recalls similar distribution of spikelets in some of the higher grass inflorescences. Such distributions show that the various sex conditions are not at all due to Mendelian segregations but to differentiations arising in tissue systems having a common origin and presumably a similar hereditary nature. The problem is much more complicated than the simple shifting of an hermaphrodite condition in the individual to a unisexual one. For instance, in the genus Artemisia, some species have all the flowers of a head bisporangiate, some species have the central flowers of the head bisporangiate and seed bearing while the marginal flowers are carpellate, some species have the central flowers of the head apparently bisporangiate but are really with imperfect gynecia and, therefore, bear no seeds, while the marginal flowers are carpellate and seed-producing. All such complicated arrangements of sexual expression arise in the ordinary course of vegetative differentiation. Facts of this nature are well known to systematists and must be taken into account by all who would acquire an adequate conception of the sexual relations and their developments in the higher plants.

It is the careful study of the evolutionary changes and progressions in such diverse groups of the higher plants and exhaustive physiological and ecological experiments, especially on those species that are in a transition condition from a bisporangiate to a diecious state, that will give a real insight as to the nature of sex in Angiosperm sporophytes rather than isolated studies on the cytology of species that have already reached the goal of sexual segregation; Cytological studies can be made an aid in the solution of the problem of sex if their pursuit is not allowed to obscure the more fundamental basis of the phenomena as presented by sexual plants in general.

Ohio State University, Columbus.

THE HOARY BAT IN OHIO.

L. S. HOPKINS.

The rarity of the Hoary Bat—**Lasiureus cinereus** Baeuvois—in Ohio as well as the rather meager information to be had concerning it and the scarcity of authentic specimens taken in the state, make it desirable to have a permanent record of a specimen taken in Kent, Ohio, August 12th, 1919, by Mr. A. R. Balch and brought to the writer for identification.

The bat in all probability would never have been noticed had it not met with an accident which resulted in a badly broken wing. As it was, its unusual size was the distinguishing mark which directed attention to it.

The specimen, after being carefully killed, was photographed with the wings partially folded and also in an expanded position. Unfortunately, the negative of the former position was broken after the wings had been allowed to dry in the expanded position in which it had been placed merely to show its size, which was slightly over sixteen inches.

From such literature* as is available the following information is to be had.

The Hoary Bat is the largest as well as the rarest of all North American bats. Its fur is variously described as "a rich chocolate brown, overlaid with white"; "fur mingled dark-brown and light yellowish-brown more or less tipped with silvery white"; "body colors rich chocolate brown or smoky-fawn color, overlaid with white, giving it a brilliant hoary appearance."

In their "American Animals" Stone and Cram say of this species: "In the north where they nest and make their home among the forests and mountain fastnesses, they are only seen occasionally and still less frequently are specimens obtained."

It is rarely seen in this part of the United States and then only as a migrant, since it spends its summer north of us from Maine to Ontario and the New England mountains generally, occasionally getting as far south as the northern Adirondacks, while it winters to the south of Ohio.

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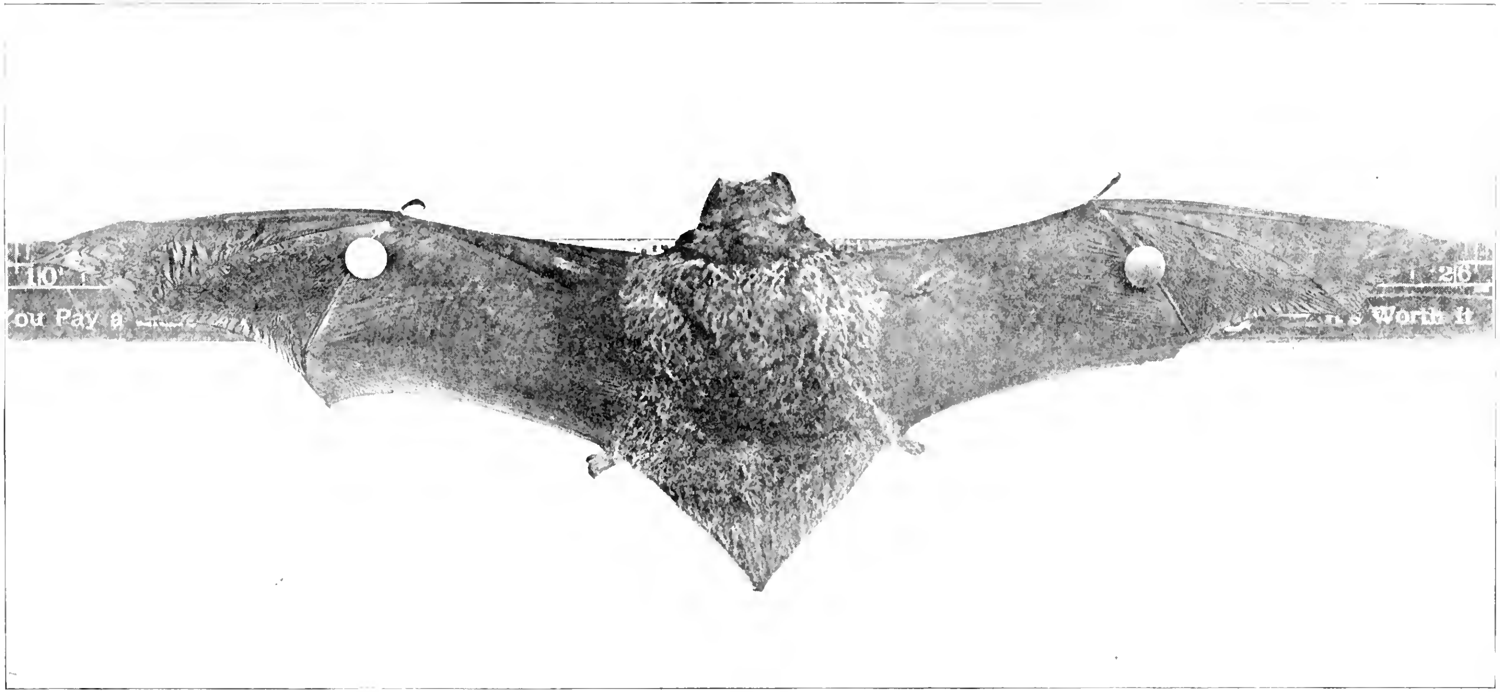
* American Animals, Stone and Cram, 1910; page 204. Jordan. Manual of Vertebrates, 1899; page 330. Geological Survey of Ohio, Vol. IV, 1882, page 88.



THE HOARY BAT (*Lasiureus cinereus* Baeuvois)

The characters of typical specimens are as follows:

Length, 4–5.5 inches; tail, 2–2.33 inches; expanse of wings, 10–15 inches, averaging about 12–14; ear .33–.50 inches. Teeth 32; molars 5; front upper premolars hidden by being wedged between the next and the canine; upper incisors small, strongly convergent, lower ones crowded; lower canines pointing backward. The lips and ears are marked with black and the interfemoral membrane, within which the tail is included, is covered with fur.

The photograph from which the illustration was made, was taken before the bat was skinned and shows its size to be 16.225 inches which is 1.225 inches longer than the size given by any of the authorities quoted.

The bat was carefully skinned and the skin, after being preserved to the best of an amateur's ability, has been deposited in the museum of the Ohio State University.

State Normal College, Kent, Ohio.

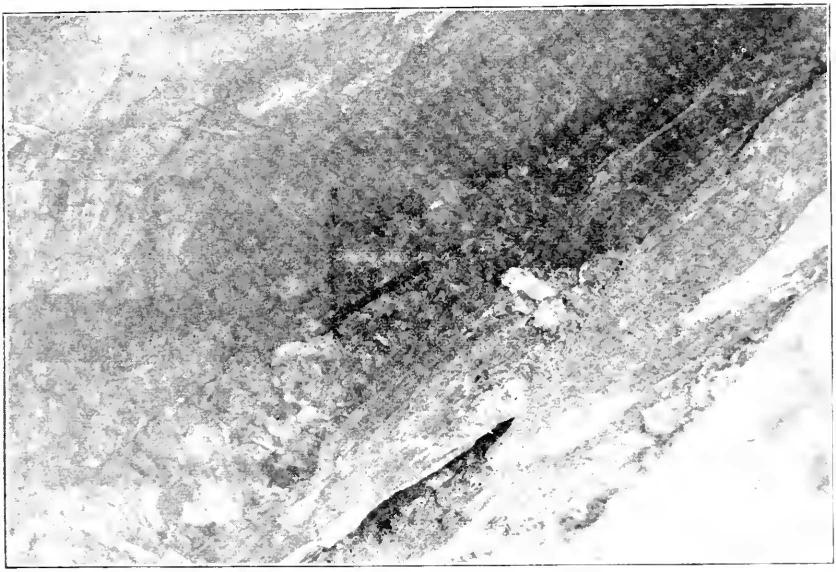
THE ORIGIN OF THE CAVES AT PUT-IN-BAY, OHIO.

KENNETH COTTINGHAM.

Certain features of the caves on Put-In-Bay Island are so unusual and so different from the ordinary solution cavern as to be apparent to the most casual observer. The absence of rounded forms, the sub-angular appearance of floor and roof, the similarity between depressions in the floor and protuberances on the roof, or vice-versa, impress even the tourist. The caves at Greenfield, Ohio, occur in rock of almost identical lithology—in fact, in the same formation though in a different member. Yet the Greenfield Caves consist of narrow, winding passages, often on two or three separate levels—the true type of caves produced by solution. At Put-In-Bay the rooms are cavernous—low, nearly as broad as long, and without passages. It is true that if the Put-In-Bay Caves were formed entirely by solution—and presuming that they are recent—just such cavernous features would result, for the ground water would stand at lake level and be comparatively quiet; while at Greenfield the ground water was well above local stream level, and therefore more potent. Yet this offers only a partial explanation and accounts for nothing beyond the general form of the caves.

One of the first to advance the anhydrite-gypsum theory for the origin of the Put-In-Bay Caves was E. H. Kraus (Am. Geol. XXXV, 167-71). While no trace of either anhydrite or gypsum was found in the caves, Kraus cites the occurrence of the latter in wells, surrounded by highly brecciated dolomite. The theory that the swelling of hydrated anhydrite could be great enough—either in volume or intensity—to produce caverns at first seems untenable. The conversion of anhydrite to gypsum is accompanied by a change in volume variously estimated. Credner, Fritsch, Bauer and Geikie hold the increase as low as 33%. By Nauman, Zirkel and Dana it is placed at 60%, and J. Roth has calculated it to be as high as 62%. Kraus points out that the increase of volume of water converted to ice is 9% to 10%, while the resultant force exerted is 138 tons per square foot; and though the compressibility of gypsum is a little greater than that of water, the increase of volume, at a minimum, is more than three times as much.

The better known caves of the island—those which have been popularized by the tourist—offer much evidence in strong support of the Kraus theory. However, necessary excavations and structures, such as stairs in the entrances, have obliterated additional and possible valuable data. Partly for this reason and largely out of curiosity, two caves which hitherto had



1. Lower part of Victory Cave.

drawn no attention, were explored. The first was on the property of James Duff, and the second on land held by Hotel Victory.

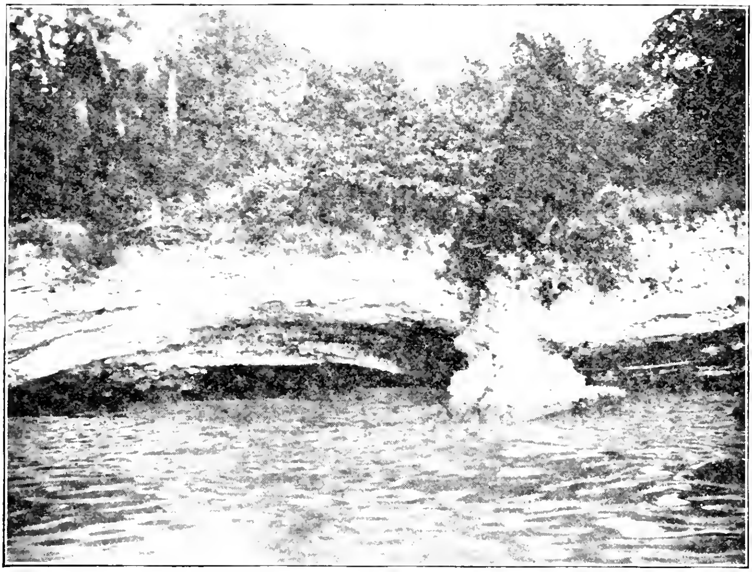
The entrance to the Duff Cave was under a ledge of rock, the angle of descent about 30°, direction N. 10° E., and the distance from mouth to ground water—on slope—about 60 feet. The entry is not the usual tortuous passage, but a long cleft in the rock, with average dimensions of 3′ x 150′ x 60′, terminating in an inclined chamber at ground water level about 4′ x 200′ x 35′, the floor of which is on the approximate slope of the entrance.

Corresponding layers in the floor and the roof are strikingly prominent. Unquestionably the swelling of the anhydrite caused faulting, and entrance from the surface is by way of the fault space. The throw is about four feet and the horizontal displacement about three feet. It is possible that a deeper chamber was the seat of activity, but if so it lies below lake level and the presence of water prevented exploration. No occurrence of slickensides was noted, due perhaps to the fact that the partial doming accompanying the faulting eliminated shear.

2. Duff's Cave. This lies just above ground-water level.
Note correspondence in floor and roof, and degree of displacement.

Fundamentally Victory Cave is similar, differing only in proportions. The descent averages 40°, and is broken at but one point, where for a distance of fifteen feet it is vertical. From entrance to ground water level is about 150 feet, on slope. Masses of loose rock obscure true conditions. Certainly it is not a cave in the usual meaning of the term. Here again is evidence of faulting, with a throw of five feet and little or no horizontal displacement. No chamber was found—the open fault continues without a break to lake level, where the water and detritus obstruct further exploration. It is probable that a low chamber lies below and beyond.

The numerous ledges and low bluffs of dolomite scattered about the interior of the island may be the surface expression of similar features. However, much of the island is hummocky, due to masses of outcropping rock. Whether these knolls and ledges are results of erosion or of such internal distrubances as faulting is problematical, and would only be revealed by

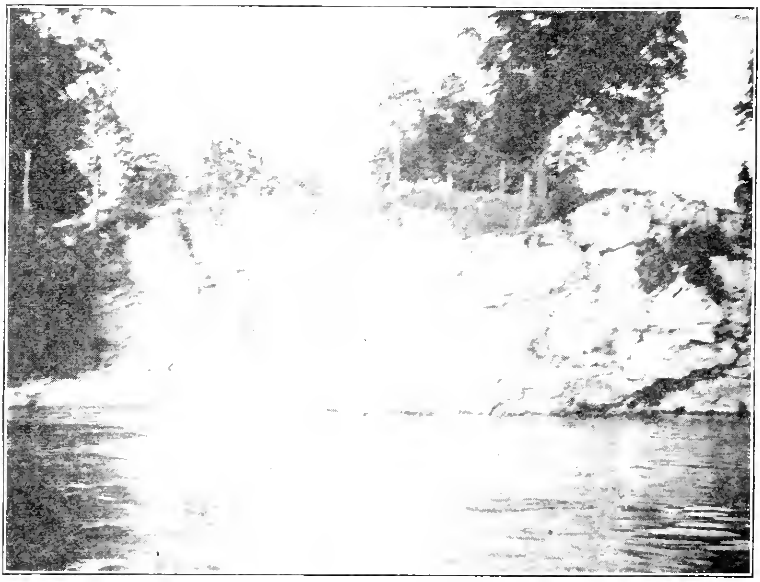


4. Characteristic shore features.
Doming and subsequent solution.

careful search. One fact arguing against solution caves is the absence of sink-holes. They are extremely rare in any case; where they do occur they are over known caves, and are due to the partial collapse of domed strata rather than collapse following solution.

Solution does occur to a limited extent. It was not found in the interior, but may be seen readily at the base of the shore cliffs, where caverns are formed at lake level. However, there has also been marked disturbance of the strata, as shown in the shore cliffs of most of the Dolomitic islands. Of all shore caverns observed, perhaps two-thirds have resulted from doming of the roof.

There were no large stalactites or stalagmites in either Duff's or Victory Cave. Small stalactites of less than an inch in length were found in the upper part of Duff's Cave; likewise, deposition from solution has left a slight incrustation at a few points near the entrance in Victory Cave.



5. Domed Strata.

All evidence seems to confirm the Kraus view—that the caves as a class have resulted from the hydration of anhydrite, arching of overlying rock, and subsequent solution of the gypsum-filled lenses. In the two caves named above faulting was produced. Both are open, thrust faults, and entrance is gained by way of the fault space.

POLEMONIACEÆ OF OHIO.

DOROTHY E. SCHODDE.

POLEMONIACEÆ (PHLOX FAMILY.)

Herbs or sometimes slightly woody plants with opposite or alternate, simple, lobed, or compound leaves, the blades of the leaves or leaflets entire. Flowers hypogynous, tetracyclic, bisporangiate, corymbose-capitate, cymose, or paniculata, actinomorphic or only slightly zygomorphic. Calyx persistent, tubular or campanulate, five parted. Corolla sympetalous, convolute in the bud. Andrecium of five stamens united with the corolla and alternate with its lobes; anthers versatile. Gynecium mostly of three carpels; style simple, stigmas three, linear. Ovulay mostly with two to numerous ovules in each cavity; capsule mostly loculicidally three valved. Seeds sometimes enveloped in mucilage and emitting spiral tubes when wetted.

1. Leaves opposite, simple, entire; corolla salverform. *Phlox*.
1. Leaves alternate, compound or pinnatifid. 2.
2. Leaves pinnatifid or dissected, segments linear; corolla funnelform or salverform in ours; cultivated. *Gilia*.
2. Leaves pinnately compound, with or without tendrils, alternate. 3.
3. Leaves without tendrils, alternate; corolla tubular-campanulate to somewhat rotate; low herbs. *Polemonium*.
3. Leaves ending in tendrils which are branched; climbing herbaceous vines; cultivated. *Cobaea*.

Phlox L. Phlox.

Usually perennial, erect or diffuse herbs, with opposite, entire leaves, or some of the upper ones alternate. Flowers in terminal cymes or cymose panicles, sometimes closely massed, blue, purplish, red, or white. Calyx five cleft, the lobes acute to subulate. Corolla salverform, with a five-lobed limb and narrow tube. Stamens unequal, included or only slightly exserted. Ovulary with 1 to 4 ovules in each cavity; style usually slender. Capsule ovoid, at length distending and rupturing the calyx tube; seed usually one in each cavity, not emitting spiral tubes when wetted.

1. Leaves flat, broad or narrow. 2.
1. Leaves subulate and rigid, sharp pointed, mostly crowded and fascicled; stems long, creeping, sending up flowering shoots usually with few flowers; corolla pink or rose, turning purple with age, rarely white, each petal with deeper spots at the inner and a deep notch at the outerend. *P. subulata.*
2. Panicle narrow, usually compact, elipsoid or elongated; stem erect, purple spotted, leaves ovate-lanceolate, usually tapering to the apex from a broad base. *P. maculata.*
2. Panicle or corymb flat-topped or broadly pyramidal; stem not spotted. 3.
3. Cymes panicled and broadly pyramidal, pedicels and peduncles very short; stem strictly erect with oblong-lanceolate to ovate-lanceolate leaves; the large veins uniting prominently near the margin. *P. paniculata.*
3. Cymes corymbose, simple, or flowers scattered; pedicels and peduncles long, or if short then the plants not strictly erect. 4.
4. Plants glabrous or nearly so; calyx teeth shorter than the tube, triangular-subulate; corolla lobes rounded, entire, pink or rose. 5.
4. Plants pubescent; calyx teeth longer than the tube, slender; corolla blue or turning purple with age. 6.
5. Flowers long pedicelled; leaves linear-lanceolate, or rarely oblong-lanceolate; calyx teeth very long pointed. *P. glaberrima.*
5. Flowers short pedicelled; leaves oblong-lanceolate, upper ones ovate-lanceolate; calyx teeth acute. *P. ovata.*
6. Plants with prostrate or creeping vegetative shoots, the leaves of which are mostly of the ovate-lanceolate type; calyx teeth rather short pointed. 7.
6. Plants without prostrate or creeping shoots, erect or ascending; leaves mostly of the lanceolate type, usually long tapering; calyx lobes with long bristle tips. *P. pilosa.*
7. Corolla lobes obcordate or wedge-obovate, notched or entire, about the length of the tube, pale lilac or bluish; leaves of the vegetative shoots of an eliptic or oblong type, sessile; plants glandular-pubescent. *P. divaricata.*
7. Corolla lobes round-obovate, mostly entire, about $\frac{1}{2}$ inch long, reddish-purple, leaves of the vegetative shoots of the spatulate type, petioled; plants sparingly pubescent. *P. stolonifera.*

1. **Phlox maculata** L. Spotted Phlox. Plant with erect, simple or branched stem, sparingly pubescent and usually flecked with purple. Leaves ovate-lanceolate, usually tapering to the apex from a broad base, sessile; flowers short-pedicelled, in a compact ellipsiod or elongated narrow panicle; calyx teeth triangular-lanceolate, acute or acuminate, about one-fourth the length of the tube; corolla blue, pink, or purple. Rather general in woods and moist places. June–August.

2. **Phlox paniculata** L. Garden Phlox. Plant with erect, stout or slender stem which is simple or slightly branched above; usually glabrous, sometimes puberulent. Leaves oblong lanceolate to ovate-lanceolate with closed venation; flower cymes panicled, broadly pyramidal; calyx teeth more than one-half the length of the tube; corolla pink, purple, or white, its lobes obovate, entire, shorter than the tube. General. Escaped from gardens. July–September.

3. **Phlox ovata** L. Mountain Phlox. Plant with slender stem, glabrous or nearly so, ascending from a decumbent base, 1–2 feet high. Upper leaves ovate or ovate-lanceolate sessile by a rounded or subcordate base, acute at the apex, 1–2 inches long; lower leaves oblong or ovate-oblong, narrowed into slender often margined petioles; flowers short-pedicelled; calyx teeth lanceolate to triangular-lanceolate, acute or acuminate; corolla pink or red, its lobes rounded entire. Fulton Co. May–August.

4. **Phlox glaberrima** L. Smooth Phlox. As lender, simple-stemmed, erect or ascending plant, glabrous or only slightly pubescent, 1–3 feet high. Leaves lanceolate to linear acuminate at the apex, narrowed at the base, 1–4 inches long, sessile or the lower ones short-petioled; flowers short pedicelled; calyx teeth subulate-lanceolate; corolla mostly reddish-pink, its lobes obovate, rounded or obcordate, longer than the tube. Butler Co. May–July.

5. **Phlox pilosa** L. Downy Phlox. Downy often glandular plant with slender, simple or branched, erect or ascending stem, 1–2 feet high. Leaves linear to lanceolate, long-acuminate, 1–4 inches long, sessile, the base narrowed and rounded; flowers short-pedicelled; calyx teeth setaceous-sublate, longer than the tube; corolla blue, pink, or white, its lobes ovate, entire, tube usually pubescent. Northern part of state as far south as Franklin County. April–June.

6. **Phlox divaricata** L. Wild Blue Phlox. A viscid pubescent plant with slender, ascending or diffuse stem, 1–3 feet high, producing leafy shoots at the base. Leaves of the creeping shoots oblong or ovate, those of the flowering stems ovate-lanceolate ɛo lanceolate; flowers faintly fragrant; calyx teeth subulate; corolla bluish to lilac, its lobes obcordate, emarginate or entire, about as long as the tube. General and abundant. April–June.

7. **Phlox stolonifera**. Sims. Creeping Phlox. An hirsute or pubescent plant with slender stem producing creeping, leafy shoots at the base. Leaves of the creeping shoots obovate, narrowed into petioles; flowering stems ½ ft. to 1 ft. high; leaves oblong to lanceolate; flowers slender-pedicelled; calyx teeth linear-subulate; corolla pink, purple, or violet, its lobes rounded and mostly entire, about one-half the length of the tube. Hocking Co. April–June.

8. **Phlox subulata** L. Ground Phlox. A more or less pubescent plant with tufted, much branched and diffuse stems forming mats. Leaves persistent, subulate to linear-oblong ½–1 inch long, ciliate, rigid, commonly fascicled at the nodes; flowers slender-pedicelled; calyx teeth subulate, from a broad base; corolla pink to white, its lobed emarginate or entire and shorter than the tube, with two dark-red spots at the inner side. General. April–June.

Gilia R. & P. Gilia.

Herbs with opposite or alternate, entire, pinnatifid, palmatifid or dissected leaves, small or large, solitary, cymose, capitate, or paniculate flowers. Corolla rotate to salverform. Stamens included or exserted. Capsule at length rupturing the calyx. Seed coats commonly mucilagenous when wetted, some species emitting spiral thread-like tubes.

1. **Gilia rubra** (L.) Heller (Gilia cornucopifolia Pers.) Standing-cypress. An erect plant with a wand-like stem, 2–3 feet high, thickly clothed with alternate, crowded, pinnately divided leaves and a leafy panicle of showy, scarlet flowers, the corolla tubular funnel form. Cultivated. Escaped in Erie and Lake Counties. June–September.

Polemonium (Tourn.) L.

Perennial or rarely annual herbs with alternate, rarely opposite pinnately compound leaves, and mostly large cymose-panicled flowers. Corolla rotate to funnel form. Seeds mucilagenous and emitting spiral threads when wetted.

1. Leaflets opposite, 5–7; stamens included or only slightly exserted; flowers ½ inch broad; low herbs not more than 1 foot high. *P. reptans.*
1. Leaflets alternate, at least below, 9 to 21; stamens exserted; flowers 1 inch broad; herbs growing 1 to 3 feet high; cultivated. *P. caerulium.*

1. **Polemonium cærulium** L. European Jacob's-ladder. An erect, smooth or sometimes hairy plant, 1–3 feet high, with bright blue flowers collected in a long panicle. Cultivated.

2. **Polemonium reptans** L. Greek Valerian. A glabrous or slightly pubescent plant with weak slender stem, at length reclining or diffuse, about 1 foot high. Flowers cymose panicled, blue, about ½ inch broad. General and abundant in woods. April–May.

Cobæa. Cav. Cobæa.

High climbing herbs with alternate, pinnate leaves ending in compound tendrils, the lowest leaflets unlike the others and imitating stipules. Flowers solitary, on axillary peduncles. Corolla bell-shaped with short and broad, spreading lobes; stamens declined; ovulary surrounded at the base by a fleshy gland.

1. **Cobæa scandens** Cav. Cobæa. A smooth, high climbing vine with large, dull purple flowers having long stamen filaments which coil when old. Commonly cultivated. Blooms in autumn.

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DESCRIPTIONS OF NEW NORTH AMERICAN TINGIDÆ.*

Carl J. Drake.

Corythucha platini new species.

Hood moderately elevated, abruptly constricted at the middle, about one and a half times as long as high, the width and height of globose portion subequal. Median carina noticeably less than one-half of the height of the hood, not strongly raised or strongly arched at the middle, its length subequal to length of hood. Lateral carinæ not widely separated from the hood, with five or six distinct areolæ, highest near the middle, the areolæ becoming smaller towards both anterior and posterior ends. Margins of paranota and elytra with spines much reduced or entirely wanting, the anterior margins of paranota with spines nearly normal. Tumid elevations of elytra normal. Rostrum extending to meso-metasternal suture. Costal area of elytra with three rows of areolæ, the outer margin nearly straight. Length, 3.7 mm.; width, 2.1 mm.

General color pale testaceous, a few of the nervelets embrowned. Body beneath piceous. Legs and antennæ brownish, the tips of each darker. Areolæ hyaline. Hood with some of the nervelets brown. Pronotum pale brown, the posterior portion becoming lighter; paranota with two or three nervelets in front of the middle usually brown. Elytra with a spot on the tumid elevation, a narrow band near the base, and a very narrow oblique band near the apex brown. In both bands the areolæ are hyaline and the apical one is more or less indistinct.

Six specimens from California; Kerman, April 26, 1917, and Fresno. This insect infests the sycamore tree, but it is quite distinct from either *Corythucha ciliata* Say or *C. confraterna* Gibson. In general appearance it somewhat resembles *C. drakei* Gibson or *C. essigi* Drake. Off-color or teneral forms of *C. obliqua* Osborn and Drake somewhat resemble *platini*, but the low median carina of the latter readily separate the species. *Types* in my collection.

* Contribution from Department of Entomology, The New York State College of Forestry, Syracuse, N. Y.

Corythucha marmorata var. **minutissima** new variety.

Hood slightly more than twice the height of median carina and one and one-half times as long, the length of hood one and one-third times its height. Lateral carinæ well delveoped, not widely separated from hood, with four distinct areolæ. Antennæ reaching a little beyond posterior margin of paranota, clothed with several long bristly hairs, the third segment slightly more than twice the length of the fourth. Median carina raised anteriorly, two rows of areolæ at middle, its height one-half its length. Elytra extending a little beyond the apex of abdomen, costal area with the outer margin distinctly concave, biseriate at the middle and triseriate anteriorly and posteriorly. Marginal spines of elytra and pananota rather small. Length, 2.37 mm.; width, 1.49 mm.

Body beneath piceous, legs and antennæ brown. Disc of pronotum brown, the posterior extension becoming lighter towards apex. General color of membraneous portions whitish, with brown marmorations quite like a fully colored example of typical *marmorata*.

Almenda, California, November 16, 1911, collected by F. W. Nunemmacher. The very small size and lateral carinæ will at once distinguish this form from either typical *marmorata*. Uhler or the variety *informis* Parshley. Parshley[1] gives a good discussion of the variations of *marmorata* which agree with the many specimens before me. The lateral carinæ in variety *minutissima* are developed as in *C. morrilli* Osborn and Drake. *C. morrilli*, according to the numerous specimens at hand, is a very variable species. *C. mexicana* Gibson, if it is distinct, is not more than a variety of *C. morrilli* O. & D. *Type* in my collection. More specimens may prove *minutissima* to be a distinct species.

Corythucha heteromelecola new species.

Hood moderately elevated, abruptly constricted near the middle, its height slightly more than one-half its length. Median carina moderately arched, with two rows of areolæ at middle, distinctly shorter than the hood. Lateral carinæ terminating far from base of hood, raised anteriorly, with three or four distinct cells and with the anterior cell largest. Antennæ beset with a few long bristly hairs. Spines on margins of elytra and paranota rather short. Rostrum reaching almost to tip of rostral sulcus. Elytra with costal margin distinctly concave, the costal area triseriate. Length, 3 mm.; width, 1.9 mm.

General color above light yellowish brown. Areolæ mostly hyaline. Nervures yellowish. Crest of hood slightly embrowned. Elytra with tumid elevation and sutural area more or less embrowned, the transverse bands only faintly outlined or entirely wanting.

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[1] Occasional Papers of the Museum of Zoology, Univ. of Michigan, No. 71, page 20.

Several specimens, taken on *Heteromeles arbutifolia* at Stanford, California. I have heretofore determined this insect as *Corythucha incurvata* Uhler. Prof. E. P. Van Duzee kindly sent me a typical specimen of *C. incurvata* Uhler, which has been carefully compared with Uhler's type deposited in the California Academy of Science. Gibson[2] erroneously states that the types are in the National Museum. According to Uhler[3] the *types* were deposited in California Academy of Science. The species can be distinguished from *incurvata* by the much less elevated hood. *C. bullata* Van D., according to paratype before me, has a slightly higher hood than *incurvata*. All three species feed upon the California Christmas-berry tree. *Type* in my collection. *Paratypes* in California Academy of Science and my collection.

Corythucha sphæralceæ species new.

Hood moderately raised, somewhat flattened posteriorly, abruptly constricted just back of the middle, armed with numerous rather long spines on the nervures, its length twice its height. Median carina slightly shorter than length of hood, attached to the hood near its base, with mostly one row of areolæ, a little less than one-half the height of the hood, highest a little in front of the middle and with the distal portion sinuate. Lateral carinæ with five or six distinct areolæ, highest near the middle, terminating not far from the base of hood. Rostrum reaching the meso-metasternal suture. Antennæ beset with a few long hairs. Elytra with the outer margins slightly concave or nearly straight, tumid elevations moderately large. Costal area triseriate. Outer margins of elytra and paranota, nervures of elytra, paranota, carinæ and hood armed with numerous rather long spines. Length, 3.28 mm.; width, 1.86 mm.

Body black. Legs and antennæ brownish, the tips of each darker. General color above brownish or pale testaceous, some of the nervures partly embrowned. Areolæ hyaline. Tips of spines black.

The general color somewhat resembles that of *C. eriodictyonæ* O. & D., but readily separated from it by the hood and the much longer lateral carinæ. In some specimens the color markings are more or less wanting. Numerous specimens, taken on *Sphaeralcea* sp., Deep Springs Valley, Inyo Co., California, July, 1918, collected by Prof. Ferris. *Type* is in my collection. *Paratypes* in the California Academy of Science, Leland Stanford University and my collection.

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[2] Transactions of the American Entomological Society, Vol. XLIV, p. 93.
[3] Calif. Academy Science, Vol. IV, Sec. II, p. 223.

Corythucha pacifica new species.

Resembles C. eriodictyonæ Osborn and Drake, the spines long and numerous, but with a larger hood and with the lateral carinæ not so widely separated from the base of hood. Length, 3.5 mm.; width, 2.18 mm.

Pronotum pale brown, the posterior extension becoming lighter towards the apex. Median carina slightly shorter than the length of hood, its height one-fourth of hood, uniseriate, arched a little in front of middle. Lateral carinæ terminating rather close to base of hood, with five or six distinct areolæ, the areolæ largest near the middle and becoming smaller both anteriorly and posteriorly. Hood moderately elevated, constricted a little back of the middle, its height three-fourths its length, the anterior portion in front of constriction very narrow, the width of posterior portion a little less than its height. Spines on margins of paranota and elytra and erect spines on reticulations long, the tips of each blackish. Elytra broad, the costal area with three or four rows of areolæ. General color yellowish or light brown. Elytra with a cross-band near base and usually another more or less distinct one near apex, part of sutural area and a few small veinlets in costal area brown, the areolæ in bands only partly clouded.

Several specimens from Alpowa, Washington (late Heidemann collection). *Type* in Cornell collection; *paratypes* in Cornell University collection, California Academy of Science, and my collection.

Teleonemia montivaga new species.

Moderately elongate, rather narrow, the reticulations gray or brownish gray, the antennæ and legs black, the tibiæ becoming flavous anteriorly. Disc of prônotum finely pubescent, brownish; collum and posterior extension yellowish brown. Pronotum rather finely punctured, tricarinate, the carinæ parallel, faintly raised and slightly produced at the middle in front; carinæ thin, slightly raised, the areolæ barely distinct; paranota faintly carinate, areolæ indistinct. Length, 3.74 mm.; width, 1.36 mm.

Antennæ a little more slender than in *nigrina* Champ., clothed with very short hairs; first and second segments subequal; third segment a little less than twice the length of the fourth. Spines on the head much reduced. Elytra moderately expanded at the middle; costal area uniseriate, the areolæ long and very narrow; subcostal area mostly biseriate, broad; sutural area with large areolæ. Female genital segment with large rounded and flattened tubercle on each side. Rostrum extending to the meso-metasternal suture, the rostral laminæ and bucculæ yellowish. Body beneath dark brown, the abdomen becoming darker posteriorly.

Two specimens; *type*, Mt. Diablo, California, July 15, 1918, in my collection. Allied to *nigrina*, but readily separated from it by antennæ and carinæ; differing from *vidua* Van Duzee by much shorter third antennal segment, etc. According to Van Duzee[4] the third antennal segment of *vidua* is nearly three times the length of fourth.

Teleonemia novicia new species.

Antennæ brown, a little longer and more slender than in *nigrina* Champ., clothed with short hairs, first segment a little stronger and shorter than the second; third segment almost twice the length of the fourth. Rostrum not quite reaching the meso-metasternal suture, the rostral laminæ widely separated on the mesosternum. Prothorax rather finely punctured, slightly and obtusely produced anteriorly, not densely pubescent, tricarinate, each carina thin, parallel, faintly raised, the areolæ barely distinct; paranota very narrow, turned back against the surface of the pronotum, the areolæ becoming distinct anteriorly. Last abdominal segment in the female with a rather prominent, pilose somewhat kidney-shaped protuberance on each side, the protuberance not long like in *nigrina*. Elytra with the margins nearly straight, only moderately constricted beyond the middle, apex broadly rounded; costal area very narrow, the areolate elongate; subcostal area mostly biseriate, the areolæ small; discoidal area not deeply impressed, the areolæ small and slightly larger than those of the subcostal area; sutural area with large areolæ. Length, 4 mm.; width, 1.2 mm.

Disc of pronotum reddish brown, paranota, carinæ, and distal portion of triangular process yellowish brown. Antennæ and legs brown, the tibiæ becoming flavous anteriorly. Body beneath dark brown, slightly tinged with ferrugineous.

Two specimens, Oriocle, California, July 11. *Type* in my collection. Allied to *T. nigrina* Champion, but readily separated from it by the more slender and longer antennal.

Teleonemia haytiensis new species.

Antennæ reaching to a little beyond the base of elytra, moderately slender, sparsely and minutely pubescent, the third segment two and one-third times as long as the fourth. Pronotum distinctly tricarinate, rather coarsely punctured, projecting angularly over base of hood; paranota uniseriate, not quite reflexed back against the pronotum; carinæ slightly more foliaceous than in scrupulosa Stal, uniseriate, the areolæ large, mostly rectangular, the median carina quite strongly raised anteriorly. Rostrum reaching between the middle coaxæ. Body beneath, pronotum and portion of elytra (subcostal and discoidal areas

[4] Proc. of Calif. Acad. Sci., Vol. VIII, p. 278.

only sparsely) clothed with short, decumbent pubescence. Elytra constricted a little beyond the middle; costal area uniseriate, the areolar large; subcostal area uniseriate, the areolæ large; discoidal area sparsely pubescent, the areolæ moderately impressed.

General color yellowish brown. Pronotum reddish brown, the paranota and carinæ yellowish. Body beneath dark brown, slightly tinged with red. Elytra with the greater part of costal and a broad somewhat Y-shaped mark in sutural area brown. Bucculæ and rostral laminæ yellowish.

Two specimens; Porto au Prince, Hayti; *types* in my collection. Akin to *scrupulosa* Stal from which it can be readily separated by the much longer and sparsely pubescent antennæ. It somewhat resembles *T. vanduzeei* Drake, but the longer and much stronger antennæ readily separate it from this species.

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THE RELATION OF HAIRY LEAF COVERINGS TO THE RESISTANCE OF LEAVES TO TRANSPIRATION.*†

J. D. Sayre.

INTRODUCTION.

A great many of our common plants have hair-like structures on their leaf surfaces. These epidermal hairs can readily be divided into two classes; those that contain protoplasm, and sometimes chlorophyll, which are called glandular hairs; and those that are dead, and are filled with air.

It is obvious that the first kind of hairs add to the evaporating surface of the leaf, but there is some doubt as to the effect which dead air-containing hairs have on the water loss from leaves. The following paper deals only with the dead air-containing hairs. There are several different forms of these hairs: (a) Unicellular structures perpendicular to the leaf surface; (b) One or more celled structures lying parallel with the leaf surface; (c) Unbranched, many-celled structures, extending more or less parallel to the leaf surface; (d) Many celled structures, much branched, having the branches both parallel and perpendicular to the leaf surface.

The mullein plant (*Verbascum thapsus*) which was used in the following experiments, is covered with hairs of the last named type. Of all the plants found in this locality it has the densest covering of hairs. The experimentation involved the obtaining of continuous records of the common environmental factors influencing plant processes, with records of the water loss from the plants.

HISTORICAL.

Statements have been made by various authors as to the relation of hairs to transpiration, but these assertions do not seem to have been founded on experimentation.

Warming (1) says: "It is evident that transpiring will be very materially reduced when the transpiring surface is clothed by air-containing bodies, in and between which the air is so firmly lodged that its circulation is obstructed."

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* Thesis presented for Degree of Master of Science at the Ohio State University, Columbus, Ohio.

† Papers from the Department of Botany, Ohio State University. No. 116.

Jost (2) seems to consider hairs as effective in retarding air currents near the surface of the leaf: "Development of hairs full of air can also effectively retard transpiration, since such a covering protects the plant from the effects of air currents, producing a superficial region free from atmospheric movements."

Gager (3) gives practically the same statement: "Certain structural features of the plant operate to reduce transpiration. The epidermal hairs, as for example on mullein leaves, tend to retain the more humid air near the surface of the leaf, even when the wind blows."

Cowles, in his text book (4) gives a somewhat different aspect given to the whole matter: "Hairs commonly are believed to have an important role in the retardation of transpiration, but the evidence for this view is not abundant. Probably they are much inferior in this respect to cutin or even waxy coats. Wooly felt would seem to be most efficient. Removal of hairs in *Stachys lanata* results in an increase of 20% to 50% in transpiration. Evaporating surfaces covered with hairy felt have been shown to lose much less water than without the hairy coverings. Similar effects might be looked for in scale covered leaves or leaves with branched hairs, when the hairy coat is dense enough to retard water vapor. In most plants that are hairy, however, the hairs are erect and more or less scattered, so it is difficult to see how they can appreciably retard water vapor, though their presence may reduce the evaporating surface. It must be admitted that the known uses of leaf hairs are small in comparison with their abundant development. While the discovery of advantages now unknown is possible, it is much more likely that most of such hairs are of little or no advantage to the plant."

Little actual experimentation has been done on the relation of hairy coverings to transpiration. Wiegand (5) sums up this experimentation in his paper with the results of his own experiments. "Kerner (6) took two raspberry leaves and covered the bulbs of two thermometers with them, having the hairy side outermost in one and the smooth side in the other; the smooth one showed 2-5° F. higher than the other, which would indicate increased transpiration. Vesque (7) found by cultural experiments that with certain plants, when dryness increased, hairy coverings increased in density also. Brenner (8) found that in certain species of Quercus hairy coverings became thicker when exposed to greater intensity of sunlight." Wiegand gives the following statements concerning his own work:

"It is quite generally recognized that by far the most important factor in transpiration is evaporation; indeed, we may say that transpiration is really evaporation modified and regulated by the plant. Therefore, it seems that a study of the relation of hairy coverings to evaporation would throw much light on the subject of transpiration. Good quality blotting paper was used as the evaporating surface. The loss of water was determined by weighing. Cotton made waterproof by paraffin in gasoline, was used for the protective covering and an electric fan was used to produce wind." He draws the following general conclusions from his experimentation. "The evaporation experiments tend to show that porous coverings like cotton, wool, or hair must be very thick to produce any appreciable effect in retarding evaporation if the surrounding atmosphere is quiet, but become very efficient even in thin layers when the air is in motion. It seems probable that those plants that live in situations where a moderate water supply is available, but there transpiration must be reduced in excessively dry times, but not interfered with when the surrounding air is damp and transpiration therefore difficult employ a hairy covering to retard transpiration."

These conclusions were drawn from evaporation experiments in which cotton, wool and hair were used for protective coverings, and the water loss from a standard evaporating surface was measured. It is quite definitely known that very little water is lost from the cuticular surface of a leaf as compared with the internal surface, and while it is obvious that cotton, wool, or hair would produce those effects on a standard evaporating surface, it does not mean that the water vapor from the internal surfaces of the leaf would be retarded by these coverings.

In conclusion it may be said that very little critical experimentation has been done on the relation of hairy coverings to transpiration. The general opinion is that leaves with hairy coverings have a greater resistance to water loss in bright sunshine and in wind than leaves without these coverings.

EXPERIMENTAL METHODS.

The experiments summarized in this paper were performed under the direction of Dr. E. N. Transeau, at the Ohio State University in the research room of the Botanical Greenhouse and in a darkroom adjoining the Plant Physiology laboratory. The apparatus, with some alterations, which was used has been described by Transeau (9).

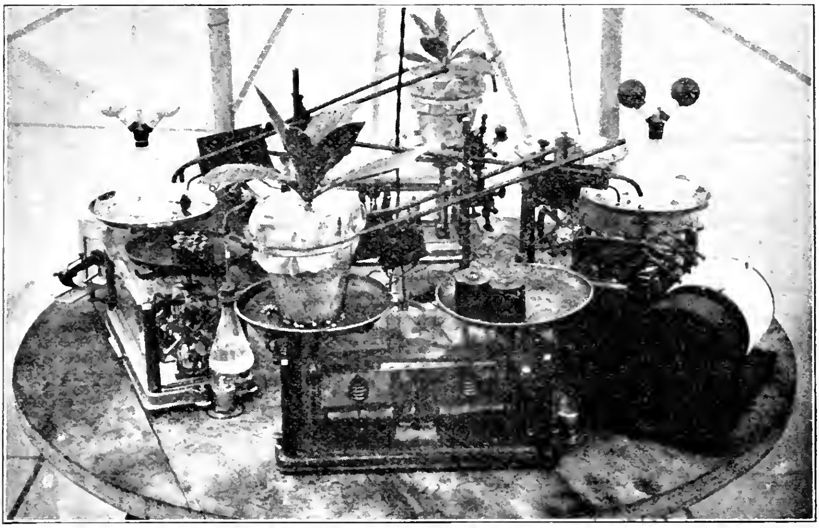

Fig. 1.
Rotating table with the apparatus and plants arranged on it. The table was turned at a very slow rate during the experiments.

In each of the experiments continuous, simultaneous, records of the following factors were secured for a period of 24 hours or more; temperature, humidity, duration of sunshine, intensity of sunshine (as shown by the increased evaporation from a black atmometer compared with that from a white atmometer), evaporation from a white atmometer cup, transpiration from one or more plants, and wind velocity. The temperature was recorded in degrees, Fahrenheit, and the humidity in percentages of saturation, on a combined hygro-thermograph, which was checked up from time to time with a standard sling psychrometer and corrected if necessary. A record of the duration of sunshine for the days on which experiments were performed in the greenhouse was obtained from the U. S. Weather Bureau Station, Columbus, Ohio. This record is expressed in percentages of possible sunshine per hour. No record of wind velocity was kept except in the experiments when an electric fan was used to produce air currents. Then a U. S. Weather Bureau anemometer was used and the velocity is expressed in miles per hour.

Fig. 2.
One of the plants used in the experiments, showing the method of sealing and irrigating the pot.

The evaporation and transpiration records were determined as described by Transeau by replacing the loss of weight of a plant or atmometer, which is balanced on one pan of a balance, by dropping steel shot each weighing a gram on the pan beside the plant and recording the number of shot required to keep the plant balanced, with the time interval between shot.

This is done automatically by the shot dropping tubes and chronograph designed by Transeau. A plant or atmometer is placed on a pan of the balance, which is prevented from vibrating in wind or by a slight jar with a mercury cup and piston attached to one beam, and balanced by an equal weight placed on the opposite pan. When the loss of weight causes the pan to rise to a certain height an electric circuit is closed which operates the shot dropper and the pen on the chronograph. The pen makes a straight line on the drum, which is revolved by a clock at a known rate, except when the electric circuit is closed. From these results (the number of shot and the time interval between each) the rate of water loss in grams per hour is calculated. This apparatus, which can be used to take six or more records at one time, affords a very satisfactory method of determining comparative transpiration rates.

In obtaining the evaporation data, standardized white spherical cups were used. The evaporation from blackened cups was also measured by using spherical cups, covered with washed carbon. The white cups, because of the method of using them, were standardized with a new cup mounted on a standard non-absorbing mounting, and the black cups were standardized with the two white cups.

TABLE I.

Standardization of White Cups Without Mercury Valves With a New Cup Mounted on Standard Mounting With Mercury Valves.

Cup No.	16–161	16–211	16–225	16–201
Total evaporation, grams. (12 days).....	268.5	273.1	269.1	285.8
Coefficient, old..........................	.95	.92	.95	.96
Coefficient, new........................	1.02	1.00	1.01	.96

Cup 16–201—.96 (New) taken as standard.

TABLE II.

Standardization of Black Carbon Covered Cups With Restandardized White Cups.

	White Cups, Coe.		Black Cups, Coe.	
	16–161	1.02	16–307	.92
	16–211	1.01	16–375	.93
Total evaporation, grams. (10 days)......	272.7		365.6	
Total evaporation, grams. (10 nights)....	103.8		103.5	
Coefficients..............................	1.01		1.01	

The transpiration rate was determined from plants, (Fig. 2), which were growing in six inch pots at the time they were used. In every experiment plants as nearly alike as possible in size and color were chosen. The potted plants were placed in six inch aluminum shells and sealed with paraffined cloth, cut to fit the top of the pot and shell, with a slit along the radius to a hole in the center for the plant stem. Small paraffined cloth washers were placed closely around the stem and carefully made air tight with warm paraffin. The six inch pots did not fit down in the shell, but rested on the edge, which left an air space between the bottom and sides of the pot and the shell. This space insured aeration of the soil as well as perfect drainage.

The matter of maintaining a uniform amount of moisture in the soil was at first done by watering the plants every 24 hours with as much water as they had lost during that time. Later porous cup irrigators were obtained which kept the soil in a six inch pot in perfect condition. The method of operating the irrigators was to seal a T-tube in the open end and fill it with water and insert it in a hole in the pot made by taking out a core of soil. A small piece of soft rubber hose was put on the straight end of the T-tube, with a pinch cock to close it and the arm of the T-tube was connected with a reservoir which was arranged so that the water level was below the pot.

In order to compare the transpiration rates of several different plants a very careful record of the leaf areas was kept and the transpiration from equal leaf areas was used. The leaves were measured by tracing their outlines on paper and measuring their total area with a planimeter which was adjusted to read in square centimeters. Leaf areas on every plant for every experiment were taken before the apparatus was started and as soon as the experiment was completed and as there was a considerable increase in leaf area for this length of time some method of taking an average had to be determined. By plotting the areas on cross section paper, using time as abscissæ and leaf area as ordinates, and assuming that the increase was a straight line between those two points, the area represented at noon was taken as the leaf area for that experiment. All results were reduced to the same area basis.

These experiments were performed in the research room of the greenhouse and in a dark room adjoining the Plant Physiology Laboratory. The dark room is light proof and has no openings except into the halls of the building. While the framework of the greenhouse cast shadows on the plants and apparatus and produced unequal light conditions during the course of a day. In order to produce equal light conditions, the entire apparatus was arranged on a rotating table such as described by Livingston (10) in Plant World for use in standardizing porous cup atmometers (Fig. 1). The table was rotated by a small electric motor at a slow rate which was not fast enough to produce an increase in water loss, although it insured proper light and ventilation for the cups and plants.

The electric current for operating the shot droppers was taken from the electric light circuit in the greenhouse, and transformed by means of a bell ringer from 116 volts to 16 volts, which did away with the use of dry cells. The electrical connections for operating the recording and shot dropping apparatus were made by means of two wires hung from the roof of the greenhouse directly above the center of the table, into two concentric mercury cups. Small wires led from the mercury cups to the recording and shot dropping apparatus.

In order to properly ventilate the room where the experiments were performed and not to allow any direct air currents to blow on the apparatus, the table was placed in the center of the room and the ventilators directly above it were disconnected so that only those at the two ends of the room could be raised.

CALCULATION OF RESULTS.

The results of these experiments are expressed on an hourly basis. The time is recorded as hours, beginning with 1 for 1 A. M., and running up to 24 for 12 P. M., to correspond to the 24 hours of each day. The temperature which is taken from the thermographic record sheet, is the mean for each hour, and is expressed in degrees Fahrenheit. The humidity, taken in the same way, is recorded as saturation deficit (100%—humidity) and is expressed in percentages. The duration of sunshine record, which begins at sunrise and ends at sunset, was taken directly from the dial of the instrument, wind velocity the same way, and needed no alteration; but the hourly evaporation and transpiration rates had to be calculated.

Whenever the record sheet was taken from the drum of the chronograph, which turned at the rate of 12 millimeters per hour, the hour intervals were marked. The rate of water loss per hour was found by dividing the time interval (in millimeters) by the distance between shot marks. A table containing rate of water loss for all time intervals of 1 to 12 millimeters and distances between shot from 12 to 48 millimeters was made, and to obtain the hourly rate it was only necessary to measure the distance between shot marks and refer it to the table. The hourly evaporation rates are reduced to the rate of the Standard Cup by multiplying the chronographic rate by the coefficient of the cups. Tables I and II, on page 60, give these coefficients. The radio-evaporation is the difference between the Standard Cup and the black cups. The hourly transpiration rates are reduced to the rate of water loss from 100 square centimeters of leaf area, considering one surface of the leaf, by dividing the hourly chronographic rate by the leaf area.

All these calculations were aided very much by the use of an engineer's slide rule, an adding machine, and a planimeter.

EXPERIMENTS.

The object of these experiments was to determine the relation of the hairs on the mullein leaves to the resistance of the leaf to water loss. Two series of experiments were performed. In the first series a comparison of the transpiration rates of mullein and tobacco was made. Tobacco (*Nicotiana sp.*) was chosen as a suitable plant with which to compare mullein, because it is so nearly like mullein in every respect except the hairy covering. The thickness of the leaves, the arrangement of the intercellular structures as well as the general shape and appearance of the plant are as much alike as two plants of different families could possibly be. In the second series of experiments the transpiration rates of three different mullein plants were compared. At first, the normal plants were exposed to similar conditions and their comparative rates were determined; later, the hairs were removed from the lower side of one plant and from the upper side of another, while the third plant was left with hairs on both surfaces, and the rates under different conditions were compared. The removal of the hairs caused no injury to the leaf surfaces as the leaves kept on growing as healthily as ever and a microscopic examination of the

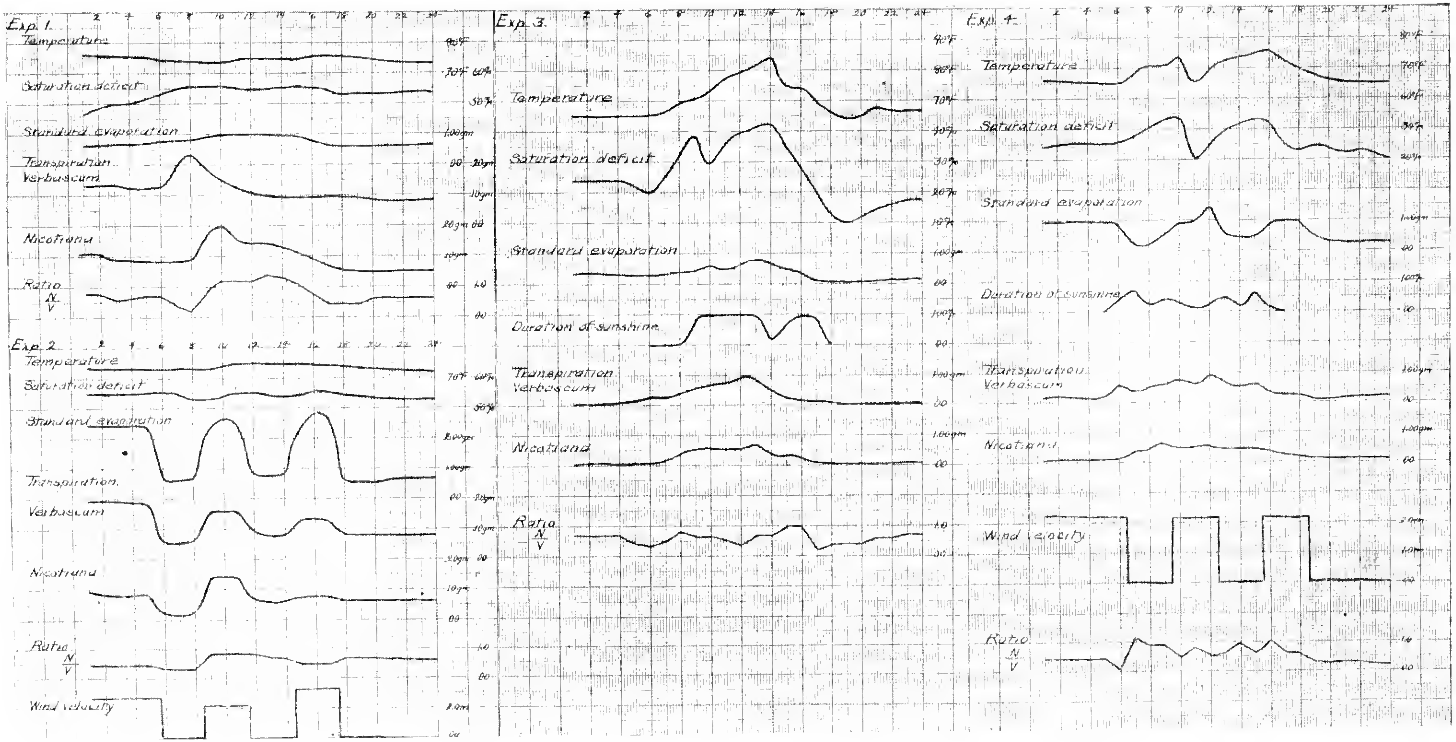

Fig. 3. Series I. Experiments 1, 2, 3 and 4.

leaves showed no rupture of living cells. The hairs were removed from the half grown leaf with curved forceps, and the leaves were allowed to grow to full size before the experiments were performed.

SERIES I. There are four experiments in this series, each one of which has one or more of the environmental conditions different from the other. The table below gives the condition under which each experiment was performed. The same two plants were used in each one of the experiments.

SERIES I.

Experiment	1.	Darkroom, still air.
	2.	Darkroom, wind.
	3.	Greenhouse, still air.
	4.	Greenhouse, wind.

The purpose of changing the conditions to which the plants were exposed was to see what comparative effect the conditions have on the resistance of the leaves to water loss. For example, wind increases transpiration, and as both plants are exposed to the same wind velocity, in order to determine their comparative resistance to water loss in wind, we compared their ratios in still air to their ratios in wind. If the ratios are the same each plant has resisted the wind to the same degree, but if they are different one of the plants has offered more or less resistance to the wind than the other. By comparing ratios, the resistance of the leaves to water loss under different conditions can be determined. The ratios used in the first four experiments are the $\frac{\text{transpiration of tobacco}}{\text{transpiration of mullein}}$ for the same time and under the same conditions, which for convenience will be designated as $\frac{\text{tobacco}}{\text{mullein}}$. (In the tables and curves simply as $\frac{N}{V}$).

Experiment 1. The hourly results of experiment 1, which was performed in the darkroom in still air, are tabulated on page 76, and expressed as curves on page 64. The temperature, saturation, deficit, and evaporation are almost constant under the conditions in the darkroom, while the transpiration rates show a rhythm in the curve about the middle

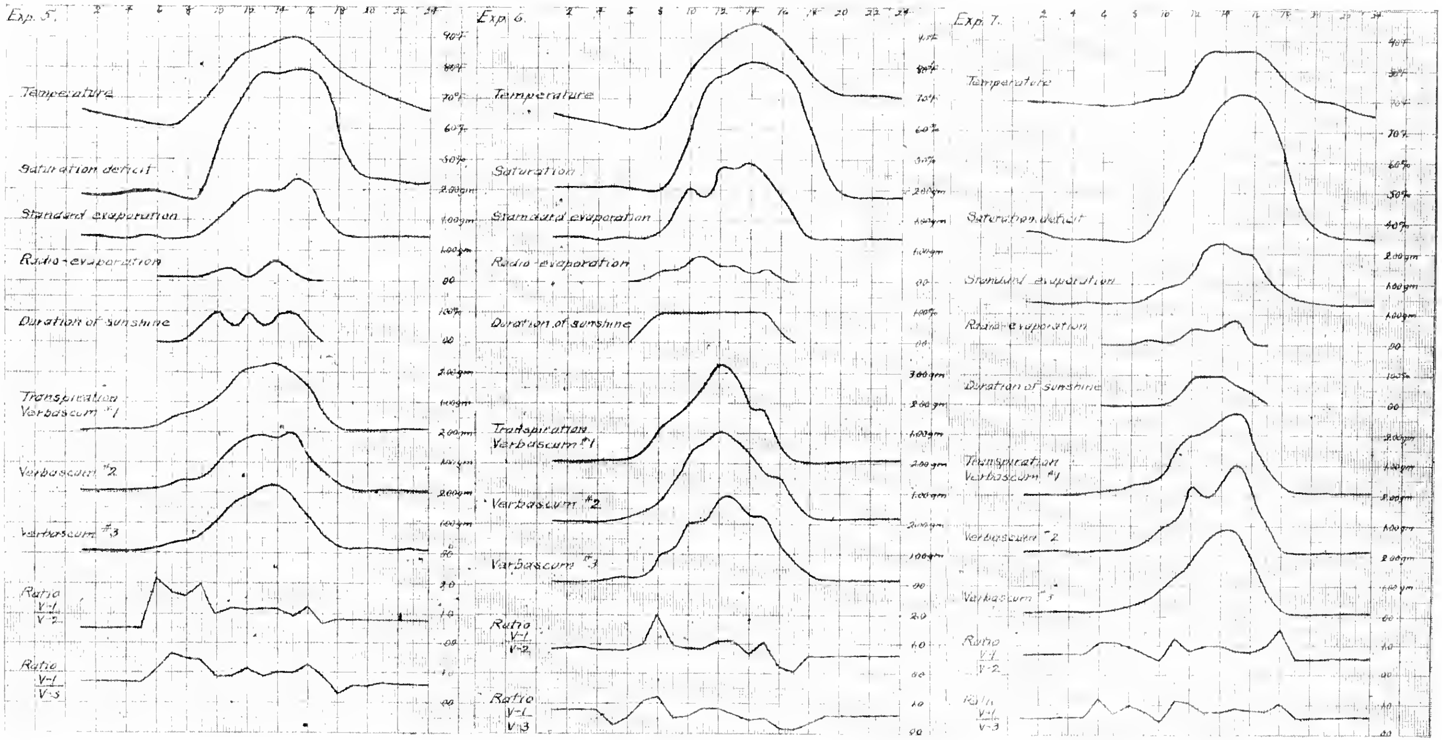

Fig. 4. Series II-a. Experiments 5, 6 and 7.

of the forenoon. The hourly ratios of the water loss from the two plants vary from 0.60 to 1.40 and the ratio for the total daily water loss is 0.81.

Experiment 2. This experiment was performed under conditions similar to experiment 1, except that an electric fan was used to produce wind, at three hour intervals. The tabulated results (page 76) and curves (page 64) show that under these conditions the temperature and saturation deficit are constant throughout the day while the results for water loss are determined by the wind velocity. The evaporation is proportional to the wind velocity, but the transpiration does not show these results, although the water loss of each plant is increased by the wind. In tobacco the highest rate of water loss is during the time when the wind velocity is least and the highest wind velocity produces the smallest increase in the rates of both plants. These irregularities are due to the fact that there is a rhythm in the curve at the time of the second interval as shown in experiment 1. The hourly ratios show less variation under the conditions of this experiment than in experiment 1, and the total daily ratio of water loss is considerably decreased; 0.59.

Experiment 3. The tabulated hourly rates of this experiment, which was performed in the Greenhouse in still air, are given on page 77 and a set of curves to correspond to this table on page 64. The variations in temperature and saturation deficit in this experiment are due to sunlight which increases them. The rates of evaporation correspond to the increased temperature and saturation deficit. There is a greater variation between the maximum and minimum rates of transpiration than in either of the two preceding experiments, due to the sunlight. This experiment is taken as a standard for comparison with the other experiments because the conditions are those to which plants are usually exposed. The total daily ratio for this experiment is 0.69.

Experiment 4. This experiment was similar to experiment 3, except an electric fan was used to produce wind, at three hour intervals as in experiment 2. The results are given on pages 77 and 64. The variations in temperature and saturation deficit occur according to the periods of day and night. The evaporation is proportional to the wind velocity, taking into consideration the changes in temperature and saturation

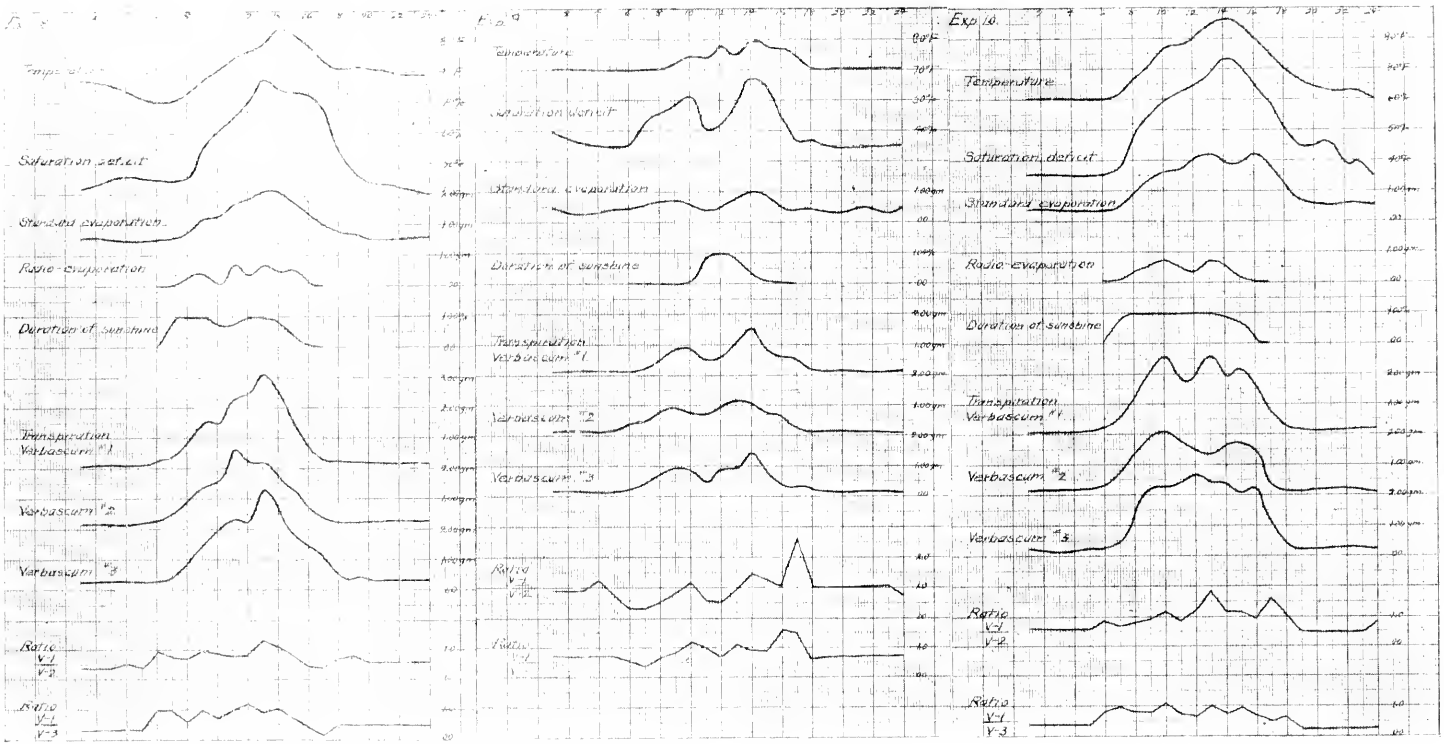

Fig. 5. Series II-b. Experiments 8, 9 and 10.

deficit. The variations in the transpiration rates are not proportional to the wind velocity or to the evaporation although there is some increase due to the wind. The total daily ratio for this experiment is 0.65.

In order to bring the results of the first four experiments together in a more compact form, a table of totals and ratios was made. This table (Table III, page 84) gives total day, night and daily rates of transpiration and evaporation for each experiment, and in experiment 2 and 4 the total rate for the still air and the wind intervals. The mean temperature and saturation deficit for each corresponding period are also shown.

Series II. There are twelve experiments in this series which is divided into four sub-series of three experiments each. The same plants were used throughout the entire series. The transpiration rates of three mullein plants were obtained by the same method as in series I. In series II-a the normal plants were used, but in the rest of the experiments the hairs were removed from the upper leaf surfaces of one plant and from the lower leaf surface of another, while the third plant was left normal throughout the series. Each sub-series has some condition changed or modified, as in the different experiments of series I, which are given in the accompanying table.

Series II.

Series II-a.	Normal plants, greenhouse, still air.
Series II-b.	Hairs removed, greenhouse, still air.
Series II-c.	Hairs removed, greenhouse, wind.
Series II-d.	Hairs removed, darkroom, still air.

Series II-a. Experiments 5, 6 and 7, which are the results of this sub-series are given on pages 78-79, in a tabulated form, and on page 66 in the form of curves. These results show the daily march of transpiration and give a record of the common factors influencing water loss from plants. These curves represent the ordinary rates of water loss from plants of this type. Table IV, on page 84, which gives totals and ratios for this series, shows that even from plants of the same species under the same conditions, the rate of water loss is not necessarily the same. This is shown by the ratios given in this table as well as by the total rate of water

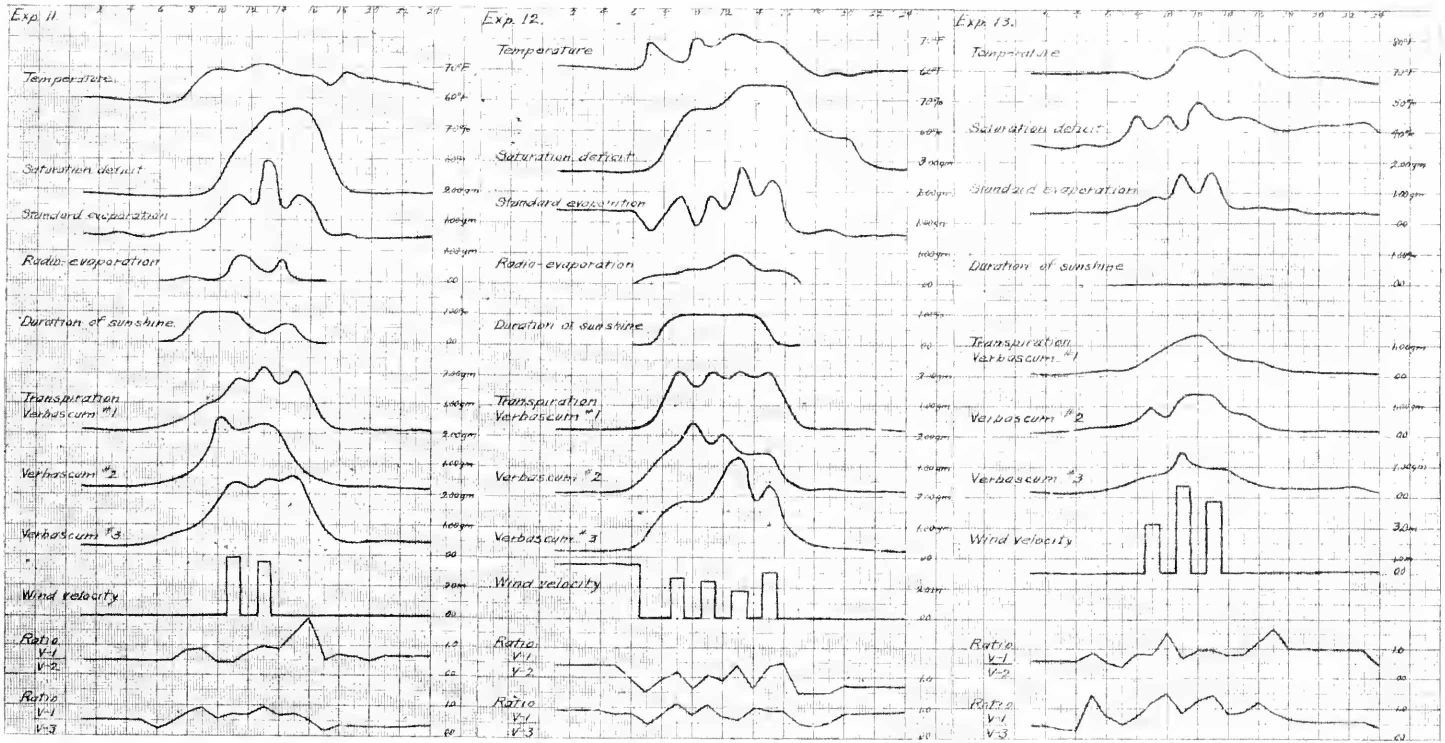

Fig. 6. Series II-c. Experiments 11, 12 and 13.

loss. The ratios which are used in this series (series II) are the $\frac{\text{transpiration of mullein}^1}{\text{transpiration of mullein}^2}$ for the same conditions and the $\frac{\text{transpiration of mullein}^1}{\text{transpiration of mullein}^3}$ for the same conditions. (Designated in the tables and curves as $\frac{\text{V-1}}{\text{V-2}}$ and $\frac{\text{V-1}}{\text{V-3}}$).

SERIES II-b. The results of this sub-series, experiments 8, 9 and 10, are given on pages 79–80 and 68. In this series mullein has the normal thick coat of hairs on its leaf surfaces, mullein[2] has the hairs removed from the upper surfaces of all the leaves, and mullein[3] has the hairs removed from the lower surfaces of all the leaves. The conditions under which the experiments of this series are run are similar to those of series II-a, or in still air in the greenhouse. The results show the daily march of transpiration, and the environmental factors. The table of totals and ratios (Table V, page 85,) shows that the removal of the hairs has not changed the ratios for the daily rates. $\frac{M^{1+h}}{M^{2+h}}=0.98$, and $\frac{M^{1+h}}{M^{3+h}}=0.82$ in series II-a, while in series II-b these are 0.99 and 0.83.

SERIES II-c. This sub-series of experiments was performed under the same conditions as series II-b, except that an electric fan was used to produce wind at hour intervals. Experiments 11, 12 and 13, on pages 81–82 and 70, are the results of this sub-series. The wind produces considerable increases in the evaporation rates, but there is no marked differences in the transpiration rates of the three plants. In Table VI, which gives the totals and ratios for this sub-series, the totals for still air and wind intervals are shown, in addition to the other totals. The total ratios for this sub-series are $\frac{M^{1+h}}{M^{2-h}}=0.91$ and $\frac{M^{1+h}}{M^{3-h}}=0.78$

SERIES II-d. The same plants that were used in the first three sub-series of this series were placed in the darkroom and a record of the water loss obtained for three days. These results are given as experiments 14, 15 and 16, on pages 82–83 and a set of curves made for these experiments on page 72. Table VII gives the totals and ratios for this sub-series: $\frac{M^{1+h}}{M^{2-h}}=0.56$ and $\frac{M^{1+h}}{M^{3-h}}=0.65$.

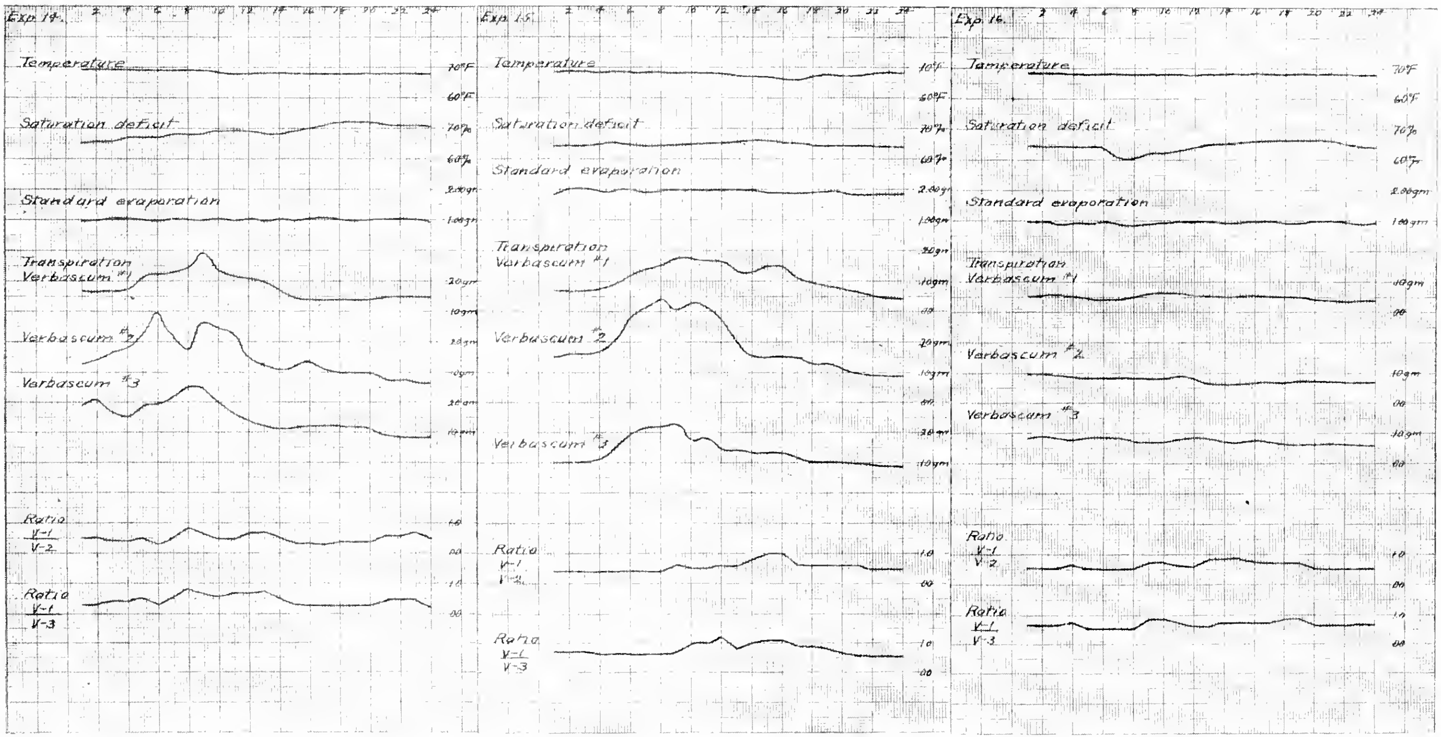

Fig. 7. Series II-d. Experiments 14, 15 and 16.

Conclusions.

The conclusions from the experiments in this paper are drawn from a comparison of the ratios given in the tables. The ratio $\frac{\text{tobacco}}{\text{mullein}}$ from experiment 3 is taken as a standard for comparison in series I, and the ratio $\frac{\text{mullein}^1}{\text{mullein}^2}$ and $\frac{\text{mullein}^1}{\text{mullein}^3}$ from experiments 5, 6 and 7 or sub-series–a as standard for comparison in series II. These represent the ratios of water loss in still air, and sunlight, or those conditions to which plants are more commonly subjected. For comparison, we assume that the numerator of the ratios does not change except in direct proportion to the environmental factors. For example, wind increases both the numerator and the denominator of the ratios or the transpiration of the two plants, but perhaps not to the same degree as when their rates are compared in still air. Under this assumption, any change in the ratios is due to an increase or a decrease in the transpiration rates of the plants used as the denominators as compared to the other plants. In the first series of experiments tobacco was used as a suitable plant with which to compare mullein, because of the very similar leaf structures of the two plants, except the absence of a hairy leaf covering on tobacco. In the second series normal mullein plants were compared with plants having the hairy covering of the leaves removed. These comparisons are made of daily results rather than hourly figures, because there is a great fluctuation in the hourly rates in some experiments and daily figures represent the average of these results.

By comparing the ratio $\frac{\text{tobacco}}{\text{mullein}}$ $(=0.69)$ in still air and light with the ratio $(=0.81)$ in still air and darkness it shows that there was a greater resistance of the mullein leaves to water loss in darkness than in light. A comparison of the ratio $(=0.69)$ in still air and light with the ratio $(=0.65)$ in wind and light shows that there was a very slight decrease in the resistance of the mullein leaves to water loss in wind than in still air. The comparison of the ratio $(=0.85)$ from the still air intervals of experiment 4 and the ratio $(=0.57)$ from the wind intervals of the same experiment and the ratio $(=0.68)$ from the still air intervals of experiment 2 and the ratio $(=0.56)$ from the wind intervals show that the mullein leaves offer less resistance to water loss in wind than in still air. A summary of these comparisons gives the following conclusions:

1. Mullein leaves offer a greater resistance to water loss in darkness than in light when compared with tobacco leaves.

2. Mullein leaves offer less resistance to water loss in wind than in still air when compared with tobacco leaves.

3. Mullein leaves respond as much or more to changes in the environment than tobacco leaves.

The ratios of sub-series-a in series II are taken as standard for comparing the other ratios of the series, because all plants are normal. The total ratios for the three experiments are compared in each sub-series. The two standard ratios are (=0.98) and)=0.82) their difference being due to the differences in transpiration rates of equal leaf areas of several plants of the same species even under identical conditions. These ratios, when the hairs are removed from the plants, become (=0.99) and (=0.83) which shows that the removal of the hair does not alter the resistance of the leaves to water loss. When the ratios of the same plants in wind and light with the hair removed are found (=0.91) and (=0.78) we see that the removal of the hairs has slightly decreased the resistance of the leaves to water loss in wind when compared with still air. This difference is due to the fact that a larger cuticular surface is exposed to the evaporating powers of the air when the hairs are removed, and that wind increases water loss from this exposed surface more than the usual rate in still air. This difference, however, is very slight as compared with the internal surface of the leaf. When the plants are placed in a darkroom and the ratios of the results obtained there are compared (=0.56) and (=0.65) there is a great difference noticed. The effect of removing the hairs from the leaves is to greatly increase the resistance in darkness as compared with plants having hairs in light. This increase, however, is caused by the increased transpiration, which in darkness is cuticular because the stomata are closed, and is much larger because a greater surface is exposed to the evaporating power of the air. Series II, therefore, warrants the following conclusions:

4. The removal of the hairs from the mullein leaves does not alter the resistance of the leaves to water loss in still air and light.

5. The removal of the hairs slightly decreased the resistance of the leaves to water loss in wind and light as compared to still air and light, because the cuticular surface is more exposed to the air.

6. The removal of the hairs greatly decreased the resistance of the leaves to water loss in still air and darkness as compared with still air and light. This is due to the greater exposure of the cuticular surface. In darkness the stomata are closed and transpiration is almost entirely cuticular.

7. Hairs as a protective covering against ordinary intensities of wind and light on mullein leaves may be disregarded. The water loss from the leaves is mostly from the internal (mesophyll) surface of the leaves. The internal water loss is from twenty to forty times greater than the external or cuticular water loss (on the basis of increased transpiration due to stomatal openings minus increased evaporation caused by increased environmental factors). The removal of the hairs increases total transpiration only to the extent that the cuticular surface is more exposed and has apparently no effect on stomatal transpiration.

LITERATURE CITED.

1. **Warming:** Ecology of Plants. 1909.
2. **Jost:** Plant Physiology. 1917.
3. **Gager:** Fundamentals of Botany. 1916.
4. **Coulter, Barnes, and Cowles:** Text Book of Botany. 1910.
5. **Wiegand, K. M.** The Relation of Hairy and Cutinized Coverings to Transpiration. Bot. Gaz. 49 : 430–444. f. 1. 1910.
6. **Kerner:** The Natural History of Plants. 1893.
7. **Vesque, M. J. et Viet, M. C.** Die L' influence du milieu sur la structure anatomique des Vegetaux. Ann. Sci. Nat. Bot. VI. 12 : 176. 1881.
8. **Brenner, M.** Die Transpiration de Pflanzen. 1904.
9. **Transeau, E. N.** Apparatus for the study of Comparative Transpiration. Bot. Gaz. 52 : 54–60. f. 1–5. 1911.
10. **Livingston, B. E.** A Rotating Table for Standardizing Porous Cups Atmometers. Plant World 15 : 157–162. 1912.

Experiment 1—Darkroom.

Time, hours.	Temperature, Degrees F.	Saturation Deficit %.	Standard Evaporation. Grams per hour.	Transpiration, Verbascum. Grams per Sq. Dm. per hour.	Transpiration, Nicotiana. Grams per Sq. Dm. per hour.	Ratio $\frac{N}{V}$
1	75	46	.66	.13	.11	.8
2	75	48	.66	.13	.11	.8
3	75	49	.66	.13	.09	.6
4	75	50	.70	.12	.09	.7
5	75	52	.76	.12	.09	.7
6	74	53	.78	.12	.09	.7
7	74	55	.82	.20	.09	.4
8	74	56	.91	.24	.09	.3
9	73	56	.95	.19	.19	1.0
10	73	56	.99	.16	.20	1.2
11	74	55	.95	.12	.15	1.2
12	74	55	.95	.11	.14	1.2
13	74	55	.95	.10	.14	1.4
14	74	55	.90	.09	.12	1.3
15	74	55	.90	.09	.10	1.1
16	75	55	.80	.09	.08	.8
17	75	54	.63	.09	.05	.5
18	75	53	.63	.09	.05	.5
19	74	53	.63	.09	.05	.5
20	74	53	.63	.08	.05	.6
21	73	53	.63	.08	.05	.6
22	73	54	.63	.08	.05	.6
23	73	54	.63	.08	.05	.6
24	73	54	.63	.08	.05	.6

Experiment 2—Darkroom.

Time, hours.	Temperature, Degrees F.	Saturation Deficit %.	Standard Evaporation. Grams per hour.	Transpiration, Verbascum. Grams per Sq. Dm. per hour.	Transpiration, Nicotiana. Grams per Sq. Dm. per hour	Wind Velocity. Miles per hour.	Ratio $\frac{N}{V}$
1	73	55	2.46	.20	.09	2.7	.4
2	73	55	2.46	.19	.08	2.7	.4
3	73	55	2.46	.19	.08	2.7	.4
4	73	55	2.42	.19	.08	2.7	.4
5	73	55	2.46	.19	.08	2.7	.4
6	73	55	.61	.06	.02	....	.3
7	73	54	.66	.06	.02	....	.3
8	73	53	.61	.06	.02	....	.3
9	73	53	2.36	.16	.14	2.2	.8
10	74	54	2.70	.16	.14	2.2	.8
11	74	55	2.46	.16	.14	2.2	.8
12	74	55	.80	.08	.07	....	.8
13	74	54	.80	.08	.06	....	.7
14	74	54	.80	.08	.06	....	.7
15	74	54	2.36	.13	.07	3.3	.5
16	74	55	2.90	.13	.07	3.3	.5
17	74	55	2.70	.13	.07	3.3	.5
18	73	54	.56	.08	.06	....	.7
19	73	53	.56	.08	.06	....	.7
20	73	53	.56	.08	.06	....	.7
21	73	53	.61	.08	.06	....	.7
22	72	52	.66	.08	.06	....	.7
23	72	52	.66	.08	.06	....	.7
24	72	52	.66	.08	.06	....	.7

Experiment 3—Greenhouse.

Time, hours.	Temperature, Degrees F.	Saturation Deficit %.	Standard Evaporation. Grams per hour.	Duration of Sunshine. Per cent per hour.	Transpiration, Verbascum. Grams per Sq. Dm. per hour.	Transpiration, Nicotiana. Grams per Sq. Dm. per hour.	Ratio $\frac{N}{V}$
1	66	24	.32	....	.09	.07	.7
2	66	24	.32	....	.09	.07	.7
3	66	24	.32	....	.10	.07	.7
4	66	24	.32	....	.12	.09	.7
5	65	23	.28	....	.14	.10	.5
6	66	20	.23	00	.28	.12	.4
7	67	25	.32	00	.28	.17	.5
8	70	32	.42	00	.45	.40	.8
9	71	39	.47	90	.64	.52	.7
10	74	30	.66	100	.72	.53	.7
11	78	37	.47	100	.79	.53	.6
12	80	40	.70	100	1.00	.55	.5
13	82	41	.89	100	.94	.70	.7
14	85	43	.70	20	.50	.35	.7
15	75	36	.52	70	.32	.32	1.0
16	75	30	.38	100	.24	.25	1.0
17	70	20	.09	100	.21	.06	.2
18	67	14	.09	....	.15	.06	.4
19	64	11	.09	....	.10	.05	.5
20	65	13	.13	....	.10	.05	.5
21	68	15	.13	....	.10	.06	.6
22	67	17	.13	....	.10	.06	.6
23	67	18	.17	....	.10	.07	.7
24	67	18	.17	....	.10	.07	.7

Experiment 4—Greenhouse.

Time, hours.	Temperature, Degrees F.	Saturation Deficit %.	Standard Evaporation. Grams per hour.	Duration of Sunshine. Per cent per hour.	Transpiration, Verbascum. Grams per Sq. Dm. per hour.	Transpiration, Nicotiana. Grams per Sq. Dm. per hour.	Wind Velocity. Miles per hour.	Ratio $\frac{N}{V}$
1	66	24	.95	....	.19	.09	2.2	.4
2	66	25	.95	....	.16	.07	2.2	.4
3	66	25	.95	....	.15	.07	2.2	.4
4	65	25	.95	....	.15	.07	2.2	.4
5	65	25	.95	....	.14	.07	2.2	.4
6	65	26	.95	40	.53	.07	2.2	.1
7	69	28	.23	70	.24	.30	....	1.2
8	71	31	.23	20	.50	.45	....	.9
9	71	33	.47	40	.64	.61	....	.9
10	74	40	.95	30	.77	.45	2.2	.5
11	65	20	.95	10	.52	.45	2.2	.8
12	70	25	1.42	20	.85	.50	2.2	.5
13	72	30	.47	50	.64	.45	....	.7
14	74	32	.47	10	.51	.47	....	.9
15	75	33	.47	60	.60	.38	....	.6
16	76	33	.95	00	.28	.31	2.2	1.1
17	72	25	.95	00	.21	.13	2.2	.6
18	70	23	.95	....	.21	.13	2.2	.6
19	68	25	.47	....	.08	.03	....	.3
20	66	24	.23	....	.12	.04	....	.3
21	65	23	.23	....	.13	.04	....	.3
22	65	23	.23	....	.14	.04	....	.2
23	65	22	.23	....	.14	.04	....	.2
24	65	20	.23	....	.14	.04	....	.2

Experiment 5—Greenhouse.

Time, hours.	Temperature, Degrees F.	Saturation Deficit %.	Standard Evaporation. Grams per hour.	Radio-evaporation. Grams per hour.	Duration of Sunshine. Per cent per hour.	Transpiration, Verbascum No. 1. Grams per Sq. Dm. per hour.	Transpiration, Verbascum No. 2. Grams per Sq. Dm. per hour.	Transpiration, Verbascum No. 3. Grams per Sq. Dm. per hour.	Ratio V-1/V-2	Ratio V-1/V-3
1	66	38	.46	......	......	05	.09	.07	.5	.7
2	65	38	.44	......	......	05	.09	.07	.5	.7
3	64	38	.39	......	......	.05	.09	.07	.5	.7
4	63	39	.38	......	......	.05	.09	.07	.5	.7
5	62	39	.48	......	......	05	.09	.07	.5	.7
6	61	39	.38	.10	00	.20	.09	.17	2.2	1.1
7	61	38	.32	.13	00	.50	.28	.31	1.7	1.6
8	65	36	.39	.16	10	.57	.35	.37	1.6	1.5
9	69	40	.67	.15	60	.85	.42	.60	2.0	1.4
10	75	55	.91	.37	100	1.06	1.11	1.07	.9	.9
11	83	65	1.55	.45	50	1.71	1.42	1.74	1.2	.9
12	85	75	1.93	.17	90	2.14	1.80	1.81	1.1	1.1
13	87	78	1.93	.49	50	2.14	1.90	2.26	1.1	.9
14	89	78	1.93	72	100	2.29	1.80	2.26	1.2	1.0
15	91	79	2.42	.23	100	1.92	2.00	1.92	.9	1.0
16	88	79	2.16	00	50	1.60	1.23	1.22	1.3	1.3
17	83	75	1.02	.00	00	.54	.78	.56	.7	.9
18	78	60	.50	......	......	.08	.10	.23	.8	.3
19	76	45	.40	......	......	.08	.10	.16	.8	.5
20	73	44	.42	......	......	.08	.10	.13	.8	.6
21	71	43	.42	......	......	.08	.10	.13	.8	.6
22	69	42	.40	......	......	.08	.10	.13	.8	.6
23	67	42	.42	......	......	.08	.10	.13	.8	.6
24	66	42	.44	......	......	.08	.10	.13	.8	.6

Note: All plants normal.

Experiment 6—Greenhouse.

Time, hours.	Temperature, Degrees F.	Saturation Deficit %.	Standard Evaporation. Grams per hour.	Radio-evaporation. Grams per hour.	Duration of Sunshine. Per cent per hour.	Transpiration, Verbascum No. 1. Grams per Sq. Dm. per hour.	Transpiration, Verbascum No. 2. Grams per Sq. Dm. per hour.	Transpiration, Verbascum No. 3. Grams per Sq. Dm. per hour.	Ratio V-1/V-2	Ratio V-1/V-3
1	65	41	.45	......	......	.08	.09	.10	.8	.8
2	64	41	.45	......	......	08	.09	.10	.8	.8
3	63	41	.45	......	......	.08	.09	.10	.8	.8
4	62	41	.35	......	......	.08	.09	.10	.8	.8
5	61	41	.43	......	......	.08	.09	.22	.8	.3
6	60	40	.43	.00	00	.13	.16	.24	.8	.5
7	60	40	.43	.04	70	.31	.33	.28	.9	1.1
8	62	40	.56	.39	100	1.13	.53	.91	2.1	1.2
9	70	45	1.23	.41	100	1.41	1.33	2.18	1.0	.6
10	80	60	2.10	.70	100	2.10	2.48	3.04	.8	.6
11	85	75	1.77	.81	100	2.50	2.68	3.04	.9	.8
12	90	77	2.73	.49	100	3.38	3.06	3.92	1.1	.8
13	93	81	2.73	.59	100	3.10	2.80	3.92	1.1	.7
14	95	82	2.90	.24	100	1.83	2.42	3.26	.7	.5
15	93	81	2.42	.48	100	1.83	1.65	3.26	1.1	.5
16	90	79	1.93	.00	10	.52	1.60	2.38	.3	.2
17	85	75	1.01	.00	00	.10	.68	.87	.1	.1
18	78	60	.44	......	......	09	.13	.28	.6	.3
19	74	45	.38	......	......	.09	.13	.13	.6	.6
20	72	38	.38	......	......	.09	.13	.13	.6	.6
21	72	37	.38	......	......	.09	.13	.13	.6	.6
22	71	37	.38	......	......	.09	.13	.13	.6	.6
23	70	37	.38	......	......	.09	.13	.13	.6	.6
24	70	37	.38	......	......	.09	.13	.13	.6	.6

Note: All plants normal.

Experiment 7—Greenhouse.

Time, hours.	Temperature, Degrees F.	Saturation Deficit %.	Standard Evaporation. Grams per hour.	Radio-evaporation. Grams per hour.	Duration of Sunshine. Per cent per hour.	Transpiration, Verbascum No. 1. Grams per Sq. Dm. per hour.	Transpiration, Verbascum No. 2. Grams per Sq. Dm. per hour.	Transpiration, Verbascum No. 3. Grams per Sq. Dm. per hour.	Ratio V-1/V-2	Ratio V-1/V-3
1	70	37	.41	......	......	.09	.12	.13	.7	.6
2	69	37	.35	......	......	.09	.12	.13	.7	.6
3	69	35	.35	......	......	.09	.12	.13	.7	.6
4	69	35	.37	......	......	.09	.12	.13	.7	.6
5	69	35	.41	......	......	.09	.12	.13	.7	.6
6	68	35	.35	.00	00	.18	.16	.13	1.1	1.3
7	69	34	.35	.00	00	.18	.16	.25	1.1	.7
8	70	34	.35	.00	00	.31	.30	.31	1.0	1.0
9	71	36	.50	.12	00	.43	.50	.51	.8	.8
10	72	45	.91	.02	00	.47	.97	1.00	.4	.4
11	72	55	.97	.14	20	1.57	1.15	1.31	1.3	1.2
12	83	60	1.20	.58	90	1.96	2.31	1.75	.9	1.1
13	87	75	2.25	.40	100	2.15	1.94	2.62	1.0	.8
14	87	81	2.34	.56	100	2.55	2.38	2.85	1.0	.8
15	87	83	2.04	.86	60	2.74	3.03	2.85	.9	.9
16	87	82	1.95	.00	40	1.70	2.02	1.97	.8	.8
17	83	75	1.20	.00	00	.82	1.01	.98	.8	.8
18	77	66	.70	......	......	.22	.12	.19	1.7	1.1
19	73	45	.55	......	......	.08	.12	.13	.6	.6
20	71	38	.44	......	......	.08	.12	.13	.6	.6
21	70	36	.35	......	......	.08	.12	.13	.6	.6
22	68	35	.35	......	......	.08	.12	.13	.6	.6
23	66	34	.35	......	......	.08	.12	.13	.6	.6
24	65	34	.35	......	......	.08	.12	.13	.6	.6

Note: All plants normal.

Experiment 8—Greenhouse.

Time, hours.	Temperature, Degrees F.	Saturation Deficit %.	Standard Evaporation. Grams per hour.	Radio-evaporation, Grams per hour.	Duration of Sunshine. Per cent per hour.	Transpiration, Verbascum No. 1. Grams per Sq. Dm. per hour.	Transpiration, Verbascum No. 2. Grams per Sq. Dm. per hour.	Transpiration, Verbascum No. 3. Grams per Sq. Dm. per hour.	Ratio V-1/V-2	Ratio V-1/V-3
1	67	42	.52	......	......	.08	.19	.23	.4	.3
2	66	43	.57	......	......	.08	.21	.24	.3	.3
3	65	45	.46	......	......	.09	.18	.24	.4	.3
4	64	46	.45	......	......	.09	.18	.23	.5	.3
5	62	45	.44	......	......	.09	.19	.23	.4	.3
6	61	45	.44	.04	00	.25	.24	.25	1.0	1.0
7	60	45	.52	.03	100	.36	.48	.38	.7	.9
8	63	45	.70	.37	100	.70	.96	1.05	.7	.6
9	68	55	1.25	.37	100	1.53	1.42	1.40	1.0	1.0
10	70	60	1.25	.01	70	1.49	1.51	2.08	.9	.7
11	75	65	1.67	.72	80	2.24	2.65	2.33	.8	.9
12	77	70	1.84	.39	100	2.45	2.65	2.20	.9	1.1
13	79	78	2.08	.71	100	3.11	2.27	3.30	1.3	.9
14	85	75	2.08	.56	80	2.56	2.27	2.58	1.1	1.0
15	82	74	1.63	.53	30	1.44	1.70	1.84	.8	.7
16	80	73	1.36	.00	00	.64	1.32	1.47	.4	.4
17	73	68	.85	.00	00	.25	.63	.90	.3	.2
18	71	55	.72	......	......	.21	.29	.36	.7	.5
19	72	46	.62	......	......	.19	.22	.32	.8	.5
20	71	44	.49	......	......	.13	.21	.24	.6	.5
21	70	43	.52	......	......	.13	.21	.25	.6	.5
22	69	42	.52	......	......	.13	.21	.25	.6	.5
23	69	41	.52	......	......	.13	.21	.25	.6	.5
24	69	40	.52	......	......	.13	.21	.25	.6	.5

Note: Verbascum No. 1, normal.
Verbascum No. 2, hairs removed from upper leaf surfaces.
Verbascum No. 3, hairs removed from lower leaf surfaces.

EXPERIMENT 9—GREENHOUSE.

Time, hours.	Temperature, Degrees F.	Saturation Deficit %.	Standard Evaporation. Grams per hour.	Duration of Sunshine. Per cent per hour.	Transpiration, Verbascum No. 1. Grams per Sq. Dm. per hour.	Transpiration, Verbascum No. 2. Grams per Sq. Dm. per hour.	Transpiration, Verbascum No. 3. Grams per Sq. Dm. per hour.	Ratio V-1/V-2	Ratio V-1/V-3
1	70	40	.44	....	.13	.14	.18	.9	.7
2	70	38	.35	....	.13	.14	.18	.9	.7
3	70	37	.30	....	.13	.14	.18	.9	.7
4	70	36	.33	....	.13	.10	.18	1.3	.7
5	70	35	.41	....	.13	.15	.18	.8	.7
6	70	35	.44	00	.14	.32	.21	.4	.6
7	70	43	.67	00	.16	.47	.44	.3	.3
8	70	46	.70	00	.52	.87	.82	.5	.6
9	72	49	.73	00	.81	.97	.98	.8	.8
10	75	52	.63	00	.94	.77	.82	1.2	1.1
11	73	40	.41	90	.47	.77	.45	.6	1.0
12	78	42	.55	90	.63	.97	.86	.6	.7
13	74	48	.80	70	1.10	1.17	.98	.9	1.1
14	80	58	1.05	40	1.57	1.02	1.48	1.5	1.0
15	78	55	.87	00	.88	.73	.93	1.2	.9
16	77	45	.41	00	.64	.58	.36	1.1	1.7
17	75	37	.48	00	.54	.19	.34	2.8	1.5
18	70	37	.41	....	.14	.14	.22	1.0	.6
19	70	35	.33	....	.14	.14	.19	1.0	.7
20	70	35	.30	....	.14	.14	.19	1.0	.7
21	70	35	.44	....	.14	.14	.19	1.0	.7
22	70	35	.45	....	.14	.14	.19	1.0	.7
23	70	35	.29	....	.14	.14	.19	1.0	.7
24	70	43	.44	....	.13	.14	.18	.9	.7

NOTE: Verbascum No. 1, normal.
Verbascum No. 2, hairs removed from upper leaf surfaces.
Verbascum No. 3, hairs removed from lower leaf surfaces.

EXPERIMENT 10—GREENHOUSE.

Time, hours.	Temperature, Degrees F.	Saturation Deficit %.	Standard Evaporation. Grams per hour.	Radio-evaporation. Grams per hour.	Duration of Sunshine. Per cent per hour.	Transpiration, Verbascum No. 1. Grams per Sq. Dm. per hour.	Transpiration, Verbascum No. 2. Grams per Sq. Dm. per hour.	Transpiration, Verbascum No. 3. Grams per Sq. Dm. per hour.	Ratio V-1/V-2	Ratio V-1/V-3
1	70	35	.32	......	......	.08	.13	.21	.6	.3
2	70	35	.33	......	......	.08	.13	.17	.6	.4
3	70	35	.35	......	......	.08	.13	.17	.6	.4
4	70	35	.30	......	......	.08	.13	.19	.6	.4
5	70	35	.33	......	......	.12	.18	.24	.6	.4
6	70	36	.33	.07	10	.22	.26	.27	.8	.8
7	72	37	.41	.13	100	.47	.63	.46	.7	1.0
8	77	48	.92	.42	100	1.09	1.34	1.35	.8	.8
9	80	55	1.35	.58	100	1.84	1.87	2.26	.9	.8
10	87	60	1.68	.73	100	2.64	2.14	2.26	1.2	1.1
11	88	62	1.68	.55	100	1.70	1.87	2.41	.9	.7
12	90	65	2.10	.32	100	2.00	1.60	2.71	1.2	.7
13	95	68	2.25	79	100	2.64	1.34	2.41	1.9	1.0
14	97	74	1.93	.68	90	2.00	1.60	2.41	1.2	.8
15	95	72	2.22	.17	80	2.28	1.74	2.10	1.3	1.0
16	90	65	1.93	.12	00	1.70	1.51	2.30	1.0	.7
17	85	60	1.18	.00	00	.64	.38	1.13	1.6	.5
18	80	50	.66	......	......	.22	.20	.31	1.1	.7
19	76	44	.54	......	......	.11	.20	.30	.5	.3
20	74	45	.54	......	......	.11	.20	.30	.5	.3
21	73	47	.54	......	......	.11	.20	.30	.5	.3
22	73	39	.54	......	......	.11	.20	.30	.5	.3
23	73	40	.54	......	......	.11	.20	.30	.5	.3
24	70	35	.54	......	......	.09	.11	.21	.8	.4

NOTE: Verbascum No. 1, normal.
Verbascum No. 2, hairs removed from upper leaf surfaces.
Verbascum No. 3, hairs removed from lower leaf surfaces.

Experiment 11—Greenhouse.

Time, hours.	Temperature, Degrees F.	Saturation Deficit %.	Standard Evaporation. Grams per hour.	Radio-evaporation. Grams per hour.	Duration of Sunshine. Per cent per hour.	Transpiration, Verbascum No. 1. Grams per Sq. Dm. per hour.	Transpiration, Verbascum No. 2. Grams per Sq. Dm. per hour.	Transpiration, Verbsacum No. 3. Grams per Sq. Dm. per hour.	Wind Velocity. Miles per hour.	Ratio V-1/V-2	Ratio V-1/V-3
1	60	48	.55	......	......	.12	.25	.24	......	.4	.5
2	59	48	.59	......	......	.12	.25	.24	......	.4	.5
3	59	48	.66	......	......	.12	.25	.24	......	.4	.5
4	59	48	.55	......	......	.12	.25	.24	......	.4	.5
5	58	48	.54	......	......	.12	.25	.30	......	.4	.4
6	58	48	.61	.00	00	.12	.30	.44	......	.4	.2
7	58	48	.55	.07	00	.27	.49	.65	......	.5	.4
8	65	48	.52	.17	80	.62	.71	.78	......	.8	.7
9	68	48	.90	.00	100	.96	1.13	1.10	......	.8	.8
10	70	55	1.54	.00	100	1.11	2.58	1.75	......	.4	.6
11	68	64	1.93	.97	100	1.88	2.18	2.40	4.0	.5	.7
12	72	70	1.42	.75	40	1.67	2.18	2.13	......	.7	.7
13	72	75	3.14	.23	30	2.30	2.38	2.40	3.5	.9	.9
14	69	76	1.42	.75	60	1.67	1.99	2.40	......	.8	.6
15	68	77	1.93	.00	60	2.10	1.18	2.66	......	1.7	.7
16	68	75	1.56	.00	00	1.25	.59	1.88	......	2.1	.6
17	63	63	.66	.00	00	.16	.37	.91	......	.4	.1
18	69	50	.64	......	......	.16	.25	.45	......	.6	.3
19	68	49	.55	......	......	.16	.25	.45	......	.6	.3
20	67	49	.55	......	......	.16	.25	.45	......	.5	.3
21	66	49	.55	......	......	.16	.25	.45	......	.6	.3
22	64	48	.55	......	......	.16	.25	.45	......	.6	.3
23	63	48	.55	......	......	.16	.25	.45	......	.6	.3
24	63	48	.55	......	......	.16	.25	.45	......	.6	.3

Note: Verbascum No. 1, normal.
Verbascum No. 2, hairs removed from upper leaf surfaces.
Verbascum No. 3, hairs removed from lower leaf surfaces.

Experiment 12—Greenhouse.

Time, hours.	Temperature, Degrees F.	Saturation Deficit %.	Standard Evaporation. Grams per hour.	Radio-evaporation. Grams per hour.	Duration of Sunshine. Per cent per hour.	Transpiration, Verbascum No. 1. Grams per Sq. Dm. per hour.	Transpiration, Verbascum No. 2. Grams per Sq. Dm. per hour.	Transpiration, Verbascum No. 3. Grams per Sq. Dm. per hour.	Wind Velocity. Miles per hour.	Ratio V-1/V-2	Ratio V-1/V-3
1	62	47	1.43	......	......	.20	.15	.22	3.5	1.3	.9
2	61	47	1.43	......	......	.20	.15	.22	3.5	1.3	.9
3	61	47	1.43	......	......	.20	.15	.22	3.5	1.3	.9
4	60	47	1.43	......	......	.20	.15	.22	3.5	1.3	.9
5	60	47	1.43	......	......	.20	.15	.23	3.5	1.3	.8
6	60	47	1.43	.00	00	.20	.21	.23	3.5	.9	.8
7	70	47	.72	.25	00	.36	.70	.81	......	.5	.4
8	65	55	1.19	.26	80	1.22	1.33	1.55	......	.9	.7
9	62	65	1.93	.37	100	2.18	1.68	1.88	2.6	1.2	1.1
10	71	67	.96	.48	100	1.58	2.43	1.88	......	.6	.8
11	68	67	1.93	.48	100	2.18	1.68	1.88	2.2	1.2	1.1
12	72	70	1.42	.96	100	1.98	2.04	2.82	......	.9	.7
13	72	75	2.90	.96	100	2.18	1.49	3.30	1.9	1.4	.6
14	70	75	1.93	.48	100	1.98	2.99	1.88	......	.6	1.0
15	70	75	2.41	.45	20	2.18	1.49	2.36	3.0	1.4	.9
16	66	75	1.10	.34	00	1.03	.66	1.09	......	1.5	.9
17	60	65	.77	.17	00	.23	.39	.45	......	.5	.5
18	58	61	.77	......	......	.22	.28	.46	......	.5	.4
19	60	58	.76	......	......	.18	.27	.31	......	.6	.5
20	58	58	.58	......	......	.18	.23	.22	......	.7	.8
21	60	50	.58	......	......	.18	.23	.22	......	.7	.8
22	60	48	.58	......	......	.18	.23	.22	......	.7	.8
23	60	48	.58	......	......	.18	.23	.22	......	.7	.8
24	60	47	.58	......	......	.18	.23	.22	......	.7	.8

Note: Verbascum No. 1, normal.
Verbascum No. 2, hairs removed from upper leaf surfaces.
Verbascum No. 3, hairs removed from lower leaf surfaces.

Experiment 13—Greenhouse.

Time, hours.	Temperature, Degrees F.	Saturation Deficit %.	Standard Evaporation. Grams per hour.	Duration of Sunshine. Per cent per hour.	Transpiration, Verbascum No. 1. Grams per Sq. Dm. per hour.	Transpiration, Verbascum No. 2. Grams per Sq. Dm. per hour.	Transpiration, Verbsacum No. 3. Grams per Sq. Dm. per hour.	Wind Velocity. Miles per hour.	Ratio V-1/V-2	Ratio V-1/V-3
1	69	36	.30	......	.06	.12	.13	......	.5	.4
2	69	35	.30	......	.06	.12	.13	......	.5	.4
3	69	34	.32	......	.06	.12	.16	......	.5	.3
4	69	35	.32	......	.06	.23	.16	......	.5	.3
5	69	35	.32	......	.17	.20	.11	......	.8	1.5
6	69	35	.35	00	.17	.29	.20	......	.5	.8
7	69	38	.50	00	.18	.40	.36	......	.4	.5
8	68	45	.53	00	.41	.52	.60	......	.7	.6
9	67	40	.90	00	.77	1.00	.69	3.2	.7	1.1
10	69	45	.71	00	1.00	.53	.77	......	1.8	1.4
11	77	40	1.69	00	1.16	1.38	1.42	5.6	.6	.8
12	78	50	.96	00	1.33	1.38	1.03	......	.9	1.2
13	76	45	1.69	00	1.16	1.22	.88	4.7	.9	1.3
14	75	44	.48	00	.66	.81	.86	......	.8	.7
15	77	45	.48	00	.50	.71	.56	......	.7	.8
16	74	43	.55	00	.46	.38	.38	......	1.2	1.2
17	70	40	.41	00	.26	.15	.30	......	1.7	.8
18	68	40	.48	......	.16	.15	.26	......	1.0	.6
19	68	41	.30	......	.14	.15	.26	......	.9	.5
20	68	42	.30	......	.14	.15	.26	......	.9	.5
21	67	42	.30	......	.14	.15	.26	......	.9	.5
22	67	42	.30	......	.14	.15	.26	......	.9	.5
23	66	43	.30	......	.14	.15	.26	......	.9	.5
24	70	40	.30	......	.06	.12	.13	......	.5	.4

Note: Verbascum No. 1, normal.
Verbascum No. 2, hairs removed from upper leaf surfaces.
Verbascum No. 3, hairs removed from lower leaf surfaces.

Experiment 14—Darkroom.

Time, hours.	Temperature, Degrees F.	Saturation Deficit %.	Standard Evaporation. Grams per hour.	Transpiration, Verbascum No. 1. Grams per Sq. Dm. per hour.	Transpiration, Verbascum No. 2. Grams per Sq. Dm. per hour.	Transpiration, Verbascum No. 3. Grams per Sq. Dm. per hour.	Ratio V-1/V-2	Ratio V-1/V-3
1	69	65	.99	.07	.13	.19	.5	.3
2	69	66	.97	.07	.14	.21	.5	.3
3	69	66	1.01	.07	.16	.17	.4	.4
4	69	67	1.00	.07	.16	.15	.4	.4
5	69	67	.99	.12	.23	.19	.5	.5
6	69	67	.97	.12	.31	.19	.3	.3
7	69	68	.97	.13	.21	.23	.5	.6
8	69	68	.97	.14	.17	.26	.8	.8
9	69	68	.97	.19	.27	.25	.7	.7
10	68	69	1.02	.13	.25	.20	.5	.6
11	68	69	.99	.12	.23	.16	.5	.7
12	68	69	1.01	.11	.15	.14	.7	.7
13	68	68	.96	.10	.13	.12	.7	.8
14	68	68	1.09	.07	.11	.12	.6	.5
15	68	69	.97	.04	.12	.12	.3	.3
16	68	70	1.08	.04	.13	.12	.3	.3
17	68	71	1.07	.04	.11	.12	.3	.3
18	68	72	1.06	.04	.10	.12	.4	.3
19	68	72	1.00	.04	.10	.12	.4	.3
20	68	72	1.01	.04	.10	.12	.4	.3
21	68	71	1.05	.05	.08	.09	.6	.5
22	68	71	1.01	.05	.08	.09	.6	.5
23	68	71	1.02	.05	.07	.09	.7	.5
24	68	71	.99	.07	.14	.14	.5	.3

Note: Verbascum No. 1, normal.
Verbascum No. 2, hairs removed from upper leaf surfaces.
Verbascum No. 3, hairs removed from lower leaf surfaces.

Experiment 15—Darkroom.

Time, hours.	Temperature, Degrees F.	Saturation Deficit %.	Standard Evaporation. Grams per hour.	Transpiration, Verbascum No. 1. Grams per Sq. Dm. per hour.	Transpiration, Verbascum No. 2. Grams per Sq. Dm. per hour.	Transpiration, Verbascum No. 3. Grams per Sq. Dm. per hour.	Ratio V-1/V-2	Ratio V-1/V-3
1	68	64	.84	07	.15	.10	.4	.7
2	68	64	1.00	.07	.16	.10	.4	.7
3	68	64	1.00	.07	.16	.10	.4	.7
4	68	65	.85	.07	.16	.11	.4	.6
5	68	65	.96	.09	.21	.15	.4	.6
6	68	64	.96	.12	.29	.20	.4	.6
7	68	64	.89	.14	.31	.22	.4	.6
8	68	64	.93	.15	.34	.22	.4	.6
9	68	64	.94	.18	.30	.23	.6	.7
10	68	65	91	.17	.33	.17	.5	1.0
11	68	65	.94	.17	.31	.18	.5	1.0
12	68	65	.92	.17	.27	.14	.6	1.2
13	67	65	.94	.12	.19	.14	.6	.8
14	67	66	.94	.13	.15	.13	.8	1.0
15	67	66	.86	.15	.15	.13	1.0	1.1
16	66	65	.90	.15	.15	.13	1.0	1.1
17	66	65	.86	.10	.15	.11	.6	.9
18	67	64	.90	.09	.13	.10	6	.8
19	67	64	.94	.08	.13	.10	.6	.7
20	67	64	.80	.07	.11	.10	.6	.6
21	67	64	.86	.06	.10	.10	.6	.6
22	68	64	.87	.05	.09	.09	.5	.5
23	68	64	.88	.05	09	.09	.5	.5
24	68	64	.97	.05	.09	09	.5	.5

Note: Verbascum No. 1, normal.
Verbascum No. 2, hairs removed from upper leaf surfaces.
Verbascum No. 3, hairs removed from lower leaf surfaces.

Experiment 16—Darkroom.

Time, hours.	Temperature, Degrees F.	Saturation Deficit %.	Standard Evaporation. Grams per hour.	Transpiration, Verbascum No. 1. Grams per Sq. Dm. per hour.	Transpiration, Verbascum No. 2. Grams per Sq. Dm. per hour.	Transpiration Verbascum No. 3. Grams per Sq. Dm. per hour.	Ratio V-1/V-2	Ratio V-1/V-3
1	68	64	.96	.05	.09	.08	.5	.6
2	68	64	.96	.05	.09	.08	.5	.6
3	68	64	.84	.05	.09	.08	.5	.6
4	68	64	.91	.05	.08	.07	.6	.7
5	68	64	.86	.04	.08	.08	.5	.5
6	68	64	.95	.04	.08	.08	.5	.5
7	68	60	.85	.04	.08	.08	.5	.5
8	68	60	.85	.04	.08	.07	.5	.5
9	68	62	.89	.05	.08	.07	.7	.8
10	68	62	.90	.06	.08	.07	.7	.8
11	68	63	.92	.06	.09	.08	.6	.7
12	68	64	.90	.05	.08	.08	.8	.6
13	68	65	.92	.05	.06	.08	.8	.6
14	68	65	.90	.05	.06	.07	.8	.7
15	68	66	.94	.05	.06	.07	.8	.7
16	68	66	.98	.05	.07	.07	.7	.7
17	68	66	.94	.05	.07	.07	.7	.7
18	68	66	.85	.05	.07	.06	.7	.8
19	68	66	.93	.05	.07	.06	.7	.8
20	68	66	.93	.04	.07	.06	.5	.6
21	68	66	.96	.04	.07	.06	.5	.6
22	68	65	.96	.04	.07	.06	.5	.6
23	68	64	.85	.04	.07	.06	.5	.6
24	68	64	.91	.04	.07	.06	.5	.6

Note: Verbascum No. 1, normal.
Verbascum No. 2, hairs removed from upper leaf surfaces.
Verbascum No. 3, hairs removed from lower leaf surfaces.

TABLE III.

SERIES I. TOTALS AND RATIOS.

	Temperature, Degrees F. Mean.	Saturation Deficit %. Mean.	Standard Evaporation. Total, Grams.	Transpiration, Verbascum. Total, Grams per Sq. Dm.	Transpiration, Nicotiana. Total, Grams per Sq. Dm.	Ratio $\frac{N}{V}$
Experiment 1—						
Night	74	51	8.00	1.24	.88	.71
Day	74	55	10.38	1.57	1.40	.89
Daily	74	53	18.38	2.81	2.28	.81
Experiment 2—						
Night	73	53	16.58	1.50	.79	.52
Day	74	54	19.71	1.31	.92	.70
Still Air	73	54	18.55	.98	.67	.68
Wind	74	53	27.74	1.83	1.04	.56
Daily	74	53	36.29	2.81	1.71	.59
Experiment 3—						
Night	66	19	2.61	1.42	.88	.62
Day	74	32	5.71	6.25	4.44	.70
Daily	70	25	8.32	7.67	5.32	.69
Experiment 4—						
Night	65	23	7.32	2.07	.67	.31
Day	71	29	8.51	5.97	4 63	.77
Still Air	71	29	3.96	3.88	2.89	.85
Wind	68	26	11.87	4.16	2.41	.57
Daily	68	26	15.83	8.04	5.30	.65

TABLE IV.

SERIES II-A. TOTALS AND RATIOS.

	Temperature, Degrees F. Mean.	Saturation Deficit %. Mean.	Standard Evaporation. Total, Grams.	Transpiration, Verbascum No. 1. Total, Grams per Sq. Dm.	Transpiration, Verbascum No. 2. Total, Grams per Sq. Dm	Transpiration, Verbascum No. 3. Total, Grams per Sq. Dm.	Ratio $\frac{V\text{-}1}{V\text{-}2}$	Ratio $\frac{V\text{-}1}{V\text{-}3}$
Experiment 5—								
Night	67	40	5.03	.93	1.14	1.33	.81	.69
Day	79	63	15.73	15.40	13.19	14.35	1.17	1.07
Daily	73	52	20.76	16 33	14.33	15.68	1.14	1.04
Experiment 6—								
Night	67	39	4.84	1.07	1.39	1.64	.77	.65
Day	81	66	20.28	18.30	20.69	27.34	.88	.68
Daily	74	53	25 12	19.37	21.08	28.98	.91	.67
Experiment 7—								
Night	68	36	4 63	1.11	1.48	1.56	.75	.71
Day	78	60	14.76	15.10	15.89	16 59	.95	.91
Daily	73	48	19.39	16.21	17.37	18.15	.93	.89
Expers. 5, 6, 7—								
Night	67	38	14.50	3.11	4.01	4.53	.77	.68
Day	79	63	50 77	48.80	49.77	58.28	.98	.83
Daily	73	51	65.27	51.91	52.78	62.81	.98	.82

TABLE V.

SERIES II-B. TOTALS AND RATIOS.

	Temperature, Degrees F. Mean.	Saturation Deficit %. Mean.	Standard Evaporation. Total, Grams.	Transpiration, Verbascum No. 1. Total, Grams per Sq. Dm.	Transpiration, Verbascum No. 2. Total, Grams per Sq. Dm.	Transpiration, Verbascum No. 3. Total, Grams per Sq. Dm.	Ratio V-1/V-2	Ratio V-1/V-3
Experiment 8—								
Night	67	42	6.07	1.52	2.46	2.98	.61	.51
Day	73	63	15.95	16.98	18.15	19.89	.93	.85
Daily	70	53	22.02	18.50	20.61	22.87	.89	.80
Experiment 9—								
Night	70	36	4.52	1.62	1.83	2.24	.86	.72
Day	74	46	7.71	8.40	8.65	8.68	.96	.95
Daily	72	41	12.23	10.02	10.48	10.92	.97	.93
Experiment 10—								
Night	71	38	5.20	1.30	2.07	2.96	.63	.44
Day	86	59	19.34	19.22	16.22	22.11	1.18	.87
Daily	78	49	24.54	20.52	18.29	25.07	1.12	.81
Exps. 8, 9, 10—								
Night	69	38	15.79	4.44	6.36	8.18	.69	.54
Day	74	56	43.00	44.60	43.03	50.68	1.03	.88
Daily	72	47	58.79	49.04	49.38	58.86	.99	.83

TABLE VI.

SERIES II-C. TOTALS AND RATIOS.

	Temperature, Degrees F. Mean.	Saturation Deficit %. Mean.	Standard Evaporation. Total, Grams.	Transpiration, Verbascum No. 1. Total, Grams per Sq. Dm.	Transpiration, Verbascum No. 2. Total, Grams per Sq. Dm.	Transpiration, Verbascum No. 3. Total, Grams per Sq. Dm.	Ratio V-1/V-2	Ratio V-1/V-3
Experiment 11—								
Night	62	48	6.80	1.68	3.05	4.40	.55	.38
Day	67	62	16.21	14.15	16.03	19.51	.88	.72
Still Air	64	55	17.94	11.65	14.52	19.11	.80	.60
Wind	70	70	5.07	4.18	4.56	4.80	.91	.87
Daily	64	55	23.01	15.83	19.08	23.91	.83	.67
Experiment 12—								
Night	59	51	12.24	2.28	2.38	2.75	.95	.82
Day	66	66	18.03	17.32	17.16	20.37	1.00	.85
Still Air	62	58	12.52	9.68	12.32	12.35	.78	.78
Wind	63	56	17.75	9.92	7.30	10.76	1.36	.56
Daily	63	58	30.27	19.60	19.62	23.11	.99	.84
Experiment 13—								
Night	68	38	3.71	1.34	1.95	2.32	.68	.57
Day	72	42	9.38	8.05	8.63	8.11	.93	.99
Still Air	70	40	8 81	6.30	6.98	7.41	.90	.84
Wind	73	41	4.28	3.09	3.60	2 99	.85	1.03
Daily	70	40	13.09	9.39	10.58	10.43	.88	.89
Exps. 11, 12, 13—								
Night	63	45	22.75	5.30	7.38	9.47	.71	.56
Day	68	56	43.62	39.52	41.82	47.99	.94	.82
Still Air	65	50	39.27	27.63	33.82	38.90	.81	.71
Wind	68	53	27.10	17.19	15.46	18.55	1.11	.92
Daily	65	51	66.37	44.82	49.28	57.45	.91	.78

TABLE VII.

SERIES II-D. TOTALS AND RATIOS.

	Temperature, Degrees F. Mean.	Saturation Deficit %. Mean.	Standard Evaporation. Total, Grams.	Transpiration, Verbascum No. 1. Total, Grams per Sq. Dm.	Transpiration, Verbascum No. 2. Total, Grams per Sq. Dm.	Transpiration, Verbascum No. 3. Total, Grams per Sq. Dm.	Ratio V-1/V-2	Ratio V-1/V-3
Experiment 14—								
Night.........	69	69	12.01	.82	1.70	1.83	.48	.45
Day..........	68	68	12.16	1.15	1.98	1.96	.58	.58
Daily.........	68	68	24.17	1.97	3.68	3.78	.53	.52
Experiment 15—								
Night.........	68	64	11.93	.85	1.74	1.33	.48	.57
Day..........	67	65	10.93	1.72	2.78	1.90	.61	.90
Daily.........	68	64	22.86	2.57	4.52	3.23	.56	.79
Experiment 16—								
Night.........	68	64	11.02	.53	.93	.83	.57	.63
Day..........	68	65	10.84	.61	.88	.87	69	.70
Daily.........	68	64	21.86	1.14	1.81	1.70	.63	.67
Exps. 14,15,16—								
Night.........	68	66	34.96	2.20	4.37	3.98	.50	.55
Day..........	68	66	33.93	3.40	5.64	4.73	.60	.71
Daily.........	68	65	68.89	5.68	10.01	8.71	.56	.65

Ohio State University,
Columbus.

THE REMARKABLE FAUNA OF A SINGLE DROP OF POND WATER.

W. J. Kostir.

Late in September, 1918, while collecting material for class use, I obtained from the east pond of Mirror Lake on the Ohio State University campus a quantity of brownish sediment so rich in a variety of forms as to attract special attention. All of the sediment in question was taken up by means of a long pipette from a spot perhaps two inches square, where it covered a layer of dead leaves on the bottom of the pond. The depth of the water at this point was only a few inches; the locality was one that was shaded by trees during part of the day.

The material was not concentrated in any way, and was examined almost immediately after it was brought into the laboratory. In a single drop—the first one examined—the following forms were found to be present, all apparently in healthy, normal, active condition:

Amoeba. Two species; a larger one of the *proteus* type and a smaller one of the *limax* type. Several specimens of each.

Arcella. A number of active specimens.

Difflugia. Two different species, one specimen of each.

Actinophrys. Several specimens.

Euglena. Two species; the larger one *E. deses*, the smaller one not identified with certainty. Several of each.

Carteria. Many specimens of *C. multifilis*.

Paramecium. Several specimens of *P. caudatum*.

Vorticella. Several specimens.

Stentor. A specimen of *S. coeruleus* and one of a distinctly different (colorless) species.

Spirostomum. Two specimens of *S. ambiguum*.

Several small flagellates and ciliates, not identified with certainty, were present in addition to these.

Two species of rotifers were present. They were not identified.

Hydra. One specimen of *H. fusca*.

Ohio State University, Columbus, Ohio.

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A PRELIMINARY SURVEY OF THE PROTOZOA OF MIRROR LAKE, ON THE OHIO STATE UNIVERSITY CAMPUS.

Mabel E. Stehle.

CONTENTS.

INTRODUCTION.

The present study, while it marks only the beginning of a thorough survey of the protozoan fauna of Mirror Lake, is an attempt to add a little to the sum total of our knowledge regarding the ecological relationships of the Protozoa. The period of study, which extended from early October, 1917, to the end of March, 1918, was clearly too limited to permit drawing any far-reaching conclusions; but even in this limited time it was possible to make many interesting observations which, it is hoped, will prove of value.

The classification adopted in this paper is largely that employed by Calkins in his work on "The Protozoa," published in 1901.

It is the writer's pleasant duty to thank those who have helped make it possible for her to do this work. She is indebted for much help and many valuable criticisms to Mr. W. J. Kostir, under whose supervision the work was done. Her thanks are due also to the following: To Dr. R. C. Osburn, for naming the fishes of Mirror Lake; to Dr. Freda Detmers, for naming the larger plants; and to Dr. E. N. Transeau, who named the algae.

METHODS OF STUDY.

Since the collections were made at or near the shore, a very simple outfit sufficed. This included a pipette one foot long, another very short one, a spoon for scraping algae from stones and wood and lifting material from the bottom, a thermometer, and tumblers. Several stations were selected, with the idea of obtaining environments as varied as possible. These included those parts of the water constantly shaded, those shaded only a part of the day, water containing much decayed material, algae and sediment in clear spring water, algae growing on submerged wood, and those on submerged rocks. Sediment was collected in water a foot or more deep and from leaves submerged but a few inches. Floating as well as submerged plant material was taken. The material was examined as soon as possible after it was collected and then every few days for a period of a month or more. When an animal appeared only after the culture had been standing in the laboratory, this fact is mentioned when the particular animal is discussed. Collections were made once a week when possible, though this rule could not always be adhered to, partly because of lack of sufficient time, partly because of the weather. It will be remembered that the winter of 1917-18 was an unusually severe one.

Reports on atmospheric temperature, degree of cloudiness, and other weather conditions were obtained from an office of the United States Weather Bureau, situated on a hill overlooking Mirror Lake. Since the limited duration of the study made impracticable any attempt to establish correlations between the appearance or disappearance of various forms and the weather conditions, only a brief summary of the latter will be given.

Relatively few clear days are recorded for the time between October 1, 1917 and February 28, 1918. In March, the sky was clear perhaps half the time. The precipitation was below normal during most of the period; in October and January it rose somewhat above the normal for this region. The temperature showed a pretty steady fall until early in December, when the mean daily temperature went below zero Fahrenheit for the first time. Exceptionally severe weather continued throughout December, January, and the first part of February.

During this period, snow was on the ground almost continuously, and ice covered the lake. After February 9, coincident with clearer weather, there were consistently higher temperatures, and the snow and ice disappeared.

DESCRIPTION OF MIRROR LAKE.

"Mirror Lake" is a small artificial pond situated in a natural ravine on the Ohio State University campus. Through this ravine a creek formerly flowed from the east and emptied into the Olentangy river nearly half a mile west of the present lake site. In 1872 a sewer was built which drained the creek; and about the same time the lake bed was excavated. The lake's supply of water came from springs which had formerly fed the creek. In 1895 all the water in the lake was emptied, most of the animal and vegetable life was destroyed, and the lake bed was enlarged by the addition of the small arm at its northwest end. Since that time fishes, aquatic plants, and other forms of life have been introduced into the pond.

Mirror Lake is made up of two bodies of water, separated only by a very narrow neck of land four feet wide (Plate I). These will be referred to as the smaller pond and the larger pond. A rapidly ascending grassy slope, covered with bushes and trees, on the north side and a gently rising one on the south side partly enclose the lake; the former is 25 feet high and the latter 27 feet. West of the lake the ground rises about nine feet to the roadway, which is about 50 feet distant; while on the east the rise is extremely gradual.

The smaller pond is at most 50 feet wide (from north-east to south-west) and 140 feet long (from north-west to south-east). The springs on the north shore furnish it with a not very copious supply of water; and the outlet is through a six inch pipe at its north-west end. Only after a heavy rain does the water in this pond reach a height sufficient to carry some of it through this pipe into the larger pond. The average depth in the smaller pond is about one and a half feet; the depth in the deepest part does not exceed two and one-half feet. The level of the water is usually about one foot higher than in the larger pond. The bottom is covered with fine black sediment and decaying leaves. More decay goes on in this pond than in the other. Many tall white poplars (*Populus alba* Linnaeus) shade this part of the lake from the sun, except for a short time in the morning and again in the late afternoon. In October, burr marigold (*Bidens laevis* Linnaeus) grew plentifully along the water's edge; this disappeared when the cold weather came on. Duckweed (*Lemna trisulca* Linnaeus) formed a compact green mat over the surface of the water at several places along the edge; it was present throughout the winter, but became scanty when ice formed on the lake. Several plants of the water hyacinth (*Eichornia* sp.) floated in this pond. Minnows (*Lepomis pallidus* (Mitchill) swarmed here during the fall; large water beetles (*Dytiscus*) were numerous; and many water striders (*Gerris*) scampered on the surface of the water.

Weather conditions affected the appearance of the water in the smaller pond considerably. In the early part of October when the study was begun, most of the water was bright green in color, due to the extreme abundance of the flagellate *Carteria multifilis*. This organism became active when the sun shone upon the pond, but settled to the bottom and made a thick green sediment on the leaves when the water was shaded from the sun. Late in October after a heavy storm the organism disappeared. For two months during the winter a heavy sheet of ice covered this part of Mirror Lake.

The larger pond is at most about 350 feet long (from north-east to south-west) and 116 feet wide (from north-west to south-east). The average depth of water is between two and two and one-half feet. A large spring (J) just north of the eastern end of the larger pond is its largest source of water. In addition, drainage water from the surrounding slopes, occasionally water from the smaller pond, and probably water from small springs in the lake bed help supply this part of Mirror Lake. The water of the large spring bubbles into a cement bowl, which is set in the cement walk. It overflows into a small gutter which carries the water to the lake, about six feet distant. The shore at this point is covered with large boulders, the submerged part of which is covered by algae (mostly *Spirogyra*). The bottom here is sandy; at the point of inflow from the smaller pond it is covered by a thick layer of fine black sediment; while in the remainder, small stones, some dead leaves, greenish brown sediment, and algae cover the bottom. The outlet of this pond is through a six-inch pipe at the southwest end; the height of water in this pipe varied from nine-sixteenths to one and seven-eighths inches during the period of study.

The shore of the larger pond is steep, and the soil of the bank is firm as contrasted with the loose marshy earth around the smaller pond. The distance from the ground level to the surface of the water averages about one foot.

The larger pond is shaded only at a few places along the shore where there are overhanging trees. There is a white poplar (*Populus alba* Linnaeus) just east of the spring, and its alga-covered roots, which extend into the water, form a habitat for many Protozoa. An alder tree (*Alnus incanus* Linnaeus) shades the water just west of the spring.

The goldfish (*Carassius auratus* Linnaeus) is very abundant in this part of Mirror Lake. During the time when ice covered the lake, these collected near the outlet of the spring, for here the water never froze. At this point the caretakers occasionally throw food (usually dry bread) to them. Tench (*Tinca tinca* Linnaeus), carp (*Cyprinus carpio* Linnaeus), and minnows (*Lepomis pallidus* (Mitchill)) are plentiful, but occur in smaller numbers than do the goldfish. Common brown rats (*Mus norvegicus* Erxleben) and muskrats (*Fiber zibethicus* Linnaeus) live in burrows along the shore. The water snake (*Natrix sipedon* Linnaeus) was seen once. Frogs and crayfishes are common. Algae were common during most of the period of study. The most common were *Spirogyra fluviatilis*, several species of *Oedogonium*, *Scenedesmus quadricauda*, *Pediastrum*, and *Ankistrodesmus*.

Descriptions of the Stations.

STATION A.

Sediment on decaying leaves in stagnant, shaded water.

This station was near the east edge of the smaller pond where the water is quiet, more or less stagnant, and from three to four inches deep. The sun shone here only for a few hours in the morning; tall white poplars (*Populus alba* Linnaeus) shaded the water for the remainder of the day. Throughout October, the decaying leaves on the bottom were covered by a thick green sediment. The leaves were carefully lifted and this sediment allowed to drain off into a tumbler. Examination showed this color to be due to enormous numbers of a small green flagellate, *Carteria multifilis*. At the end of the month, following a heavy storm, all the sediment on the leaves disappeared, and for this reason collecting was discontinued at this station.

The colonial flagellate *Synura uvella* was common in this sediment. The larger ciliates, *Loxodes rostrum*, *Stentor polymorphus*, *Paramaecium caudatum* and *Spirostomum ambiguum* were conspicuous.

STATION B.

Black sediment at bottom, in stagnant, shaded water.

Station B was at the extreme southeast edge of the smaller pond, very close to the preceding station, as is shown by the similarity of forms taken at the two localities. The water was full of decaying leaves and was three inches deep. It was shaded throughout the day, except for a few hours in the early morning. In early October, when collecting began at this station, the water was covered by a compact mat of duckweed (*Lemna trisulca* Linnaeus) which shut out the light almost completely from the water beneath. As the temperature lowered, this plant became scanty, but never entirely disappeared. A pipette was inserted between the duckweed and the fine black sediment from the bottom was taken for examination. *Carteria multifilis* was present in this material during October, but was not nearly so abundant as at Station A. The larger ciliates, *Loxodes rostrum*, *Frontonia leucas*, and *Spirostomum ambiguum* were common.

STATION C.

Floating algae, in water well exposed to light.

This station was on the west side of the peninsula which extends into the larger pond. The water was about six inches deep, contained little decaying material, but often became turbid. The sun shone on this part of the lake throughout the day. In October an abundance of algae (mostly *Spirogyra*) floated at the surface and some of these were taken for examination. They became less plentiful as cold weather came on, until in December they entirely disappeared. In February, after the ice had melted, the algae resumed growth. The ciliates and flagellates were well represented at this station during the fall and again in February. The most abundant of the former were *Epistylis flavicans*, *Stylonychia mytilus*, and *Urocentrum turbo*. The flagellates *Chilomonas paramaecium*, *Trachelomonas volvocina* and *Peranema trichophorum* were plentiful. Several species of *Difflugia* were taken; these multiplied rapidly in the laboratory.

STATION D.

Alga-covered roots in clear water well lighted much of the time.

Station D was on the north shore of the larger pond just east of the spring. The shore is steep and the water is about a foot and a half deep. It was quiet and clear, and the sun shone here all the afternoon. The temperature of the water never became lower than one degree centigrade, due to the proximity of this station to the spring. A white poplar (*Populus alba* Linnaeus) overhangs the lake here and its roots extend into the water. These were thickly covered by algae (largely *Oedogonium*), which harbored many Protozoa. *Arcella vulgaris*, *Raphidiophrys pallida*, *Acanthocystis* sp. and *Amoeba radiosa* were the most plentiful rhizopods; *Cyclidium glaucoma*, *Coleps hirtus*, *Paramaecium caudatum*, *and Lionotus fasciola* represented the ciliates well; some few flagellates were taken, but they were not plentiful.

STATION E.

Sand and algae in clear, fresh, slowly running water, well exposed to light.

Station E was located at the point where the water from the spring entered the larger pond. The water was about two inches deep, clear, fresh, and always in motion. Ice never formed here, because of the uniformity in temperature of the spring water, which varied between six degrees and twelve degrees centigrade. This locality was never shaded from the sun. Large boulders covered the shore, and below the water line these were covered by a scanty growth of algae (mostly *Spirogyra*). Collections were made here in two different ways: algae were scraped from the rocks, and some of the sand was taken with a pipette. This station was an ideal habitat for rhizopods. Throughout the period of study, the following were common: *Amoeba limax*, *Amoeba radiosa*, and *Actinophrys sol*. A number of others were taken, but they were infrequent in collections. A few ciliates occurred, but their number was far below that of those taken at stations where more decaying material was present. One suctorian, *Sphaerophrya urostylæ*, occurred frequently.

STATION F.

Greenish brown sediment at bottom, in a spot well exposed to light most of the time, but shaded partly by floating algæ.

This station was located at the same place as Station C, but the mode of collection was different, sediment from the bottom being taken. The water was about six inches deep and a large mass of algae floated at the surface during part of the period of study. The presence of a thick sheet of ice for about two months did not interfere with the collecting at this station. The pipette was inserted through a hole in the ice, and the sediment taken from the bottom. This sediment was always plentiful and of a greenish brown color. The flagellates *Euglena* sp.? and *Euglena deses* predominated here, although they never became abundant. *Carteria multifilis* was plentiful during October.

STATION G.

Algae on submerged rock in clear water, well exposed to light.

This station was located in the larger pond on a large flat boulder about two feet from the shore and just east of the spring. The submerged portions were thickly covered with algae (mostly *Spirogyra fluviatilis*). The water was clear and was shaded for only a part of the morning. Because of the proximity of this station to the spring, ice never became thick enough to interfere with collecting. About this stone the gold-fish collected in large schools, for here the caretaker threw drieds bread to them occasionally. Algae were scraped from this stone and examination of this material showed a remarkable variety of forms throughout the period of study. *Phacus pyrum*, *Coleps hirtus*, *Prorodon teres*, *Strombidium gyrans*, and *Aspidisca costata* were plentiful in this locality. *Stentor coeruleus* was so abundant during January that it formed a blue scum over the algae.

STATION H.

Dead algae (Oedogonium) *forming a bright yellow, flocculent mass on bottom. Spot well lighted most of the day.*

Station H occupied a position near the east shore of the bay in the east end of the larger pond. The water here was quiet, about three inches deep and was shaded during only a few hours in the morning. Passing by this part of Mirror Lake, my attention was attracted by a mass of bright yellow flocculent material which covered the bottom. My interest was aroused to know what it was and what Protozoa were present in it. Some of the material was lifted into a tumbler with a spoon. Examination showed it to consist of dead filaments of the alga *Oedogonium*. This remained abundant as long as the temperature of the water stayed below five degrees centigrade; when it became warmer than that, the living green alga had resumed its growth. The flagellates which predominated were *Euglena viridis*, *Peridinium tabulatum* and *Synura uvella*. *Lembadion bullinum*, a ciliate, was plentiful and was taken exclusively at this station. *Pleuronema chrysalis* found an ideal habitat among this decaying material.

STATIONS I AND I′.

Algae covering submerged wooden posts, on different sides of the pond, but both well exposed to light.

Two submerged wooden posts on opposite sides of the larger pond, but apparently showing similar conditions, were selected for these stations. The sun shone on both of them throughout the day and the temperature of the water was the same in both places. A thick growth of algae (mostly *Oëdogonium*) covered the posts below the surface of the water. This was scraped off and the two collections each time were compared with each other. It was interesting to note that approximately the same Protozoa were found in both places at the same times, despite the distance between the stations. The heliozoan *Raphidiophrys viridis* was abundant in November. *Holosticha vernalis*, *Stentor roeselii*, *Frontonia* sp.? and *Euglena* sp.? were common at these places throughout the period of study.

STATION J.

Algae and sediment in clear, fresh spring water, well exposed to light.

Station J was located just north of the east end of the larger pond, in the cement bowl into which the spring bubbles. The overflow of water from the bowl is carried to the larger pond through a small gutter. This place was not shaded at any time of the day. Although the bowl was cleaned occasionally by the caretakers, a scanty growth of algae was always present on its sides. This material, together with the sediment which it contained, was taken. Examination showed it to contain an abundance of rhizopods. *Actinophrys sol*, *Nuclearia* sp.? and *Amoeba radiosa* were most plentiful. Many others were taken occasionally.

STATION K.

Greenish brown sediment and algae on large submerged stone in turbid waters, well lighted during part of the day.

This station was added to the list late in February. It was located about a foot to one side of the outlet of the larger pond. This spot receives direct sunlight in the morning and in the late afternoon; the water was relatively quiet, but turbid, and about three inches deep. Greenish brown sediment and algae were taken from the large submerged stone at this place. *Aspidisca costata*, *Chilodon cucullus* and *Stylonychia mytilus* were common at this station during the period of study.

STATION L.

Algae on submerged stone in shallow, turbid water, well exposed to light.

Station L was located at the north extremity of the island in the west end of the larger pond. The water here was never shaded, about three inches deep, and usually turbid. Collections were not made here until March. Throughout this month, the ciliates *Glaucoma scintillans*, *Spirostomum ambiguum*, *Coleps hirtus*, *Aspidisca costata*, *Colpidium colpoda*, and *Peridinium tabulatum* were frequent in collections.

STATION M.

Fine, black sediment in clear, slowly moving water, well lighted for part of the day.

This station was located at the extreme east end of the larger pond, close to the outlet from the smaller pond. The sun shone here most of the afternoon. The water was clear, always moving slowly, and the bottom was covered with fine, black sediment. A few collections of this sediment were made in March. *Lacrymaria olor*, *Amoeba villosa*, *Cochliopodium bilimbosum*, and *Heterophrys* sp.? were common in this material.

SYSTEMATIC REVIEW OF THE SPECIES TAKEN.

Class Sarcodina.

SUBCLASS RHIZOPODA.

ORDER AMOEBIDA.

Family Amoebidæ.

Amoeba limax Dujardin (?)

Throughout the period of study this form was abundant among the algae growing on the sides of the bowl of the spring (Station J), and on the sand at the point where the spring water enters the larger pond (Station E). The writer was unable to see, even with the aid of a 1.8 mm. oil immersion lens, the radiating fringe of delicate substance at the posterior end of the animal which Penard regards as distinctive of the species. The measurements given by Cash (1905) are 50–60μ; Penard gives the maximum length as 80μ. The animals taken in Mirror Lake varied in length from 29–80μ.

Material collected on March 22 contained an abundance of amebæ of the *limax* form; five days later the same material showed only amebæ with numerous short radiating pseudopodia and these were about as abundant as the *limax* form had been. Max Verworn (1896) has shown that by the use of appropriate chemicals, *Amoeba limax* may be made to assume a *proteus* form and then a *radiosa* form. Doflein (1907) obtained similar form changes in *Amoeba vespertilio*, and showed that the body form and character of the pseudopodia were quite inadequate features for distinguishing the species of *Amoeba*, depending as they do upon the conditions of the environment and the nature of the medium. The writer's observation might therefore indicate, although the evidence is by no means conclusive, that the *Amoeba limax* discussed above and the *Amoeba radiosa* named below may be different phases of the same species.

Amoeba proteus (Pallas).

This animal was present only in a very few collections made late in November and early in December. It was taken in algae from submerged rocks at Stations E and G.

Diameter 119–193μ.

Amoeba sp.?

A small, very hyaline ameba of the *proteus* type was common among the algae in the bowl of the spring (Station J), at the point where the spring water flows into the larger pond (Station E), on alga-covered poplar roots (Station D), and on algae from a submerged stone (Station G). It was taken from November to the end of February.

Diameter 32–80μ.

Amoeba radiosa Dujardin.

This species was common in all collections from the bowl of the spring (Station J). It was taken in algae at Stations F, I and I', but occurred at these places only infrequently.

Diameter of body 21–48μ; length of pseudopodia 84μ and less.

Amoeba verrucosa Ehrenberg.

Juvenile and adult forms of this species were common from November to the end of January in a few collections of algae from Station G. They were taken occasionally at the entrance of the spring into the larger pond (Station E) and on the alga-covered poplar roots at Station D.

Diameter 59–104μ.

Amoeba villosa Wallich.

This species was common during February and March in the bowl of the spring (Station J) and on the fine black sediment at Station M.

Length 122–144μ.

Biomyxa vagans Leidy. Pl. II, Figs. 1, 1a and 1b.

One individual was taken in early November among alga-covered poplar roots at Station D. At first glance it appeared to be some non-living substance which was becoming flattened out, due to the weight of the cover glass. It moved slowly and constantly, never keeping the same form two consecutive moments; and the pseudopodia, which were hyaline, were very difficult to see. One ellipsoidal granular nucleus could be distinguished but the animal was not stained so that the presence of other nuclear material in the cell was not determined. Penard (1902) described some individuals with one globular, distinctly granular nucleus, others with a half dozen or more ellipsoidal nuclei. The extended individual, (Pl. II, Fig. 1), measured 360μ.

In February several smaller animals of the same species were taken at the entrance of the spring into the larger pond (Station E). In these the pseudopodia were very numerous, long, and anastomosing, and the contractile vacuole could easily be seen.

Length of individual shown in Plate II, Fig. 2, is 144μ.

Family Arcellidæ.

Arcella vulgaris Ehrenberg.

This species was taken throughout the period of study but only in occasional collections of alga-covered poplar roots from Station D. It was rare in new material, but increased rapidly in standing cultures. The individuals varied greatly in size and were light brown in color.

Breadth of shell 48–133μ; diameter of mouth 25–59μ.

Difflugia globulosa Dujardin.

This species occurred throughout the period of study at a variety of stations in the lake. It was abundant in sediment from Stations F and K, among algae at Stations I and I', and on sediment from Station B. The animal multiplied rapidly in a standing culture.

Length 72–144μ; breadth 80μ.

Difflugia lobostoma Leidy.

This form was common only in December among algae taken at the point where the spring water enters the larger pond (Station E). It was infrequent in November and January among the dead *Oedogonium* (Station H), among floating algae from Station C, and in sediment and algae from Stations K and L.

Length 54–82μ.

Difflugia acuminata Ehrenberg.

One individual was taken in February among algae scraped from a submerged stone at Station G. Its length was 219μ and the diameter of the mouth was 48μ. A much smaller specimen was found among dead *Oedogonium* (Station H), in March.

Length 72μ.

Difflugia pyriformis Perty.

This species was taken late in January in floating *Spirogyra* from Station C, in which it was abundant. It had become plentiful about this time in a culture containing dead *Oedogonium* taken at Station H which had been standing four months.

Length 40–208μ.

Difflugia corona Wallich.

One individual was taken late in October in floating *Spirogyra* (Station C). The animal occurred abundantly late in January on the sediment at Station F, which is very close to the preceding station. All were very active and had a pair of widely divergent spines on the fundus.

Diameter of the shell 128–176μ; length of spines 48μ.

Centropyxis aculeata (Ehrenberg).

This form was not recorded from fresh collections, but was found abundantly in material from three different stations, that had been standing in the laboratory for two months. This material consisted of alga-covered poplar roots from Station D, algae from spring water at Station E, and sediment drained from leaves in the smaller pond (Station A). Some of the shells were made up mostly of sand grains; and in others, the chitinoid shell was impregnated with only a few grains of sand. Three, six or seven spines were present on the fundus.

Length 112–117μ.

Lecquereusia modesta Rhumbler.

One individual was taken in March among algae scraped from a submerged stone at Station G. The shell was impregnated with a large number of sand grains.

Length of shell 112μ; breadth 90μ.

Euglypha brachiata Leidy.

This species was common among alga-covered poplar roots (Station D) from November to the end of January.

Length 80–88μ; breadth 32μ.

Euglypha ciliata (Ehrenberg).

One individual was taken from Station G, where algae were scraped from a submerged stone. The collection was made late in January.

Length 64μ.

Trinema enchelys (Ehrenberg).

This species was infrequent in a collection of alga-covered poplar roots taken late in November from Station D.

Length 36μ; breadth 16μ.

Cyphoderia ampulla (Ehrenberg).

This form was rare in one collection made on January 30 at the point where the spring water enters the larger pond (Station E).

Length 128μ; breadth 48μ; diameter of mouth 14μ.

Pamphagus hyalinus (Ehrenberg).

On the sand at Station F in December, this form was abundant. The pseudopodia were altogether hyaline.

Diameter 32μ.

Cochliopodium bilimbosum Auerbach.

This species was abundant during February in algae from the bowl of the spring (Station J). Late in March it was common on the fine black sediment at Station M.

Diameter 25–48μ.

SUBCLASS HELIOZOA.

Order Aphrothoracida.

Actinophrys sol Ehrenberg.

Throughout the period of study, this form was abundant in the bowl of the spring (Station J), at the point at which the spring water enters the larger pond (Station E), and in algae from a submerged stone at (Station G).

Diameter 45–80μ.

Actinosphaerium eichhornii Stein.

Five individuals of this species were taken, but no two of them from the same station. In the latter part of October, the largest specimen was taken on the green sediment at Station A, another was found on the black sediment at Station B, and still another one occurred on the bottom at Station F. In November, an individual was taken in floating *Spirogyra* (Station C) and another on the sand at Station E.

Diameter 119–608μ.

Nuclearia delicatula Cienkowski.

Several individuals were taken on December 3 among algae at Station E. They were similar to Leidy's figures of *Heterophrys myriapoda*, (1879; Pl. 46, Figs 4 and 7). The latter name has been shown by Cash (1905) to be synonymous with *Nuclearia delicatula*.

Diameter 40μ.

Nuclearia sp.?

This form was abundant among algae from the bowl of the spring during the entire time that material was taken from this station. The individuals were very often colored a bright yellow and agreed with Leidy's figures, (1879; Pl. 15, Figs 2 and 3, and Pl. 16, Fig. 13), of *Heterophrys* sp.? Cash (1905) has shown this genus to be synonymous with *Nuclearia*.

Diameter 64–90μ.

ORDER CHALARATHORACIDA.

Raphidiophrys viridis Archer.

Throughout the period of study this species was taken at a variety of stations, but occurred abundantly only at Stations I and I', in algae scraped from submerged posts.

Diameter 43–80μ.

Raphidiophrys pallida Schulze.

Late in November and early in December this form was common among alga-covered poplar roots (Station D). The spicules on the animal were very long and numerous.

Diameter 96μ.

Acanthocystis sp.?

This species was abundant during December and January among algae scraped from posts at Stations I and I', and it was taken also on alga-covered poplar roots at Station D. The animals taken in Mirror Lake were very similar to Leidy's figures, (1879; Pl. 43, Figs 14 and 16).

Diameter 53μ.

Acanthocystis sp.?

Several individuals were taken on December 3 among floating algae from Station C. These agreed perfectly with Leidy's figures of *Acanthocystis* sp.? (1879; Pl. 43, Fig. 8).

Diameter 32μ.

Diplophrys archeri Barker.

Early in March one colony was observed among dead *Oedogonium* filaments from Station H. It was ruby red in color with colorless pseudopodia. The animal moved steadily across the field.

Diameter 48μ.

Class Mastigophora.

SUBCLASS FLAGELLIDIA.

Order Monadida.

Family Heteromonadidæ.

Monas fluida Dujardin.

An individual was taken on October 24 in green sediment on the leaves at Station A. It contained numerous refractive bodies and it was very metabolic.

Length of the extended form 36μ.

Anthophysa vegetans Müller.

One colony of eight individuals occurred in floating *Spirogyra* (Station C) late in October. This species was not seen again until late in March when it was abundant in algae at Station G. The colonies were 48μ in diameter.

Streptomonas cordata (Perty).

This species was common during December in alga-covered poplar roots (Station D) and among algae growing at the point at which the spring water enters the larger pond (Station E).

Length 15μ.

Order Euglenida.

Family Euglenidæ.

Euglena acus Ehrenberg.

This form was found in a culture of algae taken from a submerged stone (Station G) in the early part of December. The culture had been left standing in the laboratory for nearly two months.

Length 80–144μ; breadth 10μ.

Euglena acus Ehrenberg, variety **rigida** Hübner.

One individual was taken in sediment from Station B in late November. It was characterized by the spiral arrangement of the rod-shaped paramylum grains and the greater rigidity of the cell. There were twelve paramylum grains in the specimen taken.

Length 120μ; breadth 11μ.

Euglena deses Ehrenberg.

During October and November, this form was taken occasionally among floating *Spirogyra* (Station C) and in sediment from Station F. During the two months that ice covered Mirror Lake, the species was not taken. Late in February and throughout March, it was common in algae from Station H and from submerged posts (Stations I and I′).

Length 112–116μ; breadth 12–19μ.

Euglena gracilis Klebs.

This form was common in one collection of algae growing on poplar roots (Station D) taken in January. The organisms showed a peculiar kind of metabolic movement; the posterior end of the cell was very active while the anterior half remained motionless.

Length 40–46μ.

Euglena granulata (Klebs).

This species was exceedingly abundant in a two months old culture of algae taken from a submerged stone (Station G) early in December.

Length 80–88μ; breadth 24μ.

Euglena oxyuris Schmarda.

This organism was common in the same two months old culture that contained the *Euglena granulata*. The forms were considerably smaller than those described by Lemmermann (1913).

Length 192–200μ; breadth 24–26μ.

Euglena torta Stokes.

One individual was taken in December on alga-covered poplar roots (Station D).

Length 64μ.

Euglena viridis Ehrenberg.

This form was common in November in algae from Station H, in December among alga-covered poplar roots (Station D), and on March 1, among sediment and algae on the stone near the outlet of the larger pond (Station K).

Length 56–61μ.

Trachelomonas intermedia Dangeard.

This species was infrequent among filaments of dead *Oedogonium* from Station H taken in the early part of March. It moved very swiftly and was bright red in color.

Length 24μ; diameter 18μ.

Trachelomonas volvocina Ehrenberg.

Early in December this form was common among floating *Spirogyra* (Station C). The organism was almost spherical.

Length 20μ.

Phacus alata Klebs.

This form was common in a culture of algae taken on December 3 from Station G, which had been standing two months.

Length 19μ; width, the same.

Phacus longicauda Ehrenberg.

This species was infrequent in collections but was taken regularly throughout October, November and December, in floating algae from Station C, in sediment from Station F, and in material scraped from a submerged stone at Station G.

Length 80μ; width 32μ.

Phacus pyrum Ehrenberg.

This organism was common among algae scraped from a submerged stone (Station G) which had been taken early in December and left standing in the laboratory for two months.

Length 48μ.

Cryptoglena pigra Ehrenberg.

This minute, active species was abundant in the same material which contained the preceding form.

Length 15μ; breadth 9μ.

Family Peranemidæ.

Peranema trichophorum Ehrenberg.

This form was infrequent in newly collected algae from the bowl of the spring (Station J) and in floating *Spirogyra* from Station C. It became very abundant however in a two weeks old culture.

Length 32–80μ.

Heteronema acus Ehrenberg.

Late in October one individual was taken in algae from Station E. The cell was not perceptibly striated and the main flagellum was as long as the animal, while the trailing one was only half as long.

Length 112μ; width 32μ.

Anisonema acinus Dujardin. Pl. III, Fig. 1.

More than one individual of this species was never taken in a collection. It was taken in floating *Spirogyra* (Station C), on alga-covered poplar roots (Station D), and in algae from Stations H, I and I', throughout the period of study. This form is ordinarily described and figured with the nucleus situated on the right side, opposite that on which the contractile vacuole is located. In several individuals which the writer observed (see Pl. 3, Fig. 1), the nucleus was on the left side, that is, on the same side with the contractile vacuole.

Length 26–32μ; breadth 16μ.

Order Phytoflagellida.

Family Chrysomonadidæ.

Dinobryon sertularia Ehrenberg.

Early in October in the green sediment from the leaves at Station A these colonies were abundant. One colony was taken in November in algae scraped from submerged posts (Stations I and I′).

Synura uvella Ehrenberg.

This colonial protozoan was common throughout the fall in sediment from Station B and it was common in one collection of filaments of dead *Oedogonium* (Station H) in November. Many colonies contained only eight individuals, others as many as 32.

Diameter of colony 56–128μ.

Family Cryptomonadidæ.

Cryptomonas ovata Ehrenberg.

This species was abundant in March among *Oedogonium* filaments at Station H, in sediment from the stone near the outlet of the larger pond (Station K), and on alga-covered poplar roots (Station D). It was not seen during the time when ice covered the lake.

Length 56μ.

Chilomonas paramaecium Ehrenberg.

Although infrequent in new collections of floating *Spirogyra* (Station C), and in algae scraped from the posts (Stations I and I′), it was very abundant in cultures which had become foul. It multiplied rapidly as decay proceeded and the bacteria increased.

Length 21–27μ; width 9–11μ.

Family Chlamydomonadidæ.

Carteria multifilis (Fresenius).

This minute green flagellate caused the water in the smaller pond to assume a bright green color during a few days in October. Some interesting observations were made on its behavior in relation to light. During the day the organisms tended to congregate in those parts of the pond lighted by the sun. The water in the lighted part of the pond was of a bright green color, while in the shaded parts, a green tinge was scarcely noticeable. On days when the sky was overcast with clouds the cells settled to the bottom and formed a thick green sediment on the leaves. After a heavy rain and wind storm on October 29, these organisms were not found. *Carteria multifilis* was present in floating *Spirogyra* in the larger pond (Station C) during October; its numbers were not nearly so great, however, as in the smaller pond.

Diameter 9–15μ.

Order Diniferida.

Family Peridinidæ.

Peridinium quadridens Stein.

One individual was taken in algae from a submerged stone at Station G on December 18, and another in sediment from Station L in March. The environments were very similar at these places.

Length 40–43μ.

Peridinium tabulatum Ehrenberg.

This organism was common in sediment from Stations H and F until on December 7 a sudden drop in the temperature caused ice to form on the lake. It was taken again at the same place after thawing, but only rarely.

Length 40μ.

Gonyaulax polyhedra Stein.

Not until March did this form appear in collections. It was common in algae from posts (Stations I and I′), in filaments of *Oedogonium* (Station H), and in algae from a stone (Station G).

Length 34–48μ.

Glenodinium cinctum Ehrenberg.

One individual was taken in March in algae scraped from the submerged stone at Station G. The eye spot was unusually large.

Diameter 30μ.

Class Infusoria.

SUBCLASS CILIATA.

ORDER HOLOTRICHIDA.

Family Enchelinidæ.

Enchelydon farctus Claparede and Lachmann.

One individual was taken on March 21 in algae scraped from a submerged stone (Station G).

Length 224μ.

Pseudoprorodon niveus (Ehrenberg).

One individual was found on December 3 among dead filaments of *Oedogonium* at Station H.

Length 192μ; breadth 96μ.

Prorodon teres Ehrenberg.

This species was common throughout January and February in alga-covered poplar roots (Station D), and nearby in algae from a submerged stone (Station G). The form of the animal varied considerably, some individuals being much more elongate than others.

Length $240–282\mu$.

Lacrymaria olor Müller.

This form was rare in collections, but was widely distributed in the lake. Throughout the period of study it was taken in sediment from Station B, among algae, both from a submerged stone at Station G and on submerged posts (Stations I and I′) and in the bowl of the spring (Station J). It was found also in sediment at Station M. The actions of the organism are very interesting. The flask-shaped body usually lies hidden among debris while the exceedingly elastic neck violently waves about in search of food.

Length of the contracted animal $112–143\mu$; the extended form 512μ.

Coleps hirtus Ehrenberg.

This species was more frequently recorded perhaps than any other of the Protozoa. It was taken throughout the period of study in algae at Stations C, D, E, G, H, and L. The animal multiplied rapidly in laboratory cultures, especially in those containing *Euglenæ*, which seem to be an important item in the food of *Coleps*. Dividing individuals were always common.

Length 45–64μ; diameter 22–35μ.

Didinium nasutum (Müller).

One individual was taken in February on alga-covered poplar roots at Station G.

Length 83μ.

Family Trachelinidæ.

Amphileptus anser Ehrenberg.

After the material had stood in the laboratory two weeks, several individuals were found in algae from Station G, taken on January 24.

Length 208μ.

Lionotus fasciola (Ehrenberg).

This organism was common throughout the period of study in algae from Stations D and G.

Length 112–370μ.

Lionotus varsaviensis Wrzesniowski.

One individual was taken on March 7 in sediment from a stone near the outlet of the larger pond (Station K).

Length 96μ.

Lionotus vermicularis Stokes.

More than one individual of this species was never taken in a collection, but it was taken during the entire period of study. It was found in sediment at Station F, in algae from a submerged stone (Station G), and at the point where the spring water enters the larger pond (Station E). The writer was interested in observing the manner of feeding. The animal moved slowly along, came in sudden contact with a *Coleps*, which almost immediately became motionless. The small ciliate was then sucked down through the gullet of the *Lionotus*. The digestive juices acted so quickly that after fifteen minutes, *Coleps* could not be distinguished from the surrounding protoplasm.

Length 400–666μ.

Lionotus wrzesniowskii Kent.

This species was common in one collection, that of November 13, of algae growing at the point where the spring water enters the larger pond (Station E).

Length 518μ.

Loxodes rostrum Ehrenberg.

This organism was very abundant during the fall in sediment at Station B, where it utilized the plentiful *Carteria* cells for food. Many of the animals were strangely distorted; some were extremely concavo-convex ventro dorsally; in many others the protoplasm was protruded on various parts of the cell. The organisms were apparently little inconvenienced, and their behavior was unmodified except for a peculiar movement, which consisted of a revolution to the right on the longitudinal axis.

Length 160–288μ; breadth 48–80μ.

Family Chlamydodontidæ.

Nassula ornata Ehrenberg.

This species was common during November only, on alga-covered poplar roots (Station D). The cells were scarcely colored, but contained many food vacuoles.

Length 250–296μ; breadth 118–148μ.

Chilodon cucullus (Müller).

This form was infrequent in algae from the bowl of the spring (Station J) and in algae from Station E. It became abundant in February at these places. About this time it was common in sediment from a stone near the outlet of the larger pond (Station K) and in algae taken from submerged posts (Stations I and I′).

Length 112–208μ.

Chilodon fluviatilis Stokes.

This form was common during December in algae at Station H and in sediment from Station A.

Length 60μ.

Chilodon megalotrochæ Stokes.

This species was abundant in one collection of algae from Station E, taken on January 7.

Length 32μ.

Chilodon uncinatus Ehrenberg.

On January 24, this form was abundant in algae at the point where the spring water enters the larger pond (Station E).

Length 21μ.

Chilodon vorax Stokes.

This species was common on February 9 on alga-covered poplar roots at Station D, and in algae at Station E.

Length 128–176μ.

Family Chiliferidæ.

Glaucoma scintillans Ehrenberg.

This attractive organism, though common during February and March, in newly collected algae from submerged posts (Stations I and I′), and on alga-covered poplar roots, became very abundant in those cultures after decomposition had set in.

Length 48–64μ.

Frontonia leucas (Ehrenberg).

This form was abundant in sediment drained from leaves at Station A, during October and November. The organisms were brightly colored because of the presence of ingested diatoms and *Carteria* cells.

Length 288–400μ; diameter 80–112μ.

Frontonia sp.?

This organism was abundant in *Oedogonium* filaments (Station H) and in algae from submerged posts (Stations I and I′).

Length 144–160μ; breadth 96–112μ.

Ophryoglena sp.?

Several individuals similar to Figure 221 of Conn (1905) were taken on alga-covered poplar roots at Station D, on February 9.

Length 112μ.

Ophryoglena atra Ehrenberg.

This species was common among alga-covered poplar roots (Station D) on January 7.

Length 144μ.

Colpidium colpoda (Ehrenberg).

This form was abundant during January and February in algae at Station G; during March it was common in sediment from the stone near the outlet of the larger pond (Station K).

Length 90–112μ.

Loxocephalus granulosus Kent.

This animal was abundant late in October in algae taken from Station E. There were two adcurved setae near the anterior end of the cell. In this and other respects, the specimens seen agreed with the description and drawing of Kent (1881). The ring of larger cilia figured and described by Bütschli (1883–88) was not seen.

Length 50μ; breadth 15μ.

Colpoda sp.? Pl. III, Figs 2 and 2a.

This organism was found in algae from a submerged stone at Station G on December 3. An attempt to place it in described species failed. The cell is broadly oval, slightly tapering at the anterior end and covered by numerous fine cilia arranged in rows. A gullet lined with cilia occupies a position a short distance from the anterior end. The meganucleus is large, rounded and situated posterior to the gullet. The micronucleus lies in contact with the meganucleus; both these bodies were plainly visible even in the unstained specimen. A large contractile vacuole occupies the posterior part of the cell.

Length 89μ; breadth 74μ.

Family Urocentridæ.

Urocentrum turbo (Müller). Pl. III, Fig. 6.

This species was abundant during October in sediment drained from the leaves at Station A, and in the black sediment of Station B close by. In November it was common in floating algae from Station C; in February it was common only on alga-covered poplar roots (Station D). Several pairs of individuals taken in February presented the appearance shown in outline in Figure 6 on Plate III. The writer was unable to observe them long enough to determine whether the process was one of longitudinal division, which to the writer's knowledge is undescribed for this species, or of conjugation.

Length 63μ; breadth 46μ.

Family Microthoracidæ.

Cinetochilum margaritaceum (Ehrenberg).

In December, this organism was common in algae from Station G. It was not found again until late in March when it was abundant in sediment at Station L, at the opposite end of the larger pond.

Length 24μ.

Family Paramaecidæ.

Paramaecium bursaria (Ehrenberg).

This species was infrequent on alga-covered poplar roots (Station D) and among dead *Oedogonium* filaments (Station H), from November to the end of February. All the individuals were colored bright green by numerous *Zoochlorellæ.*

Length 122–153μ.

Paramaecium caudatum Ehrenberg.

This well-known species, usually found in hay infusions, was most common in those parts of Mirror Lake made foul by decaying organic matter. It was common in newly collected material, but soon became abundant in a culture when the growth of bacteria was at its height. It was taken in the black sediment at Station B throughout the fall. During January, February and March it was abundant on alga-covered poplar roots, (Station D), and in algae at Station G, H, and E.

Length 320–352μ; diameter 80μ.

Family Pleuronemidæ.

Lembadion bullinum (Müller).

This form was common during November among dead *Oedogonium* filaments (Station H). One individual was taken in December and another in January among algae from the submerged stones at Station G.

Length 128μ.

Pleuronema chrysalis (Ehrenberg).

This species was abundant throughout the period of study in all collections from Stations G and H. It multiplied rapidly in a standing culture. In the fall and again late in March it was abundant among floating algae at Station C and in sediment at Station F.

Length 70–102μ.

Cyclidium glaucoma Ehrenberg.

This protozoan was abundant in November among alga-covered poplar roots (Station D), in January, in algae from the bowl of the spring (Station J), and in February, on algae growing on the rocks at the point where the spring water enters the larger pond (Station E). In all these places the water was clear and fresh. The movements of the animal which are very quick and jerky, recall those of water striders.

Length 24μ.

Order Heterotrichida.

Family Plagiotomidæ.

Spirostomum ambiguum Ehrenberg.

This very large protozoan was common in the black sediment at Station B; it was taken here only during October and November. Late in March, several individuals were found in sediment at Station L.

Length 296–1280μ; breadth 30–144μ.

Metopus sigmoides Claparede and Lachmann.

This species was common in the fine black sediment at Station M, at which collections were made only in March. A few individuals were taken among *Oedogonium* filaments (Station H) about the same time.

Length 90μ.

Family Bursaridæ.

Busaria truncatella Müller.

One individual was taken in March in algae from submerged posts (Stations I and I′).

Length 224μ.

Family Stentoridæ.

Stentor coeruleus Ehrenberg.

This organism was taken throughout February at Station D, where the collections consisted of algae from a submerged stone. The animals could plainly be seen without a lens. They were common in new collections, but multiplied so rapidly that in a culture two days old, a blue scum, consisting entirely of these organisms, covered the plant material.

Length of extended animal sometimes as great as 3 mm.

Stentor polymorphus (Müller).

This form was common during the fall in sediment from Station A and on the alga-covered poplar roots (Station D). In March, several individuals were found in algae on the stone near the outlet of the larger pond (Station K) and from submerged posts (Stations I and I′).

Length of the contracted form 226μ; extended form 880μ.

Stentor roeselii Ehrenberg.

This form was abundant in collections made from December to the end of March. It was taken among algae from the submerged stone (Station G), in algae scraped from posts (Stations I and I′), and among algae growing on the rocks at the point at which the spring water enters the larger pond (Station E). Two individuals were often seen to occupy the same sheath.

Length of the extended forms $720–1440\mu$.

Caenomorpha medusula Perty.

Several individuals were taken on December 3 among algae from a submerged stone at Station G. One was found on the last day of January at the same place.

Length 104μ.

Family Halteriidæ.

Strombidium gyrans Stokes.

This species was common from October 10 until ice covered the lake, when it occurred rarely, but became common again after the thaw late in February. It was taken during the fall in the smaller pond in sediment at Station A, and in January, among algae from the submerged stone at Station G, on the posts (Stations I and I′), in the same material taken from the stone near the outlet of the larger pond (Station K), and on alga-covered poplar roots at Station D. The animal darts in such an extremely erratic manner as to defy examination. Fortunately, it has the habit of temporarily attaching itself by the posterior end and becoming somewhat quiescent, but even then it rotates on the longitudinal axis.

Length 63μ.

Strombidium typicum (Lankester).

An individual was found in each of the two collections made in January, one of alga-covered poplar roots (Station D) and one of algae from the submerged stone (Station G) very close by.

Length 126μ.

Halteria grandinella (Müller).

Several individuals were taken on alga-covered poplar roots (Station D), collected during December and January. On March 1, the form was common in sediment taken from the stone near the outlet of the larger pond (Station K).

Length 48μ.

Strombidinopsis sp.? Pl. III, Figs. 3 and 3a.

One individual was found in algae from a submerged stone at Station G, on December 3. It was free swimming, vase-shaped and nearly six times as long as broad. The anterior margin was flaring and obliquely truncate; the cilia of the peristome were very long, powerful and bent forward, forming a spiral wreath of two turns, which extended into the oral fossa. Posteriorly the cell was broadly rounded and terminated in a short conspicuous, eccentric acumination. The cilia of the cuticular surface were short, sparse, fine and arranged in longitudinal rows. The cell was hyaline and the animal's movements were rapid.

Length 118μ.

Family Tintinnidæ.

Tintinnidium fluviatile (Stein).

On March 22, one individual of this species was found on algae from the submerged stone at Station G. The lorica contained many foreign particles which made it appear rough.

The animal's movements were very erratic. It would dart swiftly in one direction, then like a flash, whirl directly about and move in the opposite direction. After coming to rest, it would occasionally project from the lorica, then almost immediately withdraw into it again.

Length of lorica 64μ.

Order Hypotrichida.

Family Oxytrichidæ.

Urostyla grandis Ehrenberg.

This species was common in February in algae from a submerged stone at Stations G and K. Late in March it was taken in sediment near the outlet of the larger pond (Station K).

Length 176–400μ; breadth 128μ.

Stichotricha sp.? Pl. III, Fig. 5.

This form appeared in a three months old culture of floating *Spirogyra* from Station C, collected on October 31. The animal was flask shaped, its anterior two thirds attenuate and neck like; the peristomial field, fissure-like and extending two-thirds of the way to the posterior end and edged by remarkably long cilia. Two oblique rows of ventral setæ were present. A large vacuole situated on the right side a fourth of the distance from the posterior end pulsated rhythmically. The writer was unable to identify this organism with any of the described species of the genus *Stichotricha*.

Length 144μ.

Uroleptus dispar Stokes.

One individual was taken on March 15 among filaments of *Oedogonium* at Station H.

Length 176μ.

Oxytricha caudata Stokes.

This species was taken a very few times among alga-covered poplar roots (Station D) and at the point where the spring water enters the larger pond, during the fall. One was found late in February in sediment (Station B), and another on March 15, in algae from submerged posts at Stations I and I′.

Length 240μ.

Oxytricha pellionella Müller.

At the entrance of the spring into the larger pond, one individual of this species was taken on the last of October. Several were taken in the middle of December among algae from a stone (Station G).

Length 80μ; breadth 16μ.

Oxytricha platystoma (Ehrenberg).

This form was abundant in a three months old culture of floating *Spirogyra* taken at Station C on the last day of October.

Length 80–128μ.

Stylonychia mytilus (Müller).

This species was common throughout the period of study in floating algae at Station C, in algae scraped from the rocks at Station E, and on the alga-covered poplar roots from Station D. Frequently the organisms were brightly colored, because of the presence of diatoms and algae.

Greatest length 192μ; breadth 112μ.

————? Pl. III, Figs 9 and 9a.

This form was found on November 21 on alga-covered poplar roots at Station D. It is a hypotrichous ciliate and differs from the genus *Histrio* in that it lacks frontal and anal styles and the nuclear material is differently disposed. The animal is orbicular, obliquely truncate at the anterior and posterior ends, and persistent in shape. The anterior end bears an uninterrupted projecting fringe of large marginal cilia, which in a similar form extended along the reflected border of the peristome nearly to the posterior end. Five scattered ventral styles were present. Staining revealed one meganucleus, somewhat crescent-shaped and centrally located, and two very much smaller micronuclei of spherical form and situated to one side of the meganucleus. Another individual, with a greater number of ventral styles was taken a few days later. This observation leads the writer to suspect that the animals were developmental stages, perhaps of some well-known hypotrich.

Length 74μ.

Holosticha vernalis Stokes.

This form was abundant from the latter part of January through March among algae in the bowl of the spring (Station J), in those on the submerged stone at Station G and among the algae scraped from posts at Stations I and I′.

Length 112–160μ.

Family Euplotidæ.

Euplotes charon (Müller).

One individual was taken among floating algae at Station C, in October.

Length 80μ; breadth 62μ.

Euplotes variabilis Stokes.

One individual of this species occurred in sediment on the leaves at Station A during October.

Length 220μ; breadth 128μ.

Aspidisca costata (Dujardin).

This species ranks with *Coleps Hirtus* in its wide distribution and frequency in Mirror Lake. It was common throughout the period of study in every station where algae grew, except in the bowl of the spring and at its entrance into the larger pond. Immature stages were invariably present in the collections.

Length 38μ.

ORDER PERITRICHIDA.

Family Vorticellidæ.

Vorticella alba Fromentel.

This species was abundant in sediment from Station B during November; it was not taken again until late in February and then among alga-covered poplar roots (Station D).

Length of zooid 48–64μ.

Vorticella microstoma Ehrenberg.

But one individual of this species was taken, among alga-covered poplar roots (Station D), on January 8.

Length of zooid 62μ.

Vorticella citrina Ehrenberg.

Several individuals were taken with sediment at Station F on November 7. The cells were hyaline and the pedicle was. about 12 times the length of the zooid.

Length of the zooid 57μ.

Vorticella nutans Müller.

Several individuals were found in a two weeks old culture of algae taken from a submerged stone at Station G on January 24.

Length of zooid 64μ.

Vorticella floridensis Stokes.

This species was common among algae from the submerged stone (Station G) during February. One occurred late in March in sediment from the stone near the outlet of Mirror Lake (Station K).

Length of zooid $80–90\mu$.

Vorticella elongata Fromentel.

One individual was taken among algae scraped from the posts (Stations I and I′) on March 1.

Length of zooid 64μ.

Vorticella aperta Fromentel.

One individual was taken among algae scraped from a stone (Station G) late in February.

Length 64μ; width of peristome 80μ; length of stalk 300μ.

Vorticella nebulifera Ehrenberg.

One individual was found in January in algae taken at the point where the spring water enters the larger pond (Station E). This organism was abundant late in February on alga-covered poplar roots from Station D.

Length of zooid $72–112\mu$.

Vorticella utriculus Stokes.

One individual was taken late in March on alga-covered poplar roots from Station D.

Length of zooid 37μ.

Epistylis flavicans Ehrenberg.

This species was common in floating *Spirogyra* (Station C), in algae from posts (Stations I and I′) and on alga-covered poplar roots from Station D. It was common throughout the period of study except during the month of January.

Length of zooid 208μ.

Vaginicola globosa (d'Udekem).

One individual of this species was found in algae from Station G. It was attached to the perisarc of the stalk of *Vorticella aperta*.

Length of lorica 48μ; of extended zooid 64μ.

Thuricolopsis innixa Stokes. Pl. III, Figs. 4 and 4a.

This form was taken on January 24, in algae from a submerged stone at Station G. When found, the animal was contracted and remained in this state for about two hours. During this time the nucleus was plainly visible and appeared narrow and band-like as shown in the figure. Food vacuoles formed rapidly after the organism became active. The writer has included drawings (Pl. III, Figs 4 and 4a) of this not very common ciliate, since no satisfactory drawing was found in any of the available literature.

Length of lorica 160μ; diameter 48μ; length of pedicle 10μ.

————? Pl. III, Fig. 8.

This organism shown only in outline in the figure indicated, was found in algae scraped from a submerged stone at Station G. The material was collected on December 3. It was apparently a hypotrichous ciliate, yet the presence of cilia other than those of the peristomial field was not determined. The animal was somewhat pear-shaped; the peristomial field extended about half way to the posterior end and was bordered by long, stout cilia. An oval nucleus occupied a central position in the cell. The oddest thing about the organism was the fact that it bore two exceedingly long cilia diagonally placed, and these waved continuously.

Length 36μ.

SUBCLASS SUCTORIA.

Family Podphryidæ.

Sphaerophrya urostylæ Maupas.

This animal was infrequent in one collection of algae taken on January 24 at the spring's entrance into the larger pond (Station E).

Diameter 48μ.

Podophyra libera Perty.

Several individuals were taken on February 21, among algae from a submerged stone (Station G). Some were conjugating. The nucleus was oval and coarsely granular; four contractile vacuoles were present. All the animals taken were without stalks. A young individual of this species is shown in Figure 7 on Plate III. The protoplasm was hyaline and the cell contained three contractile vacuoles.

Diameter of the largest 98μ.

Family Acinetidæ.

Acineta mystacina Ehrenberg.

This species was taken on December 3 in sediment from Station B, in February among algae from the submerged stone at Station G, during March in sediment from Station F and in algae from Station H. This species was the most common of the *Suctoria* in Mirror Lake. The tentacles were capable of great extension, often reaching 272μ in length. These were very efficient in paralyzing prey; and it was not uncommon to see a ciliate struggling at the end of a tentacle and after a time become motionless.

Diameter $48–56\mu$; length of lorica when present 128μ.

LITERATURE CONSULTED.

Blochmann, F. 1895. Die Mikroskopische Thierwelt des Süsswassers. Abtheilung 1: Protozoa. Hamburg.

Butschli, O. 1883–88. Die Protozoen. Bronn's Klassen und Ordnungen des Tierreichs.

Calkins, G. N. 1901. The Protozoa. New York.

Cash, J., and **Hopkinson.** 1905–09. The British freshwater Rhizopoda and Heliozoa. London. 3 Vols.

Conn, H. W. 1905. Protozoa of the fresh waters of Connecticut. State Geological and Natural History Survey, Bull. 2.

Doflein, F. 1907. Amöbenstudien, Archiv f. Protistenk., Suppl. I, p. 250.

Edmondson, C. H. 1906. The Protozoa of Iowa. Proc. Davenport Acad. Sci., 2. 1912. Protozoa of high mountain lakes in Colorado. Boulder Univ. Colo. Stud. 9, pp. 65-74.

Edmondson, C. H. and Kingman, R. H. 1911. Japanese freshwater Protozoa. Trans. Amer. Micros. Soc. Vol. XXXII, pp. 93–102.

Frenzel, J. 1892. Über einige merkwürdige Protozoen Argentiniens. Zs. wiss. Zool., LIII. pp. 334-360.

Hausmann, L. A. 1917. Observations on the ecology of the Protozoa. Am. Nat., LI, pp. 157-172.

Kellicott, D. S. 1895. Observations on some freshwater Infusoria, with descriptions of a few species regarded as new. Proc. Am. Soc. Micros. 1885-1888.

Kent, W. S. 1881. A manual of the Infusoria. London, 1881.

Landacre, F. L. 1908. The Protozoa of Sandusky Bay and Vicinity. Ohio Acad. Sci., IV, pp. 421-472.

Leidy, J. 1879. The freshwater Rhizopods of North America. U. S. Geol. Surv. of the Territories, XII.

Minchin, E. A. 1912. An introduction to the study of the Protozoa. London.

Pascher, A. and Lemmermann. 1913. Die Süsswasserflora Deutchlands, Österreichs und der Schweiz. Heft 2: Flagellate 2. Jena.

Penard, E. 1902. Faune Rhizopodique du Bassin du Leman. Geneve.

Plough, H. H. 1916. The genus Aspidisca Ehrenberg. Trans. Amer. Microsc. Soc., XXXV, pp. 233-245.

Stokes, A. C. 1888. A preliminary contribution toward a history of the freshwater Protozoa of the U. S. Journ. of the Trenton Nat. Hist. Soc., I. 1895. Notices of some presumably undescribed Infusoria. Proc. Am. Phil. Soc. XXXIII, p. 338; Journ. Roy. Micr. Soc., p. 438.

Verworn, M. 1896. Die polare Erregung der lebendigen Substanz. Mittheilung 4. Pfluger's Archiv. f. d. ges. Physiol. Bd. 65. Referred to in Verworn's Allgemeine Physiologie, 3rd ed., pp. 193-194.

Wailes, G. H. and Penard, E. 1911. Clare Island Survey—Rhizopoda. Proc. Roy. Irish Acad., XXXI, part 65.

Sand, Rene. 1899-1900. Étude monographique sur le groupe des Infusoires tentaculifères. Annales de la Société Belg. de Microscopie. Brussels.

Walton, L. B. 1915. A review of the described species of the order Euglenoidina Bloch. Ohio Biol. Survey, Bull. 4.

EXPLANATION OF PLATES.

PLATE I.

Heavy Lines—Outline of Water.
Light Lines—Paths and Bridges.
Letters—Stations.
Scale—80 feet to the inch.

PLATE II.

(All the drawings on this plate are magnified 400 diameters).

Fig. 1. *Biomyxa vagans* Leidy. An active individual.
Figs. 1a and 1b. Different shapes assumed by the above animal.
Fig. 2. A smaller individual of the same species.

ABBREVIATIONS.

c. v.—contractile vacuole.
n.—nucleus.

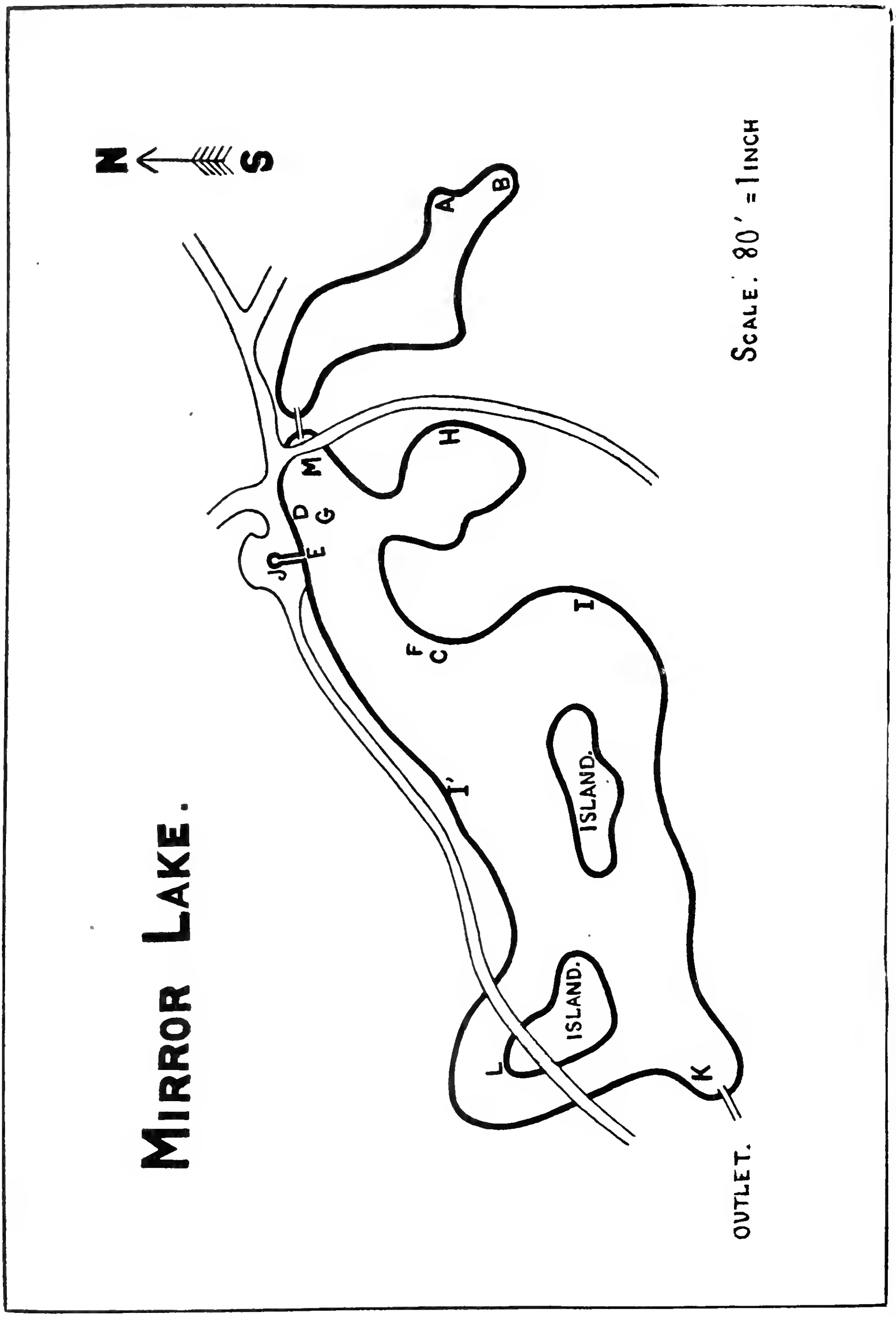
PLATE III.

(All the drawings on this plate are magnified 400 diameters, except 9a, which is magnified 200 diameters).

Fig. 1. *Anisonema acinus* Dujardin. An individual with the nucleus on the left side of the cell.
Fig. 2. *Colpoda* sp. Dorsal view of the animal.
Fig. 2a. A ventral view of the gullet of the same animal.
Fig. 3. *Strombidinopsis* sp.
Fig. 3a. The gullet in outline. It is on the opposite side from the view of the animal in Fig. 3, and can only be seen when the organism turns over.
Fig. 4. *Thuricolopsis innixa* Stokes. The expanded form with numerous food vacuoles.
Fig. 4a. A view of the contracted animal. The band-like nucleus plainly visible.
Fig. 5. *Stichotricha* sp.
Fig. 6. *Urocentrum turbo* (Muller). A pair of individuals in the act of conjugation (?) or of longitudinal division (?).
Fig. 7. *Podophrya libera* Perty. Juvenile stage.
Fig. 8. ———? Outline drawing of a hypotrichous ciliate with two very long diagonally placed cilia.
Fig. 9. ———? A hypotrichous ciliate with one crescent-shaped meganucleus and two micronuclei.
Fig. 9a. Outline of a side view of the above animal.

ABBREVIATIONS.

c. v.—contractile vacuole.
gul.—gullet.
f. p.—food particle.
megan.—meganucleus.
micron.—micronucleus.
n.—nucleus.



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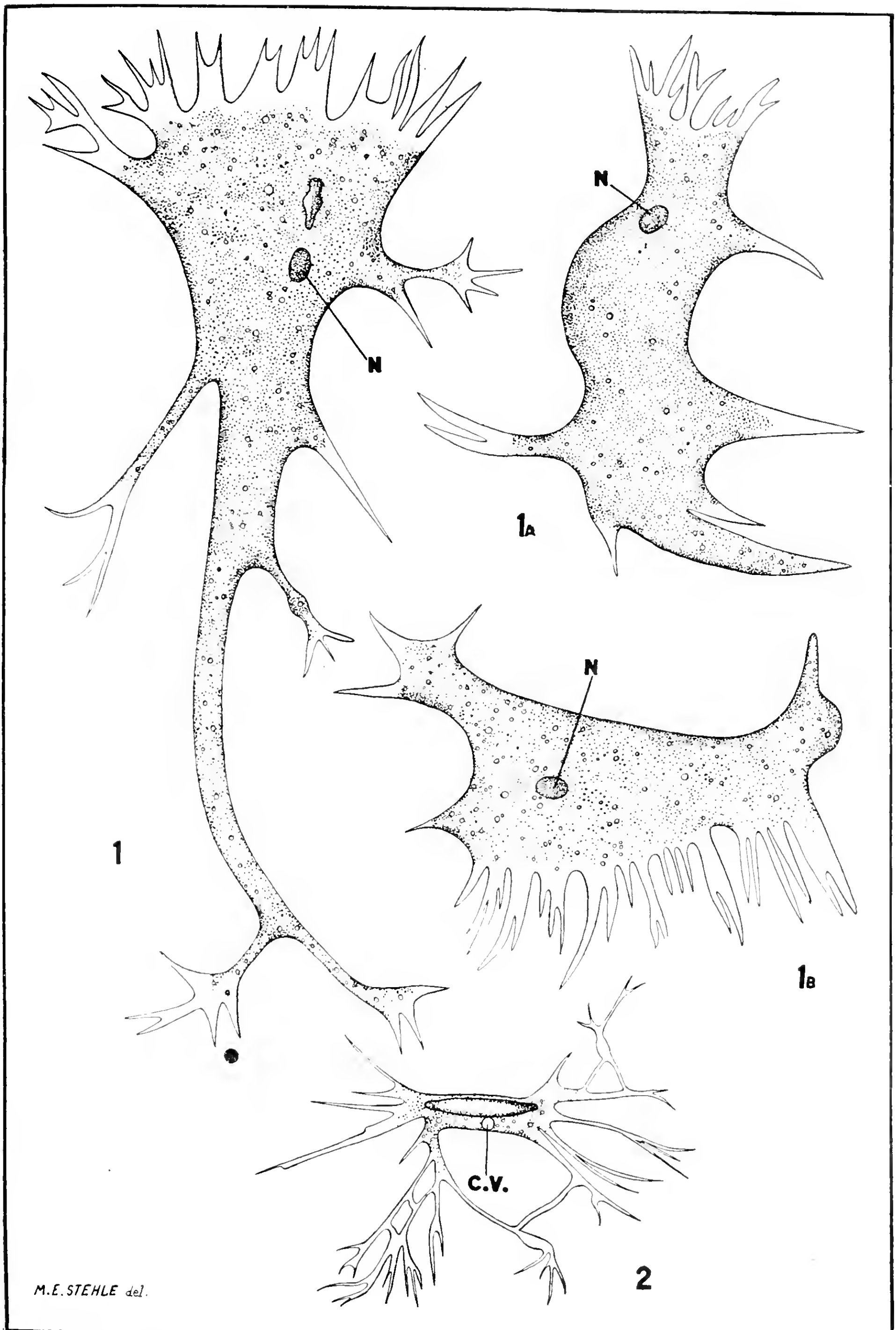

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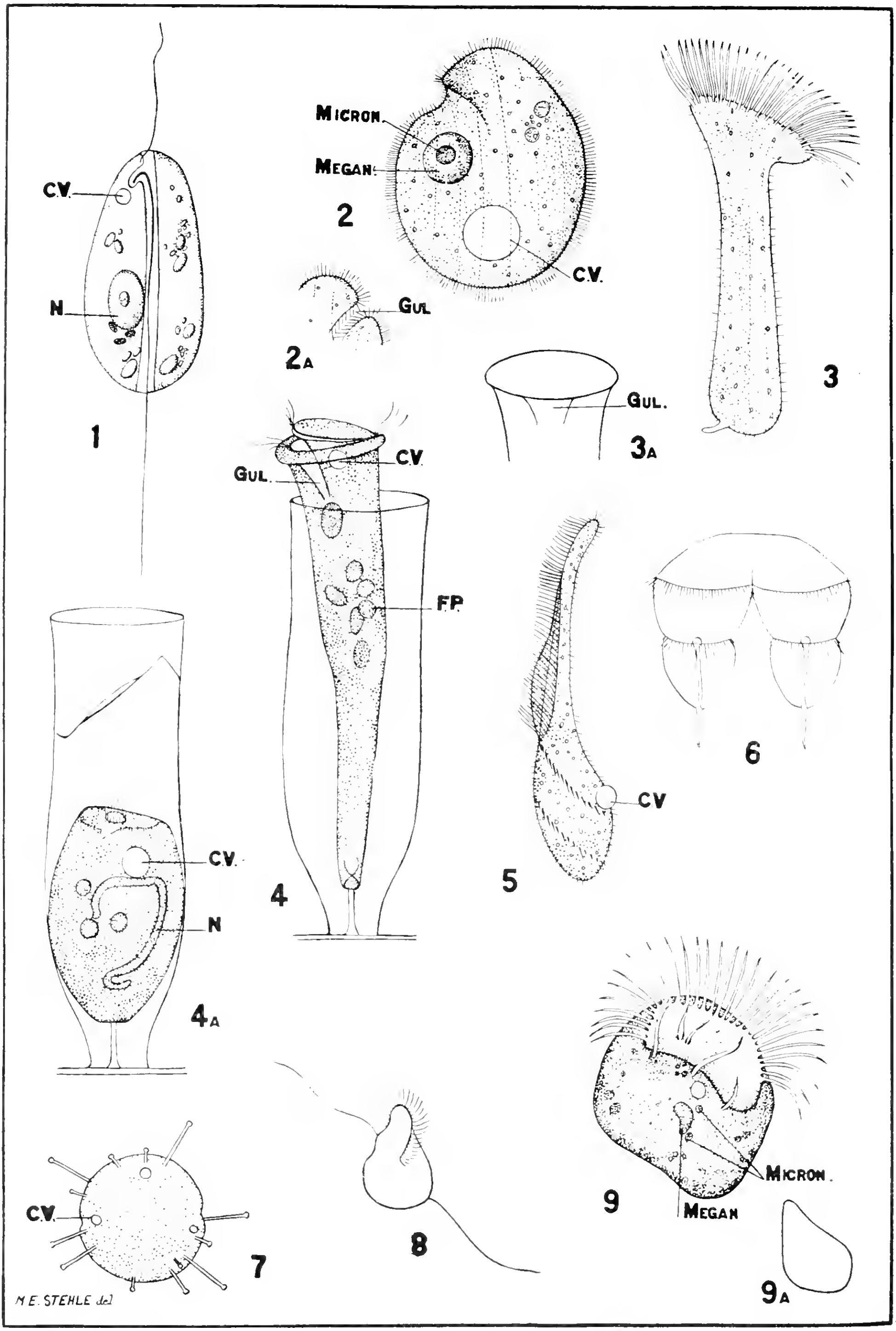

Mabel E. Stehle

ADDITIONS TO THE CATALOG OF OHIO VASCULAR PLANTS FOR 1919.*

JOHN H. SCHAFFNER.

Lists of plants giving local distribution are of great value in determining limits of geographic areas and centers of plant distribution. It is of importance to have an accurate knowledge of the distribution of plants in our state, and, of course, in all the states and countries of North America. The past year has been fruitful in additions of species and extensions of the known range of others. The more important additions to the State Herbarium are listed below.

3. **Botrychium neglectum** Wood. Wood's Grape-fern. Very common but local at Jefferson, Ashtabula Co. R. J. Sim.

4. **Botrychium lanceolatum** (Gmel.) Angs. Lanceleaf Grape-fern. Not rare at Jefferson, Ashtabula County. R. J. Sim.

18.1 **Pellaea glabella** Mett. Northern Purple Cliffbrake. Margaretta, Erie County. In Gray Herbarium, Harvard Univ. Reported by F. K. Butters.

21a. **Asplenium platyneuron X Camptosorus rhizophyllus.** (Asplenium ebenoides Scott.) Scott's Spleenwort. Southern part of Hocking County. Reported by Clara G. Mark.

28. Change name to **Athryium angustum** (Willd.) Presl. All of our specimens belong to this species as now understood. Specimens examined by L. S. Hopkins. General in the state; specimens in the state herbarium from many Counties, including Mahoning, Cuyahoga, Erie, Fulton, Defiance, Hamilton, Adams, Franklin, Hocking and Carroll.

28a. **Athyrium angustum cristatum** Hopkins. Windham, Portage County. Lewis S. Hopkins.

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* Papers from the Dept. of Botany, The Ohio State University, No. 119. Ohio State University, Columbus, Ohio.

50. **Equisetum hyemale** L. Common Scouring-rush. No specimens in the state herbarium. All specimens identified as this species are Equisetum prealtum Raf. Probably not in the state, and to be removed from the list.

51. **Equisetum prealtum** Raf. Great Scouring-rush. General in Ohio. Specimens from 22 Counties including Ashtabula, Lucas, Defiance, Montgomery, Franklin, Adams and Athens.

52. **Equisetum variegatum** Schleich. Variegated Scouring-rush. Sandy plain along lake-shore. Ashtabula Harbor, Ashtabula County. R. J. Sim.

53.1. **Equisetum kansanum** Schaffn. Kansas Horsetail. Specimens from Wood, Erie, Lorain, Summit, Stark and Monroe Counties.

53.2. **Equisetum palustre** L. Marsh Horsetail. In sticky mud in a ditch. Kent, Portage County. Lewis S. Hopkins.

63. **Lycopodium complanatum** L. Trailing Club-moss. Ironton, Lawrence County. Lillian E. Humphrey.

99.1. **Potamogeton vaseyi** Robb. Vasey's Pondweed. Sandy Lake, Portage County. Lewis S. Hopkins, Hazel M. Hopkins, and Dorothy D. Hopkins.

150. **Eleocharis ovata** (Roth) R. & S. Ovoid Spike-rush. In a ditch. Barnesville, Belmont County. Emma E. Laughlin.

205. **Carex bromoides** Schk. Brome-like Sedge. Somerton, Belmont County. Emma E. Laughlin.

256.1. **Carex swanii** (Fern.) Mack. Swan's Sedge. Specimens from Ashtabula, Summit, Medina, Geauga, Morrow and Ashland Counties.

266. **Carex torta** Boott. Twisted Sedge. Somerton, Belmont County. Emma E. Laughlin.

311. **Festuca ovina** L. Sheep Fescue-grass. Barnesville, Belmont County. Emma E. Laughlin.

341. **Sphenopholis obtusata** (Mx.) Scribn. Blunt-scaled Eaton-grass. Lakeside, Ottawa County. John H. Schaffner.

347. **Triplasis purpurea** (Walt.) Chapm. Purple Sand-grass. Painesville, Lake County. E. A. Doolittle.

391.1 **Agrostis perennans** (Walt.) Tuck. Upland Bent-grass. Specimens from Erie, Cuyahoga, Lake, Lorain, Fairfield and Perry Counties.

392.1. **Agrostis elliottiana** Schultes. Elliott's Bent-grass. In waste ground; probably introduced from the south. Cleveland, Cuyahoga County. Collected by L. D. Stair, John H. Schaffner.

417. **Anthroxanthum odoratum** L. Sweet Vernal-grass. Hillsboro, Highland County. Katie M. Roads.

440.1. **Panicum tennesseense** Ashe. Tennessee Panic-grass. Lake and Highland Counties.

475. **Lilium superbum** L. Turk's-cap Lily. London, Madison County. Mrs. K. D. Sharp.

504. **Trillium declinatum** (Gr.) Gleason. Drooping Trillium. West Jefferson, Madison County; both white and maroon colored forms. Mrs. Bayard Taylor. Ft. Ancient, Warren County; maroon form. S. E. Horlacher. And Loveland, Clermont County; white form. D. J. James. Near West Jefferwon in Brown Township, Franklin County; both colors. Mrs. Bayard Taylor.

561. Change name from **Sisyrinchium angustifolium** Mill. to **Sisyrinchium albidum** Raf. White Blue-eyed grass. Rather general. Near West Jefferson, Franklin County. Mrs. Bayard Taylor.

564. **Cypripedium reginae** Walt. Showy Lady's-slipper. Brown Township, Franklin County. Mrs. Bayard Taylor.

591. **Ibidium beckii** (Lindl.) House. Little Lady's-tresses. Clear Creek Valley, near Rock Bridge, Hocking County. Mrs. Bayard Taylor. Sugar Grove, Fairfield County. Edward S. Thomas.

665. **Papaver somniferum** L. Opium Poppy. Escaped from gardens in Hillsboro, Highland County. Katie M. Roads.

682. **Berteroa incana** (L.) DC. Hoary Berteroa. West Jefferson, Madison County. Mrs. Bayard Taylor.

700. **Lepidium draba** L. Hoary Peppergrass. Columbus, Franklin County. C. J. Willard.

703. **Thlaspi arvense** L. Field Penny-cress. In waste ground, Columbus, Franklin County. John H. Schaffner, also C. J. Willard. White Sulphur, Delaware County. Mrs. Bayard Taylor.

714. **Conringia orientalis** (L.) Dum. Hare's-ear Mustard. In waste ground, Columbus, Franklin County; Mt. Vernon, Knox County. John H. Schaffner.

715. **Hesperis matronalis** L. Dame's Rocket. S. E. of Barnesville, Belmont County. Emma E. Laughlin.

722. **Arabis patens** Sull. Spreading Rock-cress. Delaware, Delaware County. Mrs. Bayard Taylor.

755. **Cleome spinosa** L. Spider-flower. Persistent after cultivation in Hillsboro, Highland County. Katie M. Roads.

882. **Viola pedatifida** Don. Larkspur Violet. Hillsboro, Highland County. Katie M. Roads.

899.1. **Cerastium viscosum** L. Mouse-ear Chickweed. Sugar Grove, Fairfield County. Arthur R. Harper and Edward S. Thomas. Also common at Somertown and Barnesville, Belmont County. Emma E. Laughlin.

908. **Lychnis alba** Mill. White Lychnis. West Jefferson, Madison County; Urbana, Champaign County. Mrs. Bayard Taylor.

916. **Silene noctiflora** L. Night-blooming Catchfly. Hillsboro, Highland County. Katie M. Roads.

925. **Dianthus armeria** L. Deptford Pink. Clear Creek Valley, near Rock Bridge, Hocking County. Mrs. Bayard Taylor.

1012. **Potentilla pumila** Pair. Dwarf Five-finger. Somerton, Belmont Co. Very common in pastures. Emma E. Laughlin.

1022.1 **Rubus laciniatus** Willd. Cutleaf Blackberry. A waif in Columbus, Franklin County. John H. Schaffner.

1157. **Lespedeza virginica** (L.) Britt. Slender Bush-clover. Sugar Grove, Fairfield County. Edward S. Thomas.

1229. **Acer spicatum** Lam. Mountain Maple. Cat Run, Licking County. On sandstone cliff. Paul B. Sears.

1230a. **Acer saccharum rugelii** Rehd. McDermott, Rush Township, Scioto County. Forest W. Dean.

1241. **Cotinus cotinus** (L.) Sarg. European Smoketree. Escaped from cultivation near Berryville, Highland County. Katie M. Roads.

1271a. **Quercus imbricaria X velutina.** Lea's Oak. McDermott, Rush Township, Scioto County. Forest W. Dean.

1345. **Kneiffia pratensis** Small. Meadow Sundrops. Kimbolton, Guernsey County. Emma E. Laughlin. Hillsboro, Highland County. Katie M. Roads.

1471. **Frasera carolinensis** Walt; American Columbo. Reported for Big Darby Creek, Franklin County; and Big Walnut Creek, east of Westerville in Red Hill region, Franklin County, by Edward S. Thomas and A. R. Harper.

1481.1. **Asclepiodora viridis** (Walt.) Gr. Oblong-leaf Green Milkweed. Reported from Cantwell Cliff, Hocking County, by Robert F. Griggs.

1533. **Ilysanthes attenuata** (Muhl.) Small. Short-stalked False Pimpernel. West Jefferson, Madison County. Mrs. Bayard Taylor.

1561. **Castilleja coccinea** (L.) Spreng. Scarlet Painted-cup. West Jefferson, Madison County. Mrs. Bayard Taylor.

1586. **Ruellia strepens** L. Smooth Ruellia. Kimbolton, Guernsey County. Emma E. Laughlin.

1594.2. **Amsinckia intermedia** F. & M. Orange-flowered Amsinckia. A waif in waste ground. Columbus, Franklin County. John H. Schaffner.

1599. **Lithospermum latifolium** Mx. American Gromwell. Ten miles S. E. of Barnesville, Belmont County. Emma E. Laughlin.

1760. **Diodia teres** Walt. Rough Button-weed. Jackson, Jackson County. Walter F. Gahm.

1764. **Galium boreale** L. Northern Bedstraw. Harmony, Clark County. Mrs. Bayard Taylor.

1769. **Galium claytoni** Mx. Clayton's Bedstraw. Newark, Licking County, West Jefferson, Madison County. Mrs. Bayard Taylor.

1807. **Valeriana pauciflora** Mx. Large-flowered Valerian. Barnesville, Belmont County. Emma E. Laughlin.

1809. **Valeriana officinalis** L. Garden Valerian. Escaped from cultivation in Hillsboro, Highland County. Katie M. Roads.

1875. **Galinsoga parviflora** Cav. Galinsoga. Rather general and especially frequently found in lawns.

1875a. **Galinsoga parviflora hispida** DC. Hairy Galinsoga. Scioto, Jefferson, Franklin, Monroe, Columbiana, Lake and Montgomery Counties.

1880. **Silphium laciniatum** L. Compass-plant. Four miles northwest of West Jefferson, Madison County. E. N. Transeau, Mrs. Bayard Taylor.

1927. **Bellis perennis** L. European Daisy. Growing as an introduced weed in lawns. Columbus, Franklin County. A. E. Waller.

1970. **Eupatorium serotinum** Mx. Late-flowering Thoroughwort. Barnesville, Belmont County. Emma E. Laughlin.

1985a. **Vernonia altissima taeniotriche** Blake. New Antioch, Clinton County. Collected by J. S. Van Dervort. Fide H. A. Gleason.

1991. **Anthemis arvensis** L. Field Dog-fennel. Barnesville, Belmont County. Emma E. Laughlin.

2010. **Mesadenia tuberosa** (Nutt.) Britt. Tuberous Indian-plantain. Harmony, Clark County. Mrs. Bayard Taylor.

2030. **Centaurea cyanus** L. Bachelor's-button. Escaped from cultivation in Hillsboro, Highland County. Katie M. Roads.

2043.1. **Lactuca sativa** L. Garden Lettuce. Persistent for a year and coming up in waste ground near Columbus, Franklin County. John H. Schaffner.

Ohio State University,
Columbus.

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DISTRIBUTION, FOOD AND FISH ASSOCIATES OF YOUNG PERCH IN THE BASS ISLAND REGION OF LAKE ERIE.

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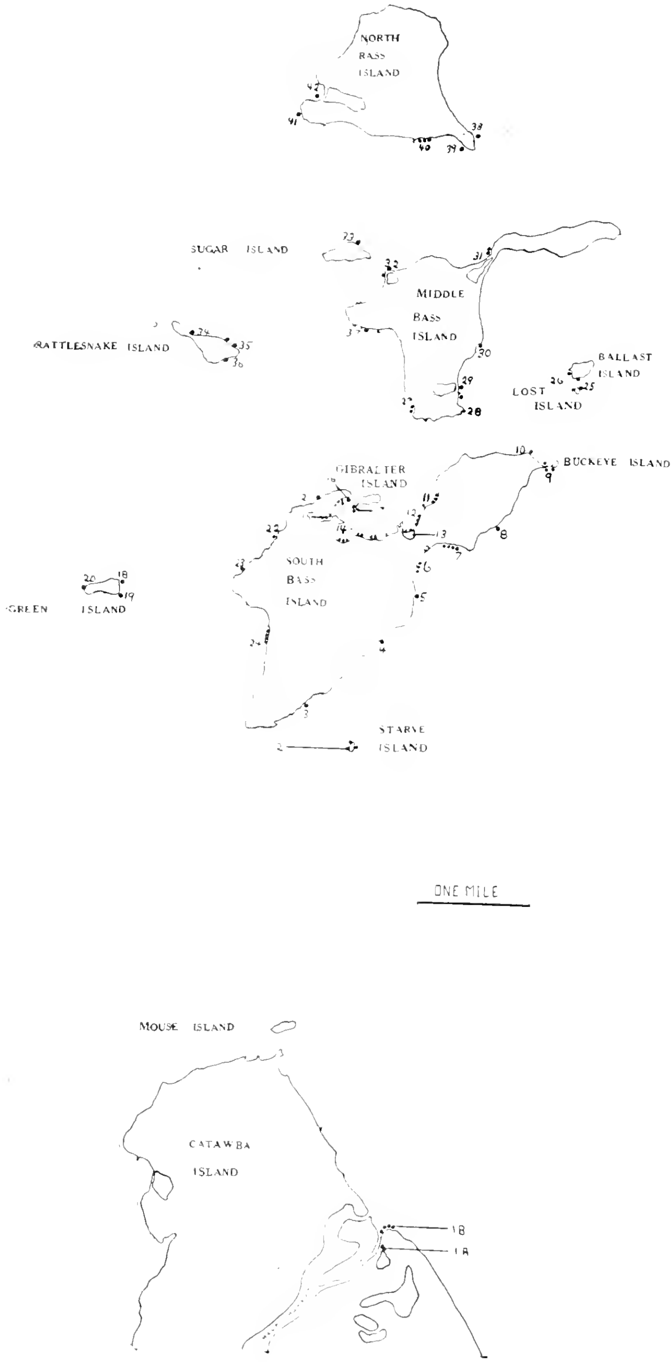
CONTENTS.

1. Introduction and Acknowledgments.

It is the purpose of this paper to outline part of the results of work upon the young fishes taken around the shores of the Bass and neighboring islands, with special reference to the habitat, associations, diet and changes in diet in the young perch. The field work was done in July, 1919, with the aid of equipment and facilities provided by the Ohio State Fish Hatchery located at Put-in-Bay and by the Lake Laboratory of the Ohio State University. It is a pleasure to acknowledge the courtesies extended to me by the staff of the hatchery and by Director R. C. Osburn of the Lake Laboratory. Mr. A. C. Baxter, Chief of State Fish and Game Protectors, kindly permitted the use of a seine in taking the specimens.

2. Materials and Methods.

A dip net was first employed in capturing specimens but the method proved too slow to be practicable and of no value whatever in obtaining a representative association from a locality and the use of a twenty foot seine was soon substituted. Several hauls were made in each locality and care was taken to get


NORTH BASS ISLAND
SUGAR ISLAND
MIDDLE BASS ISLAND
RATTLESNAKE ISLAND
BALLAST ISLAND
LOST ISLAND
GIBRALTER ISLAND
BUCKEYE ISLAND
SOUTH BASS ISLAND
GREEN ISLAND
STARVE ISLAND
ONE MILE
MOUSE ISLAND
CATAWBA ISLAND

specimens from the deeper as well as the shallow bottoms and from the top. No attempt was made to seine in water deeper than five feet. Because of the presence of stiff vegetation and numerous isolated boulders it was found quite impossible to use the seine in some localities and this was equally true along shore having precipitous sides and deep water. The paucity of data from some localities, notably Starve Island and Green Island, is to be attributed chiefly to this cause.

Before and during the operation of seining, notes were made of the character of the localities, i. e., the depths of the water, the character and slope of the bottom, the presence and character of vegetation, etc. The catch was fixed immediately in 10 per cent formalin or 90 per cent alcohol and labelled with the locality. A note of the different species included in the catch was made in a field note book and the locality mapped at once. There was consequently little confusion in tabulating the results.

The total number of perch taken was between three and four hundred of which two hundred were fixed and one hundred and thirty-eight examined for their length and stomach contents. The specimens varied in length from twenty-six to one hundred and twenty millimeters.

3. Fish Fauna of Localities Examined.

Forty-two localities, representing as many types of habitat as could be distinguished and offering a considerable range in distance, were examined. These localities have been charted on the accompanying map. Following is a description of each locality with its fish fauna so far as determined:

Locality 1, *a*. West Harbor, Catawba Island. Flat, sandy beach with no aquatic vegetation except spike rushes (Eleorchus) along the water line.

Fauna: Adults of carp, sunfish, perch, white bass, golden shiner, top minnow (Fundulus Diaphanus menona), and unidentified minnows. Fry of white bass, rock bass, perch, log perch (Percina caprodes zebra), brook silversides and unidentified minnows.

Locality 1, *b*. Reedy marsh connected by narrow channel with West Harbor channel.

Fauna: Adults of perch, sunfish and mud minnows. Fry of sunfish and large mouthed bass.

In locality *a* all specimens, with the exception of the brook silversides and minnows, were taken in the rushes along the shore. The brook silversides and minnows were taken at the surface at some distance from the shore. The fry of the brook silversides, minnows and perch were most abundant at *a*. The fry of the large mouthed bass were most abundant at *b*.

LOCALITY 2. Starve Island. All sides of the small island characterized by precipitous and irregular limestone walls and jagged rock masses. Aquatic vegetation was lacking.

Fauna: The only specimens taken here were ten darters (Cottogoster coplandi) and a few fry of the brook silversides and unidentified minnows.

LOCALITY 3. Clean steeply sloping pebble beach with little vegetation.

Fauna: Cottogaster coplandi, one fry of Percina caprodes and two fry of the small mouthed bass.

LOCALITY 4. Shallow beach with flat rock bottom strewn with stones and small boulders. No aquatic vegetation.

Fauna: Only four darters (Cottogaster coplandi) and a few minnows were taken.

LOCALITY 5. Shallow water with flat rock bottom. Depressions in the rock formed deep pools.

Fauna: Adults of Cottogaster coplandi and minnows and the fry of Dyslesion blennioides and Percina caprodes zebra taken here.

LOCALITY 6. Steeply sloping rubble beach with no vegetation except filamentous algæ.

Fauna: Adults of Percina caprodes zebra, Cottogaster coplandi, minnows and fry of Percina caprodes zebra, perch large mouthed bass and white bass.

The perch fry were relatively abundant here.

LOCALITY 7. Shallow sandy and gravel beach with spike rushes along waters edge. Some submerged vegetation.

Fauna: A varigated association. Adults of perch, carp, Percina caprodes zebra and Notropis hudsoni. Fry of carp, brook silversides, perch. Percina caprodes zebra, small mouthed bass, large mouthed bass and white bass.

LOCALITY 8. Shallow beach with flat rock bottom strewn with gravel; no vegetation.

Fauna: Adults of Percina caprodes zebra and Notropis hudsoni. Fry of Percina caprodes zebra, perch, brook silversides, small mouthed bass.

The slender fry of the brook silversides were exceedingly abundant at the surface in this locality.

Locality 9. Level rubble beach with trees along the water's edge affording shade and attachment for moss patches. Spike rushes were plentiful from the water's edge to thirty feet from shore. The beach was so situated as to be subject to constant wave action.

Fauna: Adults of Cottogaster coplandi, Percina caprodes zebra and minnows and fry of small mouthed bass were taken along the beach in three feet of water. Adults of Cottogaster coplandi, Etheostoma flabellare and fry of Etheostoma flabellare and millers thumb (Cottus ictalops) were taken in the moss patches and under stones along the water's edge.

Locality 10. Clean rubble beach with steep slope.

Fauna: Adults of Percina caprodes zebra and a five inch pickerel. Fry of perch, Percina caprodes zebra, small mouthed bass and minnows.

The fry of the small mouthed bass were very abundant here.

Locality 11. Flat, sandy beach with a few large isolated boulders; water from one to four feet deep for one hundred yards from shore; spike rushes and pond weeds along shore.

Fauna: Adults of sunfish, Percina caprodes zebra, brook silversides, and Notropis hudsoni. Fry of perch, small mouthed bass, large mouthed bass, and Percina caprodes zebra.

The single adult of the brook silversides taken here was the only one taken in forty-two localities.

Locality 12. Character of the locality same as that of locality 11 with the exception of a solid concrete wall along the shore.

Fauna: Adults of minnows were taken at the surface of the water but no other fish.

The concrete wall along the shore line and the total absence of vegetation would make this a very unfavorable locality for fish and their fry.

Locality 15. Shallow pond at Perry Monument with mud bottom; much submerged and floating vegetation.

Fauna: Adult mud minnows (Umbra lima) and Notropis hudsoni and fry of carp.

LOCALITY 14. Southern margin of Squaw Harbor. Water from one to four feet deep; fine sand and mud bottom; spike rushes and other vegetation growing in the water.

Fauna: Adults of Percina caprodes zebra, Cottogaster coplandi and perch. Fry of perch, small mouthed bass, large mouthed bass, and brook silversides.

Most of the specimens here were taken in the vegetation.

LOCALITY 15. Terwilliger Pond. Marshy pond enclosed by land except for a narrow fifteen foot channel. Water from one to seven feet deep; fine mud bottom with occasional large boulders; rank floating and submerged begetation.

Fauna: Terwilliger Pond was not examined exhaustively, consequently the following list is by no means complete: adults of the common catfish, gold fish, carp, several species of sunfish and perch were taken also the fry of the perch, green sunfish, carp, goldfish, large-mouthed bass and rock bass.

It is very probable that this pond serves as a breeding ground for several species as eggs in different stages of development were sometimes found lodged in the vegetation and successive waves of fry belonging to different species were observed at different dates.

LOCALITY 16. Peach Point. Flat, stony bar covered by two feet of water; no vegetation.

Fauna: Adults of Cottogaster coplandi, Boleicthys fusiformis, minnows and perch. Fry of rock bass, small-mouthed bass, large-mouthed bass perch, Percina caprodes zebra, Diplesin blennioides and minnows.

LOCALITY 17. Gibraltar Island. Flat, stony bar, with considerable submerged vegetation on both sides at the junction with the shore.

Fauna: Adults of rock bass (yearlings), sunfish, Cottogaster coplandi and perch. Fry of rock bass, perch, small-mouthed bass, large-mouthed bass and sunfish.

The fry of the rock bass were more abundant at this locality than at any other.

LOCALITIES 18 AND 20. Green Island. Short, sharply sloping, gravel and stone beaches in protected parts of shore; shore made up largely of perpendicular limestone walls.

LOCALITY 19. Long gravel bar covered by shallow water; no vegetation.

Fauna: (18, 19 and 20). The catch from these localities was very small, consisting of adults of Cottogaster coplandi and some minnows and the fry of the large mouthed bass, small-mouthed bass, perch and Percin caprodes zebra.

The fry of the small-mouthed bass were the most plentiful and those of the perch and large-mouthed bass very scarce.

LOCALITIES 21, 22 AND 23. Like localities 18 and 20.

Fauna: The catch here resembled that of localities 18, 19 and 20 in its paucity of material. At locality 21 three yearling small-mouthed bass were taken.

LOCALITY 24. Near Hotel Victory site. Stony beach with short slope and no vegetation except small quantities of filamentous algae clinging to stones.

Fauna: Adults of Percina caprodes zebra, Cottogaster coplandi, Notropis hudsoni were taken here and fry of perch, large-mouthed bass, small-mouthed bass, Percina caprodes zebra and unidentified minnows.

LOCALITY 25. Lost Island. Low island partly awash surrounded by steep gravel beach. Small quantities of pond weed found on western side.

Fauna: Adults of minnows and fry of white bass, small-mouthed bass and Percina caprodes zebra.

LOCALITY 26. Ballast Island. Steep rubble and gravel beach with little aquatic vegetation.

Fauna: Adults of Percina caprodes zebra, Cottogaster coplandi and Notropis hudsoni and fry of small-mouthed bass, perch, white bass and brook silversides.

LOCALITY 27. Middle Bass Island. Steep rubble beach with no vegetation.

Fauna: Adults of minnows and young of Percina caprodes zebra and small-mouthed bass.

LOCALITY 28. Short, protected beach along precipitous, rocky shore. Beach of stone and large boulders; no vegetation.

Fauna: Adults of Cottogaster coplandi and fry of small-mouthed bass and Percina caprodes zebra.

LOCALITY 29. Shallow, flat, rock bottom, partly awash and partly scooped out to form depressions; rock floor either bare or covered by sand; patches along water's edge and submerged vegetation in places.

Fauna: Adults of Percina caprodes zebra, Cottogaster coplandi and Notropis hudsoni taken here. Fry of Diplesion blennioides and Cottus ictalops taken in a mossy patch covered by a few inches of water. Fry of perch, Percina caprodes zebra, Ammocrypta pellucida and minnows.

Perch fry were found more abundantly in this locality than in any other and the only sand darter (Ammocrypta pellucida) taken was captured here on a sandy bottom in three feet of water.

LOCALITY 30. Like locality 29 but with the addition of some large boulders.

Fauna: Fry of millers thumb, fantailed darter (Etheostoma flabellare) and Diplesion blennioides taken in a mossy patch similar to that at locality 29.

LOCALITY 31. Shallow gravel beach with few boulders; submerged vegetation out to a depth of four feet.

Fauna: Adults of Percina caprodes zebra, perch and minnows. Fry of small-mouthed bass, large-mouthed bass, rock bass, white bass, perch, carp and brook silversides.

LOCALITY 32. Steep, sand beach with submerged water weeds.

Fauna: Adults of Percina caprodes zebra, Cottogaster coplandi and Notropis hudsoni. Fry of small-mouthed bass, perch and Percina caprodes zebra.

LOCALITY 33. Sugar Island. Flat gravel and boulder beach with no vegetation but bordering an area with abundant submerged weeds.

Fauna: Adult minnows and fry of small-mouthed bass.

LOCALITY 34. Rattlesnake Island. Level, sand and gravel beach with some large boulders; a little aquatic vegetation.

LOCALITY 35. Short, steep, gravel beaches in protected places along precipitous shores.

LOCALITY 36. Stone and boulder beach with gradual slope.

Fauna: (Localities 34, 35 and 36). These localities gave a uniform catch of small-mouthed bass, Percina caprodes zebra, (young and adults), adult Cottogaster coplandi, perch fry and minnows.

LOCALITY 37. Like Locality 36.

Fauna: Fry of small-mouthed bass, brook silversides and minnows were the ones taken here.

LOCALITY 38. North Bass Island. Long sand bar, partly awash.

Fauna: This shallow bar gave minnows, two perch fry and some young Percina caprodes zebra.

LOCALITY 39. Sand and boulder bottom with three feet of water; no vegetation.

Fauna: Fry of small-mouthed bass were added to the list of Locality No. 38.

LOCALITY 40. Long beach with steep slope; fine sand bottom; no vegetation.

Fauna: Adults of Percina caprodes zebra and minnows. Fry of small-mouthed bass, large-mouthed bass, Percina caprodes zebra and perch.

Adults of Percina caprodes zebra were very abundant here.

In the mouth of an inlet to a swamp in this locality the fry of the rock bass and carp were added.

LOCALITY 41. Rubble beach with gradual slope; considerable aquatic vegetation.

Fauna: Adults of Percina caprodes zebra, Cottogaster coplandi, Diplesian blenioides and minnows. Fry of perch, small-mouthed bass, rock bass and Percina Caprodes zebra.

LOCALITY 42. Protected sand and gravel beach with no vegetation.

Fauna: Adults of Cottogaster coplandi and minnows. Fry of small-mouthed bass.

4. DISTRIBUTION OF YOUNG PERCH AND ITS ASSOCIATES.

Within the limits of the region studied the young fry has a general and rather uniform distribution. In only a few of the above localities does the perch fail to appear and in such localities there is a scarcity of other species as well. Little can be said of the vertical range beyond a depth of five feet but practically all the specimens taken were found at a depth of between two and four feet.

There seems to be a little choice in the character of habitat, a slightly greater number being found in localities having flat, sandy bottoms and some submerged vegetation. The larger perch fry were all taken in such localities and all yearlings and adults taken were also found there. The character of the bottom and the presence or absence of vegetation appear to have no effect upon the younger perch in its distribution, for as it is feeding mainly upon Entromostraca in its younger stages its distribution would be limited only by its physical capacities to migrate and by the abundance of its food supply. Consequently it may be found anywhere in moderately shallow water. Later its food consists mainly of insect larvæ. These are more apt to be found in localities with considerable vegetation and it may be that the slightly greater numbers and larger sizes of the fry are found in places containing vegetation because the change in food drives them from the clean beaches where insect larvæ are few to the richer vegetation-bearing shallows.

As regards the fish associates of the young perch, there are none that put any serious obstacle in the way of its existence. The only adults taken in the same habitats were carp, sunfish, minnows, brook silversides, several species of darters, and an occasional white bass or small-mouthed bass. None of these are fish eaters to any great extent except the basses and only seven adults were taken in the forty-two localities. An examination of the stomachs of three of these showed only a small fish content. Considering the other fish fry with which the young perch is associated, the small-mouthed bass, large-mouthed bass, white bass, sunfishes, log perch and minnows—there are none which are pisciverous to any extent. The largest fry of the small mouthed bass were eating the very young fry of other fish, but these were mainly the fry of minnows and darters. The young perch keeps pace with the small-mouthed bass in growth so that it is doubtful if the young small-mouthed bass ever becomes a menace to the young perch. All the young fish mentioned are using the same food (Entomostraca) at this time and so are in a sense competitors but the waters examined swarmed with Entomostraca so that all the young fish were abundantly supplied.

In point of numbers the young perch fry were surpassed by the fry of the small-mouthed bass and of the log perch in a ratio of about four to one while the young minnows were most abundant. Locally, the young brook silversides, white bass and sunfish were more abundant than the perch, but they, like the fry of the rock bass, small-mouthed bass, fantailed darter, Diplesion blennioides and miller thumb had a local distribution.

The association and constant occurrence of the young of the four species, minnows, small-mouthed bass, log perch and perch may be attributed to three causes: (1) A wide distribution of the adults. (2) A generalized food habit with a general distribution of the food supply. (3) A generalized type and large number of breeding places.

5. Diet of the Perch.

In the present study the articles of diet found are classified as follows:

1. Copepods
2. Cladocera
3. Ostrocods
4. Chironomid larvae
5. May fly larvae
6. Caddis fly larvae and tubes
7. Larvae and adults of other insects
8. Mites
9. Annelid worms
10. Nematode worms
11. Trematode worms
12. Amphipods
13. Isopods
14. Snails
15. Crayfish
16. Fish eggs
17. Fish remains
18. Algae
19. Vegetable debris (leaves; roots, etc.)
20. Inorganic debris.

The proportion which each article of diet forms of the whole, the length of each fish examined and the number of each length have been set down in the accompanying table while the quantitative variation of the principal items of diet is shown in graphic form. Algæ, plant remains, the different worms, ostrocods, isopods, adult insects, mites, fish eggs, fish remains, and inorganic debris are purposely excluded from the graph because they form such a small proportion of the entire diet.

Specimens of 26 and 27 millimeters in length are found to have eaten copepods only but the pure diet is soon given up for one composed almost wholly of copepods but with a slight admixture of cladocera and minute chironomid larvæ. May fly larvæ are soon added and an occasional adult insect. From 30 to 40 millimeters, cladocera become increasingly important while copepods drop below fifty per cent of the total. Medium sized crustacea are first taken at this stage and form a small but rather consistent article of food. Insect larvæ, other than chironomids and may flies are also taken at this time and together with the may flies and chironomids constitute the chief food up to a length of 120 millimeters. The larger snails and crayfish are not used till the fish has reached a length of about 100 millimeters although some smaller snails are eaten earlier.

Forbes (1880,2) reports the food of the adult perch to consist of crayfish and fish in the larger specimens and of fish, crayfish, molluscs, amphipods, isopods, and insect larvæ in the others.

TABLE OF ARTICLES OF DIET.

Length in mm	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40—45	45—50	50—55	55—60	60—70	70—80	80—90	90—100	100—110	110—120
No. Examined	2	2	1	8	4	8	12	6	16	7	4	7	4	4	12	4	4	1	2	4	8	4	2	2
No. with Pure Diet	2	2	0	4	2	3	4	2	6	4	1	2	0	0	2	0	0	0	0	0	0	0	0	0
Articles of Diet:																								
Algae										86		10.2		2.5			25						10	
Other plant remains												15			11.7					7.5	21.2			10
Trematode worms					1.5	1.2	15									2.5	25		2	2				
Nematode worms						2.5						2.7												
Annelid worms																		8						
Snails																				10		20		30
Copepods	100	100	98	99	92.5	89	76.3	96.7	67.6	89.6	67.5	62	50	66.5	68.3	26.5	37.5	41	40		1.2			
Cladocerans			2	3	2.5		3	2.2	22.7		30.3		41	11	1.7						7			
Ostrocods																				2.5		2.5		
Amphipods									3.7				6	10		9		22		25	5	15		
Isopods																+								
Crayfish																						45		
Chironomid larvae				6				7					2.5		8		29	18	15	5	5	10.5		20
Chironomid pupae									2															
May fly larvae						5			1.9	2.9						10	5	18		12.5	5			
Other insect larvae												1		12.5		10	10	2	15	17.5	32.8	12	70	10
Adult insects					3.5						1.4					2.5								
Mites															+				+					
Fish remains						1.1		2			3.6	7.5							20	20			20	
Fish eggs																					7.5			
Inorganic debris																	10				1.2			

In an examination of six very young perch he finds the food to consist almost wholly of entomostraca, cladocera and copepods being in about equal quantities, and a few minute midge larvæ.

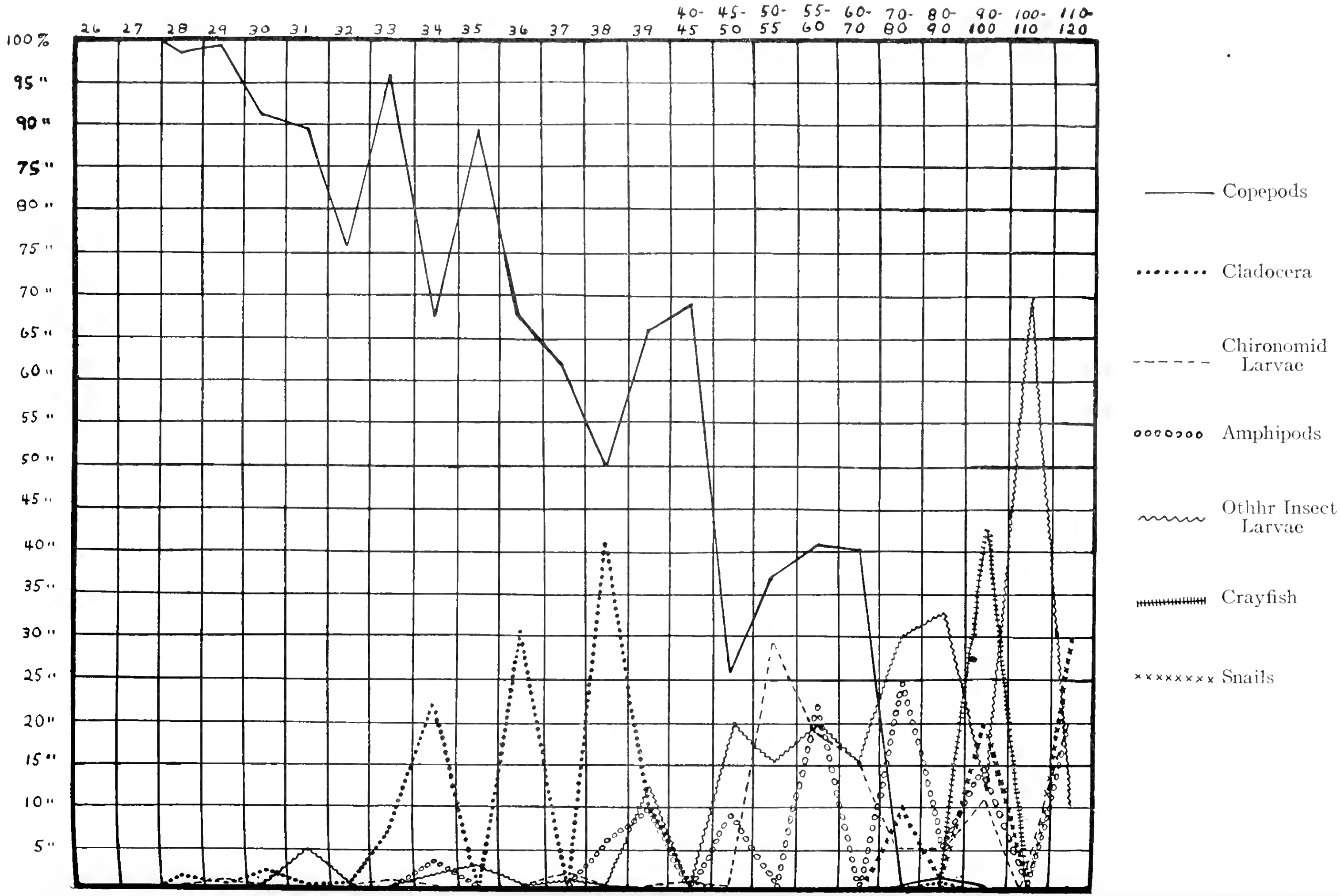
Hankinson (1908) finds that the stomachs of a few fry (of perch) contain chiefly entomostraca.

Hankinson (1916) finds the stomachs of perch from one to one and a half inches in length to contain only cyclops and diaptomus.

Pearse (1918) finds that the perch is in general a versatile feeder and that at any age it may feed largely upon entomostracans, insects, molluscs or almost anything else that is edible.

In the present study of 138 specimens of the young perch the results are generally in agreement with those of Forbes who reported upon less than twenty fish of this age. Forbes concluded that there are three periods to be recognized as expressed in the food habits of the perch, infancy, in which the fish takes only entomostraca and minute dipteran larvæ, youth, in which mainly larger insect larvæ are eaten and maturity in which crayfish and fish constitute the food. In his younger specimens, however, he finds the entomostracan food to be about equal parts of copepods and cladocera while in the present study a pure diet of copepods is encountered in the youngest fish. Apparently the age classified as maturity by Forbes has just been reached by the oldest specimens included in this report. The statement of Pearse that perch are versatile feeders at all ages is born out here except in the case of the youngest specimens which have a pure diet of Entomostraca.

Two reasons suggest themselves for the gradual but definite change in the total diet of the young perch. (1) There is a gradual increase in the size of the animals eaten which keeps pace with the increase in size of the fish and it seems probable that the perch would take larger animals as food unless it were especially equipped for straining the water for smaller objects. (2) The perch in its youngest stages is not a bottom feeder as it is when adult. A gradual change results by its turning to the bottom for food whereas it had formerly taken its food at the surface or in the middle waters. The perch in its earlier stages might be termed a generalized feeder becoming later a "versatile feeder" (Pearse, 1918), but deriving most of its food along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Copepods
Cladocera
Chironomid Larvae
Amphipods
Othhr Insect Larvae
Crayfish
Snails

the bottom. The young fry of two fish which are strictly bottom feeders (Etheostoma flabellare and Cottus ictalops) were taken with the young of the perch and their diet consisted mainly of large larvæ of insects, fish eggs, and amphipods while the young perch were eating only entomostraca and a few chironomid larvæ. The young perch were clearly not deriving their food from the bottom at this time. Consequently it seems that the change in the behavior of the perch fry as it changes from a generalized feeder to a bottom feeder contributes to the change in the diet.

6. Summary.

1. The young perch of from 26 to 50 millimeters in length is found generally distributed in the shore waters at a depth of two to five feet in July in the vicinity of the Bass Islands.

2. The diet of the young perch consists wholly of copeopds in its younger stages but gradually changes to insect larvæ.

3. The change in diet is apparently associated with a change in feeding behaviour, changing from a generalized or surface feeder to a bottom feeder.

4. The young perch is associated at this time with a great number of the adults of minnows, several species of darters (Percina caprodes zebra, Cottogaster coplandi, Diplesion blennioides, and Etheostoma flabellare) a few adults of rock bass, small-mouthed bass, white bass, sunfish, perch and brook silversides and with the fry of the small-mouthed bass, large-mouthed bass, rock bass, sunfishes, darters (Percina caprodes zebra, Etheostoma flabellare), minnows, brook silversides and perch.

5. The perch fry studied here have few enemies among their fish associates.

LITERATURE CITED.

Baker, F. C. 1916. The relation of molluscs to fish in Oneida Lake. Technical publication No. 4, New York State College of Forestry, Syracuse University.

Forbes, S. A. 1880. (1) The food of fishes. Acanthopteri. Bulletin Illinois State Laboratory of Natural History, Volume I, p. 19.

1880. (2) On the food of young fishes. Ibid. Volume I, p. 71.

1883. The food of the smaller fresh water fishes. Ibid. Volume I, p. 65.

1888. Studies of the food of freshwater fishes. Ibid. Volume II, p. 433.

1888. On the food relations of fresh water fishes. Ibid. Volume II, p. 475.

Hankinson, T. L. 1908. A Biological survey of Walnut Lake, Michigan. Michigan State Biological Survey Report, p. 156.

1916. Result of the Shiras Expedition to Shiras Point, Mich. Fishes. Michigan Geological and Biological Survey, Publication 20, Biological Series, 4.

Pearse, A. S. 1915. On the food of the small shore fishes in the waters near Madison, Wisconsin. Bulletin Wisconsin Natural History Society, Volume 13, p. 7.

1918. The food of the shore fishes of certain Wisconsin Lakes. Bulletin of Bureau of Fisheries, Volume 35, (1915-1916), p. 249.

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NOTES ON THE GENERIC AFFINITIES OF CERTAIN CICADELLIDAE (HOMOPTERA).

With Descriptions of a New Genus and Two New Species.*

HERBERT OSBORN.

The following notes are based in considerable part on material collected some years since when engaged upon a study of the Leaf-hoppers affecting Cereal and Forage crops the results, especially those bearing on the economic problems involved, appearing in Bulletin 108 of the New Series of the Bureau of Entomology. A considerable amount of material illustrating the distribution and habits of species not directly connected with cultivated crops was accumulated but detailed study of this material has been delayed for various reasons but especially by the pressure of other duties connected with my university work.

It is hoped that in time a paper dealing more extensively with our American Leaf-hopper fauna may be possible but in the meantime it seems desirable to present some observations on the generic affinities of certain groups and to publish the descriptions of new forms so they may be available to other students of the group.

I am indebted to members of the staff of the U. S. Bureau of Entomology for numerous favors, especially to the lamented Prof. Webster, who was chief of the Division of Cereal and Forage Crops at the time the collections were made, and to Dr. L. O. Howard for his interest and encouragement. The figures presented are from the skillful hands of Miss Charlotte M. King and Mr. J. D. Smith and are duly credited in each case.

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Dorycephalus minor n. sp. (Fig. 1.)

Very similar to D. *platyrhynchus* Osb. but smaller the elytra in female short and the vertex especially in male distinctly shorter the female segment more produced. Length: female 12 mm.; male 7 mm.

Head flattened and produced the vertex in female more than twice and in the male a little less than twice longer than wide. Vertex nearly parallel sided the apex rounded. Front depressed at sides slightly convex medially; clypeus short, rounded at tip; loræ rounded above

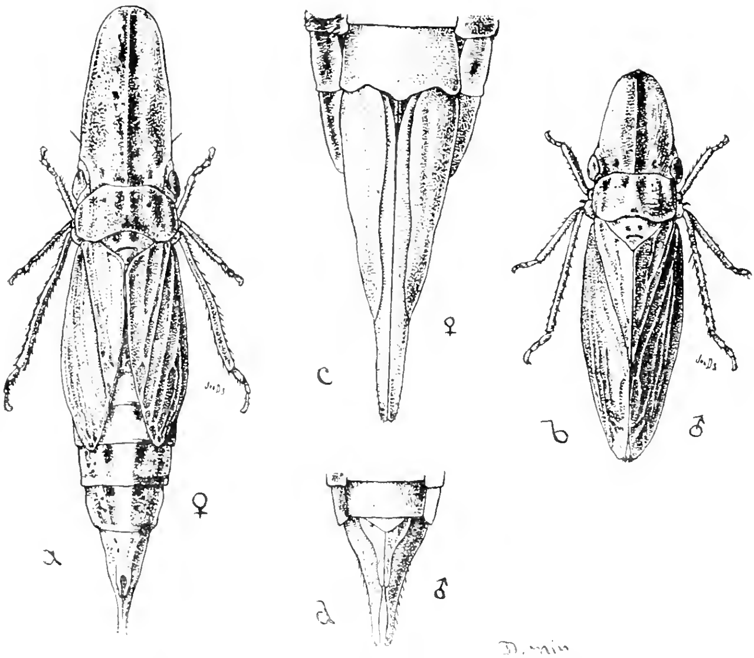

Fig. 1. *Dorycephalus minor* n. sp. *a*, female dorsal view; *b*, male dorsal view; *c*, genitalia of female; *d*. genitalia of male. (From drawings by Mr. J. D. Smith.)

tapering below. Pronotum nearly twice wider than long, posterior margin distinctly sinuate. Elytra abbreviated, reaching beyond fourth abdominal segment, tips strongly divergent, commisural line curved. Wings very short about half the length of the elytra.

Color: Dull straw color, vertex with a central broken stripe of fuscous indicated also on the anterior or part of the pronotum in the female and with two distinct dark spots on the disk of the scutellum in both sexes. A double row of black spots on dorsum of abdomen beneath, sides of frons fuscous a central dark area on abdomen of male.

Genitalia: Ultimate ventral segment of female angularly produced at middle, ovipositor extending about one-fourth its length beyond tip of pygofer. Male valve very short, rounded behind, plates broad at base, sharply contracted to near middle and extending as narrow tapering apices to beyond the middle of the pygofer.

While very similar to *platyrhynchus*, and possibly only a well marked variety, this species is distinctly smaller, the central fuscous stripe in the female is more pronounced and the hind margin of female segment angularly produced and in the male there is a very evident difference in the shorter head and smaller size. Moreover the specimens were taken in a tract of prairie grass at Brookings, S. Dak., where no *Elymus*, the foodplant of *platyrhynchus*, was to be found.

Type No. 22811, female allotype, male paratypes, in National Museum, in Osborn Collection, Ohio State University; all taken at same time, June, 1909, Brookings, S. Dak.

Neoslossonia putnami Osborn. (Fig. 2a.)

Dorycephalus putnami Osborn Dav. Acad. Sci. X, p. 163 (1907).
Neoslossonia atra Van Duzee Bul. Buf. Soc. Nat. Hist. IX, p. 218 (1909).

This species has been taken very rarely so far and the only suggestion as to food habit is the note of VanDuzee that one of the two specimens that he took in Florida was from a Palmetto "hummock." The specimen from which the writer described the species came from Chester, Ga., which I take it is out of the range of the palmetto so that it should be looked for in a palmetto association rather than upon this plant itself.

Only males have been described and it is possible that the female is a short winged form that does not occur where easily taken in ordinary sweeping. I did not find any signs of the species in examining palmetto in the isolated patch occurring on Smith Id., N. C.

The males are densely black and the details of genitalia shown in the accompanying figure will serve to identify the species in this sex. The females should be sought in protected parts of the plants where males may be found and if not discovered on leaves or stems should be looked for at the crown or even below the surface of the ground. No doubt examples of both sexes and the nymphal stages will be found in abundance when the proper habitat and food plant is determined.

In venation of clavus which VanDuzee makes one of the principal characters for the genus this species agrees perfectly with *Dorycephalus* and about the only basis for separation is the shorter, more triangular furrowed head and the black color.

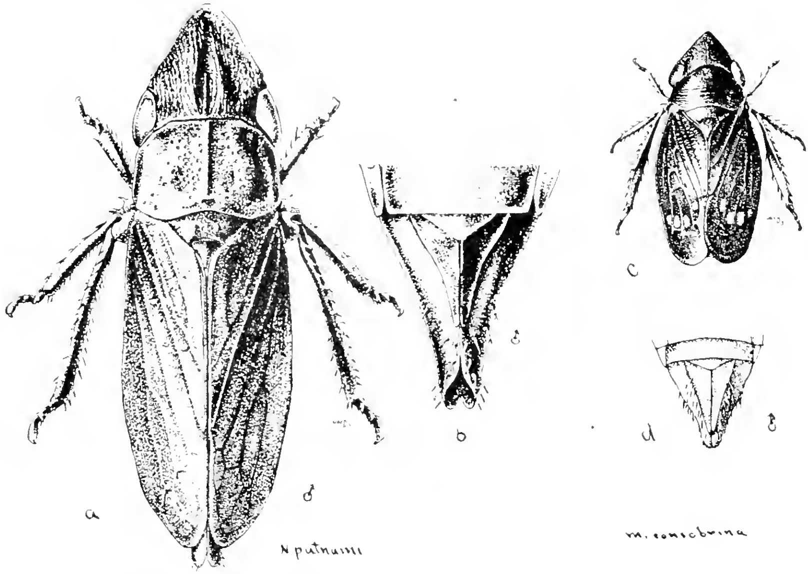

Fig. 2. *a*, *Neoslossonia putnami*, male dorsal view; *b*, genitalia of male; *c*, Memnonia consobrina, male dorsal view; *d*, male genitalia. (From drawings by Mr. J. D. Smith.)

Memnonia Ball.

This genus is placed by VanDuzee next to *Xestocephalus* in the Acocephalini but in general fascies and shape of head and especially in the position of the ocelli these genera seem to be more closely related to *Parabolocratus* or *Dicyphonia* and in depth of head and rounded margin nearer *Nionia* and *Drionia*. I took *M. consobrina* Ball as far east as Ottawa County, Kansas. (Fig. 2*c*). I have it also from Clay County of that state.

Dicyphonia Ball.

Dicyphonia ramentosa Ball, which I have, taken in western Kansas, seems to me to stand between the flatter, broad-headed *Parabolocratus* on one side and the sharp-nosed *Acurhinus* and *Cochlorinus* on the other. Except in the shorter head and flatter body it represents fairly well the Dorydine group of the old world.

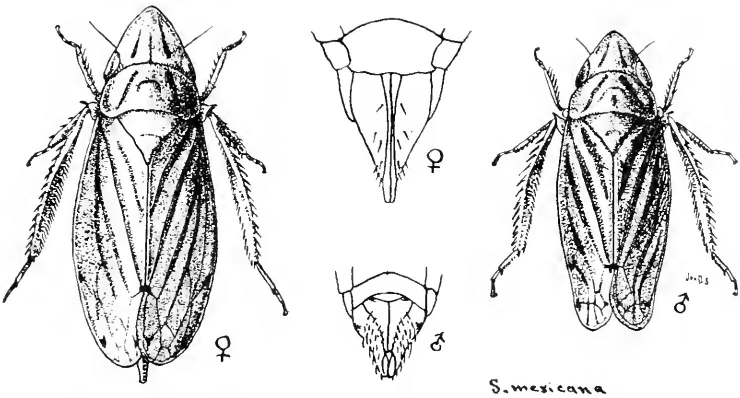

Fig. 3. *Spangbergiella mexicana;* dorsal view and genitalia of female and male as indicated. (From drawings by Mr. J. D. Smith.)

Spangbergiella Sign.

This genus is tropical or subtropical but *vulnerata* and *mexicana* extend into the southern U. S. The single vein of clavus seems the most evident character structurally, but the oblique, red stripes of vertex and pronotum appear constant. Lathrop* has indicated the characters for separating the species and connected the sexes I believe correctly.

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* Cicadellidae of South Carolina, Bull. S. C. Exp. Sta., 1919.

Parabolocratus Uhler.

This genus is very closely related to the preceding but aside from having two claval veins and the absence of oblique stripes, the most evident characters, the head is shorter, more paraboloid and elytra usually shorter. The species *flavidus*, *viridis* and *major* present many gradations and it is possible that with sufficient material may be connected but *flavidus* is essentially southern *major* northeastern and *viridis*, while widely distributed, seems best represented in the Mississippi Valley and the plains region.

Cochlorhinus, *Uhleriella* and *Huleria* are all Pacific coast forms and I have attempted to show their affinities in the key while the excellent descriptions of Uhler, Ball and VanDuzee will enable the student to readily identify the different species listed in Van Duzee's Catalogue.

Acurhinus nov. gen.

Head strongly produced, the vertex with sides nearly straight subacute, apex acute, slightly concave above, frons reaching close to eyes, antennal pits touching eyes and ocelli very close to eye border. A decided furrow beneath the margin between vertex and front and the front strongly convex. Costa with strongly reflexed veinlets next the outer anteapical which is much reduced.

The species grouped here have some striking resemblances to *Dicyphonia* on one hand and to *Platymetopius* and *Deltocephalus* on the other but they seem to me to belong rather between *Dicyphonia* and *Cochlorhinus* than in the group Deltocephalaria. In fact *maculatus* was placed doubtfully in the genus *Dorydium* at the time of its description.

Type of the genus *Acurhinus maculatus* (Osborn).

Acurhinus maculatus (Osborn).

Dorydium (?) maculatum Osborn, Ohio Naturalist, Vol. IX, p. 464.

This species, described from Guatemala, differs from *pyrops* quite distinctly in that the dark markings of the front are oblique or nearly longitudinal instead of forming transverse teeth projecting from the blackish area below the head margin and the elytral nervures are not so strongly margined with fuscous. The female segment is broadly concave, not excavate at middle.

Acurhinus pyrops. (Crumb).

Deltocephalus pyrops Crumb Ann. Ent. Soc. Am. Vol. DeLong Bulletin, Tenn. Exp. Sta.

Platymetopius pyrops VanDuzee Catalogue, 1917. Lathrop, Leaf-Hoppers, South Carolina Bull. S. C. Exp. Sta., 1919.

This species which was described as a *Deltocephalus* and later transferred by VanDuzee to *Platymetopius*, has been in my collection for some years. It has always seemed to me out of place in either of these genera and especially on account of the deep furrow below the vertex margin, and the cylindro-conic front to have closer affinity with the Dorydine series.

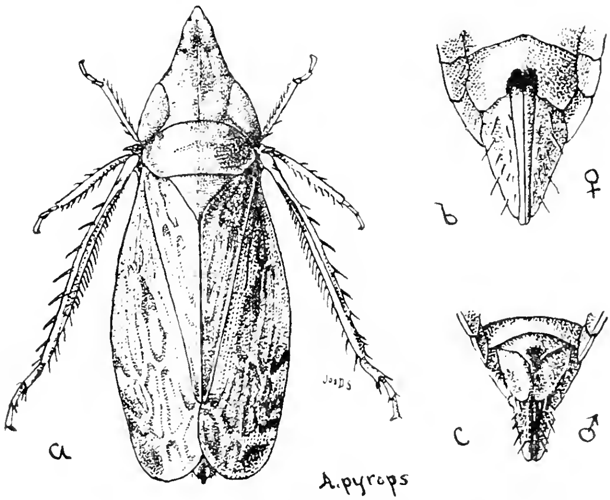

Fig. 4. *Acurhinus pyrops*. *a*, dorsal view of female; *b*, female genitalia; *c*, male genitalia. (From drawings by Mr. J. D. Smith.)

It seems clearly congeneric with *maculatus* which perhaps has the Dorydine fascies a little more pronounced but the two are so close in many structural points that their resemblance can hardly be ascribed to convergence.

The species was described from Tennessee has been reported from South Carolina and I have specimens from Southern Illinois through the kindness of Mr. C. A. Hart.

Dorydiella floridana Baker.

Dorydiella appears to me to belong to the division Dorydiaria rather than the Euscelidaria where it has been recently placed by VanDuzee. In the folicaeous margin of head, character of front and general fasciesit seems associated with *Cochlorhinus* and *Huleria* rather than with *Acinopterus*, next to which it was placed by VanDuzee, evidently on account of the similarly pointed elytra, a character, however, which is found also in *Dorydium* and some of its allies. Especially in head

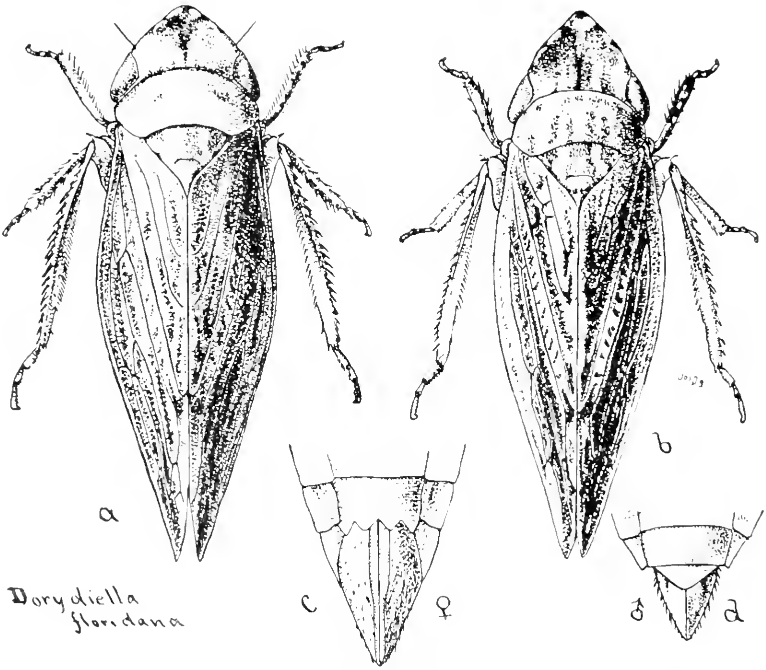

Fig. 5. *Dorydiella floridana*. *a*, dorsal view of male; *b*. dorsal view of female; *c*, genitalia of female; *d*, genitalia of male. (From drawings by Mr. J. D. Smith.)

characters *D. floridana* comes very close to *Huleria* Ball and I would place the genus next to this or perhaps group *Cochlorhinus Huleria* and *Dorydiella* together in a closely related series.

Of the American genera we may then consider *Dorycephalus*, *Neoslossonia*, *Hecalus*, *Spangbergiella* and *Parabolocratus* as forming one series; *Dicyphonia*, *Acurhinus*, *Cochlorhinus*, *Uhleriella*, *Huleria* and *Dorydiella*, another of close affinities, with *Xestocephalus*, *Memnonia*, *Drionia* and *Nionia* as less distinctly related, although these latter genera present in the matter of ocellar location considerable agreement and their differences are due to varied development of the vertex.

Drionia nigra Ball.

This very interesting species described from Medford, Oregon, may be recorded also from Mt. Shasta, Cal., a single specimen collected by Mr. Geo. Franck and kindly loaned to me by Mr. Chris. Olsen, agreeing perfectly with Ball's description.

Nionia Ball.

This genus as indicated by Ball is very near to the old world genus *Tartessus* but differs in the absence of supernumary cell in the wing. It is a very robust form with strongly angled head but very short vertex which narrows decidedly between the apex and the eye.

It is represented in the South American fauna by a species that closely resembles our *palmeri* but my specimens from Coroicas Yungas, Bolivia, show wide variation in size and many of the individuals have the elytra distinctly brown instead of black.

Nionia palmeri VanDuzee.

This species is fairly common in the Eastern U. S. but not taken very commonly as it has evidently a distinctly restricted habitat. I have adults and nymph from Greensburg, Pa., kindly sent to me by Rev. M. Wirtner, and have also specimens from various points in Ohio, Maryland and Virginia.

The nymphs associated with the adults and very clearly belonging to this species are very robust creatures but little longer than wide, the head very short and broad, wider than the pronotum, with prominent eyes, polished but finely granulate, the pronotum short, more than twice wider than long, rugose, the meso- and meta-thoracic segments between the wing pads rough and with low median carina. The color is black except the eyes which in dry specimens are, like the adults, of a dead gray color, contrasting with the shiny polished body of jet black. Length, 2 mm.

The character of the nymph emphasizes the distinctness of this group from the other Jassinæ and if similar nymphs are found in Drionia and related genera would warrant the creation of a new division, separate from the Dorydiaria or Deltocephalaria, to receive them.

The division Dorydiaria of the tribe Jassina as placed by VanDuzee for North America includes for the most part genera in which the ocelli are directly on the margin of the head, between vertex and front and with heads flattened, the margin acute or foliaceous but including some forms in which the

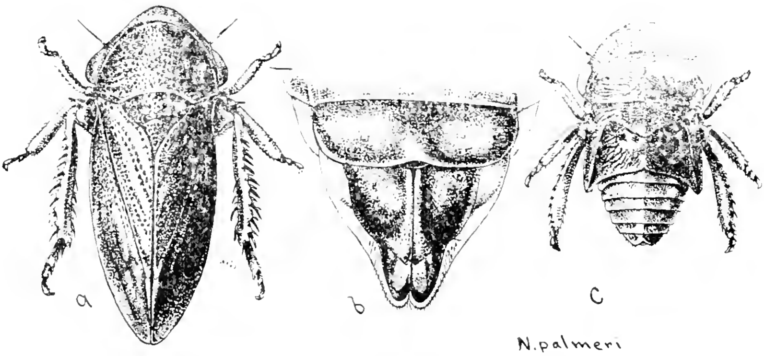

Fig. 6. *Nionia palmeri.* *a*, dorsal view of female; *b*, male genitalia; *c*, nymph. (From drawings by Mr. J. D. Smith.)

latter character is modified. While not a homogeneous group and, as constituted, including some genera which may well be subject to further study the following key is offered as an assistance in recognizing the generic affinities for the North American forms.

The group may be separated from Acucephalini by the fact that the ocelli are on the margin, not just behind it and from the Deltocephalaria by a greater overhang of the vertex on the front a character shared in some degree by some of the species of *Phlepsius*.

KEY TO NORTH AMERICAN DORYDIARIA.

A. Head margin usually acute often very thin and foliaceous.
  a. Veins of clavus fused for the apical third.
    b. Vertex very long sides nearly parallel with a median carina..**Dorycephalus**
    bb. Vertex little longer than wide, triangular, furrowed.....**Neoslossonia**
  aa. Veins of clavus not fused apically.
    c. Clavus with a single vein..............................**Spangbergiella**
    cc. Clavus with two veins.
      d. Ocelli at or near the border of the eye.
        e. Costal veins not reflexed.
          f. Head very broad with foliaceous margins..............**Hecalus**
          ff. Head narrower paraboloid or subtriangular.....**Parabolocratus**
        ee. With reflexed veins on costa opposite outer anteapical.
          g. Head rounded in front, clavus with ramose veins..**Dicyphonia**
          gg. Head acutely pointed, clavus with cross nervure..**Acurhinus**
      dd. Ocelli remote from the border of the eye.
        h. Elytra rounded at apex.
          i. Vertex as long, or longer than wide.
            k. Elytra long, anteapical cells long, vertex not spoonshaped..................................**Huleria**
            kk. Elytra shorter, anteapical cells short, vertex spoonshaped.............................**Cochlorhinus**
          ii. Vertex wider than long..........................**Uhleriella**
        hh. Elytra acute at apex..........................**Dorydiella**
AA. Head margin rounded or obtuse, not flattened.
  a. Vertex longer at middle than next the eye.
    b. Ocelli close to eye.......................................**Memnonia**
    bb. Ocelli distant from eye...............................**Xestocephalus**
  aa. Vertex very broad, eyes widely separate, head wider than pronotum.
    c. Vertex much produced, angular, pronotum extending before eyes.**Nionia**
    cc. Vertex transverse, short, pronotum not greatly produced.....**Drionia**

Deltocephalus viridis n. sp.

Light green, broad and short, occurring in long and short winged form; length 2.5 to 3 mm.

Vertex nearly as long as broad, about twice as long in the middle as next the eye, obtusely angulate, margin angularly rounded, front broad, the sutures curving slightly to the base of the clypeus, rather full; the clypeus short, lateral margins curved; the loræ divided below, distinct from the margins of the cheek, the border of the cheek nearly straight from the eye to the clypeus; pronotum about twice as wide as long, smooth, lateral borders short; posterior margin very slightly concave; scutellum broad, short, impressed on the middle; elytra of the brachypterus form reaching the penultimate segment, broadly rounded behind, divergent on the dorsum, the apical cells much shortened, discal cells shorter but in the normal position; the wings about half the length of the elytra, very delicate; the cells usually bordered with faint fuscus markings.

Color: Light grass green; the vertex with faint dusky markings near the anterior border, the front with about four dusky arcs each side; the beak brown, anterior and middle femora annulate with brown, and the tarsal spurs black; elytra either hyaline or with faint fuscus markings bordering the cells.

Genitalia: Last ventral segment of the female longer than the preceding ones; the posterior border sinuate, notched near the center, leaving a distinct, broad, rounded tooth or lobe on the median line; pygofer broad, short, equaling the ovipositor in length, very sparsely ciliate behind. Male valve very short, rounded behind, the plates broad at base and with elongate, bluntly acuminate tips, reaching to the tip of the pygofer; the pygofer short, scantily ciliate at the tip.

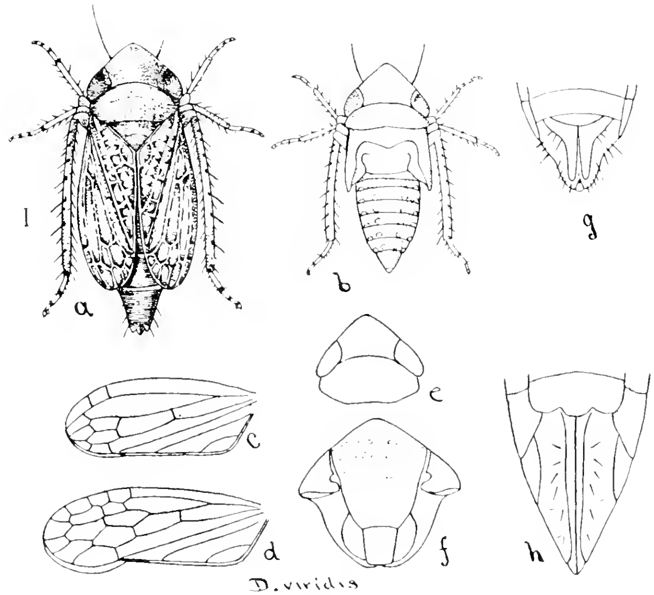

Fig. 7. *Deltocephalus viridis*, n. sp. *a*, dorsal view of micropterous female; *b*, nymph; *c*, elytron of macropterous form; *d*, elytron of macropterous form; *e*, head and pronotum of male; *f*, face; *g*, genitalia of male; *h*, genitalia of female. (From drawings by Miss Charlotte M. King.)

The nymphs are similar in form to the adults and differ from them in lacking wings, the wing pads of what appears to be the mature nymph extending but slightly beyond the borders of the thoracic segments. The eyes are dusky.

Type No. 22810. U. S. National Museum.

This interesting member of the genus occurred in considerable numbers and in long and short winged forms, and also as larvæ in the bottom of the resaca at Brownsville, Texas, living in a dense turf of fine grass, where it evidently spends the year, as the specimens were taken during February, 1910.

The species is evidently an abundant one, and there can be no question as to the food plant being the abundant grass on which the larvæ and adults occurred, as it was not taken from any of the surrounding grasses. It is well adapted to the particular environment, being of practically the same color as the grass on which it lives, and the reduction of wings is an indication that it has acquired a definite restriction to the locality in which it occurs.

The micropterous form has venation similar to Lonatura especially L. megalopa, but the macropterous venation is distinctly Deltocephaloid with both middle and outer anteapical cells divided by cross veinlets.

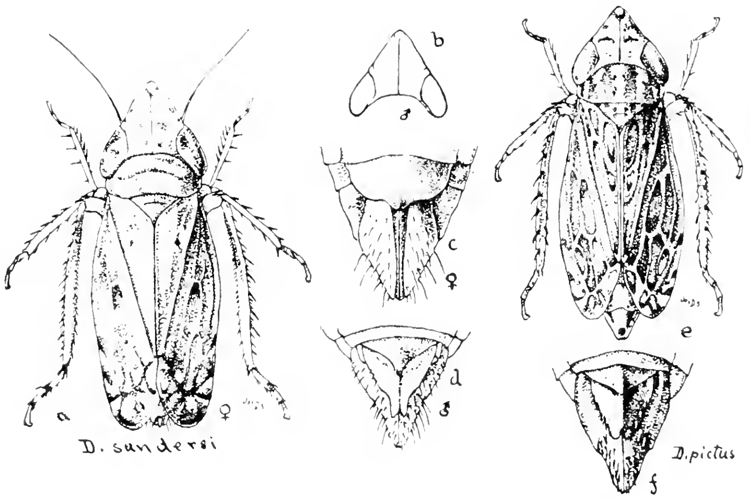

Fig. 8. *a*, dorsal view of female; *b*, vertex of male; *c*, genitalia of female; *d*, genitalia of male *Deltocephalus sandersi*; *e*, dorsal view; *f*, genitalia of male *Deltocephalus pictus*. (From drawings by Mr. J. D. Smith.)

Deltocephalus pictus Osb.

Proc. Davenport Acad. Sci., Vol. X, p. 165.

This species was described from one specimen collected on Staten Id., but has since been taken in Tennessee by DeLong, and I have taken it in considerable abundance in North Carolina. The accompanying figures will assist in the recognition of the species.

Deltocephalus sandersi Osb.

Proc. Davenport Acad. Sci., Vol. X, p. 164.

This species was first taken in the vicinity of Washington, D. C., by Prof. J. G. Sanders, but its distribution has been found to extend over quite a range of the Atlantic States and into Tennessee, where it was collected by Mr. DeLong.

Ohio State University, Columbus, Ohio.

NOTES ON ELACHISTA WITH DESCRIPTIONS OF NEW SPECIES (MICROLEPIDOPTERA.)

Annette F. Braun.

In the present paper, five new species of *Elachista* are described, four of which were reared from mines. The life histories of two other species are here recorded for the first time. As the life histories of so few of the previously described species are known, a revision of the genus as a whole will better be delayed until the life histories of more of these species and of a number of new species represented by captured specimens in the writer's collection are worked out.

Of the new species described below, all except *E. argentosa* agree in venation with the figure given by Meyrick, Handbook of British Lepidoptera, p. 664. In *E. argentosa* veins 2, 3 and 4 of the fore wing arise opposite the space between veins 9 and 10, as in *E. madarella* Clemens, to which it is closely allied in all other respects. The venation of the hind wing is the same as that of the other species described.

Most of the species of the genus are single-brooded. A search for mines from March to May on leaves of grasses and sedges is sure to result in interesting discoveries. Many larvæ which feed on the basal overwintering leaves begin to mine in the autumn, completing their growth early in the spring. Some species are strictly confined to one species of grass as a food plant, and in some instances to certain parts of the plant.

The pupæ present very reliable specific characters. Two species with quite similar imagoes may have strikingly different pupæ. There are two general types of pupæ in the genus, the extremes of which are quite sharply distinguished from one another. In one of these, represented by *E. prælineata* Braun, which is figured by Miss Mosher,* the body is stout, and from the dorsal view ovate in general outline with the lateral margins of the abdomen curving posteriorly to the anal end. In this type the cuticle is shining throughout. Examples among the species below are *E. orestella*, *E. albicapitella*, and *E. argentosa*.

* A Classification of the Lepidoptera based on Characters of the Pupa, Bull. Ill. State Lab. Nat. Hist., Vol. XII, Art. II, 1916, Plate XXVI, Fig. 100.

In the other type of pupa, the body is slender with the dorsum of the first three abdominal segments depressed and the median ridge here low. From the dorsal view, the abdomen is elongate and gradually tapering with its lateral margins almost straight, and lateral ridges more prominent. In this type, the pupa is dull, pale, of opaque appearance, sometimes shining chitinous toward head. Examples are *E. leucofrons*, *E. sylvestris* and *E. irrorata*. The tubercles which reach an extreme development in *E. prælineata*, are usually minute or absent on the wings, smaller on the head, and only very prominent on the sides of the mesothorax. There are in certain species pointed projections from the lateral ridges of the abdomen. In general, the tubercles are most conspicuous in the first type of pupa. As is apparent from the descriptions of the imagoes below, a grouping of the species on imaginal characters would not coincide with a separation on pupal characters.

The types of the new species described below are at present in the writer's collection.

Elachista argentosa n. sp.

Face and head silvery gray, with a bluish metallic luster, palpi silvery gray inwardly, fuscous beneath and outwardly; antennæ deep blackish brown throughout. Thorax deep golden brown, shading to metallic gray behind. Fore wings almost black with faint golden brown reflections in some lights; markings bluish metallic silvery. Base of wing bluish metallic silvery; a fascia just before middle produced a little toward tornus on dorsum; opposite costal and dorsal streaks at two-thirds, the costal curving outwardly in the middle of the wing and sometimes slightly dilated at its tip before apex, and rarely met by the dorsal streak; cilia dark brown. Hind wings broad, grayish brown, becoming bluish along costa near base. Legs silvery gray, middle tibiæ and all the tarsi dark brown, with tips of segments silvery. Abdomen shining fuscous. Expanse: 7–7.5 mm.

Type (♂) and two paratypes, both males, reared from larvæ mining a narrow-leaved *Carex*, Clermont County, Ohio, imagoes June 1–3; two captured specimens, male and female, Cincinnati, Ohio, June 7 and 23.

The mined leaves of *Carex* were collected May 3. The mine extends from the tip of the leaf downward, lying nearer the upper epidermis, and the parenchyma is mostly consumed. The epidermis of the mine near the point of exit, which always lies over the midrib, is slightly wrinkled. Earlier portions of the mine often extend beyond this point toward the base of the leaf, but the epidermis is nowhere else wrinkled. The pupa is surrounded by a very open irregular network. It belongs to the stout ovate shining chitinous type. There are rows of minute tubercles on dorsum of mesothorax, prominent tubercles on sides of mesothorax, faint lines of tubercles on the wings, and prominent tubercles on front of head.

Allied to *E. madarella* Clem. with which it agrees exactly in venation and breadth of hind wing. The dilated portion of the costal streak before the apex almost corresponds in position with the pale golden spot "in the middle of the wing before the tip" in that species.

Elachista sylvestris n. sp.

Face and head silvery gray, with a slight yellowish tinge, shading to golden brown behind; palpi silvery, with the lower and outer surface of second segment blackish, third segment toward apex with a little black outwardly. Antennæ blackish brown, apical fifth whitish in both sexes. Thorax and fore wings blackish brown with a faint golden brown luster; the tips of tegulæ and tip of mesothorax silvery; a silvery patch at base of wing broadest on dorsum; a nearly straight almost perpendicular slightly irregular silvery fascia just before middle; a silvery tornal spot reaching middle of wing and a costal silvery spot a little beyond it reaching to or slightly beyond the middle of the wing and curving a little outwardly in the middle of the wing; cilia dark brown. Hind wings and cilia dark brown. Legs dark brown, tips of segments silvery and a silvery band around basal third of hind tibiæ. Abdomen dark brown above, silvery beneath. Expanse: 8–8.5 mm.

Type (♂) and twenty-two paratypes (7 ♂'s and 15 ♀'s), reared from larvæ mining leaves of *Poa sylvestris*, Cincinnati and vicinity, imagoes May 30 to June 6.

The mines are found upon the stem leaves of the grass in May. The early inconspicuous mine, 1½ to 2 inches long, lies along the margin of the leaf. The larva leaves this mine, and enters a leaf at its tip, making a white mine about three inches long extending entirely across the leaf, in which the parenchyma is entirely consumed. As no empty egg-shells were found on any of the mined leaves, the moth soon after emerging presumably deposits the eggs at the base of the plant, and the young larvæ do not hatch until the following spring, when they crawl up the flowering stems. Larva entirely pale yellow. Pupa without cocoon, of the slender elongate type, pale yellow, opaque, shining chitinous only toward head; with irregular projecting tubercles on mesothorax.

Elachista albicapitella Engel.

In the latter half of March, overwintering leaves near the base of the stems of tufts of *Poa sylvestris* were found mined by larvæ of this species. At this time most of the larvæ were full grown and preparing to pupate. In the early part of the mine, the parenchyma is partially consumed, later the leaf blade becomes rather inflated and almost all the parenchyma is eaten. The larva often mines down into the sheath leaving it to enter another leaf. The leaves attacked are those nearest the base of the stem and are usually reddish. The larva doubtless begins mining in the preceding autumn.

Larva pale yellowish, first thoracic segment with two rather broad dorsal stripes sometimes nearly confluent, becoming darker posteriorly and each ending in a black spot, the spots sometimes confluent on the posterior border of the segment; mid-dorsal line whitish. A slight silken cocoon is spun of threads placed transversely to the pupa, which is of the stout ovate type, with prominent rounded tubercles on the sides of the mesothorax.

The moths appear in May following a warm early spring or in June if the season is less advanced. In this species the wing markings, although shining white, lack the silvery luster of *E. sylvestris*.

Elachista leucofrons n. sp.

Head blackish, slightly irrorated, with a creamy white patch across the face below base of antennæ, sometimes covering the whole face below the antennæ; palpi black below and at extreme apex, white above, the white completely encircling the base of the third segment; antennæ fuscous annulate with gray. Thorax blackish, with tips of tegulæ white; fore wings blackish, slightly irrorated, the irroration sometimes forming faint whitish lines of which two, one below and one above the fold and parallel with it, are most often discernible. Wing from extreme base of costa across to dorsum narrowly white; an irregular narrow white fascia at one-third, oblique in its costal half, nearly perpendicular in its dorsal half; an erect narrow white spot at tornus, and nearer apex, a similar costal spot, in one specimen nearly obsolete; a distinct row of black atoms forming a line at base of the grayish black cilia. Hind wings and cilia dark blackish brown. Legs except femora blackish, with tips of all segments and basal half of hind tibiæ, whitish. Abdomen blackish brown above, entire body silvery beneath. Expanse: 9–10 mm.

Type (♂) and five paratypes reared from larvæ mining leaves of *Hystrix patula*, Cincinnati, Ohio; imagoes May 3–12; one captured specimen May 23.

The larvæ mine the basal overwintering leaves from October or November until April of the succeeding spring. The following description is made from mines collected in the latter part of March, when the larvæ were nearly full grown. The mine is grayish, extending from the tip of the leaf-blade downward and broadening somewhat below. At about the middle of the mine the true upper epidermis of the leaf, which in this grass faces downward, due to a twisting of the leaf, is wrinkled, drawing the leaf into a fold. When the winter leaves have been frozen, new mines are made in the spring. Larva grayish, first thoracic segment with two indistinct brownish dorsal stripes, each ending in a black spot at the posterior margin of that segment. Pupa not enclosed in a cocoon, but attached flat to the leaf, with head upward; of the slender, elongate type, yellowish gray, not shining chitinous; with low rounded tubercles on the sides of the mesothorax, and small, rounded tubercles on the front of the head.

This species in its early stages may be distinguished from *E. orestella* Bsk. which makes a similar mine on the same grass, by the grayish color of the mine and larva and by the different character of the pupa. The imagoes are separated from *E. albicapitella* Engel by the absence of white on the crown, the peculiar markings of the palpi and the duller white of the wing markings.

Elachista irrorata n. sp.

Head dark gray, densely speckled with black; palpi black beneath, gray above; antennæ black. Thorax and fore wings dark gray, so densely speckled with black that the general aspect is nearly black; a narrow irregularly indented white fascia just beyond one-third the wing length; just beyond apical third, an oblique white streak reaching the middle of the wing, and opposite it a small white dorsal spot. Cilia dark gray, almost black, with a black line of scales at the base. Hind wings gray, densely and evenly irrorated with black; cilia grayish black. Legs blackish with the tips of segments and a rather broad band near the base of the hind tibiæ white. Abdomen dark gray above, becoming pale gray toward median line beneath. Expanse 8.2 mm.

Type (♀) reared from a larva mining a leaf of *Agrostis perennans*, Hazelwood, Ohio; imago July 22. Most of the parenchyma in the leaf-blade was consumed, leaving it yellowish and curled. Pupa attached to leaf with a few irregularly placed strands of silk, of the slender elongate type, very similar to that of *E. leucofrons*, but with slight differences in the mesothoracic tubercles.

The dark head and palpi, lusterless white markings, and dark apex and cilia separate this species from other similarly marked species.

Elachista cana n. sp.

Head white; palpi white, shaded with fuscous beneath; antennæ whitish at base, becoming dark fuscous toward tip. Thorax and fore wings dull whitish. Base of costa fuscous; wing slightly dusted with pale ocherous fuscous-tipped scales, which, when not too sparse, are seen to be arranged in three lines, one below costa from basal third and running into the cilia at apical third, a second along middle of fold and passing upward and outward nearly to apex, a third below the fold and running into it near the margin. Apex of the wing sometimes faintly ocherous tinged and with a few microscopic black specks in the extreme apex. Hind wings pale gray, cilia darker. Legs white, tarsi fuscous. Abdomen fuscous above, white beneath. Expanse: 8.5–9.5 mm.

Type (♂) and two paratypes, males, Tolland, Colorado, 9,000 feet, August 10 (E. Lucy Braun, collector).

Elachista orestella Busck.

The larva of this species mines the basal overwintering leaves of *Hystrix patula*, from October or November to May of the following spring. The mine at first lies near the upper epidermis (in *Hystrix* facing downward), which is drawn together, bending the leaf into a fold. Along this fold, 3 or 4 cm. in length, the parenchyma is not consumed, except when the larva nears maturity. Later the mine broadens out, and becomes several inches long. The larva occasionally makes a new mine, entering the leaf at the tip and mining downward. Larva pale yellowish, first thoracic segment with two rather broad dorsal stripes, becoming darker posteriorly and each ending in a black spot; mid-dorsal line of body whitish. Pupa suspended in a very slight cocoon, of the stout ovate type, four mesothoracic tubercles rather prominent.

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MARL DEPOSITS IN OHIO AND THEIR FOSSIL MOLLUSCA.

V. Sterki.

Reports have been published on the marls of several states, but practically nothing is known of such deposits in Ohio. Some years ago collections were made, principally at two places, and the following notes may be of interest. Specimens are in the Carnegie Museum. Many species are also in the museum of the Ohio State University, and in the collection of Dr. R. C. Rush, at Hudson, Ohio. I am indebted to Dr. Frank C. Baker for identifying Lymnæidæ, and to Dr. Bryant Walker for notes on several groups.

TINKERS CREEK MARL.

In July, 1911, Dr. R. C. Rush and I chanced to find a marl deposit along Tinkers Creek, close to the line of Summit and Portage Counties, south of the station Moran of the Wheeling & Lake Erie Railroad. This place is about one thousand feet above sea level and somewhat over four hundred feet above the level of Lake Erie, within the drainage of the latter (Cuyahoga River). Recent dredging of the creek had cut through the marl for about five or six feet, and there was thus an excellent opportunity for collecting. At one place, close to a hill, the marl was partly overlaid with one to several feet of sand and gravel, apparently "glacial drift." How extended the bed is, how deep, or thick, and how much covered, or uncovered at other places, is not yet ascertained. Generally the marl is pure, white, or whitish, but locally somewhat mixed with muck or peat. It is very rich in fossils, and, being soft and fine grained, it could be washed out with a burlap net. Thousands of shells were obtained and others were picked up from the material removed by the dredge. The shells were generally clean and in fair condition, except that the larger and thin shells were mostly broken. All were chalky (conf. the note on the Castalia shells). In September, 1912, the place was visited again and large numbers of specimens were secured.

List of Species.

Zonitoides arboreus Say, very scarce.
Vitrea indentata Say, one specimen.
Pyramidula cronkheitei anthonyi Pilsbry, one.
Polygyra profunda Say, one, found by Dr. Rush.
Succinea ovalis Say, very scarce, and so are the two following:
Succinea retusa Lea, and **S. avara** Say.
Carychium exiguum Say, one.
Lymnæa stagnalis appressa Say, rather scarce.
Lymnæa (Acella) haldemani Deshayes, very scarce; two specimens, partly broken. These are the only ones ever found fossil, anywhere, so far as known.
Lymnæa (Pseudosuccinea) columella Say, scarce.
Lymnæa (Galba) humilis modicella Say, frequent.
L. (Galba) humilis rustica Lea, rather scarce.
Lymnæa (Galba) obrussa decampi Streng, common; not typical, but probably of that form. This had not been seen from Ohio, previously, either recent or fossil; but since then, Dr. Rush has found it living in Summit County.
Planorbis campanulatus Say, not common.
Planorbis trivolvis binneyi Tryon, scarce.
Planorbis exacutus Say, not common, mostly broken or young.
Planorbis rubellus Sterki, rather scarce.
Planorbis crista Linnæus, scarce.
Planorbis parvus Say, common; adult specimens have the peristome markedly expanded; some are of a more peculiar form: whorls higher and with the outer slope steep. Many are variously deformed. One form has the whorls narrower and more slowly increasing, like those from Castalia.
Planorbis albus Muller, common; the last whorl is strongly descending towards the aperture in most specimens. (*P. hirsutus* Gould is probably not distinct from *albus*).
Ancylus kirklandi Walker, form, rather scarce.
Ancylus parallelus Haldeman, scarce.
Ancylus pumilus Sterki, scarce.

There are apparently some other species of *Ancylus* but the specimens were not sufficient for identification; more good material is desirable.

Gundlachia sp., one specimen, of an early stage, with the small anterior aperture and no *Ancylus*-like expansion; about 2 mm. long and 1 mm. wide.

Physa gyrina Say, rather scarce.

Physa integra Say, a few.

Physa heterostropha Say, scarce.

Physa sayi Tappan, rather frequent, large, mostly broken.

Amnicola limosa Say, common, variable with respect to size and shape.

Amnicola lustrica Pilsbry, abundant, very variable as to size and shape.

Amnicola —— smaller and rather different; may be distinct (Dr. Walker).

Amnicola emarginata Kuster, scarce.

Lyogyrus granum Say, apparently; common.

Valvata tricarinata Say, common, most specimens of a somewhat peculiar form: umbilicus narrow, all three keels threadlike or even lamellar; some are scalaroid.

Valvata sincera Say, frequent, axial striæ fine and slight; the largest has a diameter of 4.7 mm.

Pisidium compressum Prime, common, of different forms: the typical, and *lævigatum* (with the beaks unridged, of quiet water).

Pisidium fallax Sterki, rather scarce.

Pisidium variabile Prime, common.

Pisidium pauperculum Sterki, abundant; different forms, especially: *crystalense*, also recent in Ohio, and *nylanderi*, recent in Maine. A few specimens with partially reversed hinges.

Pisidium sargenti Sterki, rather scarce.

Pisidium adamsi affine Sterki, a few, like those from Meyer's Lake.

Pisidium abditum Haldeman, apparently, rather scarce.

Pisidium walkeri Sterki, scarce.

Pisidium scutellatum Sterki, scarce.

Pisidium ohioense Sterki, rather scarce, like recent specimens, e. g., from Garrettsville, Ohio.

Pisidium splendidulum Sterki, frequent.

Pisidium rotundatum Prime, scarce.

Pisidium medianum Sterki, frequent, rather small form.

Sphærium sulcatum Lamarck, frequent; one specimen with partially reversed hinge.

Sphærium striatinum Lamark, scarce.
Sphærium stamineum Conrad (*solidulum* Prime?), a few, imperfect.
Sphærium rhomboideum Say, a few fragments.
Musculium truncatum Linsley, not scarce but almost all broken.
Musculium securis Prime, one valve, immature.

Of *Unionidæ*, fragments only, are frequent in the top layer, below the sand. None of them could be identified.

It appears that there are several species and forms of *Sphæriidæ* in addition to those cited, and more good specimens are needed for exact identification. All those listed (except *P. pauperculum nylanderi*) are found recent in Ohio, and are widely distributed.

On the gastropods, a few additional notes may be in place. *Lymnæa stagnalis* and *L. haldemani* are not known to be living in this section now; however, they are found in other parts of Ohio, but are rare. Years ago they were listed as found, *e. g.*, in Congress Lake; but careful search there by several collectors during the last twenty years has been in vain.

The first eight species of the list, land snails—*Stylommatophora* and *Carychium*—each represented by one or a few specimens, have evidently been brought there by accident and are not real parts of the fauna. Collectively they constitute only a small part of one per cent of the whole number.

It is evident that the marl was formed in a pond or lake, but connected with a stream as shown by the presence of *Sphærium stamineum* (or *solidulum*) and typical forms of *Pisidium compressum* and *fallax*. At least where the material was collected, it was neither marshy nor directly exposed to floods, or there would be numerous shells of land snails washed in, and the marl would be mixed with sand and debris. It is also significant that there are apparently missing some more or less amphibious species, such as *Segmentina*, *Aplexa*, *Pomatiopsis* and *Sphærium occidentale*, which preferably live in the shallow water of marshy places. The first three of these are represented in the Castalia marl.

This deposit is certainly older than the one at Castalia and older than some marl-like deposits, mixed with muck and peat, in the southern part of Summit County, *e. g.*, in the canal cut south of Summit Lake and at the southern end of Long Lake.

CASTALIA MARL.

In Erie County, west of Castalia and east of Sandusky Bay, is a marl deposit extending over several miles, with the surface about thirty feet above the level of Lake Erie, about ten feet deep where opened, and underlaid with clay. The marl has been used, for many years, for manufacturing Portland cement, and analyses have shown it to be over ninety-nine per cent carbonate of lime. Most of it is soft, but at places with hard concretions, and here and there are blocks and even rock-like masses of travertine, at least partly formed among reeds and rushes, and mosses, mostly *Hypnaceæ* so far as seen. The surface of most of the area is nearly level, and dry, covered with grass and weeds and locally with shrubbery. Some parts are still marshy with a luxuriant marsh vegetation, and in places even covered with open water.

The marl is rich in shells, from bottom to top, and evidently the mollusks had once inhabited the region. At some places they were found in extraordinary numbers; for example, in a perpendicular, artificial bluff at the end of a digging, about four feet from the surface, there was a layer about three inches thick, which was chiefly composed of small and minute shells. The marl of this layer was quite soft, loose and of finer grain than above and below, and through atmospheric influences had disintegrated to fine sand and dust. The dust and clean shells had accumulated on a narrow ledge at the foot of the bluff. Somewhat less than a quart of it was scooped up and taken along, and at a conservative estimate there were over a hundred thousand shells in it, representing more than fifty species, for the most part land snails. Most common was *Carychium*, probably more numerous than all others combined, then: *Pupillidæ*, small *Zonitidæ*, *Helicodiscus*, *Strobilops*, also *Segmentina*, etc. The largest were *Polygyra monodon* and *hirsuta*. Evidently these snails were washed together and deposited as drift by the outer edge of an exceptionally high and widespread flood. The outcropping layer could be followed on a stretch of more than forty feet, though not everywhere with the same wealth of shells.

Most of the larger shells were picked up at various places where a steam shovel had been working but many were taken in situ. Siftings for the smaller ones were gathered here and there, especially where they had been washed together by rains. Only parts of the area exposed could be searched over, though on a stretch of about a mile, in 1915 and 1917. I acknowledge with thanks that on both occasions the officers and engineers of the Portland Cement Company showed me much kindness by giving information and chances to ride on the engines of their trains to and from the marl field.

Most of the shells are chalky. Those of *Pyramidula alternata, Polygyra multilineata* and some *P. profunda* still show more or less of the reddish markings. But many are like fresh ones, translucent or transparent, *e. g.*, all of *Vallonia* and *Pupoides marginata*, some of *Zonitoides minusculus, Vitrea indentata, Gastrocopta armifera, contracta, tappaniana*, and all of one form of *Succinea avara*.

List of Species.

Gastrodonta ligera Say, a few.

Zonitoides arboreus Say, rather frequent.

Zonitoides minusculus Binney, abundant, markedly different forms; some are quite small with narrow whorls. Many have a "lip" deposit in the peristome, close to the margin to a good distance from it.

Vitrea hammonis Strom (*radiatula* Alder), common.

Vitrea wheatleyi Bland, a few.

Vitrea rhoadsi Pilsbry, one shell, not full-grown.

Vitrea indentata Say, common; many are distinctly though narrowly umbilicate.

Euconulus fulvus Muller, frequent.

Euconulus chersinus Say, scarce.

Euconulus sterkii Dall, scarce.

Agriolimax campestris Binney, some shell plates.

Limax ——? one shell plate, 5 mm. long, 3.5 broad and rather thick. This is of particular interest, since no indigenous Limacid of large size is known to inhabit this region.

Circinaria concava Say, rather frequent.

Helicodiscus lineatus Say, common.

Pyramidula solitaria Say, a few, rather large.

Pyramidula alternata Say, rather scarce.

Pyramidula perspectiva Say, scarce.

Pyramidula cronkheitei anthonyi Pilsbry, scarce.

Punctum pygmæum Draparnaud, rather scarce.

Sphyradium edentulum Draparnaud, one specimen.

Polygyra profunda Say, common, mostly large, diam. 30–33 mm., though some are smaller; the spire is rather flat, the shell and lip strong. One shell, apparently normal (not deformed), has no vestige of a tooth on the basal part of the lip.

Polygyra multilineata Say, abundant; variable as to size (larger diam. 18–26 mm.) and elevation of the spire. Some, especially the smaller ones, have the umbilicus only partially covered; one has a distinct tooth on the peristome like that of *profunda*, and a few others have a vestige of the same; one is reversed (sinistral).

Polygyra albolabris Say, scarce; one has a small parietal tooth.

Polygyra thyroides Say, common; one specimen has the last whorl exceptionally rounded, and also the aperture, especially in its basal part.

Polygyra pennsylvanica Green, one found.

Polygyra palliata Say, rather scarce.

Polygyra tridentata Say, rather scarce, near the typical form.

Polygyra fraudulenta Pilsbry, common, rather large and strong-shelled.

Polygyra monodon Rackett, common to abundant; variable with respect to size, elevation of the spire and width of the umbilicus, but there are no *fraterna* (and none approaching it); in some specimens the parietal lamella is slightly but plainly extending to the umbilical end of the peristome; in one, apparently nowise deformed, it is entirely within the aperture. Most of the shells show more or less reddish color, but some appear to be albinoes.

Polygyra hirsuta Say, frequent; a few have the umbilicus not entirely covered; some have a distinct projecting tooth on either side of the notch in the peristome.

Strobilops labyrinthicus Say, rather scarce.

Strobilops affinis Pilsbry, common to abundant.

Vallonia pulchella Muller, fairly common; not chalky. A few are apparently near *excentria*.

Pupoides marginata Say, common, none chalky. Some apparently mature, have no lip in the peristome or a slight one; one is an albino.

Gastrocopta (=**Bifidaria**) **armifera** Say, rather scarce, all of the typical form.

Gastrocopta contracta Say, common, variable as to size and shape; mostly rather stout and ventricose, peristome markedly continuous in most, and well everted; in some, the aperture is more than usually obstructed, especially the parieto-angular and the columellar lamellæ being large, while in some others the columellar is exceptionally small.

Gastrocopta pentodon Say, scarce; one specimen is much like the form *gracilis*.

Gastrocopta tappaniana Adams, abundant; few specimens are typical, i. e., of the usual size and subcylindrical shape; most are small, 1.4 to 1.7 mm. long, and oval (form *curta*), generally with the lamellæ and plicæ well formed, though the infraparietal is missing in most; some are more conical, with the last whorl exceptionally large and well rounded.

One specimen, supposedly of a *Gastrocopta*, is of a very peculiar shape: long. 3, diam. 1.5 mm.; cylindrical, perforate, whorls $6\frac{1}{3}$, the last not much larger, well rounded, without any crest or impression over the palate; a very small, vestigial parietal lamella, a somewhat stronger columellar; in the palate there is a slight irregular callus with apparently a vestigial lower palatal plica; shell chalky, had apparently been colorless. In the absence of more evidence it cannot be regarded as a distinct species, but may be a monstrous, overgrown specimen of *G. tappaniana*. Similar forms of recent *G. armifera* have been seen.

Gastrocopta corticaria Say, very scarce.

Vertigo ovata Say, somewhat scarce; some specimens are small, with the lamellæ and plicæ strongly developed; one is larger than the average*, 2.3 mm. long, with the upper palatal plica exceptionally large and strongly directed upward.

Vertigo morsci Sterki, very common; many are rather small (length 2.3 to 3 mm.), and more ovoid-turriculate than cylindrical, but in these also the last whorl is comparatively small; the presence of an infraparietal is rather exceptional: of one hundred specimens it was found only in ten, a small nodule or vestigial. Some specimens are quite short, oval, with the last whorl somewhat flattened below

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*W. G. Binney, in Mon. Am. Land Shells, p. 334, gives the length of *V. ovata* as 3 mm. This is evidently a mistake, or error.

and keeled at the periphery; evidently they had been injured, and then formed a premature aperture, of almost normal configuration. All are remarkably alike, and resembling *ovata* more than *morsei*, but a careful examination reveals their nature.

This, the largest of the vertigos, has a rather restricted area of distribution, recent, so far as known: Michigan, northwestern Ohio (Castalia), and northeastern Indiana. It should be looked for also in marls of other states.

Vertigo elatior Sterki, common; some specimens are rather small, short, but still different from *ventricosa* Morse, at the basal part, and with the palatal callus and plicæ stronger. It is widely distributed as recent, and found also e. g., in loess of southern Indiana, collected by Mr. A. A. Hinkley.

Vertigo tridentata Wolf, one shell, like the originals from Illinois.

Vertigo milium Gould, a few, of different shapes: some rather ventricose, others narrowly cylindrical.

Succinea ovalis Say, frequent, with a short spire, form *totteniana* or near.

Succinea retusa Lea, frequent, small and mostly young; different forms; a few with the whorls rather ventricose, the majority narrow with the whorls flattened; the latter appear to be of the form *decampi* Gould (Dr. Walker).

Succinea avara Say, rather scarce; near the common, or typical form with the whorls well rounded; not chalky but like fresh, a few reddish, the others pale corneous.

Succinea avara? peculiar form, possibly distinct; larger, 8–10 mm. long, with 4–4½ rather flat whorls; the spire is long and very slender. All of these are chalky, as are also *L. ovalis* and *retusa*.

Carychium exiguum Say, abundant, variable as to size and shape; generally somewhat small, 1.5–1.9 mm. long; some are ventricose with the penultimate and middle whorls large, others narrowly cylindrical or turriculate, resembling *exile*.

Carychium exile Lea, rather scarce; some appear not to be characteristic and are doubtful; their rib-like striæ are slight and irregular.

Lymnæa (Galba) reflexa Say, common. "The specimens are mostly immature and show a great amount of variation. Evidently the body of water in which they lived was subject to much fluctuation in amount of water." (Dr. Baker). Some specimens are much like *elodes* Say, and a few resemble *palustris* Muller.

Lymnæa (Galba) nashotahensis Baker, rather frequent. "This species was originally described from marl deposits in Wisconsin and it is of great interest to find it in your locality. It is apparently related to both *reflexa* and *elodes*." (Dr. Baker).

Lymnæa (Galba) humilis modicella Say, fairly common.

Lymnæa (Galba) humilis rustica Lea, rather common, small; there are forms intermediate between the two.

Lymnæa (Galba) parva Lea, not common, small.

Lymnæa (Galba) dalli Baker, common, small and variable.

Lymnæa (Galba) caperata Say, common, mostly rather small.

Lymnæa (Galba) —— caperata, form? Small, with short, pinched-in spire and pointed apex, and comparatively large body whorl; nothing like it has been seen before.

Planorbis trivolvis Say, abundant, somewhat variable; some are more or less deformed, crippled.

Planorbis umbilicatellus Cockerell, two specimens, rather small and apparently immature.

Planorbis parvus Say, common; somewhat small, with narrow whorls, markedly different from most of the Tinkers Creek marl. Many are variously deformed, crippled.

Planorbis crista Linnæus, scarce; both forms: the one known as *cristatus*, and *nautileus*, smooth, also intermediate specimens. Rare, recent, in Ohio, Indiana, etc., but probably overlooked at some places, on account of its small size.

Segmentina armigera Say, common, rather small.

Ancylus kirklandi Walker, apparently, a few.

Ancylus rivularis Say (?) few.

Ancylus pumilus Sterki, several.

There are evidently several other Ancyli, but the specimens were insufficient, immature, and broken. One is probably of an undescribed species.

Gundlachia ——, one specimen; the same as from the Tinkers Creek marl, partly broken, but enough is left to show its shape.

Physa gyrina Say, common; different forms: typical, and *hildrethiana* Lea. (Dr. Walker).

Physa elliptica Lea, frequent.

Physa integra Say, rather scarce, with the whorls strongly convex.

Physa aplectoides Sterki, scarce.

Aplexa hypnorum, Linnæus, rather scarce, mostly young and adolescent.

Goniobasis livescens Menke, frequent; "a river form like the one in the Sandusky River above Fremont."—(Mr. Calvin Goodrich). This is a remarkable occurrence especially since the snail was found over a wide stretch and at various depths, so that it could hardly have been confined to a stream, or streams, running through the marsh.

Pomatiopsis lapidaria Say, frequent.

Pisidium compressum Prime, scarce.

Pisidium pauperculum Sterki, scarce.

Pisidium abditum Haldeman, rather scarce, small and slight.

Pisidium ohioense Sterki, a few.

Pisidium rotundatum Prime, scarce.

Pisidium medianum Sterki, a few, small.

Of *Unionidae* not a trace was found.

In this fauna the "land-snails" are largely predominating, composing about fifty species out of seventy-three gastropods, and the proportion is still more marked with the numbers of specimens. As previously mentioned, they were found over a wide stretch, from bottom to top, and had evidently been living there* and gradually buried. The region was evidently marshy, possibly with streams running through it, with parts permanently above water covered with mosses and taller vegetation, inhabited by land snails favored by a moist atmosphere. The water was probably generally shallow, its level changing considerably with the seasons. This appears to account for quite a number of things: the irregular and stunted growth of many *Lymnæidæ* and *Planorbidæ,* the absence of Naiades and Sphæria,† and the scarcity of Pisidia, also for the absence of

*Except possibly part of those in the probable drift layer mentioned; unfortunately an exact separate list of them has not been kept.

†Except *G. occidentale* Prime, which might have been expected.

Campeloma, Amnicolidæ and *Valvata* and the presence of *Segmentina* and *Pomatiopsis.* The occurrence of *Goniobasis* is difficult to account for; possibly it is a case of adaptation.

There is hardly a doubt that the Castalia marl is of comparatively recent origin, possibly still in the process of formation in the eastern marshy part of the area. It would be worth while to study more exactly than has been done, the present fauna of the vicinity and compare it with that of the marl.

CONCLUSION.

The two lists, though probably not complete, show that the faunas under consideration are radically different. The Tinkers Creek deposit is a lake or pond formation. As has been pointed out, the few land snails may be left out of consideration, since the fauna is essentially lacustrine, even with a few amphibious species missing. The Castalia fauna, on the other hand, is for the most part terrestrial, there being fifty species of Stylommatophora and *Carychium.* By a coincidence the numbers of Basommatophora in each list is about the same, twenty-one, nine of which are common to both:

Lymnæa humilis modicella and **rustica.**

Planorbis trivolvis, the common form abundant at Castalia with nothing like *binneyi*, which (alone) is scarce at Tinkers Creek.

Planorbis parvus, the only species abundant at both places, but represented by markedly different forms;

Planorbis crista, scarce in both;

Ancylus Kirklandi, and **pumilus,** apparently in both;

Gundlachia ——, one specimen in each;

Physa gyrina, and **integra,** somewhat different forms.

Of Streptoneura, Tænioglossa, there are eight in all, six at Tinkers Creek, two at Castalia, none of them common to both.

Sphæriidæ: about nineteen species, all at Tinkers Creek, some common to abundant, others apparently scarce; six of *Pisidium* are also at Castalia, all scarce.

There is a total of 110 species, only 15 of which are common to both faunas.

New Philadelphia, Ohio.

DESCRIPTIONS OF HORSEFLIES FROM MIDDLE AMERICA. I.*

James S. Hine.

During the continuance of my studies of North American Tabanidæ more or less material has come to hand from southern localities. Panama and the northern parts of South America are of interest as showing the southern limits of distribution of many of the North American species.

Previous to the writing of this paper much time was consumed reading and studying descriptions of species of Tabanus of older authors in an attempt to identify such species as I have had in hand but only partial success has attended my efforts. There has accumulated, with what has been received from the United States National Museum and the Philadelphia Academy of Natural Sciences a number of rather obscure species mostly of small size for which descriptions are given in the following pages.

I have followed with interest the work of Dr. Adolpho Lutz on the horseflies of Brazil and am not unacquainted with his generic treatment of the subfamily Tabaninæ. At first it was the intention to arrange my species in genera according to his arrangement but it is evident that if the whole North and South American horsefly fauna is to be harmonized with it more genera will have to be erected, for I found among my material species that do not fit in any so far established. As it does not seem advisable to describe new genera to receive such species until a more comprehensive consideration of the whole fauna is attempted, I have concluded with some reluctance, to consider everything in the genus Tabanus in the wide sense.

Since an oversight has allowed a preoccupied name to stand in literature for a number of years, it seems to be advisable to offer the following new generic name:

Stichocera, new name, to take the place of Dicrania and Dicranomyia, both of which are names for the same genus. Macquart proposed Dicrania in 1834, but it is antedated by Dicrania in the order Coleoptera 1825. Hunter recognizing this fact in 1900 proposed Dicranomyia to replace it, in Transactions

* Contribution from Department of Zoology and Entomology, Ohio State University, No. 60.

of the American Entomological Society, XXVII, 135, but Dicranomyia had been used by Stephens for a genus of crane-flies in 1829, and a large number of Palearctic as well as Nearctic species are included under it at the present time.

KEY TO SPECIES DESCRIBED IN THIS PAPER.

1. Eyes distinctly hairy....................2
   Eyes bare....................3
2. Abdomen red with a black middorsal stripe. Cross veins of the wings margined plainly with fuscous....................*lautus* n. sp.
   Abdomen dark, each segment with a narrow, white posterior border expanding into a small triangle at the middle of the dorsum....................*punensis* n. sp.
3. Third antennal segment with a long, slender process on basal part....................4
   Third antennal segment with only a prominence on basal part....................8
4. Body unusually robust, wings nearly hyaline....................*validus* n. sp.
   Body of usual form, wings plainly marked with black or brown....................5
5. First posterior cell wide open....................6
   First posterior cell closed....................7
6. Wing crossed by a wide, black band in the region of the stigma, body fuscous, ...*umbratus* n. sp.
   Wing marked with brown in patches from base to apex, body red..*murreus* n. sp.
7. A hyaline spot in the marginal cell near apex....................*festivus* n. sp.
   No hyaline spot in the marginal cell....................*fulmineus* n. sp.
8. Wings with the cross veins and furcation of the third vein margined with fuscous....................9
   Wings uniform in color or hyaline....................11
9. Abdomen red with a regular black middorsal stripe, first antennal segment enlarged....................*mordax* n. sp.
   Abdomen dark all over, first antennal segment of normal size....................10
10. Legs black, front tibia narrowly white at base, antenna yellow..*modicus* n. sp.
    Legs largely red. antenna yellow with the annulate portion black. .*furvus* n. sp.
11. Abdomen not striped....................12
    Abdomen striped....................13
12. Thorax striped, legs black....................*tantulus* n. sp.
    Thorax not striped, legs largely reddish....................*bruesii* n. sp.
13. Abdomen red with a middorsal black stripe....................*tacitus* n. sp.
    Abdomen black with a middorsal gray stripe and an additional stripe on either side....................14
14. Wings lightly infuscated all over, subcallus denuded, rather slender species, ...*trivittatus* Linnæus
    Wings hyaline, subcallus not denuded, small short species.....*curtus* n. sp.

Tabanus fulmineus n. sp.

Length 16 millimeters. Body entirely rust red. Vestiture mostly pale yellowish but black at tip of abdomen. Antennæ and palpi colored like the body, proboscis black at the tip, palpi long and slender nearly as long as the proboscis, first segment of the antenna nearly cylindrical, upper angle of the third segment produced into a long slender process three-fourths as long as the segment; front narrow, sides parallel, frontal callosity widest below, slightly narrowed, slender, elongate, reaching nearly to the vertex. Wings an intense brown, an elongate hyaline spot in the discal cell and a small rounded one in the first submarginal cell just before the branching of the third vein which is devoid of a stump. First posterior cell closed and rather long petiolate.

Legs colored like the body, apical part of front tibia and all the tarsi darker.

Holotype female taken at Gatun, Canal Zone, July, by D. E. Harrower. In my collection.

Tabanus festivus n. sp.

Length 15 millimeters. Whole body yellowish brown abdomen darker towards the tip, palpi slender and elongate nearly as long as the proboscis. First segment of the antenna nearly cylindrical, third segment with the basal process long and slender reaching beyond the beginning of the annulate portion of the segment, front very narrow, sides nearly parallel, frontal callosity elongate and slender, nearly reaching the vertex. Wing glossy yellowish to the stigma and the apical third of the discal cell, from thence to the apex intense brown with the exception of two rather small reniform hyaline spots one in the marginal and the other in the first submarginal cell. Just behind the stigma the color is nearly black, giving the effect of a small rectangular spot. First posterior cell closed.

Holotype female from Gatun, Canal Zone, taken by D. E. Harrower, in my collection.

A paratype from Lion Hill, Canal Zone, taken by August Busck, in the U. S. National Museum.

Two other specimens from Gatun, Canal Zone, and one from Costa Rica.

Tabanus murreus n. sp.

Length 15 millimeters. Color pale yellowish, abdomen slightly darker toward the tip. Apex of the front tibia and its tarsus fuscous. Third segment of the antenna with a long, slender, basal process, palpi long and slender; front very narrow, frontal callosity linear and reaching the vertex. Wing glossy yellowish, more intensely colored on the margins of the veins. Behind the stigma and widening toward the posterior margin is a rather pronounced brown area. Apex of wing from a line drawn from the distal end of the stigma to the tip of the third vein grayish hyaline encroached upon by diffuse brownish in the region of the apex of the first submarginal cell. First posterior cell wide open.

Holotype female from Bartica District, British Guiana, in my collection.

Tabanus umbratus n. sp.

Length 15 millimeters. General color dark brown, darkest toward tip of the abdomen, fourth abdominal segment with a light triangle produced by gray vestiture in the middle of the dorsum with its base on the posterior margin of the segment. Third segment of the antenna with a slender basal process about half as long as the segment, general color of the whole antenna fuscous; palpi elongate slender slightly more than half as long as the slender proboscis, front rather narrow, frontal callosity widest below and narrowed above reaching about three-fourths of the distance to the vertex. Thorax faintly striped; legs pale brown, tarsi slightly darker; wings hyaline with an irregular fuscous band averaging nearly three millimeters in width extending from the costa to the posterior margin in the region of the stigma. No stump on the anterior branch of the third vein, first posterior cell wide open, most of the anal cell very slightly infuscated.

Holotype female from Huguito, San Mateo, Costa Rico, collected by Pablo Schild. In the U. S. National Museum.

Tabanus validus n. sp.

Total length 16 millimeters. Body unusually robust. Thorax brown with very faint gray stripes, especially anteriorly, abdomen distinctly paler in color than the thorax, but darkened apically and with a very small patch of yellow hairs in the middle of the dorsum on the posterior margin of each of segments two to six. First antennal segment enlarged and produced into a distinct angle dorsally where it is furnished with short black hairs; third segment mostly black with a long slender basal process which is about half the length of the segment. Front narrow, frontal callosity widest below, gradually narrowed above and visible for about three-fifths of the distance to the vertex. Wings nearly hyaline, front border only faintly yellowish, first posterior cell wide open, anterior branch of the third vein without a stump. Legs dark, nearly uniformly colored throughout, hind tibia distinctly ciliate outwardly with a dense row of fine dark hairs.

The species shows some relationship with members of the genus Stibosoma.

Holotype female from Higuito, San Mateo, Costa Rico, collected by Pablo Schild. In the U. S. National Museum. Paratype with the same date in my collection. Two other specimens in the U. S. National Museum, one, only 13 millimeters in total length.

Tabanus modicus n. sp.

Total length of the body 11 millimeters. Whole body black with a whitish bloom especially on the thorax and base of the abdomen. Palpi rather slender, pale, with sparse dark colored pile, somewhat shorter than the proboscis. Antenna yellow, first segment slightly produced forward above and furnished with black pile, third segment angulate above near the base and with a tip of black pile but not drawn out into a process. Front moderately narrow, frontal callosity below practically as wide as the front, shining black, widest portion distinctly longer than wide, then gradually narrowed to a line which connects with a shining area at the vertex. Thorax without apparent stripes, wing fuliginous, darker along costal border and on the margins of the cross veins at apexes of the basal and discal cells and at the furcation of the third vein. First posterior cell wide open anterior branch of the third vein without an appendage. Legs black, front tibia narrowly white at the base.

Holotype female from British Guiana, in my collection.

Tabanus mordax n. sp.

Total length 16 millimeters. Abdomen bright reddish yellow on the sides and with a regular black middorsal stripe at least a millimeter in width. The seventh abdominal segment is wholly dark brown both above and below and the extreme lateral edges of most of the other abdominal segments is of the same color, and there is a midventral black stripe also, so the dorsal and ventral views present almost exactly the same coloration. First antennal segment mostly reddish distinctly enlarged above somewhat produced forward and furnished with short black pile, third segment dark, only very slightly reddish at the extreme base, basally with a distinct angle above but not produced. Palpi reddish, rather slender, about two-thirds as long as the dark colored proboscis. Front of average width, frontal callosity widest below where it is distinctly narrower than the front, narrowed gradually above and reaching two-thirds of the distance to the vertex. Legs fuscous except all the tibiæ are reddish on basal half or more. Wings reddish hyaline, all the cross veins and furcation of the third vein narrowly margined with fuscous. Anterior branch of the third vein with a very short stump near its base.

Holotype female from Sapucay, Paraguay, collected in February by W. T. Foster. In the U. S. National Museum. Paratype from the same locality in my collection.

Tabanus furvus n. sp.

Total length 11 millimeters. Thorax and abdomen nearly uniformly dark brown with a very small area of lighter color on each side of the basal part of the second abdominal segment. Antenna mostly yellow, annulate portion of the third segment black; first segment, of normal size with just a slight tip of black hair anteriorly above, base of the third segment bluntly angulate above, palpi slender, pale, black haired little more than half as long as the dark colored proboscis. Front of median width, sides parallel, frontal callosity shining black, below not quite so wide as the front, sides parallel for a short distance then quite abruptly narrowed to a line which reaches two-thirds of the distance to the vertex but does not connect with a black shining spot at the vertex. Front leg dark except the tibia which is pale on basal half. Middle and hind legs almost entirely reddish, femora slightly darkened basally. Wings fuliginous hyaline, distinctly fuscous on the margins of the cross veins and furcation of the third vein. Anterior branch of the third vein without a stump.

Holotype female from Songo, Bolivia, in my collection.

Tabanus trivittatus Fabricius.

Length 12 millimeters. A dark colored rather slender species. Thorax without stripes but with more or less greenish irridescent vestiture. Abdomen dorsally with a little reddish on the sides of the first two segments and with three narrow pale longitudinal stripes, one on the middorsum and one on either side of it. Ventrally abdomen quite broadly red basally. Front narrow, narrower below than at the vertex, frontal callosity nearly as wide as the front and nearly twice as high as wide and without or with only an obscure line above it; subcallus denuded and shining dark brown. Antenna yellow, first segment darker slightly enlarged and produced anteriorly above, third segment with a small tooth near the base above, annulate portion short, only about half as long as the basal portion. Palpi robust nearly as long as the proboscis which is shorter than usual. Wings uniform fuliginous all over, first posterior cell wide open, no stump on the anterior branch of the third vein. Femora and tarsi all black, front tibia white on basal three-fifths, black beyond; middle and hind tibia pale, black only at the extreme apex of each.

I have more than a score of specimens of this species from Bartica, British Guiana, and from other adjacent localities, many of them collected by H. S. Parish. The species answers the description of trivittatus almost in detail.

Tabanus curtus n. sp.

Total length 9 millimeters. Front gray, of medium width, very slightly narrowed below, frontal callosity shining dark brown, nearly square, a disconnected fine line above continued for a short distance only. Antenna yellow, first segment somewhat enlarged, gray pollinose, black haired above; third segment rather wide with a basal angle above, annulate portion shorter than the basal portion; palpi white, robust, with scattering black hairs. Thorax dark dorsally without stripes, clothed with gray vestiture especially laterally and ventrally. Femora black basally, more or less reddish apically, front tibia white on basal three-fifths, otherwise black, middle and hind tibiæ red, tarsi all dark, front ones black. Wings hyaline, first posterior cell wide open, no stump on the anterior branch of the third vein. Abdomen with a prominent middorsal gray stripe and one on either side of it of the same color and of equal width, intervals dark brown, venter fuscous with reddish showing through in places and with red hind margins to the segments.

Holotype female from Pedernales, Venezuela, January 25, 1911, collected by S. Brown. In the collection of the Philadelphia Academy of Natural Sciences. Paratype in my collection.

Tabanus tantulus n. sp.

Total length 10 millimeters. Thorax dark with four gray stripes, the lateral ones just above the attachment of the wings, the median ones located one on either side of the middorsal line, pleura and below white pollinose. Abdomen above dark with a gray pollinose posterior margin to each segment slightly widest on the middorsal line; ventrally similarly colored. Front gray of medium width, frontal callosity shining black, elevated, widest below where it is only slightly narrower than the front, gradually narrowed above and reaching only a little more than half way to the vertex. Antenna reddish brown, somewhat fuscous, first segment somewhat enlarged, third segment with a prominent angle at base above, wide annulate portion elongate, longer than the basal portion. Palpi slender, almost as long as the black proboscis. Wings hyaline, a very short stump near the base of the anterior branch of the third vein, first posterior cell wide open; legs entirely black in all their parts.

Holotype female from Mallali, British Guiana, April 31, 1907. In my collection.

Tabanus bruesii n. sp.

Total length 9 millimeters. Body dark grayish fuscous all over. Thorax without stripes but clothed with gray vestiture. Abdomen dorsally dark with a narrow pale posterior border to each segment, ventrally similar. Front wide, frontal callosity as wide as the front, wider than high, shining black, rectangular, above with a short connected line which almost but not quite reaches a wide shining black broadly cordate spot at vertex. Antenna nearly black, small, slender, first segment nearly cylindrical, third segment with almost no basal prominence above, annulate portion shorter than the basal portion. Palpi white, robust, very short, nearly the same length as the very short black proboscis. Wings hyaline, no stump on the anterior branch of the third vein, first posterior cell wide open. Legs mostly pale, femora with darker streaks, extreme tips of tibiæ, especially the front ones, and all the tarsi somewhat darker in coloration.

Holotype female from San Bartolome, Peru, July, 1913, collected by C. T. Brues. In my collection.

Tabanus tacitus n. sp.

Total length 15 millimeters. Thorax dark narrowly striped with reddish brown. Abdomen above red with a narrow black middorsal stripe, lateral margins of the segments narrowly black and furnished with black pile; ventrally the color is similar to the dorsum. Front of medium width, sides parallel, yellowish gray pollinose, frontal callosity dark brown, widest below, scarcely as wide as the front, gradually narrowed to a line above reaching to three-fifths of the distance to the vertex. Antenna prominent, first segment reddish, enlarged, produced on the upper anterior border and furnished with short black pile. Third segment black, basally above with a distinct angle which is not produced, annulate portion about equal in length to the basal portion. Palpi rather slender, elongate, nearly as long as the black proboscis. Wings pale reddish hyaline, anterior branch of the third vein with a short stump, first posterior cell wide open, no distinct infuscation on the cross veins and furcation of the third vein. Femora nearly black except at extreme apexes which are pale, middle and hind tibiæ reddish, front tibia pale on basal part infuscated on apical half, all the tarsi infuscated.

Holotype and one paratype from Montevidio, Uruguay. Holotype female in the U. S. National Museum, paratype in my collection.

Tabanus lautus n. sp.

Length 13 millimeters. Eyes densely hairy. Thorax dark, obscurely striped and rather densely light pollinose. Abdominal dorsum red with a blackish irregular stripe on the middle line. Venter similar but the blackish is more diffuse and quite evident along the lateral margins of the segments. Front wide, sides clearly parallel, frontal callosity small, reddish rounded, convex, located at the lower angle of the eyes and without a linear extension above. Antenna clear black, first segment nearly cylindrical, third segment wide at the base, distinctly angulate on the dorsal side, annulate portion shorter than the basal portion. Wings faintly reddish hyaline with margins of the cross veins and the furcation of the third vein distinctly infuscated. Anterior branch of the third vein with a very short stump on one side but none on the other. First posterior cell wide open, front femur nearly black, others slightly infuscated, front tibia reddish basally, infuscated on the apical half, other tibiæ red, all of the tarsi infuscated, the front ones quite dark.

Holotype female from Metucana, Peru, Summer of 1913, altitude 7300 feet, collected by C. T. Brues. In my collection.

Tabanus punensis n. sp.

Total length 13 millimeters. Eyes densely hairy. Front wide, sides parallel, frontal callosity as wide as the front, transverse, distinctly wider than high, no line above, a partially denuded spot at the vertex, antenna mostly black, first segment partly reddish with long and prominent black hairs, third segment small prominent above but not with a distinct angle, annulate portion about equal to the basal portion. Thorax dark faintly gray striped, wings hyaline veins dark brown, anterior branch of the third vein without a stump, first posterior cell wide open. All the femora black, front tibia with the basal third red remainder infuscated, middle and hind tibia red with extreme apexes infuscated, all the tarsi slightly infuscated. Dorsally abdomen black with each of the segments narrowly margined posteriorly with gray which is expanded at the middle into a well marked triangle; ventrally mostly red with base and apex and extending out along the midventral line diffuse brownish.

Holotype female from Puno, Peru, November 2, 1898. In my collection.

Ohio State University, Columbus, Ohio.

Scientific Results of the Katmai Expedition of the National Geographic Society.

THE CRANE-FLIES (TIPULIDÆ, DIPTERA).

Charles P. Alexander.

The crane-flies collected by Prof. James S. Hine and A. J. Basinger, members of the Katmai Expedition, have been submitted to me for examination. The material is of exceptional interest in the high percentage of undescribed species that it includes. The types of the new species are deposited in the collection of Ohio State University.

FAMILY TIPULIDÆ.

SUBFAMILY LIMNOBIINÆ.

Tribe Limnobiini.

Genus Limnobia Meigen.

Limnobia hudsonica Osten Sacken.

1861 *Limnobia hudsonica* Osten Sacken; Proc. Acad. Nat. Sci. Philadelphia, 1861, p. 289.

One specimen, Savonoski, Naknek Lake, July, 1919.

Limnobia sciophila Osten Sacken.

1877 *Limnobia sciophila* Osten Sacken; Bull. U. S. Geol. Geog. Survey Terr., 3, p. 197.

One specimen, Katmai, July, 1917. The species had previously been recorded from Kodiak Island by Coquillett.

Limnobia indigenoides, sp. n.

Allied to *L. indigena;* mesonotal præscutum brown with three brownish black stripes; mesopleura and mesosternum broadly dark brown; femora brownish yellow, with a single narrow, brown ring before the apex; wings subhyaline with heavy dark brown seams to the cord and outer end of cell 1st M_2; abdominal tergites brownish black, narrowly ringed caudally with yellowish.

Male.—Length 8 mm.; wing, 10 mm.

Rostrum and palpi dark brownish black. Antennæ black, the flagellar segments subcylindrical with conspicuous verticils. Head dark brown, sparsely brownish gray pruinose, most of the pruinosity destroyed in the type; a delicate, impressed median line.

Mesonotal præscutum dark brown with three brownish black stripes, the median stripe entire, broadest anteriorly; scutum with the lobes dark brown, the median area pruinose; scutellum dark brown; postnotum reddish brown. Mesopleura dark brown; metapleura and lateral sclerites of the postnotum paler brown; sternites dark brown. Halteres dark brown, the base of the stem and the knobs obscure yellow. Legs with the fore coxæ dark brown; remaining coxæ obscure yellowish; trochanters obscure yellow; femora brownish yellow with a narrow, brown band before the tip; tibiæ light brown, narrowly tipped with dark brown; tarsi dark brown; tarsal claws very long and slender, with two teeth, the longest just before midlength, the second basal in position. Wings subhyaline with a heavy dark brown pattern along the veins, as follows: a large spot at the origin of Rs; the large stigmal blotch, continued down onto the fork of Rs; cord and outer end of cell 1st M_2 narrowly seamed with brown; narrow brown seams along veins Cu, Cu_2, and the Anal veins; veins dark brown. Venation: Sc_1 ending slightly before midlength of Rs, Sc_2 at the tip of Sc_1; Rs long, square and long-spurred at origin; r removed from the tip of R_1 but this distance considerably shorter than in *L. indigena*, a little shorter than the basal deflection of Cu_1; basal deflection of Cu_1 a short distance before the fork of M.

Abdominal tergites brownish black, conspicuously ringed caudally with yellowish, the yellow pattern narrowed or obliterated at the lateral margins of the segments; sternites two to four yellowish, the lateral margins narrowly black; remaining sternites brownish black, slightly paler medially, the caudal margin very narrowly pale. Hypopygium obscure brownish yellow.

HABITAT.—Alaska.

Holotype, ♂, Katmai, August, 1917 (Jas. S. Hine).

Limnobia indigenoides is most nearly related to *L. indigena* Osten Sacken but is readily told by the coloration of the femora and the unusual reversal of pattern of the abdominal tergites. The wing-pattern is much heavier and confined to the veins beyond the origin of the sector with the exception of narrow seams to the cubital and anal veins.

Genus Dicranomyia Stephens.

Dicranomyia halterata Osten Sacken.

1869 *Dicranomyia halterata* Osten Sacken; Mon. Dipt. N. Amer., pt. 4, pp. 71, 72.

A few males and females from Savonoski, Naknek Lake, July, 1919.

Dicranomyia aquita Dietz.

1915 *Dicranomyia aquita* Dietz; Can. Ent., Vol. 47, pp. 331, 332.

A few specimens of both sexes from Savonoski, Naknek Lake, July, 1919, and one from Katmai, August, 1917. The species had hitherto been known only from the types taken in the vicinity of Great Slave Lake.

Dicranomyia melleicauda Alexander.

1917 *Dicranomyia melleicauda* Alexander; Can. Ent., Vol. 49, pp. 22, 23.

A single female of this autumnal species was taken on Kodiak Island in September, 1919 (Jas. S. Hine). The species had hitherto been known only from the type-locality (Colorado).

Dicranomyia duplicata Doane.

1900 *Dicranomyia duplicata* Doane; Journ. N. Y. Ent. Soc., Vol. 8, pp. 185, 186, pl. 7, fig. 12.

One female specimen from Katmai, July, 1917.

Tribe Eriopterini.

Genus Erioptera Meigen.

Erioptera katmai, sp. n.

General coloration black, dusted with gray; wings of normal shape, yellowish gray, veins dark brown, Sc more yellowish; cell 1st M_2 open, Anal veins divergent.

Female.—Length, 7 mm.; wing, 7 mm.

Rostrum and palpi black, the former dusted with gray. Antennæ black, the basal flagellar segments short-cylindrical, the distal segments oval. Head black, dusted with gray.

Thorax black, dusted with brownish gray, the type specimen badly rubbed. Halteres conspicuously light brownish yellow. Legs with the coxæ, trochanters and femora black, the tibiæ and metatarsi brown, tipped with black, the remaining tarsal segments black. Wings of almost normal shape and size, yellowish gray, the stigmal region but little darker; veins dark brown, Sc yellow. Venation: Sc_1 ending just before r; that section of R_2 before r about equal to R_{2+3}; cell 1st M_2 open; 2nd Anal vein straight.

Abdomen dark, sparsely pruinose and provided with an abundant, short, appressed, golden yellow pubescence. Ovipositor with the valves horn-colored, the tergal valves slightly upcurved, compressed, the tips subacute, the sternal valves shorter, straight, the tips acute.

HABITAT.—Alaska.

Holotype, ♀, Savonoski, Naknek Lake, June, 1919. (Jas. S. Hine).

Erioptera katmai is closely related to *E. angustipennis* Alexander (North-western Canada), from which it is readily told by the almost normal wings. Both of these species, as well as the forms belonging to the *microcellula* group, deviate from the characters of the subgenus *Erioptera* in the straight 2nd Anal vein.

Genus Ormosia Rondani.

Ormosia subnubila, sp. n.

Related to *O. nubila* Osten Sacken; patches of dark hairs on the wings not forming transverse clouds; cell 1st M_2 broader, strongly widened distally.

Female.—Length 6 mm.; wing, 8.2 mm.

Rostrum and palpi brownish black. Antennæ black, the flagellar segments oval, the distal segments more elongated. Head gray.

Thorax dark brown, dusted with brownish gray, the pronotal scutellum yellowish on the sides. Pleura gray pruinose with sparse yellowish hairs arranged in patches; mesosternum with yellowish hairs. Haltees light yellow, the extreme base of the stem darkened. Legs with the coxæ and trochanters gray pruinose, provided with conspicuous yellow hairs; remainder of the legs dark brown. Wings broad, grayish subhyaline, with faint dark clouds along the cord and some of the longitudinal veins beyond the cord; stigma conspicuous, dark brown; veins dark brown; a more nearly hyaline area before the stigma cephalad of the end of the sector. Venation: Sc_2 a little before midlength of the distance between the origin of Rs and the end of Sc_1; cell 1st M_2 closed, much broader than in *O. nubila*, strongly widened distally; m and the outer deflection of M_3 subequal; Anal veins convergent.

Abdomen black, sparsely pruinose and with appressed yellowish hairs. Ovipositor with the tergal valves horn-colored but very dark at the base, the valves strongly upcurved to the acute tips; sternal valves much shorter, straight, the tips subacute.

Habitat.—Alaska.

Holotype, ♀, Savonoski, Naknek Lake, July, 1919 (Jas. S. Hine).

Genus Helobia St. Fargeau et Serville.

Helobia hybrida (Meigen).

1804 *Limonia hybrida* Meigen; Klass. Beschr. Eur. Zweifl. Ins., p. 57.

A few males and females from Savonoski, Naknek Lake, June, 1919.

Tribe Limnophilini.

Genus Limnophila Macquart.

Limnophila subunica, sp. n.

General coloration gray; wings long and narrow, grayish subhyaline, the stigma and small clouds at the origin and end of Rs brown; radial sector longer than R_{2+3}.

Male.—Length, 8 mm.; wing, 8.6 mm.

Rostrum light gray; palpi brown. Antennæ of the male elongated; basal scapal segment brown, sparsely dusted with gray; second scapal segment yellowish brown; flagellar segments brownish black, the basal segments indistinctly yellowish at the extreme base, the segments provided with a conspicuous white outspreading pubescence and moderately long verticils. Head gray.

Mesonotal præscutum yellowish gray with a barely indicated darker median stripe; remainder of the mesonotum and the pleura clear light gray, the dorso-pleural membrane brown. Halteres very pale brown, the knobs dark brown. Legs with the coxæ yellow, indistinctly darkened at the base; trochanters yellow; femora dark brown, more yellowish basally, this color narrowest on the fore legs, broadest on the hind legs where only the tips are darkened; tibiæ and tarsi dark brown. Wings much longer and narrower than in *L. unica;* grayish subhyaline, marked as follows: stigma conspicuous, oval, dark brown; a faint brown cloud at the origin of Rs and a larger and more conspicuous seam at r-m and the deflection of R_{4+5}; outer end of cell 1st M_2 indistinctly seamed with brown; veins brownish black. Venation: Rs long, only slightly arcuated at origin, from one-third to one-fourth longer than R_{2+3}; r at the tip of R_1, inserted on R_2 about twice its length beyond the fork of R_{2+3}; cell 1st M_2 long and narrow, with the basal deflection of Cu_1 inserted at about one-third its length; cell M_1 nearly twice the length of its petiole which is about one-half longer than the basal deflection of Cu_1.

Abdomen brownish gray, the basal sternites more yellowish.

Habitat.—Alaska.

Holotype, ♂, Katmai, June 10, 1919 (Jas. S. Hine).

Limnophila subunica is closely allied to *L. unica* Osten Sacken of North-eastern North America, from which it is readily told by the long, narrow wings with Rs elongate and scarcely arcuated at origin, cell 1st M_2 long and narrow, with the basal deflection of Cu_1 near one-third its length, and other characters. The specimens of *L. unica* recorded by Coquillett (Proc. Washington Acad. Sci., Vol. II, p. 399; 1900) from Yakutat and Sitka presumably refer to the present species.

Limnophila aleutica, sp. n.

General coloration dark brown, sparsely pruinose; legs dark brown, the femoral bases yellow; wings yellow, Rs long, about equal to R_2, r at the tip of R_1; cell M_1 present.

Male.—Length, 10.5 mm.; wing, 10 mm.

Rostrum dark brown; palpi black. Antennæ short; first scapal segment black, sparsely pruinose; basal segments of the flagellum brown, rather enlarged, oval, the distal segments darker and more elongated. Head greyish brown.

Thorax dark brown, shiny, sparsely brownish pollinose, the postnotum with a gray pruinosity. Pleura gray. Halteres rather long, pale, the knobs brown. Legs with the coxæ yellow, the fore and middle coxæ brownish basally; trochanters pale; femora dark brown, the bases narrowly yellowish, broadest on the posterior femora, narrowest on the fore femora; tibiæ pale brown, passing into dark brown at the tips; tarsi dark brown. Wings with a strong yellowish tinge, the subcostal cell even more saturated; stigma conspicuous, dark brown; a faint brown cloud at the end of Rs; veins dark brown. Venation: Rs long strongly arcuated to slightly angulated at origin, subequal to R_2; R_{2+3} but little longer than the basal deflection of R_{4+5}; r at the tip of R_1 and on R_2 at about two-fifths its length; cell M_1 longer than its petiole; basal deflection of Cu_1 at or slightly before midlength of cell 1st M_2.

Abdomen dark brown, sparsely yellowish pollinose. Male hypopygium rather large and conspicuous; ninth tergite produced medially into a rather large, tumid, subquadrate lobe that is gently concave apically; pleurites short and stout; outer pleural appendage slender, chitinized, expanded distally into a flattened blade; inner appendage bent strongly cephalad a short distance beyond the base.

HABITAT.—Alaska.

Holotype, ♂, Katmai, June 10, 1919 (Jas. S. Hine).

Paratopotypes, 3 ♂'s.

Limnophila aleutica may be placed temporarily in the subgenus *Phylidorea* Bigot which includes *L. ferruginea*, *L. adusta* and others. In this group it approaches most nearly *L. similis*, *L. terræ-novæ* and other dark colored species from which it is readily told by the elongate radial sector.

Tribe Pediciini.

Genus Tricyphona Zetterstedt.

Tricyphona frigida Alexander.

1919 *Tricyphona frigida* Alexander; Rept. Canadian Arctic Exped., 1913–18. Vol. 3C, pp. 7c, 8c.

This species was taken at Katmai, June 10, 1919.

SUBFAMILY TIPULINÆ.

Tribe Tipulini.

Genus Stygeropis Lœw.

Stygeropis ominosa, sp. n.

Female.—Length 16 mm.; wing, 15.8 mm.

Generally similar to *S. bergrothi* Williston, differing as follows:

Size larger. Frontal prolongation of the head entirely dark in color. Antennæ with the first scapal segment dark brown, transversely wrinkled; second scapal and first flagellar segments conspicuously reddish yellow, the remainder of the flagellum gradually passing into black. Head obscure gray, the middle of the vertex suffused with brown, paler adjoining the inner margin of the eyes.

Thorax brownish gray, with three dull gray stripes that are indistinctly paler medially, the median stripe split by a capillary black line. Halteres with the base of the stem bright yellowish brown. Legs comparatively stout, especially the fore legs. Wings with a strong fulvous brown tinge that is about intermediate in intensity between *S. dimidiata* and *S. fuscipennis.* Abdomen obscure gray, the caudal margins of the segments narrowly pale, the lateral margins of the tergites broadly yellowish buff, the dorso-median area suffused with brown; ovipositor horn-colored.

HABITAT.—Alaska.

Holotype, ♀, Savonoski, Naknek Lake, July, 1919 (Jas. S. Hine).

Stygeropis fuscipennis Lœw.

1865 *Stygeropis fuscipennis* Lœw; Berliner Ent. Zeitschr., Vol. 9, p. 129.

A specimen of each sex from Savonoski, Naknek Lake, July, 1919.

Stygeropis dimidiata Lœw.

1865 *Stygeropis dimidiata* Lœw; Berliner Ent. Zeitschr., Vol. 9, p. 129.

A number of specimens of both sexes, from Savonoski, Naknek Lake and Katmai, June, 1919. This series shows that this species varies considerably in the coloration of the frontal prolongation of the head and, to a slight degree, in the pattern of the mesonotal præscutum.

Genus Tipula Linnæus.

Tipula hinei, sp. n.

Generally similar to *T. centralis* Lœw; antennæ bicolorous; mesonotum light brown, the præscutum with three clear gray stripes that are narrowly margined with brown, the median stripe split by a capillary brown line; male hypopygium with the ninth tergite as in *centralis*, the U-shaped posterior notch much wider.

Male.—Length 16.5 mm.; wing, 17.6 mm.

Female.—Length 22 mm.; wing, 17 mm.

Frontal prolongation of the head brown, sparsely pruinose; palpi brown. Antennæ with the basal three segments yellow, the flagellar segments distinctly bicolorous, the basal enlargement conspicuous, black, the remainder of the segments brownish yellow; distal flagellar segments slightly more unicolorous. Head light gray, paler adjoining the inner margin of the eye; a narrow, indistinct, capillary line that is impressed on the vertical tubercle.

Mesonotal præscutum light brown, the region before the pseudosutural foveæ more grayish; three clear gray stripes that are narrowly margined with brown, the median stripe split by a capillary dark brown line that broadens out slightly behind; scutum dull gray, each lobe with two clearer gray areas that are encircled by brown; scutellum and postnotum gray with a narrow brown line. Pleura dull gray. Halteres dark brown. Legs with the coxæ faintly gray pruinose; trochanters brownish yellow; femora pale brown, more yellowish basally, the tips narrowly brown; tibiæ and tarsi brown. Wings of the type of *T. septentrionis* Lœw and related species, whitish subhyaline with a heavy brown and gray clouded pattern.

Abdomen brown, the basal tergites paler, the segments pale laterally; sternites pale reddish brown. Male hypopygium as in *T. centralis*, the ninth tergite as in this species but the median notch broadly U-shaped, the adjacent angles subacute. Ninth pleurite small, complete or nearly so; outer pleural appendage rather small, pale basally, covered with a dense pale pubescence and rather long black setæ; inner pleural appendage compressed, the caudal margin roughened and blackened. Ninth sternite profoundly incised beneath. Eighth sternite unarmed.

The female is generally similar to the male but the wing-pattern more tesselated with white. Abdominal tergites buff with three conspicuous brown stripes, the lateral margins conspicuously light gray. Ovipositor and dorsal shield shiny dark brown; lateral margins of the tergal valves with comparatively few (about ten) blunt teeth.

Habitat.—Alaska.

Holotype, ♂, Katmai, August, 1917 (Jas. S. Hine).

Allotopotype, ♀.

Tipula alaska Alexander.

1918 *Tipula alaska* Alexander; Can. Ent., Vol. 50, pp. 412–414.

One male specimen from Katmai, August, 1917.

Tipula fragilina Alexander.

1919 *Tipula fragilina* Alexander; Can. Ent., Vol. 51, pp. 171, 172.

A few specimens from Kodiak in September, 1919, (Jas. S. Hine). Prof. Hine states that the flies of this species were very numerous in the woods during September.

Tipula tænigaster, sp. n.

General coloration of the thorax light gray, the præscutal stripes very ill-defined; legs dull yellow; wings subhyaline; abdomen long and moderately slender; ovipositor with only the tergal valves functional, these short and stout, the outer face flattened and reticulate.

Female.—Length 20 mm.; wing, 13.5 mm.

Frontal prolongation of the head dark above, light gray pruinose; lateral and ventral surfaces obscure brownish yellow; nasus rather long and very broad at the base; palpi brown. Antenna with the basal segment light brown, pruinose above; flagellum black. Head light gray, the middle of the vertex between the eyes with a brown cloud and a capillary dark brown line.

Mesonotum clear light gray, the præscutum with three very indistinct and ill-defined darker gray stripes; a very restricted yellowish triangular area at the humeral region; scutellum brown, more sparsely pruinose than the remainder of the thorax. Pleura light gray, the dorsopleural membrane and the area immediately ventrad of the base of the halteres dull yellow. Halteres light brown. Legs with the coxæ light gray; trochanters dull yellow; remainder of the legs dull yellow with only the distal tarsal segments darkened. Wings comparatively narrow, subhyaline; stigma comparatively large, brown; veins brown. Venation: base of R_2 nearly perpendicular at origin; petiole of cell M_1 nearly equal to m; cell 1st M_2 long and narrow, about as long as cell M_1; m-cu punctiform.

Abdomen comparatively long and slender; basal tergites pale brown; remaining tergites rather bright yellow; a distinct, slightly interrupted, dorso-median line; lateral margins of the tergites rather broadly grayish buff; basal sternites yellowish; segments five to eight pruinose. Ovipositor and dorsal shield light castaneous; valves of the ovipositor very short and stout, the outer face flattened, microscopically pitted and reticulate and with a narrow ridge down the middle; proximal face convex, shiny, provided with pale, erect hairs; sternal valves microscopic.

Habitat.—Alaska.

Holotype, ♀, Katmai, July, 1917 (Jas. S. Hine).

This interesting fly belongs to the group of *T. pribilofensis* Alexander, *T. subarctica* Alexander and other species; the structure of the ovipositor is very different from the other members of the *arctica* group, in which the tergal valves are flattened, with the outer margin serrate. It is possible that this fly is the female of the paratype specimen of *T. subarctica* from this region (see Report Canadian Arctic Expedition, Vol. III, part C, p. 16c; 1919) but it now seems probable that this paratype is not conspecific with the holotype from Camden Bay, Alaska.

Tipula subarctica Alexander.

1919 *Tipula subarctica* Alexander; Rept. Canadian Arctic Exped., 1913–18, Vol. 3C, pp. 15c, 16c.

A paratype of this species was taken at Katmai in July, 1917; a second male from Savonoski, Naknek Lake, June, 1919 (Jas. S. Hine). As remarked under the discussion of the preceding species, this male may belong to *Tipula tænigaster.*

Tipula katmaiensis, sp. n.

Nasus lacking; antennæ with the scape reddish brown, flagellum black, the segments short, binodose; mesonotal præscutum brownish gray with two indistinct brown stripes; wings with a rather strong brownish yellow tinge, stigma brown; abdomen reddish with a black dorso-median stripe; hypopygium simple.

Male.—Length about 11 mm.; wing, 12 mm.

Frontal prolongation of the head dark brown, dusted with yellowish gray; nasus lacking; palpi brownish black. Antennæ with the scapal segments reddish brown, the first segment slightly darkened at the base; flagellar segments black, the intermediate segments short but with the inner face strongly constricted at mid-length, the basal swelling being but little thicker and a little shorter than the distal portion of the segment; outer flagellar segments cylindrical and crowded, the apical segment minute. Head yellowish gray with a moderately conspicuous, capillary, brown, median line; vertical tubercle of moderate size, entire; eyes small.

Mesonotal præscutum obscure brownish gray with two indistinct brown stripes, the lateral stripes obliterated, the stripes submedian in position, separated by a narrow line of the ground color; remainder of the mesonotum brownish gray. Pleura brownish gray. Halteres yellow, the knobs brown. Legs with the coxæ rather large, gray; trochanters yellowish brown; femora and tibiæ reddish yellow, the tips narrowly dark brown; metatarsi pale brown, the tips and the remainder of the tarsi dark brown. Wings strongly brownish yellow, the stigma brown; veins dark brown, Sc and R more reddish brown. Venation: cell 1st M_2 small but high; m short; cell M_1 about twice the length of its petiole.

Abdominal tergites with the first segment brownish black, gray basally; remaining tergites reddish with a continuous black median stripe and paler sublateral stripes; lateral margins of the tergites conspicuously buffy; sternites reddish, very sparsely pruinose. Hypopygium small, pale reddish brown. Ninth tergite with a broad median notch, the lateral lobes squarely truncated. Ninth pleurite complete; outer pleural appendage long, slender, only slightly flattened, provided with sparse, rather short, hairs; inner pleural appendage very long and comparatively narrow, directed dorsad, the tip bent cephalad into the notch of the tergite; at its base, this appendage is expanded into a flattened portion that is directed laterad. Ninth sternite with a broad but comparatively shallow U-shaped median notch. Eighth sternite unarmed.

HABITAT.—Alaska.

Holotype, ♂, Katmai, July, 1917 (Jas. S. Hine).

This interesting little *Tipula* is very closely allied to *T. cineracea* Coquillett in its general size and habitus, the conspicuous lack of a nasus and the venational characters, especially the very high cell 1st M_2. It differs from *cineracea* in the shorter antennæ, with the first flagellar segment entirely dark; the dark brownish gray coloration of the body, the more saturated wings and the details of the male hypopygium; in *cineracea*, the outer pleural appendage is much broader, subspatulate and conspicuously light yellow in color; the notch of the ninth sternite is small, V-shaped and that portion of the sclerite cephalad of it is feebly carinate.

Tipula besselsi Osten Sacken.

1877 *Tipula besselsi* Osten Sacken; Proc. Boston Soc. Nat. Hist., Vol. 19, pp. 42, 43; April, 1877.

Specimens from Savonoski, Naknek Lake, June, 1919.

Tipula appendiculata Lœw.

1863 *Tipula appendiculata* Lœw; Berliner Ent. Zeitschr., Vol. 7, p. 287.

Specimens from Katmai, July, 1917, and from Savonoski, Naknek Lake, June, 1919.

Tipula cimmeria Speiser.

1900 *Tipula strigata* Coquillett; Proc. Washington Acad. Sci., Vol. 2, pp. 402, 403; December 7, 1900; preoccupied.

1909 *Tipula cimmeria* Speiser; Kilimandjaro-Meru Exped., Diptera 4 Orthorapha, p. 57.

One male from Savonoski, Naknek Lake, June, 1919.

Urbana, Illinois.

IMPATIENS PALLIDA FORMA SPECIOSA F. NOV.

O. E. Jennings.

A number of color forms of the Spotted Jewelweed or Touch-me-not (*Impatiens biflora* Walt.) have been described in recent years* and Clute has described† a white form of the Pale Jewelweed (*I. pallida* Nutt.). As herbarium specimens of Impatiens are quite unsatisfactory on account of the very perishable flowers the writer has been careful in the last two or three years to note and collect unusual forms.

The most notable find thus far has been a pale cream-colored and altogether very pretty form of the ordinarily pale yellow-flowered *Impatiens pallida*. This new acquaintance appears not to be Clute's white-flowered form and so it is described as follows:

Impatiens pallida forma **speciosa** f. nov.

Perianthiis cremoricoloratis, sepali saccati parte ventrali intrinsecus rubro-maculata.

The perianths cream-color; the ventral inner surface of the saccate sepal dotted with red.

The type specimen (Pennsylvania Herbarium, Carnegie Museum) was collected by O. E. Jennings, August 27, 1919, from among an extensive bed of typical *Impatiens pallida* on the moist rocky walls of a cool, narrow ravine in Schenley Park, Pittsburgh, Pa.

This form appears to hold much the same relation to *I. pallida* as does forma *Peasei* Weatherby to *I. biflora*. Other characters were noted for f. *speciosa*, as follows: Stems shining, not glaucous (*I. biflora* is usually strongly glaucous, in this region at least); the petioles and upper surface of the midrib are castaneous, the lower surface of the leaves paler; the cream-colored flowers contrast strongly with the pale lemon of the typical *I. pallida*, the carmine-red dots making a striking and very pleasing combination of color; the sac averages about 2 cm. long and about the same in width (wider when pressed out for a specimen), the spur being slender and abruptly appressed to the sac, green-tipped, and about 5 mm. long; the petals are about 2 cm. long, 12 mm. wide, with the basal lobe about 10–12 cm. long and 3–5 mm. wide, the petal having a few carmine-red dots at the base.

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*Weatherby, C. A. Color Forms of Impatiens biflora. Rhodora *19*:115-118. July, 1917.

Further Notes on Impatiens biflora. Rhodora *21*:98-100. May, 1919.

†Clute, Willard N. Amer. Bot. *7*:67. 1904.

WATER STRIDERS NEW TO THE FAUNA OF OHIO, INCLUDING THE DESCRIPTION OF A NEW SPECIES.*

Carl J. Drake.

During the summer of 1916 the writer paid considerable attention to the aquatic and semiaquatic Heteroptera of Ohio, especially in the vicinity of Columbus. The most fertile collecting grounds were the numerous ponds in the bed of the old abandoned canal (near Ira, Hebron, Prentiss, and Rockbridge), the lakes near Akron, Buckeye Lake and Mirror Lake on the campus of Ohio State University. The Olentangy River also furnished a number of favorite and secluded haunts for many species.

All of the water-striders known to occur in the state, save three or four species, were collected on Mirror Lake, also on a rather large stagnant pond in the bed of the old canal at Rockbridge. Some rather interesting records were noted relative to their breeding habits, migration and pterygopolymorphism. *Trepobates pictus* H. S. was by far the most prolific species on Mirror Lake and only occurred in the apterous form. It is probably our most variable water-strider in color-forms. The insect breeds in stagnant ponds, lakes and parts of slow-moving streams. On the Rocky River, near Cleveland, the writer took many nymphs and adults, including a single example of an alate form. The latter had broken off its wings at the usual place in order to permit coition. *Gerris canaliculatus* Say spends the winter in the mature form. Nymphs and adults, both apterous and alated forms, were observed by the hundreds on the old canal at Rockbridge during July, August and September. Many records were recorded for the capture of one or two macropterous forms on the Olentangy River, Mirror Lake and numerous small ponds at various times during the summer. In a number of instances it seems that the insect must have migrated to Mirror Lake or to the small ponds and pools during night, or early morning or evening, as no specimens were present on these waters during the previous days. Similar observations were observed for *Merragata brunnea*

* Contribution from the Department of Entomology, New York State College of Forestry, Syracuse, N. Y.

Drake,† *Gerris rufoscutellatus* Latr. and *G. conformis* Uhl. The size of the wing-pads in the short winged form of *M. brunnea* are very valuable. About the middle of July *Gerris remigis* Say became rather scarce upon Mirror Lake, but two or three days later many long winged forms had immigrated to the lake. These alate forms began to slowly disappear and in less than two weeks they had all migrated to new waters. A number of other records were recorded for the migration of *G. rufoscutellatus*, *G. conformis* Say, *G. remigis*, *G. marginatus* Say, *G. buenoi* Kirk., *Microvelia hinei* (n. sp.), *M. borealis* Bueno to Mirror Lake and other ponds in the vicinity of Columbus. *Gerris canaliculatus*, *G. conformis* and *M. hinei* n. sp. seems to have only visited Mirror Lake occasionally and did not breed there during the summer. One specimen of *G. marginatus* was captured "in flight" along the south bank of the lake during the fore part of June. The writer also observed the notonectid *Notonecta undulata* Say, leave the water and migrate by flight from Mirror Lake. It was during the middle of May and the insect was captured by Mr. De Long and the writer as it was flying away from the lake.

A more detailed report upon the aquatic and semiaquatic Heteroptera will appear in a subsequent paper. A complete bibliography relating to the Hemiptera of Ohio has been published by Osborn and Drake in "Additions and Notes on the Hemiptera-Heteroptera of Ohio," Ohio Journal of Science, Vol. XV, pp. 501-508.

Velia stagnalis Burmeister.

Six specimens, all apterous; Sandusky Bay, Lake Erie (legit V. R. Haber); Rockbridge (legit A. J. Bassinger). This Species has been reported from Ohio, Pennsylvania, District of Columbia, North Carolina and the West Indies. It breeds in stagnant water.

Microvelia fontinalis Bueno.

Two examples, collected on Lake Abram, near Berea, by the writer. The macropterous form is unknown. The Vellinæ‡ of the Atlantic States have been carefully studied.

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† Drake, Carl J., Florida Buggist, Vol. III, No. 1, p. 2, 1919.
‡ Bueno, J. R. de la Torre, Bul. Brookl. Ent. Soc., Vol. XI, pp. 52-61, 1916.

Microvelia borealis Bueno.

This species is found throughout the state, both apterous and macropterous individuals being quite common. Specimens are at hand from Cleveland, Berea, Wooster, Tiffin, Buckeye Lake, Prentiss, Hebron, Columbus (Mirror Lake and numerous small ponds in the vicinity of Columbus), Sugar Grove, and Rockbridge. It is usually a little larger than *M. buenoi*§ or *M. hinei* (new species described below) and the hind tibiæ are distinctly curved in the male.

Microvelia hinei new species.

Winged Form. General color velvety black or dark brownish black, the hemelytra with white area in the cells. Head a little longer than wide, with an impressed median, longitudinal line and with two more or less distinct broad, reddish brown marks (one on each side of impressed median line) on the basal portion; eyes prominent, the distance between them greater than their diameters; head with silvery gray pile next to the eyes. Antennæ slender, rather short, not reaching to the posterior margin of pronotum; first segment strongest, curved, subequal in length to the third; second segment shortest; third segment slenderest; fourth segment longest, about two and a half times the length of the first, at its widest part about equal to the second in thickness, fusiform. Antennæ and legs dark brown, the coxæ, trochanters, basal portion of femora and usually a rather large area on first antennal segment flavous. Elytra brownish black, the cells with white areas, the outer margins hairy. Pronotum a little wider than long, with a broad, transverse, finger-like flavous line near the anterior margin, with two transverse rows of foveæ (one on each side of flavous line), usually with a broad, dark, median streak; humeral angles tumid, rather prominent, the lateral margin reddish brown. Abdomen beneath blueish gray. Femora practically straight in both sexes.

Male a little shorter and more slender than female. Genital segments not prominent, usually retracted within the abdomen; first genital segment very broadly, deeply and roundly notched beneath, the posterior margin above nearly straight. Length, (male) 1.6 mm., (female), 1.65 mm.; width, (male), .6 mm., (female), .65 mm.

Apterous Form: Smaller than the winged form and usually considerably lighter in color. Thorax with two segments visible above, the prothorax longest and the posterior margin concave. Connexivum rather broad, light yellowish brown, the outer margin and narrow border between segments dark brown. Body beneath flavous or brownish, the pile silvery gray. Thorax dark brown, usually conspicuously marked with flavous or reddish brown, a broad transverse line near the anterior margin of the prothorax and a broken median line (usually to the second abdominal segment) flavous. The last two

§ Drake, Carl J., Bul. Brookl. Ent. Soc., Vol. XV, pp. 19-21, 1920.

abdominal segments a narrow median line and a spot on each side of the first two segments, more or less grayish. The color markings are somewhat variable in different specimens. Length, 1.4 mm.; width, about .51 mm. The male is slightly smaller than the female.

The species is named in honor of Prof. J. S. Hine. *Type*, winged male from Mirror Lake, Columbus, in my collection. *Morphotypes*, apterous male and female, from a small pond in the old canal near Ira, Ohio. Numerous specimens, from Ira (Summit Co.), Buckeye Lake, Hebron, Delaware, Columbus (Mirror Lake and several small ponds near the University campus), Prentiss and Rockbridge, during the summer of 1916. The specimens from Ira were collected by Prof. Hine and the writer on a small pond in the old canal. The species was taken in company with *M. borealis* Bueno, *M. americana* Uhler, *Merragata foveata* Drake, and *M. brunnea* Drake. It lives and breeds near the shore of stagnant ponds and small lakes. *Paratypes* in the collections of Ohio State University, New York State College of Forestry and the writer.

Merragata brunnea Drake.

The types of this species and *M. foveata* are from Ohio. The species ranges from Nebraska east to New York City and south to Florida. The writer collected immense numbers of nymphs and adults at Gainesville, Florida, during the summer of 1918. All records indicate that the insect lives and breeds in ponds, swamps and near the shore of small lakes. Both brachypterous and macropterous forms are quite common.

Merragata foveata Drake.

This insect ranges from Colorado to Illinois and Ohio, and east to New York and south to Florida. The writer took an alate example in an old swamp near Gainesville, Florida.

Gerris argenticollis Parshley.

Two males were collected at Sandusky by the writer. I have another example from Mississippi. It was described from the New England States.

New York State College of Forestry, Syracuse, New York.

NOTES ON THE GENUS PLATYCOTIS STAL.

H. L. Dozier.

The genus *Platycotis* is represented in the United States by two distinct color varieties of one and the same species, *Platycotis vittata* Fabr., and a smaller, pale yellow species, *P. minax* Godg. which is found in California on oak.

Van Duzee gives the distribution of *P. vittata* as follows: N. J., Pa., Md., D. C., N. C., Ga., Fla., Texas, Ariz., Calif., Vanc. Isd (Mexico). The writer found last instar nymphs on oak at Columbia, S. C., April 23, 1918.

P. vittata and its color variety *quadrivittata* have long been regarded as two distinct species on account of coloration. The fact that each of these also is found in two forms, with and without a porrect horn, in both sexes has only added to the synonomy of the species.

This confusion seems to be cleared up by the following observations, which were made at Gainesville, Fla., while attempting to work out the life history. A colony of sixteen males and fourteen females, all typical *quadrivittata* adults, was confined about the first of April, 1918, on an oak limb, enclosed in a new bobbinet netting for observation. This colony was confined at the edge of "hammock" forest under natural conditions, being on the same limb from which the colony was taken *en nature*.

Observations were made every few days but no eggs were deposited. On April 17, a little over two weeks, all were living but had changed in markings from *quadrivittata* to almost typical *vittata*. They had lost all of the lines, except a bare trace of the one on side of pronotal horn near its end, and had assumed the mottled appearance of *vittata*. On this date observations were discontinued due to the writer leaving Florida. Whether the change in markings was physiological, due to being confined or whether it is a question of senility or what is unknown.

This seems to prove conclusively that these two color varieties are the same species. This is the position taken by Van Duzee in his "Check List of Hemiptera."

Platycotis vittata Fabr.

Fabricius, Syst. Rhyng., p. 20, 1803, *Centrotus*.

Crescent City, Sevenoaks (Van Duzee), Lake City IV-9-93 (Station Collection), Gainesville III-18-18. This species is less abundant than the color variety, *quadrivittata*, occurring on oak shrubs.

This species may be easily distinguished from all our other species of membracids (except *Umbonia* and *Lephopelta*) by its very short posterior tarsi. It usually has a long compressed pronotal horn which varies greatly in length and may be entirely absent. The wing venation shows considerable variation. Green body color, mottled or speckled with orange.

Technical Description.—Sea-green, mottled or speckled with orange spots; a long, compressed porrect horn darker and sanguineous at tip; the pronotal horn varies much in shape and length and may be entirely absent; eyes bright red; tegmina hyaline, bases punctate and marked with green and orange, veins fuscous. Very striking in shape and coloration. Sexes similar in size and markings.

Head, including eyes, over twice as broad as long, yellowish with fuscous markings on upper margin adjoining the eyes; base sinuate; eyes large, bright red, changing to brown in dried specimens; ocelli not prominent, brown, nearer each other than to the eyes; clypeus triangular, tip rounded, rugose, hirsute.

Pronotum coarsely punctate, not pubescent; a dorsal median impunctate line extending from the pronotal horn to the posterior process; ground color sea-green, mottled with orange spots; metopidium yellowish on the margin adjoining head, two transverse, polished, fuscous callosities just beneath the furrow above which is a polished interrupted yellowish-green ridge, two smaller, fuscous, impunctate spots above this ridge and fuscous markings at base of pronotal horn; humeral angles prominent, angular but blunt; a long, compressed porrect horn, greatly variable in shape and length and may be entirely absent, tip sanguineous; posterior process gradually acute, slightly decurved and extending beyond the abdomen, tip fuscous.

Tegmina hyaline, base and costal region lightly punctate, marked with green and orange, veins fuscous; under wings entirely hyaline. Under surface of body yellow with slight greenish tinge. Legs yellow, hirsute; tibiæ marked with fuscous on outer side; tarsi fuscous.

Length 9 mm.; length including horn 13 mm.; width between humeral angles 5 mm.

var. **Platycotis quadrivitta** Say.

Say, Jl. Acad. Nat. Sci. Phila., vi, p. 300, 1831; Complete Writings, ii, p. 379, *Membracis*.

Abundant in March and April. St. Augustine (Johnson), DeLand III-25-18 Col. F. Wooten, Lake City IV-9-93 (Station Collection,) Gainesville III-25-17, III-18-18, IV-17-18.

This variety may be distinguished at once from *vittata* by its coloration: pale yellowish-green with four sanguineous vittæ or lines extending near to the middle, the lateral ones short and oblique. Abundant during the latter part of March and through April on oak (Quercus laurifolia and Q. virginiana) at edge of the "hammocks." Sometimes abundant on oak shade trees in the city. It is gregarious, occurring in large colonies of from fifty to a hundred individuals collected along the branches as shown in Fig. 1.

Technical Description.—Identical in size and structure with *vittata*. Differs only in coloration, as follows: Ground color of thorax yellowish-green, four sanguineous vittæ extending near to the middle, the lateral ones short and oblique, extending backwards and joining with margin of thorax; lower margin of thorax red; tip of posterior process fuscous. Base and costal region of tegmina marked with lighter green and yellow.

A horned male adult of this variety collected by E. A. Hartley, at Colorado Lake, near Corvallis, Oregon, has the humeral angles, pronotal horn and the sanguineas vittæ considerably marked with dark fuscous.

The life history of the species has never been worked out. The writer's observations tend to show that it is single-brooded. According to Funkhouser (1917, Biology of Menbracidæ), all the species studied by him have five instars. The following description of the last stage nymph, presumably the fifth instar, has been drawn up from a large series that produced typical *quadrivittata* adults. In this stage they are gregarious. The pronotal developments are very pronounced and the wing pads fully formed.

The vestigial porrect spike of the nymph is strikingly suggestive of the adult *Platycotis* and together with the two simple, heavy spines and bright red eyes make the identification of the species reasonably sure in the last instar.

Technical Description.—Length 8 mm.; maximum width 3.5 mm. Body robust; ground color yellowish-white marked with black. On upper margin of head a black transverse band extending from eye to eye; a like band connecting the lower borders of the eyes; thorax of the ground color, a black band extending near the anterior margin from base of wing pad to wing pad; a dorsal median line of the ground color extending from head, through pronotal horn, to tip of abdomen; this median line bordered with fuscous on thorax; each abdominal segment on dorsum heavily banded with black, broken on each side, with exception of the last three segments, by a heavy band of red, variable in width; anterior pronotal process porrect; pronotum not entirely covering mesonotum dorsally but extending posteriorly as far as the metanotum as an acute point; wing pads fully developed, second pads not extending quite as far posteriorly as the first; legs flavus.

Head much deflexed; frontal tuberosites small; eyes bright red; ocelli pale; clypeus distinct; beak well developed, light fuscous. Prothorax well developed and strongly chitinized; anterior process projecting far forward as a compressed blunt cone, black; mesathorax and metathorax distinct; two simple, heavy, black, divergent spines arising one on each side of the mesonotum; wings pads long. Abdomen greatly swollen, no dorsal spines; under surface yellowish-white marked with fuscous along margins, in female showing impression of ovipositor, fuscous. Legs flavus without markings, hirsute.

Note: On September 16, 1919, nymphs and a hornless adult of *P. vittata* were sent to the Ohio Agr. Expt. Station from Yellow Springs, Ohio, where they were feeding on the cut-leaved birch (Betula alba var.) Some of these nymphs, which appeared to be in the last instar, were hornless, others horned. This raises the interesting question as to whether hornless adults are produced from hornless nymphs and horned adults from horned nymphs.

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EXPLANATION OF PLATE I.

Fig. 1. Adults and last instar nymphs on oak branch, showing their gregarious habits. Nat. size.

Fig. 2. Beginning above: (a) Adult of the color variety, *Platycotis quadrivittata,* horned form. (b) Last instar nymph. (c) *P. vittata,* unhorned form. (Greatly enlarged.)

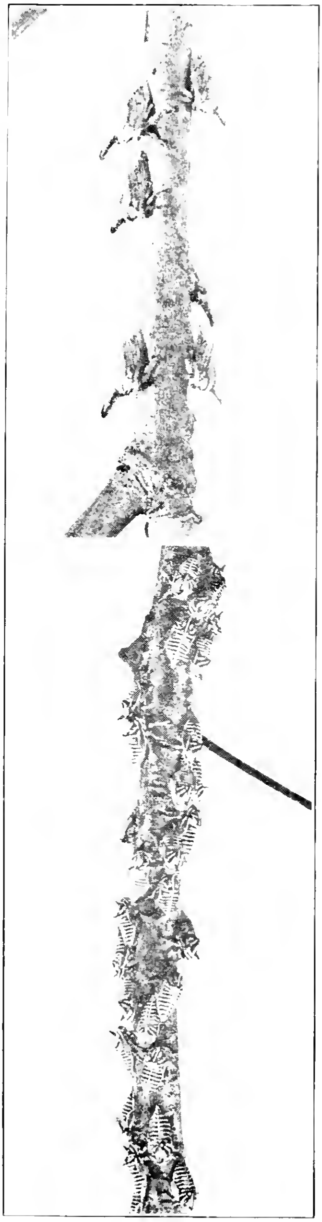

Figure 1

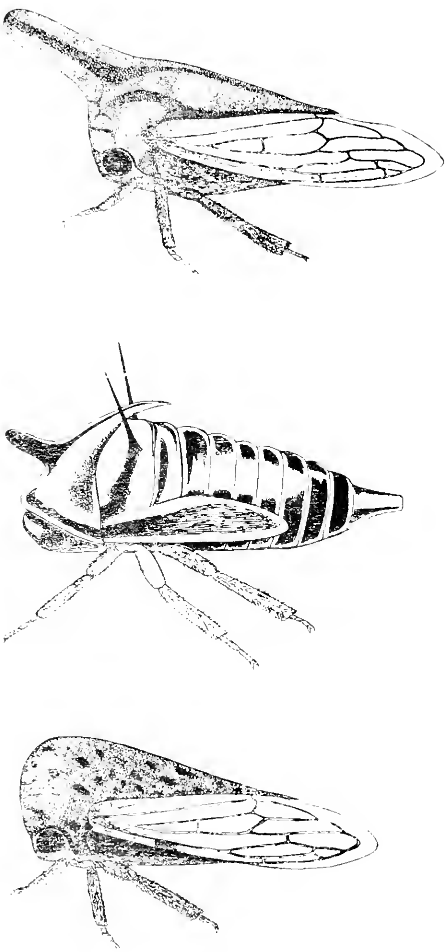

Figure 2

H. L. Dozier

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QUANTITATIVE STUDIES IN THE FOOD OF SPIDERS.*†

S. W. Bilsing.

INTRODUCTION.

Due to the scarcity of records on the feeding habits of spiders, at the suggestion of Professor Osborn, the author made a detailed study of the food habits of the spiders most abundant near Columbus and Crestline, Ohio. These observations covered a period of about six months and were commenced in June, 1913, at Columbus, and were continued during the months of June, July, August, September, near Crestline. Later observations were made in October and November near Columbus.

DISTRIBUTION AND HABITAT.

Associated with the presence of silk glands we find that spiders as a group surpass all the other orders of Arachnida with the possible exception of mites and ticks in diversity of form and size, in number of genera and species, in extent of geographical distribution and in adaptation to varied habits.

Except in the far north and far south, on tops of mountains or where there is no insect life spiders occur all over the world. They occur far up mountain slopes, in tropical forests, in grassy plains, in sandy deserts, in fresh water ponds and even between tide marks on the sea shore.

They live in all sorts of places. Some spiders like *Aranea frondosa* are found around houses and are seldom found any place else. In the corners of rooms very often one finds an irregular network of webs which is the work of *Theridium tepidariorum*. In barns and cellars are small flat webs made

*Contribution from the Dept. of Zoology and Entomology, Ohio State University, No. 62.

†Extracted from a paper written as the thesis requirement for the degree of Master of Arts, Ohio State University.

by *Tegenaria derhami.* Out on the grass in a dewy summer morning one can see hundreds of flat sheet-like webs which belong to the Agelenidæ. *Pholcus phalangiodes* makes an irregular web in cellars and packing houses. On flowers one can often find the small crab spiders with their forelegs extended, waiting for some unwary insect to fly or walk into the trap. In summer and fall *Argiope riparia* and *Argiope trifasciata* make their large vertical orb webs in weeds, tall grass and herbaceous plants. In bushes one is likely to find *Aranea trifolium* and *Metepèira labyrinthea*, both of which are orb weavers. If you pull off the bark from some old log, you may find *Dolomedes tenebrosus.* Lift up a stone and perhaps you will find *Lycosa avida* or some other wandering spider. Late in the fall *Epeira gigas* builds its web in bushes and far up in the trees. Moss and dead leaves are alive with small spiders. Look along an old rail fence, on top of fence posts or pull off the bark of a stump and you will probably find *Phidippus audax*, one of the jumping spiders.

In short, spiders are widely distributed, have a great variety of habits, and are adapted to various conditions. The distribution of spiders depends mainly on the method of capturing their food and the distribution of insects. Those spiders which have adopted the web as a means of capturing food have gained supremacy over non-netbuilding species in point of numbers. Spiders likely first used the silk only for making cocoons and egg cases. The web was probably developed first by those species which live in holes and lined the entrance with silk for protection. This may have developed later into a flat web or a flat web with a retreat at one end. From this simpler type we get a great diversity in web building. The ability to make silk and use it for a variety of purposes is certainly the important factor which has made spiders the most numerous and widely distributed order of the Arachnida.

The "ballooning habit" has enabled spiders to cross long stretches of water and become established on isolated oceanic islands; and to cross arms of the sea from one continent to another. It has also enabled them to cross elevations of land and become widely distributed which would be impossible were it not for the production of silk. The main use to which this silk is put, however, is in food getting and it is likely that it was from this necessity that the habit arose.

MANNER OF CAPTURING PREY.

Spiders are distinctly carnivorous creatures. They feed chiefly on insects but some species are known to feed on fish, birds, toads, frogs and crustaceans. Spiders are also cannibals and do not hesitate to devour weaker members of their own or other species.

They are extremely voracious and will eat a great quantity of food in a short period of time. They are also able to endure long fasts. I kept one alive in a box nearly three months without food. Its death at the end of that time was probably due not to starvation but to the season of the year as it will be remembered that most spiders die in the fall.

The most primitive way of spiders capturing their prey is seen in the Lycosidæ and Attidæ. These spiders never construct any snares but wander around in the grass or under stones in search of their prey which they capture by pouncing upon it from the rear. The struggle for existence is severer and as a result these spiders as a rule are not as numerous as web-building species.

Another class of spiders to which the genus Misumena belongs lie in wait for their prey on plants and flowers. They depend chiefly on protective resemblance to help them in capturing their prey and remain immovable until some unsuspecting insect walks into their jaws when they close in on it.

By far the larger number of spiders procure their prey by means of a snare. These spiders remain near or on this snare constantly and capture a great number of insects often a great many more than are used for food. These snares or webs present a great variety of forms, ranging from a small flat sheet on the surface of the ground to the large orbicular webs sometimes two feet or more in diameter built vertically in grass, weeds or shrubs. In giving determinations in this paper we have for the most part given what the spider captured and not what it actually ate. It will be seen that considered from an economic standpoint the value of the spider ought to be rated by the insects it destroys and not by what it eats.

There is still another class of spiders which feed on what has been captured by other spiders and are called commensal spiders. Most of these are small spiders and relatively unimportant from an economic standpoint.

The Lycosids and Attidæ capture their prey by stalking it and jumping on it from the rear. Most of them have powerful cheliceræ which they sink into their victim and so cause almost instant death. A pair of poison glands located in the cephalthorax and opening on the tip of the cheliceræ by means of ducts is the chief agency that helps in dispatching their prey. This acts almost instantly. I have taken beetles and *Lygus pratensis* away from *Phidippus audax* and *Lycosa fatifera* almost the instant they struck it, always with the same result, the insect was dead. Although most spiders suck only the juices from insects this is not always the case. A *Lycosa fatifera* which I had in captivity, ate the body wall and entire chitinous covering of the larvæ of Elateridæ and Cucujidæ. Another ate an entire grasshopper. The prey in each case being crushed and rolled until it was a mass of pulp. A writer in *Nature*, April 10, 1913, tells of a spider that devours the flesh of fish.

The net building spiders have a variety of ways of capturing their prey. The Agelenidæ or Funnel Weavers rush on the victim, sink the cheliceræ into the insect, then withdraw a short distance. If the insect is not killed, the act is repeated until the insect is disabled. It is then taken to the mouth of the funnel or inside the tube. If the insect is a large one it is usually left at the mouth of the tube where the spider ties it to the web by the legs. A small insect is usually carried directly into the tube.

The orb weavers rush on the insect and pull out a band of silk when they are near the insect. This is thrust against the insect to which it adheres very readily. The band is pulled from the spinnerets by one of the hind legs and by changing from one hind leg to the other the spiders keep at a safe distance from the insect and yet wrap up the insect so quickly that one can scarcely see how it is done. The spider is perfectly at home in its web and can pounce directly on small insects or if the insect has a poisonous sting it can keep it at a safe distance.

Some spiders build a retreat and spin a trap line from the retreat to the web. They hold this trap line taut and this holds the snare taut in turn, but when an insect strikes the web it loosens its hold and the insect becomes entangled in a mesh of threads.

Some of the Therididæ eject on the insect liquid silk from their spinning tubes and I suspect, although I have not proven it, that this liquid silk has a dissolving effect on the chitin. *Theridium tepidariorum*, one of the common Therididæ, destroys many beetles in barns and cellars and the chitinous parts of the insects seem to disintegrate in a short time after it gets into the spider web.

There are many remarkable color adaptations, but since we believe they are mostly adaptations for protection and not food getting, they will not be discussed here.

GENERAL DISCUSSION.

In determining the economic status of spiders several factors should be taken into consideration. The principal ones being the number of spiders of any given species on a certain area, the number and size of the insects used as food, and the economic status of the insects fed upon.

To gain definite information on these things has been the object sought in these observations. Although it is of necessity rather fragmentary, it is hoped that the records will show to some extent the part that these creatures play in the balance of nature. Besides the species of which records are given, many more were found in the same localities, but only the more numerous ones were studied.

Many different spiders of widely separated families may be found living together within a few feet of each other. But each species usually has a preference for a certain kind of condition, as *Argiope riparia* makes its web preferably in tall grass and weeds.

One example of the diversity of species in a limited area will be given. I found on and around a rose bush (*Rosa carolina*) about 20 feet long and 19 feet wide, the following species:

Two individuals of *Metepeira labyrinthea.*
Eight individuals of *Epeira domiciliorum.*
One individual of *Epeira gigas.*
Eleven individuals of *Epeira trifolium.*
Three individuals of *Argiope riparia.*
Eight individuals of unidentified species.

Another example that might be given is an observation made near a stump. The area was about 10 feet square. One of the Attidæ, *Phidippus audax*, was stalking a grass-hopper. The non-net building species were further represented by *Castianeira descripta* and *Lycosa avida*. An *Argiope riparia* had a web at the edge of the stump on a raspberry bush. *Epeira trivitatta* had its web on the same stalk and on a brush pile beside the stump were the webs of seven *Agelena naevia*.

The manner of capturing the prey is also of importance. If a spider builds a vertical web of considerable size and places it in weeds or grass it is evident that a great many more insects will be destroyed than if the spider built a horizontal web close to the ground or built no web at all. If the web is flat and horizontal, like those of the Agelenidæ, the class of insects will be more restricted than in the case of the large Orb Weavers. The location of the web of *Argiope riparia* accounts for the great diversity of the insects captured. A spider which captures its prey by jumping on to it from the rear is not likely to capture as many insects as would a net building species.

Besides the fact of the location of the web, the manner of actual capture seems to be of some importance. The Orb Weavers which we have observed depend on tactile responses to secure their food. If one throws something else in their webs they rush at it in the same manner as if it were an insect. The consequence is they roll up in their webs nearly every insect that chances to strike the webs.

The Lycosidæ and Attidæ depend more on sight and can see for some distance. Misumena remains perfectly quiet until the insect comes to it. The instant the insect comes within grasping distance there is one quick move and the insect is dead. The chances of securing prey in these cases are smaller in comparison to net building species.

In studying the food relations of spiders most of the observations were made directly in the field. Although excursions were made to many different locations, most of the data was collected on an area of about eighty acres. Besides the field observations, I captured a great many specimens and fed them in captivity. I secured about sixty common paste-board shoe boxes and a window pane to cover the top of each box. With this kind of a cage I was able to watch the spiders and see what they would do when insects were put into the box. Spiders kept in captivity must be supplied with water daily or they will soon die. If they are "watered" with a medicine dropper they soon learn to come and drink from the end of the dropper. By gently pressing on the bulb of the dropper the spider can be supplied with water with but little trouble and the proceeding is really interesting.

CLASSIFICATION.

In classifying the species of spiders studied, Bank's Catalogue of Nearctic Spiders was followed. Following each species is the name of the man who identified it. A later catalogue on the synonomy of spiders is Petrunkevitch's which may be found in Volume XXIX, Bulletin of the American Museum of Natural History. The classification by families is as follows:

Lycosidæ: *Lycosa avida* Walckenaer.
Lycosa carolinensis Walckenaer.
Lycosa fatifera Hentz.

Attidæ: *Phidippus audax* Hentz.
Phidippus podagrosus Hentz.

Clubionidæ: *Castianeira descripta* Hentz.

Thomisidæ: *Misumena vatia* Clerck.

Pisauridæ: *Dolomedes tenebrosus* Hentz.

Dictynidæ: *Dictyna frondea* Emerton.

Agelenidæ: *Agelena naevia* Walckenaer.
Coras medicinalis Hentz.

Epeiridæ: *Metepeira labyrinthea* Hentz.
Leucauge venusta Walckenaer.
Epeira trivitatta Keyserling.
Epeira domiciliorum Hentz.
Epeira foliata Koch.
Epeira trifolium Hentz.
Epeira gigas Leach.
Argiope trifasciata Forskal.
Argiope riparia Hentz.

DISCUSSION OF THE FOOD HABITS OF EACH SPECIES.

Lycosa avida Walckenaer.

Lycosa avida was the most common member of the Lycosids found. It was abundant in pastures and along streams, especially where there were a great many loose stones and was also often found under boards lying on the ground around buildings. This spider varies greatly in color, some individuals were nearly white while others were deep gray and some almost black.

Several individuals were kept in captivity and their food relations studied. Although this method is not entirely satisfactory, it is the best method that can be used with some Lycosids such as this one. The fact that they are constantly moving about and keep in hiding a greater part of the time make any other method of studying their food habits difficult and almost impossible.*

Lycosa carolinensis Walckenaer.

The records given on *Lycosa carolinensis* are for a single individual which was the only one seen during the summer. This was a very large one, measuring nearly one and one-half inches. Unfortunately in my absence the cage in which it was kept met with an accident late in the summer, the spider escaped and the record had to be discontinued.

Since this was a large spider I wanted to see how large an insect it would attack. A large Cicada was placed in the box with it on the morning of July 23d. The spider would not attack the Cicada but kept at the other end of the cage. During the night the Cicada was killed and the next morning, July 24th, only the chitinous shell remained, the head, the thorax, and abdomen having been completely hollowed out. From this incident and similar ones I have concluded that the Lycosids seek their prey at night.

This spider usually only sucked out the soft parts and left the chitinous parts such as legs, wings, wing covers, and body wall but in the case of a few flies the whole insects were eaten. When the whole insect was eaten, the victim was crushed and

*A tabulated list of the insects which were fed upon by this and all succeeding spiders whose food habits were observed will be found at the end of the paper on page 255.

rolled between the heavy cheliceræ until there was nothing but a mass of fine pulp.

The following is the record of the insects placed in the cage with the spider:

July 22—Larva of *Lachnosterna*, *Drasteria crassiuscula*, *Promachus vertebratus*, *Pseudopyrellia cornicina*.
July 23—*Chrysopa oculata*, *Cicada linnei*.
July 24—*Tipula flavicans*, *Melanoplus differentialis*.
July 25—*Eristalis tenax*, *Pelidnota punctata*,* *Ischnopetra pennsylvanica*.*
July 26—Larva of *Elateridæ* (Probably *Ludius attenuatus*).
July 29—*Dissosteira carolina*.
July 30—Two *Gryllus abbreviatus*.
August 2—*Apis mellifica*,* *Microcentrum retinerva*.*
August 6—*Diplax rubicundula*.
August 8—Larva of *Papilio polyxenes*.*
August 9—Larva of *Cucujus clavipes*, Larva of *Tenebria molitor*, *Drasteria erechta*.
August 10—*Oecanthus niveus*, *Coccinella 9-notata*.
August 11—*Musca domestica*.
August 12—*Nabis ferus*, *Lygus pratensis*.
August 13—*Formicidæ*,* sp. undetermined. *Tiphia inornata*.
August 16—*Tabanus lineolatus*.
August 20—*Oecanthus niveus*, *Melanostoma mellinum*, *Epicauta pennsylvanica*.*

Lycosa fatifera Hentz.

This spider is widely distributed and has been described under a variety of names and conditions. *Lycosa fatifera* varies from a reddish brown to black. It was common at Crestline, Ohio, during the entire summer. I have found as many as three individuals under one board but this is rather uncommon. One may find one with but little search, however, by lifting up boards and stones. It is found in meadows, in wheat fields, in oats fields, and in fact it can be found most anywhere.

Because of its wandering habits and comparatively good powers of vision this spider is difficult to study in the field and most of the records were obtained from specimens kept in captivity. Like the other Lycosids this spider will not attack insects with strongly chitinized bodies if other food can be obtained. Coleoptera were nearly always refused. The cheliceræ are large and strong and well fitted for crushing prey. Small insects and larva are crushed and rolled into a mass of

*Indicates the insect was not eaten, but was placed in the cage.

pulp and often the entire insect is eaten. Larva of Elateridæ and Cucujidæ were fed this spider. The body walls of these insects are strongly chitinized but the entire larva was frequently eaten. One of them also ate an entire grasshopper. When the larva was not entirely eaten as was sometimes the case, a slit was made down the dorsal side of the larva and the soft parts taken out. Although it would not eat Coleoptera with strongly chitinized body walls and hard elytra, such beetles as *Chlœnius sericæus* which have less strongly chitinized body walls were sometimes eaten.

Some of the beetles which were offered to it but were not eaten:

Nytcobates pennsylvanicus, *Tetraopes tetraophthalmus*, *Evartus sodalis*, *Pterostichus stygius*, *Pterostichus lucublandus*, *Rhynchites bicolor*, *Lucanus dama*, *Chauliognathus pennsylvanicus*, *Epicauta pennsylvanica*, *Myrmicidæ* were offered but were not eaten.

One of these spiders which was kept in captivity ate in a single day, a cockroach (*Ischnoptera pennsylvanica*) and three large grasshoppers. Two of the grasshoppers belonged to the Acrididæ and the other one was one of the Locustidæ. One of the Acrididæ was nearly as large as the spider itself. These insects were eaten on June 29th. After that the spider would not eat anything and died on July 5th.

Another one was fed entirely on larva of Elateridæ for one week to find out how many would be eaten in a limited period of time. These larvæ were kept in the cage all the time and the spider had the opportunity of eating as many as it wanted. Larvæ were eaten on the dates given as follows: One larva each on July 22, 23, 24, 25, 27, 29.

These larvæ were about an inch in length and were likely the larvæ of *Ludia attenuatus*. Sometimes the whole larva was eaten and at other times only the visceral parts.

Phidippus audax Hentz.

Phidippus audax is the most common jumping spider in central Ohio. The three white spots on the back of the abdomen and the green cheliceræ make it a spider that can be easily recognized.

It is a common spider but we could scarcely say abundant. It is most often found on rail fences, under sticks, on fence posts and on the outside of buildings. Wood seems to have some attraction for this spider and one can often find them in a clearing by pulling the bark off an old stump.

To one who can see the humorous side in the action of animals, I know of nothing of more interest than watching one of these spiders. When one of them encounters a large insect or another spider, he holds his head erect often turning it aside like a dog intently listening and lifts up one of his front legs as if to say, "I have the right of way."

Phidippus is a bold spider and will attack insects much larger than itself. I have found one sitting on the side of a stump eating a male cockroach (*Ischnoptera pennsylvanica*) two or three times the size of the spider; another one in blackberry bush eating a *Vespa germanica*. I have noted them in a rail pile eating grasshoppers several times the size of the spider. One which was kept in captivity ate a bald-faced hornet, *Vespa maculata*. As I did not see him capture the hornet I am unable to say as to whether the hornet died and the spider seized it after it had died or whether the spider killed it. I think the latter to be the case as I have never seen this spider eat an insect that has died a natural death.

It is interesting to watch one of them stalk such an insect as *Lygus pratensis*. One sunny afternoon I saw one of these spiders after a *Lygus pratensis* in a patch of tall weeds. The insect evidently was aware of the presence of the spider but seemed to misjudge the danger. It flew from one branch of the weed to the other with *Phidippus audax* constantly on its trail. The spider reminded one of a squirrel up in a big tree jumping from one branch to another, now descending a short distance, running out on a limb, now jumping to another tree, and running up the trunk to a more favorable situation for another jump. He kept up the hunt for sometime, each time he was about ready for the fatal jump, the insect flew to another branch of the weed but his stealth and persistence won. Slipping up a branch from the rear he jumped onto the insect. I took the insect from him immediately but it was already dead.

How this spider as well as *Agelena nævia* and the Lycosids can kill an insect so quickly has long puzzled me. In J. Henry Fabre's book entitled, "The Life of the Spider," is an explanation which seems to solve the problem. Mr. Fabre says the spider sinks the cheliceræ into the insect's ganglion, which is the only place that a thrust from the cheliceræ would cause instant death. This fact, it seems, is the reason why most spiders that attack insects by jumping upon them will seldom ever attack an insect with a strongly chitinized body but will attack a large insect with soft body coverings.

I have often seen *Phidippus audax* pursuing other spiders and occasionally have seen them eating small spiders such as, *Xysticus gulosus* and *Philodromus vulgaris*. But they are often the victim themselves. When one of these spiders jumps or falls into the web of *Argiope riparia* or *Argiope trifasciata* it is helpless and late in the fall many of them become the prey of these spiders.

Another incident shows that this spider possesses something which borders upon intelligence. One morning I was watching one near a large stump. He jumped around evidently in search of prey for sometime. Presently he spied a small spider, *Castianeira descripta* running about and began to pursue it. *Castianeira descripta* was too swift for him and he soon gave up the chase. Next he jumped upon a Funnel Weaver's web, *Agelena nævia*, and began searching it. The Funnel Weaver soon came from its hiding place and chased Phidippus off the web. Soon he spied a grasshopper which was crossing a small stick which was lying on top of two larger sticks.

The two larger sticks formed the base and hypotenuse of a triangle. The stick forming the base was a very large limb. Phidippus peeped up over the edge of this piece and saw the grasshopper with its head pointed in his direction. He immediately ran down the under side of the large limb to where the two large limbs came to a point and ran back up the smaller to the rear of the grasshopper. When he had stolen up to within a couple of inches of the grasshopper he made a leap and landed on the grasshopper's back.

Phidippus audax was watched to see what insects were eaten both under natural conditions and in captivity. In the field I have found them eating: Tabanidæ, Blattidæ, Vespidæ, Capsidæ, Acrididæ, Gryllidæ.

Tests were made to see how many insects of the same species this spider would eat in one week, one test on *Lygus pratensis* was as follows: Oct. 17, Oct. 18, Oct. 19*, Oct. 20*, Oct. 21, 3*; Oct. 22*, Oct. 23, 4*; Oct. 24, 2.

*Indicates insect was placed in the cage, but was not eaten.

The food of this spider where observed consisted chiefly of Diptera, Orthopera, Hemiptera, and Hymenoptera. No case was noted where this spider fed on Coleoptera. The juices are sucked from the insect, and the chitinous parts discarded.

Phidippus podagrosus Hentz.

Phidippus podagrosus is less common than *Phidippus audax.* Comstock calls this spider *Phidippus insolens.* It was found on various kinds of plants. Several females were found in oat fields. This spider is not abundant, but it was not difficult to find a few individuals in the localities where it was studied. The records were all made from spiders kept in captivity.

Castianeira descripta Hentz.

Castianeria descripta is a small black spider with red markings on the abdomen. It is commonly found under stones in meadows and pastures.

It was a common spider at Crestline, Ohio, during the entire summer. One could scarcely turn up a stone in pasture fields without finding one of these spiders. Although they were plentiful, it was difficult to gather much information as to what their food was under natural conditions. Several individuals were kept in captivity and a list of the insects eaten in captivity will be found in the table already mentioned.

Misumena vatia Clerck.

Misumena vatia is a common yellow crab spider which lives on plants and is most often found among flowers. They can usually be found in such flower clusters as Ironweed (*Vernonia gigantea*) and Boneset (*Eupatorium perfoliatum*).

They lie in wait until some insect flies or walks into their cheliceræ when it is seized. As far as I have observed they make no attempt to capture insects as other spiders do, depending wholly upon their coloration as a protective resemblance to aid them in securing their prey. One of these spiders when getting its prey sits with the abdomen down in the flowers and usually with the front legs extended. Its color is usually so nearly that of the flower upon which it rests that it can be picked out only with difficulty. The unsuspecting fly or bee which comes to feed upon the nectar of the flower sooner or later walks into the clutches of this spider. The moment the fly comes within closing distance of the front legs and cheliceræ, they are shut down like a trap. I have observed a fly alight on a flower cluster an inch or two from one of these spiders and begin walking on the flower cluster, the spider never moving, although it seemed to me that it must have been aware of the presence of the fly. The fly walked around on the flower for sometime, but finally came directly into the "jaws" of the spider. One quick movement of the legs and the fly was dead.

I have tried feeding some of them in a cage, but always with the same result. The spider would remain on the side of the box and wait till the fly or jassid jumped or flew within grasping distance of the cheliceræ and front legs. The insect could easily have been pursued, but the spider preferred to let the insect walk into the trap.

One which I observed on top of a pump lived entirely on flies. An old tin cup turned upside down on top of the shaft of the pump was its home. This one remained in the same place for a long time. Several different species of flies were eaten. *Musca domestica*, *Pseudopyrellia cornicina* and *Haematobia serrata* were the species which were taken from the spider. The location of this spider made flies about the only kind of insect which could be captured. All those which were observed on flowers preferred flies to any other kind of insects. Small bees, Andrenidæ, were also eaten.

A few references are made to the food of this spider. In an article entitled "Change of Color and Protective Coloration in a Flower Spider," (*Misumena vatia*), J. Ent. Soc., Vol. 13, pp. 85-96, Dr. Alphaeus Packard states that he saw one of these spiders holding a green fly (*Lucilia caesar*). He fed house flies to four of them which he had in captivity. Dr. Packard also notes one which had an Andrenid bee in its cheliceræ.

Besides the flies mentioned, this spider was observed to feed upon flies belonging to the Syrphidæ, the Dolichopodidæ, the Scatophagidæ, and the Asilidæ. A few bees were eaten belonging to Andrena and Colletes. I also induced one to eat *Lygus pratensis* and Jassids. I tried to feed them Gryllidæ, Acrididæ, and Nabidæ, but never succeeded in getting one to eat any of these insects. As far as I have observed their food consists chiefly of flies and I believe they will eat any kind of Diptera.

Professor Edouard Haeckel, Bulletin Sc. France et Belgique, Vol. XXIII, 1891, says that the food is confined to two species of Diptera. The observations I have made, although they may not be as complete as Mr. Haeckel's, do not bear out this statement.

Dolomedes tenebrosus Hentz.

Dolomedes tenebrosus is one of the largest of our spiders. It lives under the bark of trees, in bushes, and usually near the water. The female carries her egg sac in her cheliceræ and before the young are ready to hatch she makes a web for the young spiderlings to live upon. One of these spiders which was captured under the bark of a red oak log was kept in captivity and she raised two broods during the summer. This spider was not abundant at Crestline and the food records are only for one individual.

Dictyna frondea Emerton.

This is one of the very small spiders and was frequently found on small bushes, especially blackberry and raspberry bushes. It makes an irregular web on the top of leaves by drawing the edges of the leaves together. No retreat is constructed and the spider remains in the web all the time.

If one looks on top of ·leaves on bushes in clearings he is almost certain to find this spider. They are so small that they are easily overlooked.

The food of this spider consisted chiefly of a small fly belonging to the Anthomiidæ and the horn fly, *Haematobia serrata*. The Dolichopodidæ also formed part of their food. An occasional Jassid jumped into the web and if it was not too large to destroy the web, it was also eaten. Midges (*Chironomidæ*) and mosquitoes formed a small part of their food.

From an economic standpoint this spider is not as important as many of the larger spiders, but the fact that they destroy a considerably number of flies and mosquitoes makes them of some importance at least.

Agelena naevia Walckenaer.

Even the casual observer has noticed the web of this spider. The webs are most often in grass, but they may be made in a great many other places, such as among stones, around windows in buildings, on brush piles and a great variety of places.

The web varies somewhat but the typical web is a horizontal sheet, wide at the outer end and with a tubular retreat or funnel at the other. The web is concave and often has an irregular network of threads above it which serves as a barrier to arrest the flight of insects.

When in the grass, the web is made close to the ground and is firmly constructed. The sheet is made by stretching long threads from one side to the other, the threads being nearly parallel. Many fine threads cross these in all directions. At first the web does not have much thickness, but every time the spider crosses it she spins a dragline and the continued use of a web for a long time makes a rather thick structure. If the spider is not molested it will use the same web and stay in the same place for months.

The tubular retreat is used for emergencies. If too large an insect chances to get into the web or if the spider is pursued by one of the Pompilidæ, it retreats to the tube and escapes into the grass or if the web is high enough off the grass, the spider runs out the retreat and round on the bottom of the web and comes upon the top of it again.

Agelena will attack insects much larger than itself. On one occasion I observed one of the Pompilidæ capture a small orb weaver, *Aranea thaddeus*, which had made its web over the web of this funnel weaver's. The small orb weaver was a heavier load than the wasp could carry and both the wasp and its victim fell down upon the web of the funnel weaver. Agelena rushed out from the retreat and gave battle with the wasp. The wasp became frightened and flew away leaving the funnel weaver in possession of the orb weaver, which was carried back to the retreat, where it was eaten.

If the web of this spider is destroyed, it can be reconstructed in a single day. The web is very different in position from the orb weavers and the spiders instead of hanging on the web, run about on the top surface of it. There is nothing adhesive on the web and many insects are able to get off the web in a short time.

The manner of capturing insects is also quite different from that of the orb weavers. When an insect falls upon the web the spider rushes out from the retreat and sinks its cheliceræ into it. After the first thrust she usually withdraws a short distance to see how her victim is faring. If the insect has not been paralyzed or killed outright, she makes another rush at it. This is repeated until the insect is so disabled that it is not capable of making any resistance. Sometimes at the first thrust of the cheliceræ, the insect is not disabled and if the insect is a very large one or able to give her a good fight, the spider gives up the battle and withdraws to her retreat to await a less formidable foe. If the insect is a small one, she comes out of the retreat, seizes the victim with her cheliceræ and returns to the retreat with it. A large insect is usually dragged to the entrance of the funnel where the spider ties it to the web. This is done by circling around and around the insect so as to tie it to the web. The insect is left at the entrance of the funnel, sometimes it is carried in immediately, until it is needed as food, then it is carried into the web, where the soft parts are eaten. After the insect is crushed and mashed by the cheliceræ, the remaining hard parts are dragged out of the tubular retreat and carried to the edge of the web where they are cast over.

Small insects are so crushed and ground up by the cheliceræ that scarcely anything is left of them. One which I fed 122 jassids in a week ground them up so completely that nothing was left but fine powder when I removed the web from the cage in which the spider was kept.

Miris dolobratus was fed to another which I had in captivity. In four days this one ate 39 of these insects and there was not enough fine powder and wing covers remaining to fill a half-inch vial. Grasshoppers and similar insects which are more chitinized, are not entirely ground up, the wing covers, legs and body wall being usually discarded.

The position of the web of this spider, to a certain degree restricts the kinds of insects captured. Being near the ground as it usually is, the greater number of insects which chance to fall upon the web will belong to the grasshoppers, Jassidæ and Capsids. The barrier strands which arrest the flight of insects will cause some flying insects to be thrown upon the web. The flat surface of the top of the web enables some insects to make their escape unless they are immediately attacked by the occupant of the web. The insect will not be captured or entangled in the web unless the spider wants it for food. It is also seen that the insects found in the webs will be those the spider has tied there.

Agelena will attack a grasshopper much larger than itself but will rarely attack a large beetle. The probable reason for this seems to be that the Agelena relies on dispatching her victim by striking a vital spot with its cheliceræ. In case the insect is strongly chitinized as most beetles are, she seldom ever puts up a fight, but prefers to let them alone. I think a probable reason for this is, she is afraid to engage in mortal combat with an insect of which she is unable to strike the fatal spot at the first blow and in that case injury may come to herself. Smaller insects and grasshoppers are easily killed and often one sees this spider dragging a grasshopper over the top of the web holding the hind legs with the cheliceræ.

The feeding period extends over a long period of time. The first funnel webs were noted on May 4, 1913, and the last ones were seen the 28th of October, 1913. This fact, together with the great numbers of them and the kind of insects they eat, make it, in my opinion, the most valuable spider to the agriculturist from an economic point of view. The fact that this spider destroys almost entirely insects of an injurious character is a point worth considering. The food consists mostly of insects that do not have strongly chitinized bodies, but this spider, like many others, I believe, will eat most any kind of insect if the situation of the web makes it necessary to do so. The situation of the web and the prevalence of the insects in large measure determine the character of the food. Since Agelena's web is most often in the grass, where grasshoppers, jassids and capsids are the prevalent insects, they are most liable to be the food. The peculiar mode in which these insects fly from place to place also increases the chance of their alighting on the web of this spider. An insect such as a bee usually flies at some distance from the ground and does not alight unless it is attracted by a flower or something similar but grasshoppers and jassids fly from one place to another and come down in a sort of hit and miss way, so that their chances of falling upon a web of this kind are greatly increased.

The number of these spiders in any given area is enormous. In order to determine how numerous this spider is, I counted them on several different areas. In a clearing which was full of stumps and brush piles and which is an ideal place for this spider, I counted them in midsummer when most of them were nearly full grown. On an area of two and one-half acres, nine hundred and thirty-four individuals were counted. On a brush pile six feet in diameter, I counted thirty-two of these spiders. Another count was made along a lane for a distance of one hundred and thirty-two feet, the count being taken on both sides of the lane between the ditch and the fence. In this distance there were two hundred and sixty spiders.

Counts similar to these may be made almost anywhere in old pasture land, along a roadside, or any place where the spider is not likely to be disturbed.

This spider is a voracious eater but it can also do without food for a long time. One of them was penned up in a tin box for a month with nothing to eat. At the end of that time the spider seemed to be in just as good condition as when put into the box.

This same spider captured forty jassids in a single day. If the spider did not capture them in a short time, the jassids were able to crawl off the web. More than forty were thrown on the web, some of them escaping before the spider captured them. Each jassid was picked up by the cheliceræ and carried back into the retreat. They were left in the retreat until they were needed as food. Like most other spiders Agelena will capture many more than those it needs as an immediate food supply.

Their chances of procuring food are limited if one may judge by the number of spiders seen feeding. Out of the great number of webs visited only a small per cent was found to be feeding or even had any insects in the web. I think this is why the spider captures all the insects possible when the food supply is plentiful. Several tests were made to see how many insects would be eaten in a limited time. One of them was fed jassids, chiefly *Phlepsius irroratus*, as follows: July 1, 15; July 2, 10; July 3, 21; July 4, 26; July 6, 25; July 7, 25; total, 122.

Another was fed larval grasshoppers, as follows: July 1, 5; July 2, 6; July 3, 8; July 4, 5; July 5, 5; July 6, 6; July 7, 5; total, 40.

Another was fed *Miris dolobratus*, which was very abundant at that time: July 1, 12; July 2, 5; July 3, 13; July 4, 9; total, 39. After July 4, this one refused to eat any more and would not eat for several days.

I tried feeding Agelena with several kinds of beetles but they were nearly always rejected. I tried to feed *Rhynchites bicolor* to an Agelena which had its web in a rose bush on which this insect was plentiful. The spider came from the retreat when the insect was thrown upon the web but seldom ever tried to capture it. One day I killed one of these beetles and threw it upon the web. Two hours afterward I came back and found the spider had eaten the soft parts of the beetle. Similar experiments were tried with Coccinellidæ but the spider allowed the beetle to escape. I think this spider will eat beetles if it cannot get other food. The fact that few such insects were found in their webs is due to the abundant supply of grasshoppers which formed their chief food supply. Later in the year *Phytonomus punctatus* was sometimes found in the web of this spider. This beetle had a strongly chitinized body wall and if this is eaten I think other beetles would be captured if no other food could be obtained.

Several hundred webs were examined but spiders were feeding in a very small per cent of the webs. The following data is given on the two hundred and twenty-one webs in which spiders were seen feeding.

53% contained Grasshoppers; *12% contained Ants; 8% contained Jassidæ; 7% contained Capsidæ; 4% contained Syrphidæ; 3% contained Drasteria erechta and Drasteria crassiuscula; 2% contained Gryllus abbreviatus; 2% contained Culex pipiens; 2% contained Harvestmen and spiders; 1% contained Phytonomus punctatus; 1% contained Ceresa bubalus; 1% contained Sapromyza lupulinæ; 1% contained Fulgoridæ; 1% contained Tipulidæ; 2% all other insects.

Coras medicinalis Hentz.

This spider is named *Coras medicinalis* by Professor Comstock, Emerton places it in another genus and calls it *Coeletes medicinalis*. It is a grayish spider about half an inch in length and lives in hollow trees, under blocks of wood and in crevices. The web is similar to *Agelena nævia* and has a funnel retreat.

One specimen was kept in captivity four months and the food records are given on this single individual.

*The percentage of ants is higher than it would normally be, but is given according to the data collected. The spiders which ate these ants had their webs in a clearing around stumps. The ants captured were kings and queens which became entangled in the webs at mating time. This data on the ants was collected in a restricted area and was not obtained over a large area of varied conditions as the rest of the data was. I have watched the workers of several colonies of ants run around over the webs of spiders which were near the ants' nests and the spiders paid no attention to the ants at all, so it is my opinion that Grasshoppers, Capsids and Jassids are preferred to ants ordinarily.

Metepeira labyrinthea Hentz.

Metepeira labyrinthea was not a common species in the localities where it was studied. The web of this spider consists of both an orb web and an irregular web. The orb web is built below and in front of an irregular web. A retreat is made in the irregular net. This retreat is made of leaves so placed as to make a small tent for the spider. One or more trap lines extend from the retreat to the orb web. When an insect becomes entangled in the orb web the spider descends on the trap line and ties it up in the web. If the spider is in need of food the insect is taken back to the retreat where the soft parts are eaten and the remaining parts are thrown from the web. The web of this spider was found in bushes and berry patches but it was not common either at Crestline or Columbus.

Lecauge venusta Walckenaer.

This is one of our most beautiful spiders. It is green tinged with silvery white and golden. Although it is widely distributed it was not abundant in the places where it has been observed. The web of this spider is of the complete orb type and is built horizontally and not vertically as is most often the case with orb weavers.

The webs were found usually around shrubbery or in the woods. Deep woods is preferred to more open places. I have frequently found a web stretched across the top of a hollow stump. An old log house which was frequently visited, was one of the places where this spider was abundant. The webs here were constructed between the old logs which were the sills for the floor, the old board floor having been removed. A lilac bush on the sheltered side of the house where the board siding had been removed projected into the open space. Lecauge seemed partial to constructing its web inside the house and attaching some of the "guy" lines to this bush. Often these lines were ten or twelve feet long. No barrier web was built but the spider usually remained on one of these lines above the web and when an insect struck the web it ran down the line to capture the insect.

Sometimes in webs which were constructed in other places, the spider remained in the center of the hub. Although this spider was carefully studied wherever it was found, the lack of numbers does not permit giving very extensive data on food relations. Because of the small size of this spider, it feeds on small soft-bodied insects. It is easily frightened and permits insects which struggle much in the web to extricate themselves.

Epeira trivitatta Keyserling.

Epeira trivitatta is one of the orb weavers which constructs its web in low bushes, in swamp grass and in fence corners. It is a small spider and is often found in the same places as *Epeira domiciliorum.* Wild rose bushes and berry bushes are favorite places for these spiders to build their webs.

The color is usually brown, but varies a great deal and what I considered several distinct species in food determinations turned out to be but one after they were properly identified.

The web is of the complete orb type and is vertical or nearly so. It is a small web about twelve inches in diameter. When the web is built in a bush, the spider makes a retreat by pulling together several leaves, but when the web is made in grass the spider rests on the center of the hub awaiting its prey.

I counted thirteen of them on one rose bush (*Rosa carolina*), six feet by five feet. On another small bush I counted six. They are not as abundant as might be supposed from these figures, but one can almost always find one or two of them in a clump of bushes.

The insects used as food are wrapped up in a swathing band. The soft parts are eaten and the chitinous parts cast aside. The insect most often found in this spider's web was *Ceresa bubalus.* Next to *Ceresa bubalus*, *Lygus pratensis* was the most common one captured. *Draeculacephala mollipes* and nymphs of grasshoppers came in next. The other insects listed were only found occasionally.

Epeira domiciliorum Hentz.

Epeira domiciliorum and *Epeira trivitatta* are called varieties of the same species by Emerton. Professor Comstock makes two distinct species, naming one *Neoscona arabesca* and the other *Neoscona benjamini.*

The two spiders are found in the same situations, but *Epeira trivitatta* is the more abundant. The web is of the complete orb type and all of them observed made their webs in small bushes. This spider usually commences to build its web a little while before sunset and finishes it before dark or a little after.

All of the individuals of this species observed made a retreat above the web by drawing together several leaves. A trap line extends from the retreat down which the spider goes very quickly if an insect falls into the web. *Epeira domiciliorum* remains in its retreat in the daytime, but at the approach of darkness it descends the trap line and stations itself in the hub of the web. Smaller individuals can be lured from the retreat in the daytime by casting an insect into the web, but I have never been able to get a full grown spider to come out of his hiding place in the daytime.

When an insect is captured, it is carried up the trap line to the retreat, where the juices are sucked out and the chitinous parts are discarded.

Epeira foliata Koch.

Epeira foliata is a spider which is common and is found around houses, barns and fences.

It is more abundant around houses than barns or fences. I have found a few specimens in a deep woods and on weeds, but they were by far the most abundant on houses.

The web is of the complete orb type and is made after night. A trap line sometimes extends from the web to a retreat, but this is not always the case. When the web is made on a house, there is no retreat constructed. A crevice under the siding is usually utilized for that purpose. The younger spiders construct their webs most anywhere on the house, but the larger ones prefer a situation near the water spouting, near a window or a corner of the house, where they can find a place to remain in hiding during the daytime. The larger spiders never come from their retreats during the daytime, the smaller ones will sometimes do so, but very seldom. As soon as evening comes the spiders come forth from their places of hiding and station themselves on the center of the hub. Insects often become entangled in the webs during the daytime and the spider feeds upon them when evening comes. Many house flies become entangled in the morning and evening, when this spider is feeding. I have seen a cuckoo fly, *Chrysis parvula*, hunting for a place to deposit her eggs become entangled in this spider's web. She was unable to extricate herself and in the evening the spider dispatched her summarily. Besides what they actually eat, these spiders destroy an enormous number of gnats and midges which become entangled in the webs at night. The webs of these spiders sometimes contain so many gnats that one cannot estimate their numbers.

When an insect gets into this spider's web, the spider proceeds from the hub and ties it up. Then it returns to the hub with the insect and begins sucking out the juices. If another insect is thrown into the web it ties this insect up and goes back and begins eating the one it was interested in before the second was thrown into the web. So with a second and third, usually returning to the insect it was feeding upon first.

Sometimes each insect will be carried along on the return to the hub and deposited with the insect first thrown into the web. Several times I amused myself by catching a great number of flies and throwing them into the web of this spider one at a time. The first one was usually taken back to the hub of the web, where the spider started to eat it. If a second fly was thrown into the web, the spider tied it up and returned to the center of the hub with it and placed it along side the first one and started eating again. If still another fly was thrown in, the spider repeated the performance. So on with the third and fourth. This was kept up until the spider had accumulated enough flies to make a small ball about the size of an English walnut. Unfortunately, this was too much weight for the strength of the web and it gave way. The spider had to build a new web, but I repeated the performance the next night and he seemed as greedy as ever. One point here, I think, is of some value. No matter how many insects fly or fall into the web, they are all killed. The number of insects from which the spider actually sucks the juice may be small in comparison to the number that are actually killed. In this case the good or bad accomplished by the spider cannot be judged by the number of insects that it actually eats. If the insect is injurious, as is most often the case, the number that is destroyed does not depend on the spider's capacity, but upon the abundance of the insect. Many spiders have the habit of tying up every insect that happens to get into their webs. Where such spiders are abundant we have found them more abundant than the non-net building species, they play an important role in keeping insects in check.

Epeira foliata was studied in two situations, the one along a fence and the other on a house. They were watched all summer upon the house where they were especially abundant. Early in the summer I counted one hundred and sixty-nine individuals on this one house. Most of them were near the ground, around the windows, spouting and porches, but some of the smaller ones were along the side of the house on the second story. I counted them frequently and found the number varied but slightly until the young began to hatch, late in the summer. The number increased to several times the one hundred and sixty-nine individuals, but the young were so small that it was impossible to count them accurately. However, I counted as many as five hundred individuals.

One would naturally suppose that the house fly, *Musca domestica*, would be the insect most often eaten in such a location and such was the case. Several half-grown spiders constantly made their webs in a bed of geraniums where they did good service in destroying a green aphid which infested these plants. The number that was used as food was but a small per cent of the number that was destroyed by becoming entangled in the web. Toward the close of the summer there were not very many of these aphids to be found. Although other factors may have entered to some extent into their extermination, I think it was largely due to these spiders. Besides these insects and a few moths, other insects flew into their webs occasionally.

Excepting the gnats and midges destroyed, because it was impossible to count them, the insects destroyed are rated as follows:

85% consisted of Musca domestica; 5% consisted of Aphids; 3% consisted of Lepidoptera; 7% all other insects.

I tried to make this spider eat the common firefly, *Photinus pyralis*, but never succeeded in getting one to try it. I think this may be due to the bitter taste this insect is supposed to have.

Epeira trifolium Hentz.

The Shamrock spider as this one is sometimes called is one of our largest spiders and also one of the most beautiful ones. This spider matures late in the summer and has a comparatively short feeding period since they all die before winter.

A variety of this species, *Aranea trifolium candicans*, was also studied.

Epeira trifolium makes a large complete orb web and places it preferably in tall grass, on Boneset stalks (*Eupatorium perfoliatum*), on Ironweed (*Vernonia gigantea*) or berry bushes. A retreat is made above the web by drawing together several leaves and making a tent. The leaves are pulled together in such a way as to make a retreat that is difficult to detect. A trapline extends from the retreat to the hub of the web and as soon as an insect gets into the web, the spider comes down the trapline, wraps up the insect in a swathing band and carries it up to the retreat where the soft parts are eaten and the chitinous parts are discarded. In case the spider does not want to eat the insect immediately she returns to her position in the retreat, leaving the insect tied up in the web where it became entangled.

Where one of these spiders has a web in a patch of Ironweeds or Boneset, many honey bees fly into the web which is vertical or nearly so. In such places, one frequently finds a web with a half dozen or more bees in it. A peculiar color adaptation was noticed in this spider. Early in the season all the individuals were either white without markings or grayish with white markings. Later in the season nearly all of them were of a reddish brown color and some were nearly purple. At first I concluded that this was due to the different ages of the spiders. Later on in the season I came upon a couple of instances which have changed my opinion. I found a large specimen which made its web in a clump of Bitter Sweet bushes. A retreat was made above the web in the dead leaves of a branch of an oak tree. The limb had fallen into the bush with the leaves still hanging on it. The spider lived here undisturbed a long time and became the same color as the dead oak leaves. Nowhere else did I find a spider of that peculiar color nor did I find any other spider having a retreat in dead oak leaves. If the environment had no effect on the color of the spider, one would have expected to find similarly colored individuals in other places. Why should this one spider become so nearly alike the retreat if the retreat did not exert an influence on the spider? Another question might be advanced here. Why should the spider change color if coloration were for protection or an aid in procuring food? The spider conceals itself in the retreat until some insect flies into the web and it seems that color resemblance would not be needed for that purpose. Some credence might be given to the protective resemblance theory. A spider the same color as the leaves would not be discovered so easily by many of the spider's natural enemies. Another spider which had a retreat in a deep purple flower was the same color as the flower. These incidents cause me to believe that this spider responds to the color of its surroundings. The fact that most of them are white or grayish white early in the season and later most of them become reddish brown and purplish brown has some explanation. Early in the summer most of the wild flowers are white but later on in the fall Ironweed and purple asters are more in evidence in grassy and marshy places where this spider is most likely to construct its web. While this change may be due to the age of the spider, I am inclined to think it is a response to environment. The color change is so marked in different individuals of nearly the same size that one would suppose that some factor other than age entered into the color change. This color change may aid the spider somewhat in food getting but it is probably of more value as a protection against the numerous enemies of the spider.

Epeira trifolium was not as abundant as *Agelena nævia* and *Argiope riparia* but it was a common spider both at Crestline and Columbus. It is found in pasture lands which have been allowed to grow up in weeds, along roadsides, in bushes and most often in marshy places. As such places do not take up a definite area it is not easy to give a close estimate of the number on any given area. In a pasture field which I often visited one could count twenty to twenty-five of them on a half acre. These were in a patch of weeds and the rest of the field did not contain a dozen spiders because there was no weeds in which they could build their webs. It is fairly abundant in the places where it is likely to be found but these are restricted areas. The large size of the spider makes it an important one from the standpoint of food relations.

Many webs of this spider were observed and the spider's food is based on the contents of one hundred and forty-seven webs in which the spider was observed feeding.

22% contained honey bees; 20% contained grasshoppers; 8% contained Meloidæ, 6% of this 8% being Epicauta pennsylvanica; 7% contained Jassids; 6% contained Drasteria crechta and Drasteria crassiuscula; 6% contained Winged Ants; 4% contained Lygus pratensis;

3% contained Tipulidæ; 3% contained Sapromyza lupulinæ; 2% contained Coccinellidæ; 2% contained Bumble Bees; 2% contained Melanostoma mellinum; 9% all other Diptera not already included.

The highest per cent of any one insect fed upon by this spider was the honey bee. The reason for this is that *Epeira trifolium* does not mature until the first of August or about the time when the first fall wild flowers are in bloom. Such flowers as Golden Rod, Asters, Boneset and Ironweed all grow in places where this spider builds its web. The web is made vertical or nearly so and is often made between the stalks of two of these plants. The bees come to visit the flowers and get entangled in the web. Some of these flowers continue to bloom almost as long as the spider lives, so during their whole feeding period they are living in places where they can easily secure honey bees. I do not think they prefer bees to any other insect, but it is simply a question of the location of the web and the chance of bees flying into it. Grasshoppers are always abundant in the locations where this spider makes its web and forms the second highest per cent of the food of those observed. Nearly all the other insects which enter into the food to any extent are of an injurious character. To decide whether or not this spider is of an injurious or beneficial character several things must be considered. Whether a honey bee is of more value than the destruction of a grasshopper it is difficult to say. If we balance the insects destroyed which are injurious to farm crops against the honey bees and Coccinellidæ, we find that the higher per cent of insects destroyed are injurious ones. But the question would still remain as to what value should be given to honey bees and Coccinellidæ when they are rated against other insects. In my opinion the good they do overbalances the injury.

Epeira gigas Leach.

Epeira gigas is closely related to *Epeira trifolium*. Like *Epeira trifolium*, it is one of our most beautiful spiders. The color markings vary a great deal and Comstock gives three varieties of this same species. The color markings vary so much that one would mistake different individuals for different species. This spider is found in much the same situations as *Epeira trifolium*. However, it is more given to building its web in woods and bushes than is *Epeira trifolium*. It often makes its web in trees ten or fifteen feet from the ground.

The web is a complete orb and is more than a foot in diameter and it is built in a variety of places. One finds them in bushes, on shrubs, on weed stalks, such as Boneset and Ironweed and high up in trees. I have found them more abundant in deep woods than any place else. In one woods where they were especially abundant, they sought out the open places in the woods. This woods was exceedingly thick and somewhat marshy. In these open places were clumps of elderberry bushes, tall weeds and wild flowers. Some of the webs were attached to the elder bushes and some were high up in the trees. I have seen one side of the web tied to a tree two hundred or three hundred feet distant from the web. A retreat is built above the web and usually to one side of it by tying together several leaves and making a sort of tent. A trap line extends from the retreat to the center of the web and the spider descends this to the web and secures its prey. The spider remains in the retreat during the daytime, but comes out at night and takes a position in the center of the hub. When an insect flies into the web it is completely wrapped up by a swathing band. Like *Epeira trifolium*, this spider carries its prey up to the retreat, where the soft parts are eaten and the chitinous parts discarded. It wraps up any insect that chances to fly into the web, so the food depends to a large extent on the location of the web and the prevalence of any certain kind of insects.

This spider matures the last of August and so has a comparatively short feeding period. It was more abundant both at Crestline and at Columbus than *Epeira trifolium*, which has about the same feeding period. I counted the number in a woods of ten acres and noted eight hundred and ninety-six individuals. Nowhere else did I find them so abundant as in this one place. The woods was very thick and no stock of any kind had ever been allowed in it, so this spider had free range. Only 4% of this large number were found to be feeding or to have anything in their webs.

I counted them in other locations and found many of them on small areas. A clump of berry bushes is another location where one usually finds them in abundance. On one such clump of berry bushes, which was ten by fifteen feet there were fifteen of these spiders. In a grove of white ash trees on the edge of a wood several of these spiders built their webs about fifteen feet from the ground, and occasionally a web was suspended between two of the trees.

The percentage of insects used as food is based upon ninety-seven spiders which were observed feeding and is as follows:

20% consisted of Bumble Bees; 20% consisted of Tipulidæ; 17% consisted of other Diptera, chiefly Syrphidæ; 5% consisted of Grasshoppers; 5% consisted of Noctuid moths; 4% consisted of Lygus pratensis; 3% consisted of Apis mellifica; 4% consisted of Vespa germanica; 2% consisted of Vespa maculata; 2% consisted of Ichneumonidæ; 2% consisted of Jassids; 2% consisted of Ceresa bubalus; 2% consisted of Tiphia inornata.

A striking fact about the food of those spiders which were observed was that Bumble bees made up a large part of the food while the highest per cent of any insect eaten by its near relative, *Epeira trifolium*, was honey bees. This again is explained by the location of the webs. *Epeira trifolium* is more abundant among wild flowers in fields, while *Epeira gigas* made its web most often in open places, in woods and among shrubs. Crane flies, which are abundant in woods in late summer and fall, also formed a large part of the food. In such places Grasshoppers are less abundant and so formed a smaller per cent of the food than that of most other spiders. Syrphid flies were abundant in such a place and so entered into the food to a considerable extent. One would not expect many leaf hoppers in such a place and such is the case, only 2% of the food consisting of Jassids. Like the other large orb weaving spiders, the food of this spider where it has been observed is not relegated to any particular insect, but depends largely on what kind is at hand to be eaten.

Argiope trifasciata Forskal.

This spider has a number of names all of which are suggestive of the peculiar striped back. It was very abundant in the places where it was studied. The web is the common orb type and may or may not have barrier webs. It is of considerable diameter, usually from a foot to a foot and one-half from top to bottom, and is made vertically or slightly inclined. There are two or three types of stabilimentum and there may be no stabilimentum at all. In one type the stabilimentum reaches vertically through the web and is comparatively narrow. In another type which is not so common as the former the stabilimentum is irregular in shape being somewhat like a truncated cone narrowed at the base. Late in the season many webs do not have a stabilimentum. This is probably due to the fact that at that time most of the webs are made by mature spiders. The stabilimentum is constructed in the young stages of this spider because the web is smaller and needs more support when a large insect gets entangled in it.

No trapline is made but she hangs head downward in the center of the hub. When a very large insect becomes entangled in the web this spider often makes a hasty retreat. Sometimes it drops to the ground and remains perfectly still until the danger is past then it goes back to the dragline it spun while descending and assumes its former position on the hub of the web. At other times especially when the web is made in big weeds or small bushes, it ascends the web and lies very still on top of a leaf for sometime when it again returns to its former position. Like *Argiope riparia*, this spider makes barrier webs on each side of the main web. Sometimes the barrier web is made on only one side of the web. These barrier webs are more loosely constructed than is the main one. Although I have no definite explanation for the barrier webs, I think they are constructed for keeping out very large insects. Often when an insect strikes the web of *Argiope trifasciata* the spider begins to swing the web until it vibrates very rapidly. I think this is done for two purposes. If the insect is a large one the spider can entangle it sufficiently so that it can wrap it up in a swath of silk when it once advances on it. But if the insect is so large that it is beyond the spider's control, the insect may flounder in the web and becomes entangled without any more serious damage than destroying the spider's home which can soon be reconstructed.

This habit varies greatly with different individuals of this species and sometimes it seemed to me they were trying to shake the insect out of the web. Sometimes this spider advances on a large grasshopper without an attempt at vibrating the web. Many times the victim was twice the size of the spider and was so quickly swathed in a white band of silk that the eye could scarcely register the movements and it was with difficulty that the web was pulled off the victim. It may be that this is a sign of fright as I have made them vibrate the web violently by merely approaching the web or casting something into it, but I hardly think this is a good explanation. When an insect flies into the web the spider rushes on it from its position on the center of the hub and sometimes pierces it with the claws of the cheliceræ but more often this is omitted, the spider advancing upon the insect and when it is nearly upon it, the spider pulls a swathing band from the spinnerets and thrusts this band against the insect with one of the hind legs. The swathing band is of considerable length and of considerable width. It changes from one hind leg to the other and so keeps the insect at a safe distance. When the swathing band has adhered sufficiently, it wraps the insect up. Sometimes the insect is too large and the spider is compelled to retreat. But very seldom is this the case for this spider is able to overpower an insect several times its size. Argiope seems to possess something which verges closely on what we term good judgment for it seems to know what sized insects it can readily dispose of and in case the insect is too large it drops to the ground by means of a dragline or ascends to a leaf until all danger has passed. But once it advances upon an insect the battle is on until the insect has been securely wrapped up. The male makes the same kind of a web as the female, but, considered from the standpoint of their food relations, they are less important because of their much smaller size and short life. I have often found several males on the barrier web of the female.

The great abundance of this spider is due to the kind of snare it makes enabling it to cope with a variety of conditions in securing food. The web is built close enough to the ground so as to capture a great variety of insects that have the habit of jumping from one place to another such as grasshoppers and crickets. It is also built at a sufficient height as to capture many insects that go from place to place by flying. Such a snare has the advantage over such flat webs as the Funnel Weaver's and the spider has a still greater advantage over those spiders which make no web at all.

The webs are constructed in a variety of places. A small patch of blue grass sixty feet by one hundred and twenty feet was literally covered with the webs of this spider. On the 14th of August I counted one hundred and forty-four young spiders in this grass patch. Webs were found in oats fields; sometimes the webs were made on oats shocks. Some were found in pasture fields but they were never found in abundance in fields where cattle or sheep were pastured. They were noted on brush piles and in woods where the trees were scattering but never in deep woods. They were most abundant in places where there was an abundant growth of tall grass and weeds, especially along roadsides and fences and in orchards and clearings on wild rose bushes, on Boneset, and Ironweed. Much of the data was collected in ravines which were overgrown with bushes and weeds. In several ravines of this nature about two miles northwest of Columbus, *A. trifasciata* was very abundant. Clover fields and corn fields were adjacent to these ravines and they made a good place for the study of the food of this spider. In such places it was impossible to estimate the webs on any considerable area but it was not uncommon to find eight or ten webs in a distance of twenty-five feet.

In these ravines their food consisted chiefly of grasshoppers, tree crickets, Jassids, Membracidæ, Pentatomidæ, Coreidæ, Meloidæ, Tipulidæ and Noctuid moths. In the patch of blue grass mentioned 80% of the food consisted of grasshoppers. In the young stages of this spider most of the webs are made in the grass and grasshoppers constitute their chief food. The grasshoppers are captured in the nymph stage and destroyed before they have an opportunity of doing a great deal of damage. In such places their food consists almost wholly of injurious insects. In patches of Boneset, Ironweed and similar weeds which bloom in late summer or fall the food supply is largely honey bees, bumble bees and other Hymenopterous insects which visit these flowers and become entangled in the web of this spider. They have no decided preference for any insect so far as I have observed and the food supply is determined largely by the insects which are prevalent in the places where the web is made. Since the majority of webs are constructed in places where insects which are injurious to farm crops will be entangled, I think this spider is of value from an economic standpoint. These spiders were first noted in abundance the first of August. They were very small at this time and made their small orb webs near the ground in the grass. The last ones were noted November 4th at Columbus. After this date it was impossible to find any females. The winter is passed in the cocoon, the young spiderlings emerging in the summer. The large size of the spider and the long feeding period are factors of importance in considering its value. If people who are always so willing to crush any spider they see either through ignorance or through superstition would study this beautiful creature for a short time they would soon see they were destroying a creature of considerable value to themselves. In my studies I have handled hundreds of these spiders and have not been bitten once.

The per cent of each particular class of insects is based on the contents of six hundred and twenty-one webs of this spider is as follows:

44½% consisted of Grasshoppers; 9% consisted of Jassidæ; 9% consisted of Tipulidæ; 6½% consisted of Eurymus philodice; 5% consisted of Apis mellifica; 4% consisted of Pentatomidæ; 4% consisted of Epicauta pennsylvanica; 3½% consisted of Capsidæ; 3% consisted of Oecanthus niveus; 1% consisted of other spiders.

Like its near relative, *Argiope riparia*, this spider feeds mainly on grasshoppers; nearly half of its food consisting of that insect. The percentage of honey bees eaten is much less than that of *Argiope riparia*. This is due to two things. *Argiope riparia* matures earlier in the season and has more nearly attained its growth when the fall wild flowers begin to bloom. It thus has more opportunity of capturing bees when they visit these flowers. *Argiope trifasciata*, at least those observed, spent the earlier part of their lives in grass and there is little opportunity of capturing bees in grass. By the time it has matured sufficiently to construct a large web some of the flowers are gone and there is less chance of bees getting in the web. Nearly all of the Jassids eaten were one species, *Dræculacephala mollipes*. The Pentatomidæ taken from the webs were of several species, the one most often found being *Euchistus variolarius*. This spider was observed eating more spiders than any other spider. *Agelena nævia*, *Phidippus audax* and *Argiope trifasciata* themselves being the ones eaten. I think this was likely due to the fact that this spider lives late in November when insect life gets scarce and the opportunity for capturing spiders greater.

As far as I have observed, the cannibalistic habit is not so much developed as is generally thought to be the case in most spiders. I have observed several different species of spiders which feed on other spiders but none of them to any great extent until late in the fall when other food becomes scarce. One spider, *Xysticus gulosus*, which was very plentiful late in the fall and which I found most abundant on fence posts seemed to be given to much cannibalism. Sometimes there were three or four of these spiders on one post. Frequently one or more of them was eating some other small spider, *Philodromous vulgaris*, most often being the victim.

I have seen *Argiope riparia* and *Agelena nævia* occasionally eating one of their own species or some other spider but this practice as far as I have observed is not so common as is generally thought to be the case. One can pen a couple of spiders of some species up in a box together and if one keeps them supplied with food they live together peaceably. If food is not supplied they take to the cannibalistic habit and the weaker one becomes the victim of the larger. I had a *Dolomedes tenebrosus* penned in a small box for sometime and neglected to feed it for a few days. It became hungry and devoured the contents of its own egg sac which it had been carrying around for several days. In another box I kept two individuals belonging to *Lycosa avida*. One of these was much larger than the other but they got along very well for some time. One evening I dropped a large fly between them and both of them jumped to get it. The smaller one was the quicker and got the fly first, but the larger spider was not to be outdone so he pounced on the smaller one and killed it, and the fly besides, and ate the fly and the head of his cage-partner. Since 83% of the food of the spiders observed consisted of insects injurious to crops, I think this spider should be considered of some benefit to the agriculturist. It takes a toll of a few honey bees for the good it accomplishes but in this case the percentage of honey bees is not high, being only 5%.

Argiope riparia Hentz.

Argiope riparia, because of its large size and bright coloring, is perhaps the best known of all of our common spiders. Where this spider has been studied it has been more abundant than any other spider except *Agelena nævia*. The web is very large, often being more than two feet in diameter. The web is either vertical or a little inclined and the spider when at rest stations itself in the center of the hub. It has the peculiar habit of making a small "clearing" when about to make its web in thick tall grass. This is done by drawing aside the grass around a central point in which the web is to be made. In this way the web is not so easily injured by tall grass swaying into it. And again when insects become entangled in the web and attempt to escape, they are less liable to be able to get hold of something which may help them to extract themselves. This species like Metargiope, usually but not always builds a barrier web on each side of the main one. Like *Argiope trifasciata*, to which it is closely related, it makes the web firm by a stabilimentum which extends vertically through the center of the web.

The webs are built in a great variety of places but are preferably built in tall grass and among weeds. I have found webs of this species in barns, in hay mows, and one in the cone of the roof of an old log house where the spider was content to remain for a month. Some are built in grain fields and a great many in pastures. The webs are most abundant along ditches which are overgrown with tall grass and weeds; and along fences and in pasture land which has been allowed to become overgrown with Boneset, Ironweed and similar plants and along roadsides which have become overgrown with golden rod and asters. In order to gain an estimate of the numbers of these spiders, counts were made in these various locations and repeated from time to time.

Soon after the appearance of these spiders in early summer, I counted the webs of thirty-six individuals on a single wild rose bush, which measured ten by sixteen feet. The webs were so numerous that often one which was built near the ground was directly under another farther up in the bush. Such bushes as this one seems to be one of the favorite places for the home of this spider. At another place fourteen spiders were counted in a fence corner which was sixteen feet long and four feet deep. This was an exceptionally large number, but it is given to show how numerous this spider is in some places. Along this rail fence in a distance of thirty rods, one hundred and fifty-six spiders were counted. A pasture field which bordered a woods and contained one and one-half acres, was visited daily for several weeks. This field was covered with tall grass, Boneset and Ironweed. The spiders seemed to show a preference for building their webs between Boneset stalks and on this account many honey bees were captured. In making the count in this place I walked up and down across it, taking a small strip each time, about three feet wide. It will be seen that an accurate account of a web-building species could be obtained in this way which would be impossible in case of the Lycosids and other species which wander from place to place. One count taken here gave one hundred and forty spiders. Another count taken later on in the season gave one hundred and fifty-seven individuals. This number will seem to be a little inconsistent with the number given for a small area. The reason is that cattle and hogs were pastured here. Where cattle were allowed to pasture the spiders gradually left and moved to a field where they were undisturbed.

Observations were made along a public road for a distance of sixty rods. The distance from the ditch along the side of the road to the fence varied from two to three feet. This space was overgrown with golden rod, blackberry bushes, timothy and asters. In this distance three hundred and twenty-two individuals were counted. The number was counted several times, but remained fairly constant. It is seen that these spiders are very abundant in a great variety of places. The fact that they are of a large size and very abundant makes them of some importance from the standpoint of their feeding habits. The position of the web has a great deal to do with the food eaten. Webs of *Argiope riparia* are placed in so many situations that a great variety of insects is captured. The vertical position of the web aids in capturing any kind of insect that happens to be moving in its path. The spider waits for its prey on the center of the hub and does not build a retreat. When an insect becomes entangled in the web it advances upon it, pulls out a swathing band and thrusts this against the insect. The spider changes from one hind leg to the other just as *Argiope trifasciata* does and so keeps the insect at a safe distance. Sometimes the insect is pierced with the cheliceræ, but often this is not the case. The spider merely wraps it up to await the time when it is needed as food. Many insects were taken from webs and kept a day before the swathing band was removed. Often the insect was alive when the band was taken off which would not have been the case had the spider pierced it with the cheliceræ. The insect is always wrapped so tightly that it cannot make any resistance nor injure the web after it has once been enswathed. In case the insect is too large the spider drops to the ground by means of a dragline or else ascends to some leaf where it lies very quiet until the danger is past, when it returns to its former position on the hub of the web. This spider also makes barrier webs similar to *Argiope trifasciata*.

The first *Argiope riparia* was recorded at Crestline on July 4th. It was about one-third grown at this time. I began to record them in greater numbers soon after this time. They emerge from the egg-sac much before this, but are so small that they are seldom noticed. The last ones were recorded on October 21st, at Columbus. All the data given on the number of spiders and the amount of food eaten was gathered on an area of about forty acres. As far as we have observed, *Argiope riparia* will feed upon any kind of insects. A few times I have seen them cut the common firefly, *Photinus pyralis*, loose from the web and cast it aside. They do this sometimes with other insects, such as wasps, when there is a sufficient supply of grasshoppers. The places and manner of constructing their webs have accustomed them to feeding upon a great variety of insects. This wide range of food habits is one of the factors which accounts for their prevalence. We had hoped to see what influence these spiders would have in the control of the Chinch Bug, *Blissus leucopterus*, but unfortunately the cold continuous rainy weather in early summer nearly wiped out this pest in the vicinity where they were very destructive the year previous. A few chinch bugs were found in the webs early in the summer, but the rainy weather so completely killed them off that when the spider had attained any considerable size, there was scarcely a chinch bug to be found.

When *Argiope's* web was constructed in meadows and pastures it fed chiefly on grasshoppers, Capsids, Jassids, *Phytonomus punctatus*, Lepidoptera, chiefly *Eurymus philodice* and other insects injurious to grasses. If the webs were in shrubbery, Membracidæ, Oecanthus and grasshoppers were eaten. A great many webs were constructed on and near the wild flowers and weeds and in those cases honey bees and blister beetles were the principal toll. An area was selected which would be representative of a variety of food conditions. In this area were a great many Boneset and Ironweed stalks. When these came into bloom they were frequented by honey bees and it is because of this that the percentage of honey bees is so high. If the records had been taken from pastures only, the percentage of honey bees would have been very small. Again, if an area with only Boneset bushes and Ironweed stalks had been included, the percentage of honey bees would have been much higher. The tract of land referred to embraced a couple of pasture fields, a small tract on the edge of a woods which was entirely cleared of brush piles, etc., and which was for many years seeded to blue grass. A creek traversed the tract and this was overgrown with weeds, grass and small bushes. Part of it was covered with scattering trees. In this part were many piles of brush and rubbish; in another part of it was a young Catalpa grove which was seeded to blue grass. It will thus be seen that a variety of conditions was obtained.

Insects common to different conditions would be entrapped and a list of such insects are given. Not all the insects could be identified, especially some of the smaller ones which were badly broken up. Only the juices are sucked from the insect, after which it is cut loose from the web and thrown out to the ground. Argiope wraps up practically every insect that happens to strike the web. Webs were noted in which there were two or three grasshoppers, a Capsid and a locust tree borer all at the same time. Many times she has her web checkered with a half-dozen insects, yet if another insect strikes her web she goes at once to the place and ties it up. One often finds deserted webs with several insects in them which have not been eaten. Many times the insects which are captured are much larger than the spider herself.

The observations on the food of this spider took in the entire feeding time of the spider and extended over a period of about four months. During that time data was taken on two thousand two hundred and forty-nine individuals and the percentages of the insects used as food are based on the webs of one thousand two hundred and fifty spiders.

35% of the webs contained grasshoppers; 14% contained Apis mellifica; 9% contained Epicauta pennsylvanica; 5% contained Lygus pratensis; 4% contained Drasteria erechta and Drasteria crassiuscula; 4% contained Ceresa bubalus; 3% contained Coccinella 9-notata; 2% contained Epicauta vitatta; 2% contained Jassids; 2% contained Phytonomus punctatus; 2% contained Tiphia inornata; 2% contained Onthophagus hecate; 1% contained Cyllene robinæ.

This spider's food includes a large variety of insects. It is a voracious feeder. The large size of the spider and the fact that only the juices are sucked are important facts because a large number of insects are destroyed by one spider in a limited time. One of these spiders, a very large one which I watched for a long time and whose food because of the situation of the web consisted chiefly of grasshoppers, sucked the juice from five full-grown grasshoppers in a week. Some of these grasshoppers were larger than the spider itself. If on the two and one-half acre tract mentioned the spiders fed on grasshoppers entirely for one week and each destroyed five, there would be seven hundred grasshoppers destroyed each week. This is a high estimate perhaps because some spiders smaller than the one referred to would not eat that number in a week's time. But if the number were much less than seven hundred it is seen that they would be of a considerable aid in keeping down insects. 64% of the insects destroyed were of an injurious character; 19% were of a beneficial nature, and 2% were neither injurious nor beneficial to farm crops. The other 15% represented a varied number of different insects, a few of which were beneficial but the majority of which have no direct bearing either way as regards farm crops.

TABLE SHOWING INSECTS FED UPON.

x—insect eaten.
c—insect was eaten in cage.
w—insect was killed in web.
f—insect was eaten in the field.

Order	Lycosidæ			Attidæ		Clubinidæ	Thomisidæ	Pisauridæ	Dictynidæ	Agelenidæ	
	Lycosa avida	Lycosa carolinensis	Lycosa fatifera	Phidippus audax	Phidippus podagrosus	Castianeria descripta	Misumena vatia	Dolomedes tenebrosus	Dictyna frondea	Agelena naevia	Coras medicinalis
Odonata											
Agrion, sp.										x-f	
Orthoptera.											
Ischnoptera pennsylvanicus	x-c		x-c	x-f-c							x-c
Orchelimum nigripes	x-c			x-c							
Scudderia furcata	x-c									x-f-w	
Melanoplus bivitattus	x-c	x-c	x-c	x-c				x-c		x-f-w	x-c
Melanoplus differentalis	x-c	x-c	x-c	x-f				x-c		x-f-w	x-c
Gryllus abbreviatus	x-c	x-c	x-c	x-c	x-c			x-c		x-f-w	x-c
Oecanthus niveus	x-c	x-c		x-c	x-c			x-c			x-c
Oecanthus fasciatus	x-c										
Cyrtophyllus concavus			x-c								
Scudderia curvicauda			x-c								
Melanoplus femur-rubrum			x-c								
Dissosteira carolina		x-c								x-f-w	
Microcentrum retinerva										x-f-w	
Orchelimum vulgare								x-c			
Xiphidium brevipennis								x-c		x-f-w	
Encoptolophus sordidus										x-f-w	
Hemiptera.											
Miris dolobratus	x-c		x-c	x-c						x-f-w	
Miris amoenus	x-c									x-f-w	x-c
Adelphocoris rapidus	x-c		x-c	x-c		x-c		x-c			
Lygus pratensis	x-c	x-c	x-c	x-f	x-c	x-c	x-f	x-c		x-f-w	x-c
Macrotylus lineolatus	x-c										
Lopidea confluenta	x-c										
Nabis ferus	x-c	x-c			x-c			x-c		x-f-w	x-c
Kolla bifida	x-c					x-c					
Cicadula 6-notata	x-c										
Phlepsius irroratus	x-c			x-c		x-c		x-c		x-f-w	x-c
Graphocephala coccinea	x-c					x-c					
Draeculacephala mollipes	x-c			x-c	x-c	x-c		x-c		x-f-w	
Ormenis septentrionalis	x-c									x-f-w	
Cicada linnei		x-c									
Macrotylus amoenus				x-c							
Poecilocapsus lineatus				x-c							x-c
Bruchomorpha dorsata				x-c							
Deltocephalus inimicus					x-c					x-f-w	
Ceresa bubalus				x-c						x-f-w	
Campylenchia curvata				x-c						x-f-w	
Enchenopa binotata				x-c							
Deltocephalus inimicus										x-f-w	
Phymata wolffi										x-f-w	
Acrosternum hilaris										x-f-w	
Acanalonia bivitatta										x-f-w	
Jassidæ, sp. undetermined							x-f		x-f		
Neuroptera.											
Chrysopa oculata		x-c	x-c	x-c							

TABLE SHOWING INSECTS FED UPON.
(Continued.)

Order	Lycosidæ			Attidæ		Clubinidæ	Thomisidæ	Pisauridæ	Dictynidæ	Agelenidæ	
	Lycosa avida	Lycosa carolinensis	Lycosa latifera	Phidippus audax	Phidippus podagrosus	Castianeria descripta	Misumena vatia	Dolomedes tenebrosus	Dictyna frondea	Agelena naevia	Coras medicinalis
Lepidoptera.											
Drasteria erechta	x-c	x-c	x-c	x-c						x-f-w	
Drasteria crassuiscula	x-c	x-c								x-f-w	
Haematopsis grataria	x-c			x-c							
Pieris rapæ	x-c										
Pieris rapae, larvæ	x-c										
Anosa plexippus, larva	x-c										
Spilosoma virginica				x-c							
Heliophilus unipunctata						x-c					
Arctia nais										x-f-w	
Estigmene acraea										x-f-w	
Apantesis nais										x-f-w	
Mamestra picta, larvæ										x-f-w	
Diptera.											
Eristalis transversus	x-c						x-f				
Mesograpta marginata	x-c										
Eristalis tenax	x-c	x-c	x-c								
Heliophilus latifrons	x-c										
Melanostoma mellinum	x-c	x-c								x-f-w	
Allograpta obliqua	x-c			x-c							
Haematobia serrata	x-c			x-c			x-f		x-f		x-c
Lucilia caesar			x-c					x-c		x-f-w	
Musca domestica	x-c	x-c	x-c	x-c	x-c	x-c	x-f	x-c		x-f-w	
Pseudopyrellia cornicina	x-c	x-c			x-c		x-f			x-f-w	
Tabanus sulcifrons	x-c			x-c						x-f-w	
Tabanus lineolatus		x-c									
Sapromyza lupulinæ	x-c			x-c	x-c	x-c		x-c		x-f-w	x-c
Tipula flavicans	x-c	x-c	x-c							x-f-w	x-c
Tipula abdominalis	x-c			x-c						x-f-w	
Promachus vertebratus	x-c	x-c	x-c								
Leptogaster murinus	x-c										x-c
Anthrax lateralis			x-c								
Mesograpta polita					x-c	x-c		x-c			x-c
Sarcophaga carnaria				x-c							
Asilus antimachus				x-c							
Promachus bastardii				x-c							
Psilopodinus sipho					x-c			x-c			
Holomyza plumata						x-c					
Sapromyza philadelphica										x-f-w	
Pachyrhina ferruginea										x-f-w	
Tipula trivitatta										x-f-w	
Culex pipiens										x-f-w	
Oncodes costalis										x-f-w	
Tabanus costalis										x-f-w	
Anthomiidæ; sp.									x-f	x-f-w	x-c
Dolichopodidæ	x-c						x-f		x-f		
Syrphidæ sp. undertermined							x-f				
Scatophagidæ, sp. undeter							x-f				
Asilidæ, sp. undetermined							x-f				
Chironomidæ, sp. underter									x-f		
Culicidæ, sp. undetermined									x-f		
Coleoptera.											
Coccinnella, 9-notata		x-c									
Coccinnella, sp. undeter	x-c										
Lachnosterna, larva	x-c	x-c									
Tetraopes tetraophthalmus	x-c										
Crotoparis lunatus	x-c										
Podarus rugulosus	x-c									x-f-w	
Elateridae, larvæ	x-c	x-c									
Ludia attenuatus, larvæ	x-c	x-c	x-c								
Epicauta pennsylvanicus	x-c	x-c								x-f-w	

TABLE SHOWING INSECTS FED UPON.
(Continued.)

Order	Lycosidæ			Attidæ		Clubinidæ	Thomisidæ	Pisauridæ	Dictynidæ	Agelenidæ	
	Lycosa avida	Lycosa carolinensis	Lycosa latifera	Phidippus audax	Phidippus podagrosus	Castianeria descripta	Misumena vatia	Dolomedes tenebrosus	Dictyna frondea	Agelena naevia	Coras medicinalis
COLEOPTERA (Continued)											
Cucujus clavipes, larvæ	x-c	x-c	x-c								
Tenebrio molitor, larvæ		x-c	x-c								
Chlaenius sericaeus			x-c								
Megilla maculata										x-f-w	
Chauliognathus pennsylvanicus										x-f-w	
Rhynchites bicolor										x-f-w	
Melanotus communis	x-c										
HYMENOPTERA.											
Larvæ, undetermined	x-c										
Pupæ, undetermined	x-c										
Myrmicidæ, sp	x-c				x-c						
Colletes, sp	x-c			x-c		x-f					
Agapostemon splendens	x-c									x-f-w	
Tiphia inornata	x-c	x-c	x-c	x-c						x-f-w	
Bombus americanorum	x-c										
Megachile infragilis			x-c								
Vespa germanica			x-c	x-f							
Vespa arenaria				x-c							
Vespa diabolica				x-c							
Vespa maculata				x-c							
Augochlora viridulus				x-c							
Augochlora fervidus				x-c							
Adrena, sp. undetermined				x-c			x-f				
Chrysis parvula										f x-w	
Camponotus pennsylvanicus										f-x-w	
OTHER SPIDERS EATEN:											
Aranea thaddeus										f-x-w	
Agelena naevia										f-x-w	
Argiope riparia											x-f.w
Lycosa avida	x-f										

TABLE SHOWING INSECTS FED UPON.
(Continued.)

Order	Epeiridæ								
	Metepeira labyrinthea	Leucauge venusta	Epeira trivitatta	Epeira domiciliorum	Epeira foliata	Epeira trifolium	Epeira gigas	Argiope trifasciata	Argiope riparia
Odonata.									
Diplax obtusa			x-w-f						
Orthoptera.									
Melanoplus differentialis		x-w	x-w-f	x-w-f				x-w-f	x-w-f
Melanoplus bivitattus			x-w-f				x-w-f	x-w-f	x-w-f
Xyphidium brevipennis		x-w				x-w-f	x-w-f	x-w-f	
Gryllus abbreviatus		x-w	x-w-f			x-w-f		x-w-f	
Oecanthus fasciatus								x-w-f	x-w-f
Oecanthus niveus		x-w	x-w-f			x-w-f	x-w-f	x-w-f	x-w-f
Encoptolophus sordidus						x-w-f		x-w-f	
Melanoplus femur-rubrum							x-w-f	x-w-f	
Microcentrum retinerva							x-w-f	x-w-f	
Amblycorpha oblongifolia							x-w-f		
Scudderia furcata								x-w-f	
Orchelimum vulgare								x-w-f	x-w-f
Scudderia texensis								x-w-f	
Hemiptera.									
Nabis ferus	x-w-f		x-w-f	x-w-f		x-w-f			x-w-f
Bruchomorpha dorsata	x-w-f		x-w-f		x-w-f				
Graphocephala coccinea		x-w-f	x-w-f				x-w-f	x-w-f	
Draeculacephala mollipes	x-w-f	x-w-f	x-w-f	x-w-f	x-w-f	x-w-f	x-w-f	x-w-f	x-w-f
Kolla bifida		x-w	x-w-f						x-w-f
Ceresa bubalus	x-w-f		x-w-f			x-w-f	x-w-f	x-w-f	x-w-f
Stenodema vicinum	x-w-f								
Lygus pratensis	x-w-f	x-w	x-w-f	x-w-f		x-w-f	x-w-f	x-w-f	x-w-f
Poeciloscytus basalis		x-w							
Horcias dislocatus var goniphorus		x-w							
Miris amoenus		x-w			x-w-f				
Miris dolobratus			x-w-f						x-w-f
Adelphocorus rapidus		x-w	x-w-f			x-w-f	x-w-f	x-w-f	
Deltocephalus inimicus		x-w							
Ormenis septentrionalis		x-w	x-w-f	x-w-f	x-w-f				x-w-f
Phymata wolffi			x-w-f				x-w-f		
Cicadula punctifrons			x-w-f						
Cicadula, 6-notatta			x-w-f						
Phlepsius irroratus			x-w-f				x-w-f		
Podisus maculiventris	x-w-f			x-w-f				x-w-f	x-w-f
Aphididæ, sp. undetermined					x-w-f				
Euthochtha galeator							x-w-f	x-w-f	x-w-f
Hymenarcys nervosa									x-w-f
Cosmopepla bimaculata								x-w-f	x-w-f
Mormidea lugens									x-w-f
Acrosternum hilaris								x-w-f	x-w-f
Brochymena annulata								x-w-f	
Euchistus tristigmus									x-w-f
Euchistus variolarius								x-w-f	x-w-f
Peribalus limbolarius								x-w-f	x-w-f
Acanthocephala terminalis								x-w-f	x-w-f
Alydus eurinus								x-w-f	
Anasa tristis								x-w-f	
Campylenchia latipes								x-w-f	x-w-f
Nabis subcoleopterus									x-w-f
Acanalonia bivitatta									x-w-f
Neuroptera.									
Chrysopa oculata			x-w-f						
Lepidoptera.									
Haematopia grataria		x-w	x-w-f						
Halisidota caryæ, larva			x-w-f	x-w-f					
Drasteria erechta				x-w-f	x-w-f	x-w-f	x-w-f	x-w-f	

TABLE SHOWING INSECTS FED UPON.
(Continued.)

ORDER	EPEIRIDÆ								
	Metepeira labyrinthea	Lecauge venusta	Epeira trivitatta	Epeira domiciliorum	Epeira foliata	Epeira trifolium	Epeira gigas	Argiope trifasciata	Argiope riparia
DIPTERA (Continued)									
Eurymus philodice				x-w-f				x-w-f	x-w-f
Pieris rapæ								x-w-f	x-w-f
Apantesis nais				x-w-f					
Drasteria crassiuscula						x-w-f	x-w-f	x-w-f	
Vanessa atlanta						x-w-f			x-w-f
Basilarchia archippus							x-w-f		
Phyciodes nycteis								x-w-f	
Tolype vedella								x-w-f	
Pamphilia peckius								x-w-f	
Euphyes metacomet									x-w-f
DIPTERA.									
Sapromyza lupulinæ	x-w-f	x-w	x-w-f			x-w-f			
Culex pipiens	x-w-f	x-w		x-w-f	x-w-f	x-w-f	x-w-f		
Tipula flavicans	x-w-f		x-w-f	x-w-f	x-w-f	x-w-f	x-w-f	x-f-w	
Tipula abdominalis							x-w-f	x-w-f	
Pseudopyrellia cornicina	x-w-f		x-w-f	x-w-f				x-w-f	x-w-f
Musca domestica			x-w-f	x-w-f	x-w-f	x-w-f	x-w-f	x-w-f	
Syritta pipiens	x-w-f					x-w-f			
Mesograpta marginata	x-w-f		x-w-f		x-w-f	x-w-f			
Eristalis transversus			x-w-f				x-w-f	x-w-f	x-w-f
Helophilus latifrons			x-w-f				x-w-f		x-w-f
Holomyza plumata		x-w							x-w-f
Melanostoma mellinum			x-w-f			x-w-f	x-w-f	x-w-f	
Psilopodinus sipho			x-w-f	x-w-f		x-w-f	x-w-f		
Dolichopodidæ, sp. undetermined									x-w-f
Haematobia serrata				x-w-f					
Promachus vertebratus				x-w-f			x-w-f		x-w-f
Promachus bastardii						x-w-f			
Mesograpta polita				x-w-f					
Eristalis dimidiatus							x-w-f		
Helophilus similis				x-w-f		x-w-f	x-w-f		
Tabanus sulcifrons					x-w-f	x-w-f			x-w-f
Tabanus costalis					x-w-f				
Gastrophilis nasalis					x-w-f				
Anthrax lateralis						x-w-f	x-w-f		x-w-f
Sparnopolius fulvus									x-w-f
Sarcophaga carnaria						x-w-f			x-w-f
Tachinidæ, sp. undetermined						x-w-f			
Peleteria robusta								x-w-f	
Spallanzaria hesperidium									x-w-f
Lucilia caesar						x-w-f	x-w-f	x-w-f	
Leria helvola							x-w-f		
Pachyrhina ferruginea							x-w-f		
Eristalis tenax								x-w-f	
Euaresta bella									x-w-f
Atomosia puella									x-w-f
Leptogaster murinus									x-w-f
Diogmites umbrinus									x-w-f
COLEOPTERA.									
Diabrotica 12-punctata	x-w-f					x-w-f	x-w-f		
Ips fasciatus			x-w-f						x-w-f
Onthophagus hecate				x-w-f				x-w-f	x-w-f
Onthophagus pennsylvanicus				x-w-f				x-w-f	x-w-f
Geotrupes splendidus							x-w-f		
Euphoria inda									x-w-f
Aphodius fimetarius				x-w-f					
Pelidnota punctata									x-w-f
Aphonus tridentatus				x-w-f					
Calligrapha similis				x-w-f					
Epicauta pennsylvanicus				x-w-f		x-w-f	x-w-f	x-w-f	x-w-f

TABLE SHOWING INSECTS FED UPON.
(Continued.)

Order	Epeiridæ								
	Metepeira labyrinthea	Lecauge venusta	Epeira trivitatta	Epeira domiciliorum	Epeira foliata	Epeira trifolium	Epeira gigas	Argiope trifasciata	Argiope riparia
COLEOPTERA (Continued)									
Epicauta vittata						x-w-f	x-w-f	x-w-f	x-w-f
Agonoderus pallipes					x-w-f				
Megilla maculata						x-w-f		x-w-f	x-w-f
Coccinella 9-notata								x-w-f	x-w-f
Epicauta marginata								x-w-f	x-w-f
Diabrotica longicornis								x-w-f	
Diabrotica 12-punctata								x-w-f	x-w-f
Lema trilineata								x-w-f	
Chelymorpha argus									x-w-f
Acmaeodena pulchella									x-w-f
Chlaenius pennsylvanicus									x-w-f
Harpalus caliginosus									x-w-f
Pterostichus lucublandus									x-w-f
Melanotus communis									x-w-f
Tetraopes tetraopthalmus									x-w-f
Cyllene robinæ									x-w-f
Phytonomus punctatus									x-w-f
HYMENOPTERA.									
Megachile infragilis									x-w-f
Bombus virginica									x-w-f
Myrmicidæ, sp			x-w-f	x-w-f		x-w-f			
Augochlora viridulus			x-w-f				x-w-f		x-w-f
Mellisodes, sp									x-w-f
Vespa diabolica				x-w-f					
Vespa germanica						x-w-f	x-w-f	x-w-f	
Ichneumon volens				x-w-f					
Ichneumon laetus							x-w-f		x-w-f
Bombus vagans				x-w-f					
Bombus americanorum						x-w-f	x-w-f	x-w-f	x-w-f
Megachile latimanus				x-w-f					x-w-f
Bombus separatus						x-w-f		x-w-f	x-w-f
Apis mellifica			x-w-f			x-w-f	x-w-f	x-w-f	x-w-f
Bombus fervidus							x-w-f	x-w-f	
Chrysis parvula					x-w-f				
Agapostemon splendens						x-w-f			
Halictus coriaceus									x-w-f
Colletes, sp						x-w-f			x-w-f
Colletes speciosus									x-w-f
Tiphida inornata						x-w-f	x-w-f		x-w-f
Scolia bifasciatus							x-w-f		x-w-f
Camponotus pennsylvanicus							x-w-f		
Formicidæ, sp								x-w-f	
Vespa maculata							x-w-f	x-w-f	x-w-f
Polistes bellicosus									x-w-f
Polistes pallipes								x-w-f	x-w-f
Sphex ichneumon									x-w-f
Chlorion cyaneum									x-w-f
Ammophila extremitata									x-w-f
Ammophila nearctia									x-w-f
Pompilus americanus									x-w-f
Tremex columbia									x-w-f
Odynerus tigris									x-w-f
Odynerus forminatus									x-w-f
Ophion bilineatus									x-w-f
Hoplismenus morulus									x-w-f
Crabo 10-maculata									x-w-f
OTHER SPIDERS EATEN.									
Agelena naevia								x-f-w	
Phidippus audax								x-f-w	
Argiope trifasciata								x-f-w	

THE SYRPHID FLY, MESOGRAMMA MARGINATA, AND THE FLOWERS OF APOCYNUM.*

Raymond C. Osburn.

The flowers of the various species of the dogbane, *Apocynum* spp., have long been known to catch some of the weaker sorts of insects attracted by them, but as far as I am aware, no such wholesale slaughter of a particular species as that herein described has been noted. In fact, if I may judge by the conversations which I have held with both botanists and entomologists, the capacity of the dogbane for trapping insects has pretty generally escaped notice.

My own attention was drawn to the subject last summer when Miss Edith Weston, a young student of botany at the Ohio State University Lake Laboratory at Put-in-Bay, brought in some flowers of *Apocynum androsæmifolium* and called my attention to the fact that the flowers had "bugs" in them. A glance at the flowers showed that there were insects in nearly all of them and that these were all of one species, the common little Syrphid fly, *Mesogramma marginata* (Say). Many of these were still alive, though evidently held in such a manner that they could not escape. As the flowers are open bells, my curiosity was aroused and I began a careful examination.

Having in mind the related milkweed, *Asclepias*, whose flower clusters sometimes entangle the legs of insects by a sticky secretion, I was a little surprised to find that all of the flies in the *Apocynum* flowers were held by the proboscis. As many as four were present in some of the flowers, the little bell being as full as it would hold. Frequently the flies appeared to have made their escape by pulling off the terminal portion of the proboscis, and many of these parts were found in the flowers. Less frequently they had pulled off their heads in their struggles. In either case it would seem that the flies must "permanently vitiate their future careers" just as certainly as if they remained held.

In order to obtain some estimate of the number of flies caught, a hundred of the flowers were examined. These were taken just as they came on various flower clusters, and all were

*Contribution No. 61, Department of Zoology and Entomology, Ohio State University, Columbus.

taken that were sufficiently wide open to admit the flies. Of the 100 flowers, 81 contained flies or portions of them. Most of the 19 flowers that had not captured flies appeared very fresh, as though newly opened, and in some cases were, in fact, not yet fully open. Altogether 140 flies had been entrapped. Of this number, 32 were represented by the proboscis only and 21 by the heads, leaving 87 complete flies, alive or dead. The two sexes were represented in nearly equal numbers.

Knuth's Handbook of Flower Pollination, (translation by J. R. Ainsworth Davis, 1909, Vol. III, pp. 88–89), gives a very good account of the *Apocynum* flower and its method of pollination, quoted from Ludwig (Bot. Centralbl., Cassel, VIII, 1881, pp. 184–185). The anthers are stiff and are united to the bulbous style at about their middle. The lower half of the bulb bears the stigmatic surface, below the attachment of the anthers, while the pollen sacs open above the attachment. In pollination, the insect, in search of nectar, thrusts in its proboscis in such a manner that, to withdraw it, it must pull it upward between the edges of the anthers, and in so doing the proboscis comes into contact with the pollen. Then in visiting the next flower the pollen is brought into contact with the stigmatic surface. But for insects which are too weak to withdraw the proboscis properly, this arrangement forms what has been called a "pinch trap."

Ludwig discusses this pinch trap, as observed by him, and indicates the insects noted by Loew to have been caught by *Apocynum androsæmifolium* in the Berlin Botanical Garden. But one thing Ludwig failed to notice, or perhaps it was not shown in the flowers examined by him. Some of the flies are not held between the edges of the anthers at all, but are stuck fast on the outer surface of the anthers and, in one case observed, on the inner surface of the corolla.

There is therefore, another factor, not hitherto noted, in the process of entrapment, namely, the adhesive nectar. The presence of this factor is borne out by the behavior of the flies at work. *Mesogrammas* coming to a flower cluster were often seen to enter and emerge without difficulty for several times, but, as the same individual was watched, it would eventually be caught. Sometimes after a little difficulty, one would pull loose, but only to enter another flower, as though definitely bent on this particular form of suicide, when it would be permanently held. Prof. M. E. Stickney, of Denison University, confirmed this observation and we repeated it together a number of times.

The proper explanation appears to be that the flies are not held until the proboscis becomes sufficiently gummed-up with the sticky secretion. Larger insects appeared to have but little trouble, though in one case a drone fly (*Eristalis tenax*) was caught, by the proboscis, between the anthers. This is a robust, active fly a half inch or more in length.

The patch of *Apocynum* plants, on which these observations were made, was some sixty feet long by five or six feet in width. There were many thousands of the flowers and, if the 100 carefully examined form a sufficient basis for an estimate, there must have been at least as many of the flies caught as there were flowers. A careful survey of the flowers in the patch indicates that this estimate is not far from wrong.

Mesogramma marginata is a common little fly, 5 to 6 mm. long, but one seldom sees in it in such numbers. Its habits seem to indicate that in the larval stage it feeds on aphids, like many other Syrphid larvæ, and thus it is a beneficial insect. This being the case, the dogbane is a detrimental plant in regions where aphids do any damage.

Insects Caught.—Aside from the *Mesogramma*, other insects appeared to visit the flowers without difficulty, though a few individuals of other species were caught. The list of those captured, as observed in several hours collecting at the patch on different occasions, is as follows: *Mesogramma marginata*, many thousands; *Eristalis tenax*, one; one small Tachinid; one small Muscid; and one small Tineid moth.

Insects Not Caught.—On each visit to the *Apocynum* patch, observations were made as to what were the regular visitors, and a collection was made of all the insects seen to enter the flowers. Insects were swarming about the flowers and most of the following list of 25 species were common: *Eristalis tenax*, *Syrphus americanus*, *Sphærophoria cylindrica*, *Syritta pipiens*, *Limnophora narona*, *Peleteria robusta*, *Pseudopyrella cornicina*, *Anthrax alternata*, *Bombylius fulvibasis*, *Stomoxys calcitrans*, *Sarcophaga melampyga*, *Lygæus kalmii*, *Formica fusca subsericea*, *Apis mellifera*, *Megachile latimanus*, *M. brevis*, *Hylæus modestus*, *Heriades barbatus*, *Halictus sp.*, *Basilarchia* *archippus, Vanessa huntera, V. atalanta, Pholisora catullus, Thymelicus otho egeremet.*

Loew states that *Syritta pipiens* was caught at the Berlin Botanical Garden, but though this Syrphid was common at Put-in-Bay, none were held by the flowers.

Bembower (Ohio Naturalist, XI, No. 8, June, 1911, "Pollination Notes from the Cedar Point Region") gives a list of ten insects visiting the related species, *Apocynum hypericifolium*, but does not mention that any were captured by the flowers. Loew, however, noted that 56 flowers of this species in the Berlin Botanical Garden captured 88 small Muscids and Syrphids between early morning and 3 P. M.

Apocynum pubescens also grows at Put-in-Bay and some observations were made on the flowers for comparison. The blossoms are much smaller and do not open widely, so that it is more difficult for even so small a fly as *Mesogramma marginata* to enter them. However, a few of them had forced their way in and were held in the same manner.

In the Journal of Heredity for October, 1917, there is an unsigned article on "The Too-perfect Milkweed" which indicates that "specialization has over-reached the capacities of the organism specialized, and thus the specialization has defeated its own ends." It might appear at first glance that this is true of the flowers of *Apocynum*, for in some cases, at least, the flowers were so full of *Mesogrammas* that nothing else could enter, and if these were held on the first attempt to enter, such flowers would fail to be pollinated. However, it must be stated that in no case was a *Mesogramma* observed to be held on its first visit, but only after it had entered several flowers. It appears then, that a number of flowers might be pollinated even by this insect, before its proboscis accumulated enough of the sticky secretion or before this secretion evaporated sufficiently to become sticky enough to hold the fly.

Evidently the *Apocynum* flower is constructed in such a manner that insects, after reaching the nectaries, must ordinarily withdraw the proboscis through the slit between the anthers. At the same time the apparatus fails of perfect adaptation in that it does not exclude insects too weak to force the anthers apart. Moreover, to catch these insects defeats the purpose, so to speak, of the mechanism, by preventing, to some extent, the visits of other insects which might be more effective in producing pollination.

The old explanation was that such flowers penalize those visiting insects found guilty of being too weak to function satisfactorily as pollinators, by condemning them to death and carrying their execution into immediate effect. Even if such a teleological explanation appealed to one, he might with perfect propriety inquire what good it would do the flower to penalize itself with sterility at the same time, since the captured flies may block up the entrance to other insects. Moreover, if the insects learned anything by the death or capture of their fellows one could see the logic of such an explanation, but apparently they do not. Instead they keep on going to their death in spite of the "horrible examples" right under their noses, just as they have done, no doubt, for ages past, and the flowers, similarly, keep on interfering with their own pollination by holding the flies in captivity. Certainly, any flower that habitually clogs up its own system with insects, after devising special structures to prevent their being useful, is open to criticism by the etiologist.

Ohio State University, Columbus, Ohio.

EXPLANATION OF PLATE I.

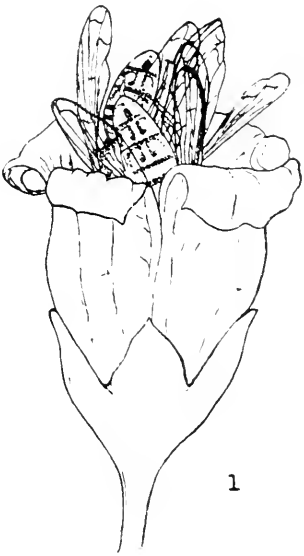
Fig. 1. Flower of *Apocynum androsaemifolium* with three *Mesogramma marginata* entrapped.

Fig. 2. Flower partly cut away, to show stigmatic surface of pistil (s), ring of attachment of anthers (r), nectaries (n), and opening of pollen sacs (p).

Fig. 3. Looking into a flower-cup, showing two heads of flies with proboscis caught between anthers, and part of a proboscis stuck on the outer side of an anther.

Fig. 4. Characteristic position of entrapped fly. The proboscis is held between the anthers close to their attachment to the stigma.

Drawings by Mrs. Walter V. Balduf.



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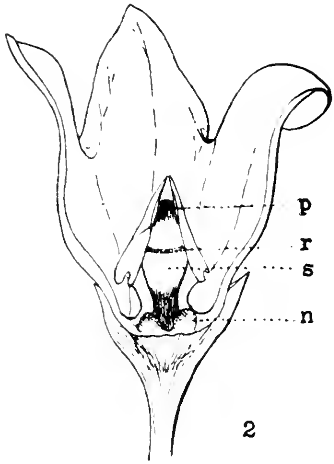

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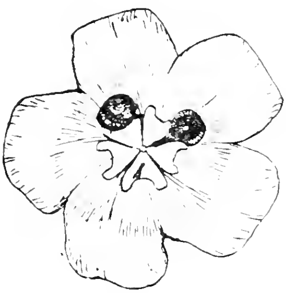

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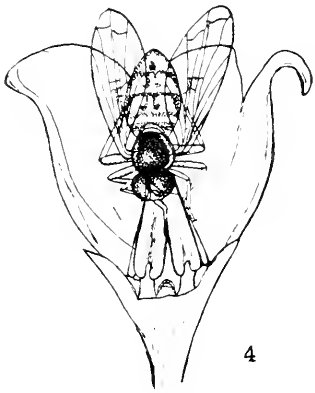

4

R. C. Osburn

XII. DESCRIPTIONS OF DIPTERA OF THE FAMILIES ANTHOMYIDAE AND SCATOPHAGIDAE.

John R. Malloch.
Illinois Natural History Survey

In presenting the descriptions of species of the genus Hylemyia I have added a key for their separation and include all of the species of the genus represented in the collections made by Professor Jas. S. Hine. Some of the species are recorded from this continent for the first time but there is no doubt as to their occurrence here as in most cases the specimens have been compared with European examples. Owing to the very great similarity of the species comprising the group I have figured the hypopygia of most of them in order that there may be no doubt as to the identity of the species in my hands and recorded here. It is not at all impossible that some of the species listed as new may be forms previously known from Europe though unrecognized by me.

Subfamily phaoniinæ.

Phaonia albocalyptrata sp. n.

Male. Black, slightly shining, head, thorax, abdomen and legs with rather dense bluish gray pruinescence; orbits and cheeks with the pruinescence slightly silvery. Thorax with four black vittæ. Abdomen with a narrow black dorsocentral vitta. Legs entirely black. Wings clear, veins fuscous. Calyptræ and their fringes white. Knobs of halteres fuscous.

Eyes with moderately dense hairs; frons at narrowest part over three times as wide as distance across posterior ocelli; orbits with bristles on their entire length, each orbit one-fourth as wide as interfrontalia; arista almost bare; third antennal segment about 1.75 as long as second; parafacial as wide as third antennal segment, not narrowed below; cheek nearly twice as high as widest part of parafacial, with a series of setulæ above the marginal bristles. Two or three pairs of very weak acrostichals among the fine hairs proximad of the suture; prealar bristle a little over half as long as the bristle behind it; postsutural dorsocentrals 4; hypopleura bare; sternopleurals 1:2. Abdomen narrowly ovate; basal sternite with some hairs; fifth sternite with a broad, shallow rounded posterior excision; hypopygium small. Fore tibia without long ventral hairs, median bristle, or apical posterior bristle; fore tarsus slender, longer than tibia; mid femur with rather long hairs on basal half of ventral and posteroventral surfaces, but without bristles; mid tibia with one posterior bristle; hind femur with fine bristles and long hairs on anteroventral surface, the posteroventral and ventral surfaces with long hairs on basal half; hind tibia with three or four anteroventral, and two anterodorsal bristles, the calcar short, about one-fifth of the tibial length from apex. Costal thorn short; outer cross-vein curved; last section of fourth vein about 1.75 as long as preceding section.

Length, 6 mm.

Type and two male paratypes, Savonoski, Naknek Lake, Alaska, July, 1919.

Phaonia citreibasis sp. n.

Male and Female. Glossy black; orbits and cheeks whitish pruinescent; thorax with gray pruinescence, distinctly but not conspicuously vittate; abdomen in male with a poorly defined dorsocentral vitta, in female entirely glossy black. Legs black. Wings clear, conspicuously orange colored at bases, the cross-veins narrowly infuscated. Calyptræ and halteres orange yellow.

Male. Eyes with very sparse short hairs; frons about as wide as distance across posterior ocelli; interfrontalia not obliterated; orbits setulose almost to anterior ocellus; parafacial as wide as third antennal segment, but little narrowed below; cheek nearly twice as high as widest part of parafacial, with a series of lower marginal bristles and some setulae above them; arista pubescent; third antennal segment over twice as long as second. Presutural acrostichals distinct, usually two weak pairs with many interspersed hairs; prealar bristle nearly as long as the bristle behind it; post-sutural dorsocentrals 4; hypopleura bare; sternopleurals 1:2 or 1:3. Abdomen elongate oval; basal sternite bare; dorsum with long bristles, especially apically; hypopygium small; fifth sternite with a broad basally truncate excision. Fore tibia without a median bristle, the ventral hairs distinct, but not long; fore tarsus slender, much longer than tibia; mid-femur with setulose hairs ventrally, those on basal half of posteroventral surface longer and stronger than the others; mid tibia without anterodorsal bristles, and with two to four posterior bristles; hind femur with a series of bristles on anteroventral surface and long hairs on posteroventral; hind tibia with two to four anteroventral, and two anterodorsal bristles, the calcar long, posterior surface with a few short hairs. Costal thorn short.

Female. Similar to male in thoracic chaetotaxy. The frons is one-third of the head width, the orbits narrow, each with 2+4 bristles and some weak setulæ. Legs without the long hairs present in male.

Length, 8 mm.

Type, allotype, and two paratypes, Savonoski, Naknek Lake, Alaska, July, 1919.

Mydaea hirtiventris sp. n.

Male. Black, shining, with bluish gray pruinescence on thorax and abdomen. Antennæ and palpi black. Thorax with four black vittæ. Abdomen unmarked. Legs black, hind tibiæ brownish. Wings clear, bases yellow. Calyptræ and halteres yellow.

Eyes separated by a little more than width across posterior ocelli; orbits setulose to anterior ocellus; interfrontalia distinct on its entire length; eyes nearly bare; parafacial as wide as third antennal segment, not narrowed below; cheek nearly twice as high as width of parafacial; arista with its longest hairs a little longer than its basal width; third antennal segment over twice as long as second. Prealar a little over one-third as long as the bristle behind it; sternopleurals 1 : 2. Basal sternite with numerous hairs. Fore tibia with the posteroventral hairs longer than usual; mid femur with strong bristles to beyond middle of posteroventral surface; mid tibia with two or three posterior bristles; hind femur with rather short, closely placed bristles on entire length of anteroventral surface, and some weaker bristles on basal half of posteroventral: hind tibia with two or three anteroventral and anterodorsal bristles, the setulæ on apical half of anterior surface stronger than usual.

Length, 7 mm.

Type, Katmai, Alaska, 1917. One male.

Hebecnema pallipes sp. n.

Male. Shining black, head with brownish pruinescence, thorax with faint grayish pruinescence, which is only visible when the surface is viewed from an angle of 45 degrees, abdomen densely brownish pruinescent, with a slight coppery tint, and without any markings. Legs yellowish testaceous, coxæ and tarsi fuscous. Wings slightly smoky. Calyptræ and halteres yellow.

Eyes bare, separated by not more than the width of anterior ocellus, the facets on upper surface much enlarged; parafacial linear; cheek a little higher than width of third antennal segment; longest hairs on arista about as long as width of third antennal segment. Chaetotaxy of thorax as in *umbratica* Fallen. Fifth sternite with a very deep, U-shaped posterior excision, the lateral extensions bare apically. Fore tibia without median or apical posterior bristles; mid femur with several bristles on basal half of posteroventral surface; mid tibia with two posterior bristles; hind femur with four or five bristles on apical half of anteroventral bristles. Outer cross-vein straight; inner cross-vein before apex of first vein; last section of fourth vein about 1.75 as long as preceding section.

Length, 5 mm.

Type, Katmai, Alaska, 1917. One male.

Limnophora tendipes sp. n.

Male. Black, opaque, densely gray pruinescent, with a bluish or greenish tinge on pleura and sides of abdomen. Back of head concolorous with thorax, the other parts densely silvery pruinescent. Thorax indistinctly vittate, two narrow submedian vittæ distinct anteriorly. Abdomen with most of first tergite, two large subtriangular spots on second and other two on third tergite, and a central one on fourth blackish. Legs colored as body. Wings clear, darker at bases. Calyptræ white. Halteres fuscous.

Width of narrowest part of frons over twice as great as distance across posterior ocelli; interfrontalia much wider than orbits, the latter with long setulose hairs on entire length; parafacial twice as wide as third antennal segment, and equal to height of cheek, the vibrissal angle produced much beyond base of antenna, in line with outer side of apex of third antennal segment, lower half of cheek hairy except anteriorly; arista swollen on basal fourth, almost bare; vibrissal angle with numerous setulose hairs, the vibrissæ not differentiated, situated much above lower margin of cheek; eyes with sparse fine hairs. Thorax with 4 series of fine presutural acrostichal hairs; postsutural dorsocentrals 4; sternopleurals 2; prosternum bare. Legs long and slender; fore tibia with one or two posterior median bristles, and a long apical posterior bristle; mid femur with a series of posteroventral bristles which become much shorter apically; mid tibia with one or two anterodorsal, two posterodorsal, two posterior and one or two posteroventral bristles; hind femur with long setulose hairs on basal half of posterior surface, and four or five bristles on apical third of anteroventral; hind tibia with three or four fine bristles on each of the following surfaces; anteroventral, anterodorsal, and posterodorsal; hind tarsus with a bristle near the base on ventral surface; apical tarsal segment on all legs broad. First posterior cell much widened at apex.

Length, 9 mm.

Type, Cordova, Alaska. One male.

SUBFAMILY ANTHOMYIINÆ.

Hydrophoria galeata sp. n.

Male. Black, slightly shining, thorax and abdomen with dense lead gray pruinescence. Head with dense pale gray shining tomentum on orbits, parafacials and cheeks; antennæ and palpi black. Thorax when viewed from behind indistinctly vittate. Abdomen when viewed from behind with an almost linear black dorsocentral vitta; hypopygium gray pruinescent, forceps glossy black. Legs black. Wings clear. Calyptræ white. Halteres yellow.

Narrowest part of frons not wider than distance between posterior ocelli; orbital hairs extending a little more than midway to anterior ocellus; interfrontalia obliterated at middle; parafacial at base of antenna wider than third antennal segment, but little narrowed below;

longest hairs on arista about equal in length to width of third antennal segment; cheek about equal in height to widest part of parafacial. Two or three pairs of strong acrostichals and many interspersed hairs in front of suture; prealar very short; hypopleura bare. Abdomen narrow, subcylindrical, tapered apically; no ventral tufts present; hypopygium small, the inferior forceps very long, slightly sinuous, thickened on apical half; fifth sternite with processes elongate, subcylindrical, their inner margins with a few fine hairs, their outer margins with a number of long bristles. Fore tibia with a median posterior bristle, the apical posterior bristle long; mid femur with some long bristles on basal half of posteroventral surface; mid tibia with an anterodorsal, and two posterodorsal and posterior bristles; hind femur with a series of anteroventral bristles and three or four bristles on middle of posteroventral surface; hind tibia with three or four posterodorsal, about eight anterodorsal and two or three anteroventral bristles, and two or three posterior setulæ. Costal thorn very short; outer cross-vein curved, very oblique.

Length, 7.5 mm.

Type, Katmai, Alaska, July, 1917. One male.

Hydrophoria congrua sp. n.

Male. Black, shining, with bluish gray pruinescence, most distinct on abdomen. Orbits and cheeks silvery when viewed from the side above. Thorax rather indistinctly quadrivittate. Abdomen with a black dorsocentral vitta, which tapers slightly posteriorly. Legs black. Wings slightly grayish. Calyptræ white. Halteres dull yellow.

Narrowest part of frons about as wide as distance across posterior ocelli; orbits haired to above middle; interfrontalia with a pair of fine bristly hairs above middle; parafacial a little wider than third antennal segment, hardly narrowed below; cheek as high as widest part of parafacial; arista with very short pubescence; third antennal segment not much longer than second. Thorax without distinct presutural acrostichals; prealar about half as long as the bristle behind it; hypopleura bare. Fifth tergite shining, pruinescent, with a few fine hairs; basal hypopygial segment with some long bristly hairs which are curved upward; fourth tergite not conspicuously bristly on sides; fourth sternite without conspicuous bristles; fifth sternite with rather short processes which are fringed with fine hairs on apical half of inner margins and have a dense fringe of longer setulose hairs at bases. Fore tibia with an anterodorsal and posterior bristle near middle; mid femur with long bristles on posteroventral surface; mid tibia with one anteroventral, one posterodorsal, three posterior and one posteroventral bristles; hind femur with long bristles on anteroventral and posteroventral surfaces, those on the last surface interrupted beyond middle; hind tibia with three anteroventral, seven or eight alternately long and short anterodorsal, and three long and one or two short posterodorsal bristles, posterior surface bare. Costal thorn short.

Length, 6.5 mm.

Type and paratype, Anchorage, Alaska, June 6, 1917.

Pegomyia lativittata sp. n.

Male. Black, slightly shining, densely gray pruinescent. Orbits and cheeks with silvery pruinescence; antennæ, arista, and palpi black. Thorax similar to that of *lysinoe* Walker, with a very broad black vitta behind suture on each side of dorsum and two linear submedian vittæ anteriorly. Abdomen with a uniform broad black dorsocentral vitta, and the posterior margin of each tergite black; hypopygium shining black, very slightly pruinescent. Legs reddish testaceous, coxæ, fore legs and all tarsi black, fore femora slightly paler than tibiæ, mid and hind tibiæ slightly darker than their femora. Wings slightly brownish, yellow at bases. Calyptræ and halteres yellow.

Narrowest part of frons barely wider than anterior ocellus; interfrontalia obliterated above middle; bristles confined to anterior half of orbits; antennæ elongate, third segment about twice as long as second; arista almost bare; parafacial at base of antenna as wide as third antennal segment; cheek a little higher than widest part of parafacial, with a series of bristles on lower margin. Three pairs of presutural acrostichals, between which there are four or more series of weak hairs; prealar nearly as long as the bristle behind it; sternopleurals 1 : 2. Abdomen slightly depressed, the bristles on apices of tergites long; hypopygium small; fifth sternite almost bare on inner margins of processes and without strong bristles. Fore tibia with one anterodorsal and two posteroventral bristles, the apical posterior bristle strong; fore tarsus much longer than tibia; mid femur with one bristle beyond middle and three on basal half of anterior surface, one beyond middle of anteroventral and a series of about eight on posteroventral surface; mid tibia with one anterodorsal, one posterodorsal, and two or three posterior bristles; hind femur with a series of bristles on anteroventral and four or five on middle half of posteroventral surface; hind tibia with one anteroventral, two anterodorsal, and two posterodorsal bristles. Lower calyptra not protruded.

Length, 8 mm.

Type, Savonoski, Naknek Lake, Alaska, July, 1919. One male.

Pegomyia jacobi sp. n.

Male. Black, slightly shining, densely gray pruinescent. Head black, the orbits and cheeks with silvery pruinescence. Thorax with the sides of dorsum more conspicuously pruinescent than disc; two linear vittæ apparent on anterior margin. Abdomen with a rather broad subinterrupted inconspicuous black dorsocentral vitta, the bases of the bristles set in black dots, fifth sternite with the processes glossy black. Legs reddish testaceous, coxæ, femora except their apices, and the tarsi black. Wings clear, yellow at bases. Calyptræ and halteres yellow.

Narrowest part of frons as wide as distance across posterior ocelli; interfrontalia not obliterated; orbits bristled on entire length; parafacial at base of antenna as wide as third antennal segment, narrowed below;

cheek as high as widest part of parafacial, with a series of bristles on lower margin; third antennal segment 1.5 as long as second; arista almost bare. Two or three pairs of closely placed acrostichals and some interspersed hairs in front of suture; prealar half as long as the bristle behind it; sternopleurals 2 : 2, the lower anterior one weak. Abdomen subcylindrical, the tergites with strong apical bristles; hypopygium of moderate size; fifth sternite with the processes chitinised, rounded at apices, bare on apical half internally and with some fine hairs basally on inner margins. Fore tibia with one anterodorsal and one posterior bristle, apical posterior bristle long; fore tarsus a little longer than tibia; mid femur without strong bristles on anteroventral surface, the posteroventral with a complete series; mid tibia with an anterodorsal bristle and adjacent to it on the anterior surface a weak setula, one posterodorsal and three posterior bristles; hind femur with a series of long, irregular anteroventral bristles and a similar posteroventral series which is interrupted before apex; hind tibia with two anteroventral, three anterodorsal, and two posterodorsal bristles. Costal thorn small; outer cross-vein slightly curved. Lower calyptra slightly protruded.

Length, 6 mm.

Type, Katmai, Alaska, July, 1917. One male.

Hylemyia Robineau Desvoidy.

I have not used the subgeneric names given to segregates of this genus by recent European authors. Included in the genus as recognized in this paper there are species which would fall into the restricted subgenera Hylemyia and Phorbia.

The following species are included in the key and recorded for the first time for this continent: *uniseriata* Stein, *fuscicebs* Zetterstedt, and *sepia* Zetterstedt. Only in the case of the last named have I any doubt as to the identification. The species which has previously been identified by authors, including myself, as *fuscicebs* Zetterstedt is *cilicrura* Zetterstedt according to Stein who has re-examined the types of the species.

The key here presented is not designed for the identification of all American species of the group as there are many more species which are not included and are closely related to those in the key.

Some of the hypopygial drawings are not mentioned in the text and reference must be made to the explanation of plates for names.

KEY TO MALES.

1. Third abdominal sternite of male deeply, roundly excavated in middle posteriorly, produced caudally on each side in the form of two long narrow processes which are armed with very long bristles that extend to or beyond apex of abdomen, the tips of the bristles forming fine hairs; legs of female entirely or almost entirely yellowish, the apical abdominal segment furnished with some stout curved spines. *setiventris* Stein

   Third abdominal tergite transverse at apex, not produced at each side caudally, in male; legs of female entirely or almost entirely black........2

2. Fifth abdominal sternite with some very stout sharp spines on at least a part of the inner margin of each process.................................3

   Fifth abdominal sternite with at most some setulæ on part of the inner margin of each process...4

3. Spines on fifth sternite extending the entire length of the inner margins of the processes, longest at middle................*spiniventris* Coquillett

   Spines on fifth sternite confined to basal half of each process, longest at base..*marginata* Stein

4. Hind tibia with a close series of short, erect setulose hairs on one or other of the ventral surfaces; inferior forceps of hypopygium very long and slender...5

   Hind tibia with at most a partial series of short setulæ on the posterior or posteroventral surface or on both (cf. *nidicola*)......................8

5. Fore tibia with a very weak setula at apex on posterior surface; hind femur with long fine bristles on entire length of posteroventral surface; hind tibia with anteroventral and posteroventral setulæ................6

   Fore tibia with a strong, slightly curved bristle at apex on posterior side, the apex of which is usually blunt; only the posteroventral surface of hind tibia with erect setulose hairs..................................7

6. Parafacials much wider at base of antennæ than third antennal segment, and about one-third the width of eye; acrostichals very closely placed. *triseriata* sp. n.

   Parafacials about as wide as third antennal segment, and about one sixth the width of eye; acrostichals widely separated.....*fusciceps* Zetterstedt

7. Hind femur with a few bristles at extreme apex of posteroventral surface which are directed apicad; mid metatarsus without long setulose hairs on dorsal surface..............................*cilicrura* Zetterstedt

   Hind femur with a series of closely placed fine bristles on more than apical half, which are directed basad; mid metatarsus with some long setulose hairs on dorsal surface..................*trichodactyla* Zetterstedt

8. Mid tibia with one or more anteroventral bristles on apical half..........9

   Mid tibia without any anteroventral bristles..........................10

9. Fore tibia with a long blunt-tipped strong bristle at apex on posterior side; acrostichals in a single series, which is sometimes rather irregular. *uniseriata* Stein

   Fore tibia with a short weak sharp setula at apex on posterior side........20

10. Fore tibia with a long strong, curved blunt-tipped bristle at apex on posterior side..11

    Fore tibia with a short sharp pointed setula at apex on posterior side......12

11. Mid metatarsus with very long bristles on dorsal surface; processes of fifth sternite each with two or three short blunt setulæ at apex on inner side (Fig. 3); arista pubescent..........................*fabricii* Holmgren

    Mid metatarsus with normal hairing; processes of fifth sternite without short, blunt setulæ at apex on inner side...............*angustitarsis* sp. n.

12. Processes of fifth abdominal sternite very long, much curved, slightly widened at apices, their tips chitinised, glossy, almost bare outwardly, furnished with short pile-like hairs inwardly; eyes separated by about twice the width across posterior ocelli; hind tibia with two antero-dorsal bristles..*constrictor* sp. n.

    Processes of fifth abdominal sternite not as above, much shorter, and usually straight, their tips not glossy..............................12a

12a. Fifth abdominal sternite with a pair of contiguous downwardly projecting processes in center of the excavation, the apical lateral extensions of the sternite dilated apically (Fig. 5); pale gray species, the thorax with three pale brown vittæ; anterodorsal surface of hind tibia with ten to twelve setulæ from base to apex; halteres yellow...*hinei* sp. n.
Fifth abdominal sternite not as above; the species much darker than above and otherwise not as stated....................................13

13. Halteres brown or fuscous; very small species, not over three millimeters in length; fifth sternite somewhat similar to that of *hinei* (Fig. 6); hind tibia with very slender bristles; abdomen with very broad uniform black dorsocentral vitta which covers about one-fourth of the dorsum; acrostichals sparse, in two series....................*fuscohalterata* sp. n.
Halteres yellowish or whitish....................................14

14. Arista with the longest hairs at least as long as width of third antennal segment; hypopygium as in Figure 21....................*variata* Fallen
Arista with very short hairs or almost bare.............................15

15. Abdomen short and broad, rather thick, glossy and without distinct markings; hypopygium very large......................*sepia* Zetterstedt
Abdomen not as above, always distinctly pruinescent and more or less distinctly marked..16

16. Fifth abdominal sternite with dense short bristly hairs, one group which is downwardly directed at base of inner margin of each process, and another on apical half of each (Fig. 7); thorax very distinctly vittate; parafacials at least as broad at base of antennæ as third antennal segment; hind tibia with three or four anterodorsal bristles; acrostichals in two series..*atrovittata* sp. n.
Fifth abdominal sternite not bristled as above; species differing in other respects...17

17. Hind tibia with two series of short setulæ on basal two-thirds, one on the posterior and the other on the posteroventral surface; small species, three or four millimeters in length; thorax distinctly vittate. *nidicola* Aldrich
Hind tibia with at most a few setulæ on posterior surface on basal half....18

18. Third and fourth abdominal sternites, each with some very long bristles along lateral margins; dorsal abdominal vitta broad....*planipalpis* Stein
Third and fourth abdominal sternites not as above......................19

19. Mid tibia with one or more anteroventral bristles on apical half..........20
Mid tibia without anteroventral bristles................................21

20. Prealar bristle not over one-third as long as the bristle behind it; acrostichals in four series, two of the hairs usually much longer than the others; hypopygium with a short process on disc, near base, on each side (Fig. 23)...*sericea* sp. n.
Prealar over half as long as the bristle behind it; acrostichals in two rather irregular series, setulose, two of them very much longer and stronger than the others; hypopygium without processes on disc (Fig. 17)...*appendiculata* sp. n.

21. Eyes separated by distinctly more than width across posterior ocelli; orbits very narrow above; interfrontalia with two pairs of fine setulæ above middle; prealar half as long as the bristle behind it; hind tibia slightly reddish; veins three and four divergent at apices....*aliena* sp. n.
Eyes separated by less than width across posterior ocelli; hind tibia black..22

22. Thorax without any strong bristle-like presutural acrostichals, the hairs fine, in four series, one pair stronger than the others; hypopygium as in Figure 24.......................................*incursa* sp. n.
Thorax with at least one pair of bristle-like presutural acrostichals, the hairs all more or less setulose.......................................23

23. Mid femur with some long anteroventral bristles.........................24
Mid femur without any long anteroventral bristles.......................25

24. Large species, 6 mm. in length; fifth abdominal sternite glossy along inner margins of the processes; inferior hypopygial forceps short and stout, curved, and with a tooth at middle on inner side....*denticauda* sp. n.
    Smaller species, 4 mm. in length; fifth abdominal sternite and hypopygium not as above..24a
24a. Hind femur with a few long fine bristles on basal half of posteroventral surface; fifth abdominal sternite with very short fine hairs along inner margins of processes, but not fringed....................*subnitida* sp. n.
    Hind femur with short fine bristles on entire length of posteroventral surface; fifth abdominal sternite as in Figure 11, the inner margin of each process densely setulose at middle.................*parvicornis* sp. n.
25. Prealar bristle over half as long as the bristle behind it; hypopygium as Figures 28 and 44...*tridens* sp. n.
    Prealar bristle much less than half as long as the bristle behind it; hypopygium as in Figures 29 and 41...................*substriata* Stein

Hylemyia triseriata sp. n.

Male. Black, faintly shining, densely pale gray pruinescent. Anterior margin of interfrontalia and lower part of parafacials slightly rufous brown. Thorax with three narrow dorsal brown vittæ. Abdomen with a black dorsocentral vitta which is slightly dilated at anterior margin of each tergite. Legs black. Wings slightly grayish, veins brown, paler basally. Calyptræ white. Halteres yellow.

Narrowest part of frons as wide as distance between posterior ocelli; interfrontalia distinct on its entire length, with a pair of fine bristles above middle; parafacial at base of antenna about 1.5 as wide as third antennal segment, very little narrowed below; cheek a little higher than widest part of parafacial, with numerous bristles along and slightly above lower margin, one strong one directed downward at middle and several weaker upwardly directed shorter bristles between it and anterior angle; arista pubescent, much swollen at base; third antennal segment about 1.5 as long as second. Presutural acrostichals very close together, two strong and two or three weak pairs; prealar about one-third as long as the bristle behind it. Abdomen moderately depressed, parallel-sided; fifth sternite with moderately stout processes, which are bare along their inner margins except at apex, where there are about four short, blunt setulæ, the outer half with numerous long bristles. Legs as in *fusciceps* Zetterstedt, the mid tibia with a strong anterodorsal median bristle, and the hind tibia with an anteroventral series of rather strong setulose hairs and the posterior and posteroventral surfaces each with a series of longer weaker setulose hairs. Costal thorn of moderate length.

Length, 6 mm.

Type, Katmai, Alaska, June, 1917. One male.

This species must be very closely related to *Hylemyia* (*Phorbia*) *biciliata* Coquillett, but the distinct markings on thorax and abdomen and different structure of the head appear to warrant its separation therefrom.

Hylemyia angustitarsis sp. n.

Male. Black, shining. Thorax indistinctly vittate. Abdomen with a black dorsocentral vitta which is broadened at anterior margin of each tergite, where it merges with the fuscous anterior marginal fascia; hypopygium glossy black, with slight grayish pruinescence. Legs black. Wings very slightly brownish. Calyptræ and halteres whitish yellow.

Head rather small; narrowest part of frons not much wider than anterior ocellus; parafacial at base of antenna not as wide as third antennal segment, much narrowed below; cheek as high as width of third antennal segment, with a series of long fine bristles on lower margin, some of which, anteriorly, are upwardly curved; proboscis normal; longest hairs on arista a little longer than its basal diameter; third antennal segment narrow, about 1.5 as long as second. Dorsum of thorax sparsely haired; presutural acrostichals of moderate, unequal lengths, irregularly 2-rowed; prealar less than half as long as the bristle behind it; sternopleurals 1 : 2; one or two bristly hairs adjacent to stigmatal bristle. Abdomen narrow, depressed; hypopygium of moderate size; fifth sternite with a few short, fine hairs along inner margins and on inner half of each process and some long bristles on outer half. Legs more slender than usual; fore tibia with a median posterior bristle, the apical posterior one long, curved, blunt at apex; mid femur with some long bristles on basal half of posteroventral surface; mid tibia with usually one posterodorsal and one posteroventral bristle basad of middle; hind femur with a series of rather widely spaced bristles on anteroventral surface and two bristles at apex on posteroventral; hind tibia with one or two weak bristles on both antero- and posteroventral surfaces, four or five short anterodorsal and three posterodorsal bristles. Costal thorn of moderate length; veins three and four very slightly convergent apically; outer cross-vein straight.

Length, 4.5–5 mm.

Type, Katmai, Alaska, July, 1917. Paratypes, Katmai, four specimens, August, 1917; Savonoski, Naknek Lake, Alaska, seven specimens, July, 1919, one specimen, August 1, 1919.

Hylemyia constrictor sp. n.

Male. Black, subopaque, densely pale gray pruinescent. Orbits, parafacials, face and cheeks with shining whitish pruinescence; antennæ and palpi black. Thorax indistinctly vittate. Abdomen with a poorly defined broad fuscous dorsocentral vitta which is laterally dilated at anterior and posterior margins of each tergite; apices of fifth sternite glossy black; hypopygium gray pruinescent. Legs black. Wings clear, veins black, whitish at bases. Calyptræ and halteres whitish.

Narrowest part of frons about twice as wide as width across posterior ocelli; interfrontalia distinct on its entire length, with a pair of bristles in front of anterior ocellus; orbits with fine bristles to above middle; parafacial at base of antenna distinctly wider than third antennal segment and as wide as height of cheek, not narrowed below; cheek with a few long fine bristles along lower margin; arista nearly bare, much swollen at base; third antennal segment narrow, not much longer than second. Presutural acrostichals very fine and short, two-rowed; prealar about half as long as the bristle behind it; sternopleurals 1:2. Abdomen subcylindrical; hypopygium of moderate size; processes of fifth sternite very large, curved inward, their tips slightly broadened, glossy, and almost bare. Fore tibia with a bristle at middle on posterior side, apical posterior bristle weak; mid femur with sparse bristles to beyond middle on posteroventral surface; mid tibia with one anterodorsal and one posterodorsal bristle, and an anterior and two posterior setulæ; hind femur with a series of sparse anteroventral bristles; hind tibia with two anteroventral, two anterodorsal, and three posterodorsal bristles, and one or two posterior setulæ. Costal thorn very small; veins 3 and 4 slightly divergent at apices; outer cross-vein nearly straight.

Length, 5 mm.

Type, Valdez, Alaska, June 4, 1919. One male.

Hylemyia hinei sp. n.

Male. Black, subopaque, densely pale gray pruinescent. Thorax with a pale brown dorsocentral vitta which extends proximad of suture, and a broader, less distinct vitta on each side of it which does not extend proximad of suture. Abdomen with a moderately broad black dorsocentral vitta which is slightly interrupted at posterior margin of each tergite and connected with a narrow black fascia at anterior margin of each; hypopygium gray pruinescent. Legs black, gray pruinescent. Wings clear. Calyptræ white. Halteres yellow.

Head larger than usual, almost hemispherical; eyes separated by about width of anterior ocellus; orbits setulose to middle; parafacial narrower than third antennal segment, narrowed below; cheek nearly three times as high as widest part of parafacial, with long bristly hairs on lower margin anteriorly and above margin posteriorly; arista bare, swollen on basal fourth. Prealar not over half as long as the bristle behind it; presutural acrostichals rather widely separated, one or two pairs strong, a number of hairs between the strong pairs. Abdomen depressed, short and broad, slightly narrowed apically; fifth sternite with a pair of shining setulose processes at apex in center which project downward; hypopygium as in Fig. 26. Fore tarsus compressed, longer than tibia, the latter with one or two posterior bristles; mid tibia with two posterodorsal and two posterior bristles; hind femur with a series of anteroventral bristles, and a series of weaker posteroventral bristles which is more or less distinctly interrupted before apex; hind tibia with three posterodorsal, four to seven anterodorsal, and two or three anteroventral bristles, and some setulæ on middle of posterior surface. First posterior cell narrowed at apex.

Female. Similar in color to the male, the abdomen less distinctly marked. Interfrontalia velvety black. Wings yellowish at bases.

Interfrontal cruciate bristles present; each orbit about one-third as wide as interfrontalia, with three supraorbitals, the lower one directed outward, and three or four infraorbitals. Fore tibia with an additional anterodorsal bristle.

Length, 3.5–4.5 mm.

Type, allotype, and 15 paratypes, Savonoski, Naknek Lake, Alaska, July, 1919. Named for Jas. S. Hine.

Hylemyia fuscohalterata sp. n.

Male. Black, subopaque, densely gray pruinose. Orbits and and cheeks slightly silvery pruinescent. Thorax when seen from behind with five black vittæ. Abdomen with a broad black dorsocentral vitta which connects with a narrow black fascia on anterior margin of each tergite; hypopygium shining, gray pruinescent. Legs black. Wings slightly brownish, noticeably so basally. Calyptræ white. Halteres brownish, the knobs infuscated.

Narrowest part of frons about as wide as anterior ocellus; orbits haired to middle; parafacial nearly as wide at base of antenna as third antennal segment and as wide there as height of cheek, the latter with a series of fine bristles on lower margin; third antennal segment but little longer than second; arista nearly bare, swollen on basal third. Thorax with two or three pairs of fine presutural acrostichals and no interspersed hairs; prealar less than half as long as the bristle behind it; sternopleurals 1 : 2. Abdomen depressed at base, sides parallel; hypopygium of moderate size, Figure 22; fifth sternite somewhat similar to that of *hinei.* Fore tibia without bristles at middle and apex on posterior side; mid femur with long fine bristles on posteroventral surface; mid tibia with one or two small posterodorsal bristles; hind femur with long bristles on anteroventral and short setulose hairs on posteroventral surface; hind tibia with very fine bristles which are rather variable in number but average four on posterodorsal, two long and three short on anterodorsal, and two on anteroventral surface, the median part of posterior surface with some fine setulæ; tarsi subequal in length to tibiæ. Costal thorn minute; outer crossvein straight.

Female. Interfrontalia velvety black. Thorax not distinctly vittate. Knobs of halteres obscurely yellow.

Interfrontalia with a pair of cruciate bristles; lower supraorbital directed forward. Mid tibia with one anterodorsal, one posterior and two posterodorsal bristles. Tarsi shorter than tibiæ.

Length, 2.5 mm.

Type, allotype, and two paratypes, Katmai, Alaska, June, 1917.

Hylemyia atrovittata sp. n.

Male. Black, slightly shining, with grayish pruinescence. Head black, orbits, face, parafacials and cheeks with white pruinescence; interfrontalia anteriorly and upper anterior part of parafacials sometimes brownish red. Thoracic dorsum with five very conspicuous black vittæ, the interspaces drab gray pruinescent. Abdomen with a very broad black dorsocentral vitta which is slightly interrupted at posterior margin and connected with a narrow black fascia at anterior margin of each tergite; hypopygium glossy black, slightly gray pruinescent. Legs black. Wings slightly grayish. Calyptræ white. Halteres yellow.

Narrowest part of frons as wide as distance between posterior ocelli; interfrontalia not obliterated, with a pair of bristles above middle; orbits with long fine bristles to middle; parafacial at base of antenna a little wider than third antennal segment, not narrowed below; cheek higher than width of parafacial, with long fine bristles on lower margin, some of which, anteriorly, are upwardly curved; arista pubescent, much swollen on basal fifth; third antennal segment nearly twice as long as second. Presutural acrostichals long, two-rowed; many long hairs laterad of posthumerals; prealar not one-third as long as the bristle behind it; sternopleurals 1 : 2 or 1 : 3. Abdomen narrow, depressed; hypopygium of moderate size; fifth sternite with processes broad, furnished at base of each with a fringe of downwardly directed setulose hairs and on apical half with many similar hairs. Fore tibia with a median posterior bristle; mid femur with a series of bristles on posteroventral surface, their length decreasing to apex; mid tibia with two posterodorsal, and two or three posterior bristles; hind femur with a series of bristles on entire length of anteroventral surface and another on posteroventral, the latter almost ceasing before apex; hind tibia with two or three anteroventral, four or five anterodorsal and three or four posterodorsal bristles, and four or five posterior setulæ. Costal thorn very small.

Length, 4 mm.

Type, and 12 paratypes, Katmai, Alaska, June and July, 1917.

Hylemyia sericea sp. n.

Male. Black, slightly shining, densely brownish gray pruinescent. Head black, sometimes with the anterior part of interfrontalia and parafacials reddish; orbits, face and cheeks with yellowish pruinescence; antennæ and palpi black. Thorax indistinctly vittate. Abdomen with a slight silky luster, the black dorsocentral vitta linear. Legs black. Wings slightly brownish, veins dark brown, yellow at bases. Calyptræ and halteres yellow.

Narrowest part of frons as wide as anterior ocellus; orbits setulose to middle, and with a pair of very small hairs near anterior ocellus; interfrontalia almost obliterated above, with a pair of fine bristles at middle; parafacial not as wide as third antennal segment, narrowed below; arista with microscopic pubescence; third antennal segment nearly twice as long as second. Presutural acrostichals very fine, in four series, usually one pair longer than the others; prealar about one-third as long as the bristle behind it. Abdomen depressed, sides sub-parallel; hypopygium normal in size, the superior forceps with a small process on each side of disc near base (Fig. 23); fifth sternite not abnormal (Fig. 12). Fore tibia usually with one anterodorsal and one posterior bristle; mid tibia with one or two anteroventral, one antero-dorsal, two posterodorsal, and two posterior bristles; hind tibia with a series of long widely spaced anteroventral bristles which are at least as long at base as at apex; hind tibia with two to four anteroventral, about eight anterodorsal and four or five posterodorsal bristles, the bristles of the last two surfaces unequal in lengths, the posterior surface with a few setulæ near base. Costal thorn short and stout.

Length, 6 mm.

Type, Katmai, Alaska, July, 1917. Paratypes, one male, Katmai, June, 1917; Savonoski, Naknek Lake, five males, June, 1919, four males, July, 1919; one male, July 31, 1919.

Hylemyia appendiculata sp. n.

Male. Similar in color and markings to *substriata* Stein, and *sericea*. Differs from *substriata* in having the prealar over half as long as the bristle behind it, the bristles on basal half of posteroventral surface of hind femur much longer and stronger, and the inferior forceps of the hypopygium much longer and with a small tooth or projection on inner side near apex, when seen from above (Figs. 17 and 34).

Length, 6 mm.

Type, Savonoski, Naknek Lake, Alaska, July, 1919. Paratype, Bozeman, Mont., June 23, 1916.

This species is very closely allied to *anthracina* Malloch, differing in having the presutural acrostichals more widely separated, the dorsocentral black abdominal vitta linear and not dilated on anterior and posterior margins of each tergite, the posteroventral bristles on hind femur much longer and sparser, and the mid tibia with an anteroventral bristle.

Hylemyia denticauda sp. n.

Male. Similar to *substriata* in color and habitus. Differs from that species in having two to three pairs of strong presutural acrostichals, the prealar nearly half as long as the bristle behind it, the fifth sternite glossy along inner margins of the processes and with fewer and shorter hairs, the mid femur with some strong bristles on basal half of antero-ventral surface, and the hypopygium as in Figures 27 and 40.

Length, 6 mm.

Type and two paratypes, Seattle, Wash., May 25, 1919.

This species was taken by Professor Hine when on his way to Alaska and is appropriately included in this paper.

Hylemyia aliena sp. n.

Male. Black, slightly shining, densely gray pruinose. Head black, orbits, face and cheeks whitish pruinose; arista brown; palpi brownish yellow; proboscis glossy black. Thorax indistinctly vittate. Abdomen with a moderately broad dorsocentral black vitta which is slightly dilated at anterior margin of each tergite; hypopygium glossy black, with slight gray pruinescence. Legs black, hind tibiæ more or less noticeably reddish. Wings faintly brownish, veins dark brown and conspicuous. Calyptræ and halteres yellowish.

Narrowest part of frons distinctly wider than distance across posterior ocelli; orbits linear above, with bristly hairs to middle; interfrontalia with two pairs of fine bristles above middle, the upper pair small; parafacial at base of antenna as wide as third antennal segment and about three-fourths as wide as height of cheek, but little narrowed below; cheek with a series of setulose hairs on lower margin, vibrissal angle slightly produced; arista nearly bare, swollen on basal fourth, second segment as long as thick; proboscis rather slender. Presutural acrostichals short, two-rowed; prealar over half as long as the bristle behind it. Abdomen depressed, sides subparallel; hypopygium of moderate size (Fig. 25); fifth sternite without remarkable hairing (Fig. 8). Fore tibia usually with one anterodorsal and two posterior bristles; mid tibia with one anterodorsal, one posterodorsal and two posterior bristles; hind femur with a rather irregular series of bristles on anteroventral surface, and a posteroventral series of weaker bristles which does not extend to apex; hind tibia with two anteroventral, four or five anterodorsal, and three or four posterodorsal bristles, and two or three setulæ near middle of posterior surface. Costal thorn minute; penultimate section of fourth vein over two-thirds as long as ultimate; apical sections of third and fourth veins subparallel.

Length, 6 mm.

Type and one paratype, Savonoski, Naknek Lake, Alaska, June, 1919; two paratypes, same locality, July, 1919.

Hylemyia incursa sp. n.

Male. Similar to *sericea* in color, the interfrontalia and parafacial usually reddish anteriorly, and the abdomen with brownish pruinescence and a broad, poorly defined dorsocentral black vitta which is dilated at anterior margin of each tergite.

Arista distinctly pubescent. Presutural acrostichals fine and long, one pair longer than the others, but not bristle-like; prealar over half as long as the bristle behind it; posthumeral bristle not duplicated. Fifth sternite as in Figure 9; hypopygium as in Figures 24 and 43. Fore tibia with an anterodorsal and a posterior bristle; mid femur with some long bristles on basal half of anteroventral surface; mid tibia with an anterodorsal, two posterodorsal, and two posterior bristles, and sometimes an anterior setula; hind femur with long bristles on anteroventral surface, and one or two on basal half of posteroventral; hind tibia with two or three anteroventral, five or six anterodorsal, and three or four posterodorsal bristles, and some setulæ on posterior surface near middle.

Length, 5.5 mm.

Type and three paratypes, Katmai, Alaska, June 10, 1919.

Hylemyia parvicornis sp. n.

Male. Similar in color to *substriata.* The anterior part of interfrontalia and part of parafacial reddish. Thorax rather indistinctly vittate. Abdominal dorsocentral vitta slightly dilated at anterior margin of each tergite.

Narrowest part of frons about as wide as anterior ocellus; interfrontalia distinct throughout, with a pair of long fine bristles above middle; orbits with setulose hairs to near middle; parafacial at base of antenna about as wide as third antennal segment, narrowed below; third antennal segment not twice as long as wide; arista pubescent, swollen at base. Three or four pairs of moderately strong presutural acrostichals present, one pair much longer than the others; prealar one-third as long as the bristle behind it. Fifth sternite as in Figure 11; hypopygium as in Figures 20 and 43. Fore tibia with a median posterior bristle; mid femur with some long bristle on basal half of anteroventral surface; mid tibia with one or two posterodorsal and posterior bristles; hind femur with the anteroventral bristles much longer on the apical than on the basal half, the posteroventral surface with short fine bristles on entire length; hind tibia with two or three anteroventral, four anterodorsal, and three posterodorsal bristles, the posterior surface with some setulæ at middle. Last section of fourth vein less than twice as long as preceding section.

Length, 4 mm.

Type, Kodiak, Alaska, June, 1917. Paratypes, four males, same locality, June, 1917.

Hylemyia subnitida sp. n.

Male. Differs from *parvicornis* in having the thorax less distinctly vittate, the abdomen with the dorsocentral vitta distinctly interrupted at apex of each tergite, and the parafacials black.

Parafacial narrower than in *parvicornis,* and the cheeks not so high, fifth sternite with very fine hairs along the inner margin of each process, though not fringed, mid tibia with a strong anterodorsal bristle, anteroventral bristles on hind femur longer and sparser, and those on posteroventral surface longer and not forming a complete series.

Length, 4 mm.

Type, Kodiak, Alaska, July, 1917. One male.

Hylemyia tridens sp. n.

Male. Similar in color and general habitus to *sericea*. Differs from *sericea* in structure of hypopygium (Figs. 44 and 28). The prealar is as in *appendiculata*.

Length, 6 mm.

Type and one paratype, Savonoski, Naknek Lake, July and August, 1919.

FAMILY SCATOPHAGIDÆ.

Amaurosoma Becker.

I included this genus in my key to the genera of Scatophagidæ in a paper on the Diptera collected by the Canadian Arctic Expedition, but up to the present no species of this genus has been recorded from America. In the present paper I describe three species as new.

The adults are predaceous, feeding on small Diptera and other small insects; the immature stages are unknown.

Amaurosoma katmaiensis sp. n.

Female. Black. Head with whitish pruinescence; thorax opaque, gray pruinose; abdomen shining, with very slight pruinescence. Head black; interfrontalia whitish yellow, face and cheeks concolorous; antennæ black, second joint inconspicuously yellow at apex; arista black; proboscis black; palpi yellow. Thorax not vittate. Legs black, tibiæ and tarsi flavous, the tarsi of mid and hind legs slightly darker. Wings clear, veins black. Calyptra white. Halteres yellow.

Frons fully half the width of head; orbits narrow anteriorly, becoming wider to anterior ocellus, the bristles rather weak; face slightly receding below; antennæ stout, nearly as long as face, third joint with sharp upper apical angle, rounded below; arista almost bare, much swollen on basal third; vibrissa strong, a strong bristle below it. Thorax with the presutural acrostichals weak, two-rowed. All abdominal segments with widely spaced bristles on posterior margins. Legs normal; fore femur with about nine long forwardly directed bristles in two to three irregular series on middle of antero-ventral surface; mid femur with six or more widely spaced bristles in similar situation; antero-ventral surface of hind femur with three or four widely spaced bristles; fore tibia with three bristles, one anterodorsal, one posterodorsal and one posterior; mid tibia with one bristle on each of the following surfaces—anteroventral, anterodorsal, posterodorsal and posterior; hind tibia with two or three anterodorsal and two or three posterodorsal bristles. Last section of fourth vein two or three times as long as preceding section; outer cross-vein at or more than its own length from apex to fifth vein.

Length, 4.5–6 mm.

Type locality, Katmai, Alaska, June, 1917 (J. S. Hine).

Type in collection of the Ohio State University; paratype in collection of the Illinois State Natural History Survey.

Amaurosoma unispinosa sp. n.

Female. Similar in color of head, thorax and abdomen to last species, except that the black on orbits does not extend so far forward. Legs and fore coxæ entirely flavous.

Cephalic characters, thoracic and abdominal chaetotaxy as in the preceding species. Legs stout, fore femora stouter than mid and hind pairs, armed with one bristle near base on anteroventral surface; mid femur with one or two anteroventral bristles at middle, and five or six along anterior surface; fore and mid tibiæ as in preceding species; hind tibia in type with two anterodorsal and two posterodorsal bristles.

Length, 4.5 mm.

Type locality, Katmai, Alaska, July, 1917 (J. S. Hine).

Type and paratype placed as in preceding species.

Amaurosoma bispinosa sp. n.

Female. Shining black, with distinct but not very dense gray pruinescence, which is very faint on abdomen. Antennæ black; frons on anterior half golden yellow; palpi pale yellowish testaceous; proboscis glossy black. Thorax glossy at bases of bristles. Legs yellowish testaceous, femora browned apically, tarsi infuscated. Calyptræ and halteres yellowish. Wings clear.

Third antennal segment about twice as long as second, not acute at apex above; arista tapered, microscopically pubescent. Presutural acrostichals sparse, two-rowed; intra-alars very weak; prealar moderately long; anterior sternopleural absent in type. Fore femur with two strong bristles at middle on anteroventral surface; mid femur with four or five bristles on anterior and anteroventral surfaces; hind femur with two weak anteroventral bristles at middle; hind tibia with two anterodorsal and two posterodorsal bristles. Last section of fourth vein about three times as long as preceding section.

Length, 5 mm.

Type, Saldovia, Alaska, June 5, 1919. One female.

Microprosopa Becker.

There are three species of this genus in the collection all of them apparently undescribed.

Microprosopa arctica sp. n.

Male and Female. Very closely resembling *dissimilis* in color, the female differing only in having the anterior half of frons whitish testaceous, the fore coxæ almost entirely yellow, and the fine hairs on thorax and abdomen pale. The male differs from that sex of several other species in having the hypopygium dark, with paler color only on sides of venter.

Orbit with five bristles; third antennal joint rounded at apex above, cheek over one-fourth as high as eye, with one strong bristle and some weak marginal hairs in addition to the vibrissa, the bristles pale; palpi shorter and comparatively broader than in *dissimilis*. Presutural acrostichals two-rowed, but with some weak, pale hairs between the rows; disc of scutellum with very weak pale hairs. Fore femora swollen, with a few weak, black, bristly hairs on apical half of anterodorsal surface, and long soft hairs on posteroventral; fore tibia with one anterodorsal bristle; mid and hind femora without ventral bristles, the former with a few on apical half of anterodorsal surface, the hind pair with an almost complete series on same surface; mid tibia with one antero- and one posterodorsal bristle, the latter almost on the dorsal surface. Third and fourth veins subparallel or slightly convergent apically; sixth vein weak on apical half. Hypopygium of male very large; fifth sternite with the apices of the lateral processes glossy, rounded, their inner margins on basal half armed with very short, dense, erect hairs.

Length, 5–5.5 mm.

Type locality, Katmai, Alaska, July, 1917 (J. S. Hine). Six specimens.

Microprosopa triseta sp. n.

Female. Similar in color to *arctica*.

The head is slightly smaller than in *arctica*, the vibrissa and the bristle below it are black, the palpi are slightly more elongate, with the apices rather pointed. The presutural acrostichals are two-rowed, without any pale hairs between. The mid tibia in type has only one bristle on the anterodorsal surface, the hind tibia has in addition to the bristles present in *arctica* one on the anterodorsal surface near base. The venation is the same as in *arctica*, but the wing is more pointed, so that the apex of third vein is very decidedly beyond apex of fourth, while in *arctica* it is nearly in vertical line with it.

Length, 4.5 mm.

Type locality, Katmai, Alaska, July, 1917 (J. S. Hine).

Microprosopa dissimilis sp. n.

Female. Black; thorax densely yellowish gray pruinescent, almost opaque; abdomen slightly pruinescent, shining. Head black, anterior third of frons, the face and cheeks yellowish testaceous; antennæ and arista black, apex of second joint of former slightly pale; proboscis glossy black; palpi whitish testaceous, faintly infuscated at apices. Thoracic dorsum with two poorly defined narrow vittae anteriorly. Legs yellowish testaceous; all coxæ fuscous. Short hairs on thorax and abdomen black.

Each orbit with six bristles, the anterior three hair-like; arista bare, about one-third longer than antennæ, third joint of the latter slightly angulate at apex on upper side; face slightly concave in profile; cheek about one-fifth as high as eye, with three strong and several weak bristles in addition to the vibrissa; palpi long, somewhat paddle-shaped. Presutural acrostichals two-rowed; disc of scutellum with setulose hairs. Fore femora stout, furnished with very short, dense, erect hairs on ventral surfaces, and on posteroventral surface with rather irregular long bristly hairs; fore tibia with three bristles, one anterodorsal, one posterodorsal and one posterior, the ventral setulæ dense and short; mid femora with numerous irregularly arranged weak black bristles on anterodorsal surface, and a few widely placed bristles on antero- and posteroventral surfaces; mid tibia with one antero- and one posterodorsal bristle, hind femur with armature similar to mid pair, except that the anteroventral bristles are stronger, more numerous and more closely placed; hind tibia with one anterodorsal and two posterodorsal bristles. Wing-veins thick; inner cross-vein just beyond apex of first vein and middle of discal cell; third and fourth veins very distinctly divergent at apices.

Length, 6 mm.

Type locality, Katmai, Alaska, July, 1917 (J. S. Hine).

EXPLANATION OF PLATES.

Plate II.

Fifth abdominal sternites of males of Hylemyia.

Fig. 1, *fusciceps*, one side.
Fig. 2, *cilicrura*, one side.
Fig. 3, *fabricii*, one side.
Fig. 4, *angustitarsis*, one side.
Fig. 5, *hinei*.
Fig. 6, *fuscohalterata*.
Fig. 7, *atrovittata*, one side.
Fig. 8, *aliena*, one side.
Fig. 9, *incursa*, one side.
Fig. 10, *denticauda*. one side.
Fig. 11, *parvicornis*, one side.
Fig. 12, *sericea*, one side.
Fig. 13, *appendiculata*, one side.
Fig. 14, *tridens*, one side.
Fig. 15, *substriata*, one side.

Plate III.

Hypopygia of males of Hylemyia, caudal view.

Fig. 16, *fabricii*.
Fig. 17, *appendiculata*.
Fig. 18, *angustitarsis*, one superior forceps removed.
Fig. 19, *atrovittata*, one side.
Fig. 20, *parvicornis*, one side.
Fig. 21, *variata*.
Fig. 22, *fuscohalterata*, one side.
Fig. 23, *sericea*, one side.
Fig. 24, *incursa*, one superior forceps removed.
Fig. 25, *aliena*.
Fig. 26, *hinei*, one superior forceps removed.
Fig. 27, *denticauda*.
Fig. 28, *tridens*, one superior forceps removed.
Fig. 29, *substriata*, one superior forceps removed.

Plate IV.

Hypopygia of males of Hylemyia, lateral view.

Fig. 30, *fabricii*.
Fig. 31, *cilicrura*.
Fig. 32, *angustitarsis*.
Fig. 33, *hinei*.
Fig. 34, *appendiculata*.
Fig. 35, *fuscohalterata*.
Fig. 36, *variata*.
Fig. 37, *sericea*, forceps only.
Fig. 38, *sericea*, ventral processes.
Fig. 39, *atrovittata*.
Fig. 40, *denticauda*.
Fig. 41, *substriata*.
Fig. 42, *parvicornis*.
Fig. 43, *incursa*.
Fig. 44, *tridens*.

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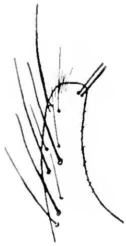

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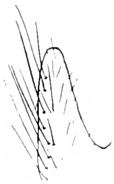

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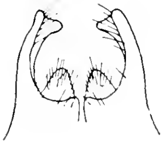

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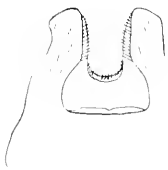

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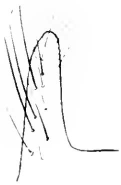

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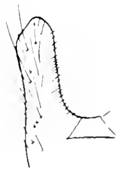

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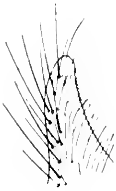

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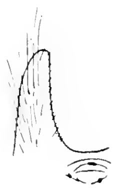

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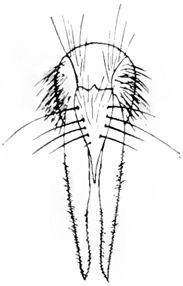
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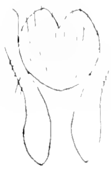
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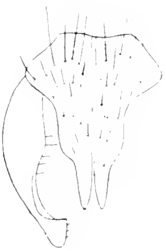
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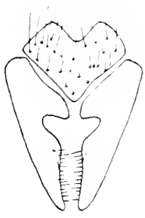
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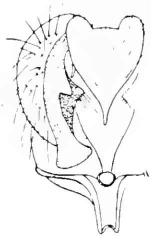
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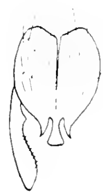
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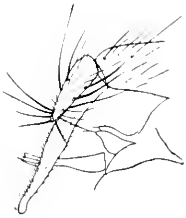

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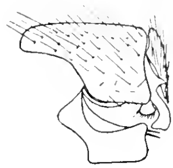

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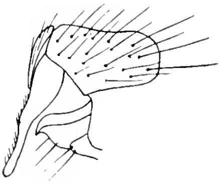

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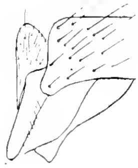

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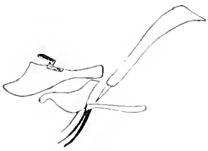

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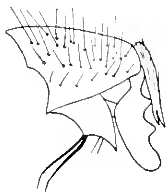

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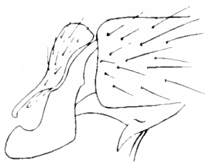

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J. R. Malloch

SCIENTIFIC RESULTS OF THE KATMAI EXPEDITIONS OF THE NATIONAL GEOGRAPHIC SOCIETY.

XIII. BEES AND WASPS.

J. BEQUAERT.

Through the kindness of Prof. Jas. S. Hine, I have been given the opportunity to examine the Aculeate Hymenoptera obtained by him during his two trips to Alaska in the summers of 1917 and 1919. The following list of the species collected includes also a few specimens taken at Seattle, Wash. Mr. Viereck has kindly confirmed the identification of *Andrena frigida*.

A general account of the Hymenoptera of Alaska was given by Ashmead in 1902.* Some additional data has been published since, the most important contribution in this respect being F. W. L. Sladen's list of the wasps and bees obtained by the Canadian Arctic Expedition.†

APOIDEA.

The bee fauna of Alaska is exceptionally rich in bumble bees, comprising as many as 19 species of *Bombus* and 4 of *Psithyrus*. It seems rather strange that only one other bee, *Andrena frigida* Sm., is thus far known from that region.

BOMBIDÆ.

I have followed in the main Franklin's arrangement in his Monograph of this family (1913), but have added for convenience the synonyms used by Ashmead in 1902.

*W. A. Ashmead. Papers from the Harriman Alaska Expedition, XXVIII. Hymenoptera. Proc. Wash. Ac. Sci., IV, 1902, pp. 117-274, Pls. IX-XI.

†Report of the Canadian Arctic Expedition, 1913-18. III, Part G, 1919, pp. 26-35.

Bombus Latreille.

Terrestris group.

1. **Bombus lucorum** Linnæus var. **moderatus** Cresson.

Kodiak, 2 ♀, 4 ☿, and 13 ♂, Sept., 1917. Katmai, 1 ♀, June 10, 1919. Savonoski, 1 ☿, July, 1919.

2. **Bombus occidentalis** Greene (*B. proximus* Ashmead; *B. mckayi* Ashmead).

Seattle, Wash., 1 ♀ and 1 ☿ of the typical form, May 25, 1919.

All the Alaskan specimens in the collection belong to the var. *proximus* Cresson: Katmai, 2 ♀, 25 ☿, and 1 ♂, Aug. 2, 1917; 1 ♀, June 10, 1919. Excursion Inlet, 1 ♀, May 31, 1919. Savonoski, 7 ☿, July, 1919.

Kirbyellus group.

3. **Bombus kirbyellus** Curtis.

Katmai, 1 ☿, Aug., 1917.

Pratorum group.

4. **Bombus melanopygus** Nylander.

Seattle, Wash., 1 ♂, May 25, 1919. Savonoski, 1 ♀ and 1 ☿, July, 1919.

5. **Bombus sylvicola** Kirby.

Katmai, 8 ☿ and 1 ♂, July 28, 1917, and Aug., 1917. Savonoski, 1 ☿ and 2 ♂, July, 1919.

6. **Bombus gelidus** Cresson.

Kodiak, 1 ♀, Sept., 1917. Katmai, 2 ☿ and 1 ♂, Aug., 1917. Valdez, 1 ☿, June 9, 1919.

7. **Bombus frigidus** F. Smith (*B. Couperi* Ashmead).

Katmai, 1 ♀ and 4 ☿, Aug., 1917. Savonoski, 1 ☿, June 9, 1919.

8. **Bombus pleuralis** Nylander (*B. juxtus* Ashmead).

Kodiak, 20 ☿ and 1 ♂, Aug., 1917. Kodiak, 2 ☿, Sept., 1917. Savonoski, 1 ♀, July, 1919.

9. **Bombus sitkensis** Nylander (*B. mixtuosus* Ashmead; not *B. sitkensis* Ashmead).

Seattle, Wash., 1 ♀, 6 ☿, and 2 ♂, May 25, 1919. Katmai, 1 ♂, Aug., 1917.

10. **Bombus mixtus** Cresson (*B. oregonensis* Ashmead).

Seattle, Wash., 10 ☿ and 1 ♂, May 25, 1919. Kodiak, 9 ☿ and 3 ♂, Sept., 1917. Excursion Inlet, 1 ♀, May 31, 1919. Yakutat, 2 ♀, May 31, 1919.

Dumoucheli group.

11. **Bombus californicus** F. Smith (*B. neglectulus* Ashmead).

Seattle, Wash., 1 ♀, May 25, 1919. The species is also known from southern Alaska.

Psithyrus Lepeletier.

Laboriosus group.

1. **Psithyrus insularis** (F. Smith).

Seattle, Wash., 2 ♀, May 25, 1919. Katmai, 1 ♀, July 28, 1917.

2. **Psithyrus consultus** Franklin.

Savonoski, 1 ♂, July, 1919. As suggested by Franklin, this is most probably the male of *P. insularis*.

In addition to the foregoing, the following species of *Bombidæ* have been recorded from Alaska:

Bombus kincaidii Cockerell (*Psithyrus kodiakensis* Ashmead; *Bombus gelidus* Ashmead).

B. strenuus Cresson (?*B. frigidus* Ashmead).

B. *polaris* Curtis. Franklin regards Ashmead's Alaskan records of this species as questionable; it has, however, again been recorded from Alaska by F. A. Lutz (Bull. Amer. Mus. Nat. Hist., XXXV, 1916, p. 520) and Sladen (1919, p. 27).

B. arcticus Kirby. There are two queens of this from Point Barrow (Stefanson Coll.) in the American Museum of Natural History.

B. edwardsii Cresson (*B. nearticus* Ashmead).

B. flavifrons Cresson (*B. alaskensis* Ashmead; *B. dimidiatus* Ashmead).

B. alboanalis Franklin (*B. sitkensis* Ashmead).

B. (*Bombias*) *nevadensis* Cresson.

Psithyrus fernaldæ Franklin.

P. tricolor Franklin.

ANDRENIDÆ.

Andrena Latreille.

1. **Andrena frigida** F. Smith.

Valdez, 2 ♀, June 4, 1919.

Originally described on the female from Nova Scotia. Morice and Cockerell (Canad. Entom., XXXIII, 1901, p. 149) have published a few notes on the type specimen which is still preserved in the British Museum. Ashmead (1902, p. 131) records the male from Muir Inlet and Sitka.

VESPOIDEA.

In addition to the species mentioned below, *Ancistrocerus albophaleratus* (Saussure), one of the Eumenidæ, is known from Alaska (Ashmead, 1902).

VESPIDÆ.

Vespa Linnæus.

Only two members of this genus, *V. norwegica* and its var. *marginata*, have been heretofore recorded from Alaska; I have also seen from that region a female of *V. rufa* Linnæus var. *americana* R. du Buysson, a form not represented in the present collection.

1. **Vespa** (**Dolichovespula**) **diabolica** Saussure.

Katmai, 1 ♀, June 10, 1919. Savonoski, 5 ♀, 1 ♀, and 2 ♂, July and Aug., 1919. There is a male of this species from Skagway, Alaska, Aug. 42, 1918, (F. M. Jones Coll.), in the American Museum of Natural History.

2. **Vespa** (**Dolichovespula**) **norwegica** Fabricius (*V. borealis* Kirby, under which name the species is mentioned by Ashmead in 1902).

This is Sladen's *norvegicoides* (Ottawa Naturalist, XXXII, 1918, p. 71), which I am not prepared at present to separate from the European *norwegica*.

The collection contains only two specimens of the typical form, both from Savonoski; a ♂ taken Aug. 8, 1919, and a ♀, July, 1919.

This species has previously been recorded from Sitka and Virgin Bay by Ashmead (1902) and from Point Barrow (north of 70° N. lat.) by myself (Bull. Amer. Mus. Nat. Hist., XXXIX, 1918, p. 22).

var. **marginata** (Kirby) (*V. marginata* Kirby; *V. albida* Sladen).

Katmai, 4 ♀, June 10, 1919. Savonoski, 1 ♀, 5 ☿, and 3 ♂, Aug. 8, 1919.

In North America, this variety is known only from Alaska and the Yukon Territory, where it is apparently common. It has been recorded from Kukak Bay (Ashmead) and from Nome and Teller (Sladen). There are specimens from Alaska in the collection of the Brooklyn Museum and I have seen a ☿ taken at Kutlik (62° 30′ N., 63° W.).

Sladen (1919) has fully described this form, which he recognizes as a distinct species. I follow, however, R. du Buysson [Ann. Soc. Ent. France, LXXIII, (1904) 1905, p. 599] in regarding this as a mere variety of *V. norwegica*, from which it differs merely in the creamy white color of the body markings. Frequently, but not always, there are ferruginous red spots on the anterior edges of the second tergite in the male and worker. I find no trace of red on any of the five queens examined. The six workers seen all have the red spots, though in one example it is very small; of the three males, two have no red.

Two of the workers from Savonoski (with distinct creamy white fasciæ and lateral red spots on the second tergite) were taken from the same nest with a queen of typical *norwegica*.

3. **Vespa** (**Vespula**) **occidentalis** Cresson.
Seattle, Wash., 1 ♀, May 25, 1919.

4. **Vespa** (**Vespula**) **vulgaris** Linnæus.
Savonoski, 1 ☿, August 8, 1919.

This worker has the scape of the antennæ entirely black, a broad black longitudinal stripe on the clypeus, a median black spot on the yellow posterior orbits, and no yellow spots on the propodeum. I have seen several similarly colored workers from California and British Columbia. They agree well in coloration with European specimens of *Vespa vulgaris* and I have provisionally referred them to that species. They could, however, be aberrant specimens of *V. occidentalis*, though numerous workers of the latter species, which I have examined, all have the antennal scape yellow in front, the clypeus yellow with one or three black dots or small spots, the posterior orbits entirely yellow, and two yellow spots on the propodeum. The occurrence of true *V. vulgaris* on the northwestern coast of America would be very interesting, but can only be definitely established through an examination of males from that region. In this connection it may be useful to add that all specimens from eastern North America which I have seen in collections identified either as *V. vulgaris* or as *V. germanica*, belong, in my opinion, to *Vespa communis* Saussure.

5. **Vespa (Vespula) acadica** Sladen, Ottawa Naturalist, XXXII, 1918, p. 72.

Savonoski, 1 ♀, July, 1919.

This interesting species is apparently the northern and boreal representative of *V. vidua* Saussure. In the American Museum of Natural History there are two workers from N. Ontario, Canada and Boisdale, Cape Breton, which also belong to *acadica;* but I have been unable to find a specimen of this species from the United States in any of the collections examined by me.

6. **Vespa (Pseudovespa) austriaca** Panzer.

Savonoski, 1 ♀, July, 1919.

This specimen agrees perfectly with the females found near New York in 1916 and which I have fully described in Bull. Brooklyn Ent. Soc., XI, 1916, pp. 102–103. Since, I have seen a female of this species from Mt. Hood, Oregon (G. P. Engelhardt Coll.) and a male from Beaver Mouth, Selkirk Mountains, British Columbia (J. C. Bradley Coll.). The genitalia of this male agree in every detail with those of a male from Thuringia, identified as *V. austriaca* by Schmiedeknecht.

American Museum of Natural History, New York City.

SURVEY OF THE FERNS AND FERN ALLIES OF OHIO.

Prof. L. S. Hopkins, of the Kent Normal School, Kent, Ohio, is organizing a survey of the entire state in order to obtain exact information about our Pteriodphytes and their geographical distribution. This work, if thoroughly done, will be of great interest and value, not only in giving us an exact list of the species, but adding information about the ecological and agricultural areas of the state. It is to be hoped that all botanists of Ohio and members of the Ohio Academy of Science will co-operate with Prof. Hopkins, either by making collections themselves or inducing some interested person to do so. In this way it should be possible to have one or more collectors in every county. The material should be sent directly to Prof. Hopkins, who will make determinations of the species.

John H. Schaffner.

Date of Publication, July 15, 1920.

The Ohio Journal of Science

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THE ORIGIN OF CEREBRAL GANGLIA.*

F. L. LANDACRE.

The problem of the origin of the cerebral ganglia presents many difficult, as well as many interesting phases. An attempt to form some conception of the present status of the problem by an examination of text books and monographs leaves one suspended between the explanations that are so simple that they will apply to no particular case, and observations and descriptions that are so complicated that one can form no general conclusion from them.

Possibly it is too early yet to form broad generalizations on this subject, and it is further possible that the generalizations may not seem what they claim to be on account of the number of exceptions cited, but since we cannot avoid generalization, and since even an incomplete generalization, provided it directs our efforts, has its value, I have ventured to attempt to reduce our present knowledge of this question to some simple statements or formula which will, at least, clear the way for investigation.

The problem has its historical background, of course, but much of this we must ignore for the present, unless it bears directly on the point of view which seems to be the most tenable at the present time. There is probably no more confused or hopeless mass of literature in Biology than that dealing with the cerebral nerves, especially the earlier literature dealing with their relation to the problem of the vertebrate head. Most of this we shall ignore, because the origin of the cerebral ganglia present a distinct problem, whose solution will undoubtedly throw much light on the larger problem. The head problem is so huge that it can not be reduced to a simple generalization at present.

*Presidential address given before the Ohio Academy of Science at its annual meeting in 1918.

One of the earliest advances that we need to note was the definite determination that all ganglia are derived from ectoderm rather than from mesoderm. This is significant, because it determined once for all the course of progress in this line.

Second, and of more significance to us today, is the fact that nearly all of the early work on ganglia was done on the spinal ganglia, and from this fact arose a very definite attitude toward the whole problem. Anyone at all familiar with this problem knows how easy it is to secure a series of stages in the development of the spinal ganglia. Since these structures are arranged segmentally, one embryo properly chosen furnishes a whole series of ganglia in the various stages of development, from very early to fairly late stages, so that the question of securing material for investigation is relatively simple. Most of the problems concerning the spinal ganglia were settled satisfactorilly, and there has been no marked modification of these early views in recent years. Authors agreed on most points, as to the mode of origin, and also as to the final fate of the ganglia. The definiteness of these results, however, gave a very decided bias to the conclusions drawn in regard to the cerebral ganglia. The ease with which the origin of spinal ganglia was determined and the uniformity with which they arise from the neural crest, and the simplicity of the neural crest in this region, influenced, unquestionably, the conception of the position and the behavior of the neural crest in the head. It is undoubtedly true that too much emphasis was given at first to the role played by the neural crest in the head. As a result, other ganglion forming structures were either overlooked or underestimated at first. For some years the tendency was very marked to attribute to the neural crest in the head too much importance in the formation of cerebral ganglia. It was not fully realized that in addition to the neural crest there were other ganglion forming structures, and, further, that the neural crest itself might behave differently in different types in the head region. It is just this fact that has obscured many of the descriptions of the formation of the cerebral ganglia. The neural crest is not at all uniform in its behavior in different types. This bias was not corrected until a different point of view had become established as a result of the nerve component work.

The next fact historically that is of great significance to this discussion is the development of the doctrine of nerve components. The first effect of this doctrine on our problem was the establishment of the conception that there were more ganglia in the head than had been suspected, since a given ganglion such as the vagus may contain a number of components, and, further, to emphasize the importance, not of the individual nerves and ganglia, but of the component parts of which they are composed. The significance of this is apparent when your attention is called to the fact that seven out of twelve cerebral nerves, exclusive of the nervus terminalis, possess ganglia; when, however, you enumerate the components of these ganglia, there are found about twenty different ganglionic masses, the origin of which must be accounted for and these are distributed among only four components. Evidently, the mode of attack must be changed from that of individual nerves and ganglia to that of their components. Fortunately, there are not twenty different modes of origin for these components. There are about five, at the most; but the point to be emphasized is that these five are distributed among components rather than among ganglia.

The general tendency of the nerve component work has been to emphasize the analysis of nerves rather than of ganglia. This was perfectly natural and inevitable. There is always, in adult types, more or less combination of these various ganglionic components, which renders the identification of the individual ganglionic masses somewhat difficult. By the study of embryos in favorable stages it has been possible to isolate and describe in detail these ganglionic masses and to plot them. This analysis was evidently the second step in the effort to determine the mode of origin of these ganglia. It would have been utterly impossible to write an accurate description of the origin of these ganglia without knowing how many there were and how they were distributed in the various cerebral nerves. The complications that have arisen from ignoring this difficulty are almost innumerable.

The next step, evidently, was to determine the origin of the ganglia whose number, position and morphological relations are known. The diversity in modes of origin is not nearly so great (as mentioned above) as are the number of ganglia, and, in fact, barring the first and second nerves, not so numerous as the number of sensory components.

The simplest way to approach this problem is to return to the neural crest as we find it in the trunk, and then call attention to the variations in its mode of behavior in the head. The classical description of the mode of origin of the neural crest in the trunk is as follows: A mass of cells derived from the ectoderm and lying in the re-entering angle between ectoderm and neural tube becomes detached, migrates ventrally, and assumes the position of the adult spinal ganglia. This conception was established early and has never been materially modified for spinal ganglia. The spinal ganglia send fibers to two general regions, first to the skin forming the somatic group of fibers and second to visceral structures directly from the spinal ganglion or from its derivative the afferent sympathetic ganglia forming the visceral afferent system.

In the head region, however, two other types of behavior of the neural crest are present. It should be emphasized in passing that the neural crest in the head gives rise to exactly the same elements, viz., the general somatic or tactile, and the general visceral ganglia, as does that in the spinal cord region. This is a generalization of the first importance in our effort to establish general principles. We need not enter into the old discussion of the derivation of the head from the body or the reverse. The homology of ganglia derived from the neural crest in the head and in the body is well established, regardless of one's conception of this disputed question. Nor, need we raise the question of the segmental value or position of the cerebral ganglia. That is another problem that is frequently dragged into the discussion of the origin of the cerebral ganglia, to the confusion of the student. Leaving aside the disputed question of cephalization, including the segmentation of the head, we can examine the behavior of the neural crest in the head region as a distinct problem.

The neural crest behaves then in three different ways in the head region. It may behave just as it does in the spinal cord region, that is, become located in the re-entering angle between the ectoderm and the brain tube and, later becoming detached, move ventrally to a position lateral to the brain tube. This whole process is identical in type with the behavior of the spinal cord neural crest, and, as mentioned above, gives rise to the same components. If we accept the current descriptions, this is probably the most common type of behavior among vertebrates.

In the second mode of behavior as seen in Ameiurus, the homologue of the neural crest remains in the lateral ectoderm, and is not located in the re-entering angle. From its position in the lateral ectoderm, it becomes detached finally and migrates to the usual position of neural crest ganglia, after which time there is nothing to indicate that its early behavior was different from the neural crest in the spinal cord region. Since, however, there are other ganglion forming structures in the lateral ectoderm, this mode of behavior raises difficulties not experienced in the study of the first type.

A third type of behavior is illustrated by the Urodeles, and, according to Tilney, by certain of the cerebral ganglia in the cat. In this mode of behavior, the neural crest is incorporated in the neural tube and completely detached from surface ectoderm. It is later erupted from the dorsal surface of the neural canal, and assumes the usual position of neural crest ganglia, after which there is nothing to indicate that its mode of origin is different from that of the neural crest in the cord.

These three types of neural crest behavior can be reduced to one type, theoretically, at least. An extremely broad neural plate would, before invaginating to form the neural canal, reach so far laterally as to incorporate the neural crest in the neural tube from which, later, it is erupted (type III). At the other extreme would be the very narrow neural plate, which would leave the neural crest completely stranded in the ectoderm, as in Ameirus (type II). The intermediate stage would have a moderately broad neural plate, which would carry the neural crest as far mesially as the re-entering angle (type I).

The ganglia derived exclusively from the neural crest in the head are, Gasserian of V, the jugular or root ganglion of IX when present, and the jugular or root ganglion of X. All of these belong to the general somatic or tactile ganglia. The neural crest further furnishes the general visceral ganglia supplying apparently free nerve endings in the mucosa. These are found in the geniculate, nodosal and petrosal ganglia, but do not form all of these ganglia, since they contain special visceral or gustatory ganglia derived from the epibranchial placodes.

The only ganglion of the general somatic or general visceral series that deviates from this description in any noticeable degree is the profundus ganglion. This ganglion always becomes more or less closely associated with the Gasserian, but it always arises from the lateral ectoderm and, curiously, sometimes so far ventrally on the side of the head that its thickening, or placode, has been taken frequently for a dorso-lateral placode, and consequently the 5th nerve has been sometimes described as having a vestigeal dorso-lateral placode, or lateral line organ. This is, of course, incorrect.

The profundus ganglion and nerve have none of the characteristics of lateral line nerves, but do have the characteristics of general somatic or tactile nerves. The mode of origin of the profundus ganglion seems to be constant, regardless of the way in which the neural crest behaves throughout the remainder of the head; that is, whichever of the three modes of behavior the neural crest follows, the profundus ganglion always arises from the lateral ectoderm, somewhat dorsal in position, however, to the dorso-lateral placode to be described later. It is best, in my opinion, to consider the source of the profundus ganglion as the most marked and constant displacement of the neural crest in the head region. This will lead to fewer complications than any other conception.

In addition to the neural crest in the head, there are two other general sources of cerebral ganglia, namely, the dorso-lateral placodes, giving rise to the acoustico-lateral, or special somatic ganglia and nerves, and the epibranchial placodes, giving rise to the gustatory, or special visceral ganglia and nerves.

Before taking these up in detail, however, it is advisable to call attention to the behavior of the ectoderm in forming the olfactory and optic placodes, so-called. Nothing is to be gained, in the present state of our knowledge, by attempting to place the placodes of these two organs in the neural crest, or dorsolateral or epibranchial series. The olfactory placodes remain in the ectoderm at the ventrolateral portion of the neural tube primitively, and are unique among the vertebrates in retaining their position in the ectoderm. They certainly have no resemblance to a lateral line placode or ganglion, and their detachment from the gill slit, at least in existing vertebrates, prevents us from homologizing them with the epibranchial series. Their origin is as unique as their anatomical structure in that they remain in the ectoderm and as compared with other nerves they are usually considered the most primitive type of receptive and conductive apparatus in the vertebrate body.

The so-called optic ganglion and placode are still more unique, in that their cells are invaginated into the neural tube and, later, evaginated to form the optic cup, thus undergoing two displacements, whereas the olfactory placode undergoes none.

There is not much satisfaction, while attempting to reduce these phenomena to a system, to have two such striking exceptions as these organs present. Still, it is better, for the present, in my opinion, to so treat them than to attempt, as is often done, to reduce all sense organs and other thickenings, even the lens, to the three ganglion forming series, and thus weaken the principle involved by doubtful homologies in the attempt to explain every detail. By admitting that we do not see the homology of these placodes with the three ganglion forming series, we at least leave something interesting to be done in the future. Aside from the fact that these placodes come from the ectoderm, they show so little resemblance to each other, or to the three fundamental series, that we cannot combine them or place them in any of our three series. It would be more logical to have five classes: *a*, neural crest, *b*, dorso-lateral, *c*, epibranchial, *d*, olfactory, or permanent skin placode, and *e*, optic, or brain placode. This increases the number of classes, but does not establish any uncertain homologies. If the area that forms the eye had remained in the lateral ectoderm and had formed the eye in that position as it does in some invertebrates, the process would have been homologous to the formation of the olfactory vesicle. It could not even then have been placed in any of the three ganglia forming series, since they form only ganglia which serve as intermediaries between sense organs and brain, while both the optic and olfactory organs contain both receptors and conductors.

Let us return now to the second of our ganglion forming series, viz., the dorso-lateral placodes. These placodes give rise to the acoustico-lateral ganglia and nerves, and are always situated at or about the level of the auditory vescicle. This series must be sharply distinguished from (1) the profundus thickening or placode, which lies at a somewhat higher level on the side of the body and appears earlier; (2) from the primordia of the lateral line organs, which usually arise much later, and give rise, not to ganglia, but to specific lateral line organs. If, as in the urodele, the lateral line primordia arise early, the relations are not so easy to understand as in Lepidosteus, where there is a considerable time interval separating the appearances of the two structures.

From this series of placodes we get the lateral line ganglia of the VIIth, VIIIth, IXth and Xth nerves, and, with the exception of the VIIIth, the behavior shows a fair degree of uniformity. The following variations should be noted:

(a) If the neural crest remains in the lateral ectoderm, as described in the second type of behavior, illustrated by Ameiurus, a large lateral mass is formed containing both the neural crest and the dorso-lateral placode combined in such a manner that it is very difficult at first to differentiate the two components. This condition in Ameiurus, however, is to be interpreted in the light of those forms which present a distinct neural crest and distinct dorso-lateral placode.

(b) Sometimes, as indicated above, it may be difficult to differentiate a dorso-lateral placode which forms ganglia from lateral line placodes which form lateral line organs, but I believe these structures to be morphologically distinct, and if any given case they are not well separated by a time interval in appearance, they should still be interpreted in the light of those forms in which there is a well defined time interval between the two sets of thickenings.

(c) Next, attention should be called to the mode of origin of the auditory ganglion. Authorities are almost equally divided as to whether it rises, on the one hand, from the auditory vesicle, or on the other, from the neural crest. If it rises from the neural crest, and is not included in (a) above as illustrated by Ameiurus, it is an exception to the behavior of the lateral line ganglia, and I have no suggestion to make as to the interpretation of this condition. However, in the types I have studied it seems to come from the auditory vesicle. The precocious appearance of the auditory vesicle seems to have incorporated the dorso-lateral placode at this level and forced it to appear, not from the smooth ectoderm, but from the infolded vesicle. The last word, however, has not been said concerning the origin of the auditory ganglia, by any means. Streeter has shown that in mammals it is distinctly double in form, and there are indications, both in Ameiurus and in the urodeles, that this double condition appears very early, and there may be two sources for this ganglion instead of one. The one source is unquestionably the auditory vesicle, and the other is somewhat in doubt. Whether this double condition corresponds to the vestibular and cochlear divisions cannot be stated.

(d) A fourth source of confusion arises in following the dorso-lateral series of placodes. Where the auditory vesicle begins to form, the thickening in the ectoderm and sometimes even the invaginations is much longer than the vesicle itself. The greater portion of the anterior and posterior extensions of the vesicle disintegrate or are incorporated in the vesicle and are concerned in the formation of neither ganglia nor lateral line organs, but their position makes it difficult to distinguish them from ganglion forming dorso-lateral placodes, and sometimes from lateral line organ placodes and even from epibranchial placodes when these form early and the anterior extension of the auditory vesicle extends ventrally in the region of the VII ganglion.

It must be evident from these facts, that the generalization that acoustico-lateral ganglia come from the dorso-lateral placodes, must be made with the clear understanding of the several modifying factors that obscure, or, possibly, alter the generalization. The dorso-lateral placodes have been studied more extensively than any other series, except the neural crest, but much of the work was done without a clear conception of the components involved, and was frequently confused by the failure to distinguish between the origin of lateral line ganglia and the origin of lateral line organs, as well as the failure to distinguish the placodes from other thickenings lying adjacent to them in the ectoderm.

The third of the sources of origin of the cerebral ganglia is the epibranchial placodes. These are much more uniform in their behavior than the dorso-lateral series, and less disturbed by adjacent structures, although sometimes closely related in position to structures resembling placodes, and concerned in gill slit formation, and of a transient nature. It must be admitted that less work has been done and less positive evidence collected as to the ganglion forming activity of the epibranchial placodes than on either of the other two ganglion forming series. This is due to several causes. First, the evidence for this conception is not so easily observed, although convincing enough when once understood. Second, until the nerve component work on the analysis of the cerebral nerves was well under way, there was no particular reason for suspecting separate gustatory or special visceral ganglia, and certainly no reason for suspecting a separate source. Third, there very early became established, on the basis of the work of Froriep and van Wijhe, the idea that the neural crest ganglia grow ventrally and form a contact with the vestigal sense organs in the position of the epibranchial placodes. This tended toward the conception that the neural crest ganglia grew into contact with the ectoderm, rather than that the ectoderm proliferates cells mesially that form a contact with the neural crest portion of the ganglion, and later became detached and added to it.

There are serious theoretical objections to this earlier view, in addition to the fact that it is not true. 1st, the neural crest proper forms, so far as we know, only general visceral and general somatic ganglia; 2nd, contact with sense organs in the vertebrate is always formed by the nerve growing out from the ganglion and not by the ganglion itself; 3rd, the epibranchial placode, with which the neural crest ganglion is supposed to form a contact, has absolutely no resemblance to a sense organ, gustatory or any other type. In addition to these three considerations, there is the well established fact that the epibranchial placodes do form typical ganglion cells, which are added to the neural crest portions of ganglia VII, IX and X.

While we are on this topic of the possible significance of the epibranchial placode, I should like to call attention to the conception that occurs in most of our standard text books on neurology, viz., that the epibranchial placodes represent phylogenetic sense organs, which may move out of the ectoderm and become buried in mesenchyme to form ganglia. This conception, in my opinion, is entirely erroneous, if we are to depend on histological and embryological evidence at hand. The conception has secured a hold on the minds of neurologists, apparently because it helps to fill in a series in the origin of ganglia, in which the olfactory cell, acting both as a receptor and as a conductor, is the simplest form. The epibranchial placode, if conceived phylogenetically as a sense organ, is thought of as moving out of the ectoderm and thus forming a ganglion. This connects the olfactory with other ganglia more detached from the ectoderm. Now, exactly the same line of reasoning could be applied to the dorso-lateral placodes, and yet, to my knowledge, this has not been done. It becomes still more unsatisfactory if applied to the neural crest. The idea is attractive, however, but certainly receives no confirmation from evidence furnished by either the structure or the mode of development of the epibranchial placodes. They are simply ganglion forming structures, as are the dorso-lateral placodes and the neural crest. In all cases the specific sense organs arise entirely separate in position, and usually later, and very frequently without any close connection with epibranchial or dorso-lateral placodes. The attractive conception should, in my opinion, be entirely disregarded for the more accurate idea that these are simply ganglion forming structures.

The evidence that epibranchial placodes form gustatory ganglia rests upon the facts, (1) that in some types a ganglion such as the visceral portion of the IXth is almost, if not entirely, placodal in origin, and in this case the visceral IXth nerve is almost exclusively gustatory in function. (2) In other types, every step in the contribution of placodal cells to the ganglion can be clearly traced. (3) Every nerve, in all forms studied that possess gustatory fibers, has epibranchial placodes proportionate in size to the gustatory component. (4) No nerve not having gustatory components has an epibranchial placode. The ganglia showing these characteristics are the genticulate, nodosal and petrosal in all forms. The Vth ganglion and nerve gives rise to no gustatory fibers, and never has an epibranchial placode.

To summarize these generalizations, it seems to me fairly safe to make the following statements:

1. That all spinal ganglia arise from neural crest cells detached from the re-entering angle between the ectoderm and the neural canal. These cells, of course, give rise to general somatic and general visceral fibers.

2. In the head region the same general condition exists, namely, that the neural crest and its homologue give rise to all general somatic and general visceral ganglia, but the neural crest in the head shows three rather distinct modes of behavior: First, that which is identical with the behavior in the spinal cord region; second, that in which the neural crest remains in the ectoderm, and later becomes detached from this position; third, that in which the neural crest is incorporated in the neural

tube and later erupted. Whichever of these three modes is followed, the end result anatomically is the same. The exceptional behavior of the profundus ganglion must, of course, be kept in mind.

3. The acoustico-lateral system of ganglia and nerves arises from the dorso-lateral placodes, which, however, are subject to certain marked variations in time and in relation to other placode like thickenings that make this generalization somewhat less valuable than it seems.

4. The gustatory ganglia arise from the third series of placodes, the epibranchial. These are not to be considered as old sense organs phylogenetically, but simply as ganglion forming structures.

5. The two special senses, the olfactory and the optic, are such striking variations from the three ganglion forming series mentioned that it does not seem best for the present to attempt to incorporate these with the three series. They are best treated separately, in which case we must establish five types of behavior which the ectoderm undergoes in forming sensory conductors between the periphery and the central nervous system. (a) The neural crest ganglia furnishing general somatic and general visceral nerves, (b) the dorso-lateral placodes furnishing acustico-lateral fibers, (c) the epibranchial placodes furnishing gustatory fibers, (d) the olfactory or permanent skin placode furnishing olfactory fibers, (e) the optic or brain placode furnishing optic fibers.

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DESCRIPTION OF HORSEFLIES FROM MIDDLE AMERICA II.*

JAMES S. HINE.

There has been notable progress in the study of Tabanidæ in the last few years. Many new genera have been added and some have been thrown into synonymy. Numerous generic characters are available in the Pangoninæ, but this can hardly be said of the Tabaninæ.

The material used for this paper is from various sources, but much of it is the property of the United States National Museum and the American Museum of Natural History.

PANGONINÆ.

The following key is offered as an aid in separating the genera of Pangoninæ of the region covered by the present paper only:

1. Eyes distinctly hairy 2
   Eyes bare 6
2. First posterior cell of the wing open .... *Diatomineura*
   First posterior cell of the wing closed 3
3. Fourth posterior cell of the wing closed .... *Scione*
   Fourth posterior cell of the wing open 4
4. Third antennal segment branched 5
   Third antennal segment not branched .... *Erephopsis*
5. Third antennal segment branched both dorsally and ventrally .... *Pityocera*
   Third antennal segment branched dorsally only .... *Stichocera*
6. First posterior cell of the wing closed .... *Pangonia*
   First posterior cell of the wing open 7
7. Third antennal segment composed of at least seven rings, the first of which is only slightly longer than the following ones 8
   Third antennal segment composed of five rings, the first of which is much longer than the following ones 10
8. Eyes of the female acutely angulate above, wings of both sexes dark on the anterior part, hyaline behind .... *Goniops*
   Eyes of the female not acutely angulate above, wings nearly uniform in color or hyaline 9
9. Front of the female wide, wider below than above, ocelli present, proboscis only a little longer than the palpi .... *Apatolestes*
   Front of the female of normal width or narrow, its sides usually parallel, proboscis often elongate .... *Corizoneura*
10. Second segment of the antenna only half as long as the first .... *Silvius*
    Second segment of the antenna distinctly more than half as long as the first .... *Chrysops*

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*Conclusion of contribution No. 60, Department of Zoology and Entomology, Ohio State University.

Pangonia translucens Macquart.

Thorax plain brown, wings uniformly nearly black, legs, antennæ, palpi and proboscis very dark colored, nearly black. First two segments of the abdomen above pale, segments three, four and five black, usually with a sparse fringe of white hairs on the posterior margin of each. In some specimens the posterior margins of segments three and following segments are pale. Segment two is marked with an elongate more or less triangular black spot in the middle of the dorsum.

Pangonia fusciformis Walker is considered as a synonym. Miss Gertrude Ricardo has redescribed Walker's type in Annals and Magazine of Natural History, Series 7, Volume V, page 170.

Seven specimens, all females, from Ecuador, Canal Zone, Panama and Gautemala show sufficient variation to include both translucens and fusciformis.

Pangonia melanopus n. sp.

Thorax brown, wing black to the axillary incision, pale yellowish to the tip of the anal vein and nearly to the tip of the first vein near the costa; from thence to the apex nearly uniform fuscous, first posterior cell closed, second submarginal cell with a long appendage. Legs very dark brown, almost black. Abdomen above, first segment wholly dark brown, second segment wholly pale yellow, third, fourth and fifth segments widely dark brown with the lateral margins yellow; abdomen ventrally, pale yellow, darker near the tip. Thorax and abdomen clothed with golden yellow hair.

Length of the female 17 millimeters. Front nearly twice as wide near the lower corner of the eyes as at the vertex, ocelli prominent, antenna with the first and second segments yellowish gray pollinose and black haired, third segment bright yellow, palpi brown.

Length of the male 15 millimeters. Colored like the female except the second abdominal segment has an elongate obscure dark marking at the middle of the dorsum and the brown of the following segments is hardly as well defined. It is doubtful if these differences would be constant in a series of specimens.

Holotype female and allotype male collected at Villa Union, Sinola, Mexico, Presidio River, by B. P. Clark, in the United States National Museum. A paratype female from Villa Union, Sinaloa, Mexico, Rusche, collector, in my collection.

This insect is closely related to *Pangonia caustica* Osten Sacken, which has the thorax clothed with black hair, instead of yellow, the tibia and tarsi rufous instead of black, and the abdomen quite differently colored, besides other differences. *Pangonia pavida* Williston has much in common with *melanopus* also.

Pangonia delta n. sp.

Length of the female 18 millimeters. A pale brown species. Body clothed with black and white hair. Wings very pale yellowish, legs largely dark brown.

Eyes black, frontal triangle and face light brown, proboscis dark brown, palpi yellowish, slender, projecting forward, antenna largely bright yellow, first two segments thinly gray pollinose and pale haired, beard very pale yellowish. Thorax pale brown, sparsely gray pollinose, not striped, dark brown haired dorsally and pale haired on the sides. Wing pale yellowish, veins yellow, first posterior cell closed and petiolate, second submarginal cell appendiculate. Legs brown, femora darker than the other parts, everywhere dark haired. Scutellum with a marginal row of long, pale hairs. Abdomen pale yellowish brown slightly darker towards the apex, first segment gray pollinose all over and with numerous pale hairs, following segments pale brown, thinly dark haired, with conspicuous long, white hairs on the posterior margin of each, most numerous toward each side.

Holotype male from Huachuca Mountains, Arizona, August 12, 1899, and paratype male from Palmerlee, Arizona, taken in September.

This is a difficult species to characterize, because it has no contrasting markings, but is very different in appearance, nevertheless, from other North American species of the genus known to me.

Pangonia parishi n. sp.

Length of the female 16 millimeters. A pale species without contrasting markings, wings fuliginous, darker on the basal half in front, legs yellow, first segment of the abdomen beneath the scutellum dark brown.

Front pale brown pollinose, at the ocelli about half a millimeter in width, very slightly wider at the lower angle of the eyes. Frontal callosity below about one-third the width of the front, gradually narrowed and apparent above nearly to the ocelli. Antenna yellow, first two segments gray pollinose and with a few dark hairs, third segment, enlarged at the base, quite abruptly narrowed, and slender to the apex. Face gray pollinose with a few pale hairs, beard very pale yellowish, palpi slender, of nearly uniform width, yellow, arcuate and black haired; proboscis dark, a little longer than the height of the head. Thorax, including the scutellum light brown above, pale yellowish on the sides and clothed with pale hair; legs yellow, tarsi darker apically; wing fuliginous, noticeably darker on the basal half in front, first posterior cell closed, second submarginal cell with a long appendage. First segment of the abdomen dorsally dark brown beneath the scutellum, otherwise first and second segments very pale yellowish with pale hairs intermixed with a very few black ones, third segment of the same ground color, black haired on the basal three-fourths and pale haired on the apical fourth, the remaining segments appear darker on account of being rather thickly black haired with only a few light ones intermixed. On account of the color of the vestiture mainly, the abdomen appears to be colored as follows: first and second segments pale, third darker with a pale posterior margin, remaining segments dark.

Holotype female and a paratype female from Ecuador, collected by Parish, in my collection.

This insect may be readily distinguished from others of its group by the dark brown marking on the first abdominal segment beneath the scutellum.

Scione aurulans Wiedemann.

The genus *Scione* of Walker, often given as *Diclisa* of Schiner, is characterized by hairy eyes and by the first and fourth posterior cells of the wings being closed. About a dozen species of rather small sized Pangoninæ are included under it. I found one species common in various localities in Central America in March, 1906, and procured a long series of specimens. With good material at hand, careful comparisons with descriptions have been made and I am convinced that I have the species which Wiedemann called *Pangonia aurulans* and which has never been recognized since, and also that *Pangonia rostrifera* Bellardi and *Diclisa misera* Osten Sacken, are synonyms.

The species occurs over a wide range for specimens are at hand from Tabasco, Jalapa and other Mexican localities, from various places in Guatemala and from San Pedro, Honduras. Specimens vary somewhat in size and in length of proboscis, but are very uniform otherwise.

It is an annoying fly where it abounds. It appeared to keep close to the ground and with its long proboscis had no trouble biting through one's trousers. More than a score of specimens were actually counted on my clothing at one time.

TABANINAE.

Tabanus punctipleura n. sp.

A large robust species of nearly uniform purplish brown color; third segment of the antenna with a long basal projection. A small conspicuous patch of intense black hairs somewhat more than a millimeter in diameter on each pleura just beneath the attachment of the wing. Length 22 millimeters.

Female. Front about three-fourths of a millimeter in width, yellowish pollinose, sides parallel, frontal callosity at the lower angle of the eye about one-third as wide as the front, shining brown, gradually narrowed and entirely disappearing slightly before the vertex; face yellowish pollinose, beard pale yellow, antenna reddish basally dark brown apically, first segment enlarged and black haired above, third segment with a slender basal projection which is more than a third of the length of the segment; palpi pale brown and largely black haired. Thorax purplish brown and largely clothed with pale yellowish vestiture especially on the sides; a minute tuft of very pale hair immediately in front of the attachment of each wing and just beneath a small round patch of intense black hair producing a conspicuous spot from which the insect is named. Immediately in front of the scutellum on the mid-dorsal line a short and a narrow transverse patch of intense black hair limited at either end by a minute tuft of nearly white hair. Wings brownish all over, stigma intense brown; legs reddish brown, tarsi darker than the other parts. Abdomen darker than the thorax but of the same general color, black haired and without markings, except a small area of white hair on each posterior lateral margin of each of segments one to four.

Holotype female from San Carlos, Costa Rica, and one paratype female from Carillo, Costa Rica, collected by Schild and Burgdorf, in the United States National Museum. A paratype from San Carlos, Costa Rica, by the same collector, and another simply labelled Costa Rica, in my collection.

The last mentioned specimen was named *Tabanus dephilippi* when I received it, but there is no reason for confusing *punctipleura* with the last named species, for they are entirely distinct.

Tabanus fumomarginatus n. sp.

Wing veins margined with fuscous, general color of the body brown, a conspicuous round black spot on the scutellum margined with gray pile. Length 18 millimeters.

Front about a half millimeter in width, sides parallel, frontal callosity shining brown, at the angle of the eyes distinctly narrower than the front and gradually narrowed to its termination half way to the vertex; antenna dark reddish, darker towards the apex where it is nearly black, first segment much enlarged, produced forward above, largely black hairy; third segment slender, with a basal prominence only, basal portion very distinctly longer than the annulate portion. Palpi pale in color, enlarged basally and narrowed towards the apexes. Eyes bare. Thorax rubbed somewhat but with pale stripes, ground color brown; scutellum with a conspicuous round black spot margined with a ring of light pile, part of which is on the posterior margin of the mesothorax, wings quite dark approaching fuscous, distinctly darker along the margins of the veins than elsewhere. Legs dark brown, front femora above and all of the tarsi nearly black, front tarsal segments distinctly wider than those of the other feet, all of the posterior cells of the wings open, furcation of the third vein without an appendage. Abdomen brown, somewhat darker dorsally than ventrally, posterior margins of the segments dorsally narrowly pale and each expanded into a gray triangle at the middle. The middorsal row of triangles does not show conspicuously for the description is taken from alcoholic material.

Holotype female and a paratype female from Rio Caiary, Uaupes, State of Amazonas, Brazil, H. Schmidt, collector, in the American Museum of Natural History. A paratype with the same date in my collection.

I have a half dozen species of Tabanus with the conspicuous spot on the scutellum, but this is fully distinct from any of them. The widened front tarsi are useful in determining this insect.

Dichelacera melanosoma n. sp.

Body shining black, except the first abdominal segment. Wing pure black with hyaline markings. Length of the female 12 millimeters.

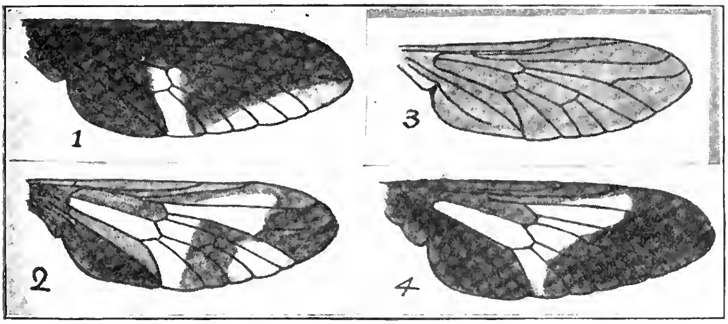
Front dark gray pollinose, frontal callosity shining black, as wide as the front, nearly square, acute angulate above and with a short linear extension towards the vertex. Antenna largely pale although much of the third segment is black, especially the annulate portion; basal extension of the third segment slender and more than half as long as the segment, palpi black, facial callus very prominent and shining black. Dorsum of the thorax plain black, including the scutellum; front leg black except the basal half of the tibia which is white, middle and hind femora black, tibiæ and tarsi white; wing black with the axillary cell, a median posterior half band and the wing margin between apex and the fifth posterior cell hyaline. The hyaline half band includes the narrow apexes of the second basal, discal and fourth posterior cells and a large part of the fifth posterior forming an area of uniform width which reaches from the middle of the wing to the posterior margin. See Figure 1. Abdomen dorsally, first segment nearly white, other segments clear black.

Holotype female from Higuito, San Mateo, Costa Rica, collected by Pablo Schild. In the United States National Museum.

Dichelacera analis n. sp.

Length of the female 10 millimeters. Front gray pollinose, frontal callosity at the lower corner of the eyes as wide as the front, higher than wide, acutely angulate above; face entirely gray pollinose without a shining callus at the middle as in damnicornis. Palpi pale, antenna pale basally, apical half of the third segment black, basal extension of the third segment pale, slender, somewhat curved, more than half the length of the segment. Thorax dorsally pale, a clear brown band distinctly convex before and slightly so behind between the wing attachments; scutellum clear brown; front femur pale basally, dark apically, front tibia and tarsus dark although the tibia is lighter colored basally, middle femur entirely pale, middle tibia and tarsus brown, hind femur pale except at apex where it is black, hind tibia and tarsus black Wing black as follows: costa including most of the first basal cell, nearly all of the anal cell, apex of the wing beyond the furcation of the third vein and a band beginning at the third vein before its furcation and extending to the posterior margin, also the posterior margin is lightly infuscated for nearly its entire length including the apical half of the axillary cell. See Figure 2. Abdomen dorsally, first segment pale, second segment nearly black, third and fourth segments black, each with a narrow posterior pale yellow margin, following segments black.

Length of the male 10 millimeters. Colored like the female, but the vestiture of the body is longer in this sex.



1. Dichelacera melanosoma.
2. D. analis.
3. D. melanoptera.
4. D. caloptera.

Holotype female, allotype male and eight paratype females from Higuito, San Mateo, Costa Rica, collected by Pablo Schild, in the United States National Museum. Two paratype females with the same data in my collection. Ten paratype females from Gatun, Canal Zone, collected by D. E. Harrower, July, in my collection.

The species resembles *damnicornis*, but does not have a shining facial callus as that species and the wing markings are differently arranged. It suggests *alcicornis* somewhat, but has the thorax banded instead of striped.

Dichelacera melanoptera n. sp.

Length of the female 10 millimeters. A dark colored species with uniformly colored nearly black wings. All the tibia white except at the apexes where they are dark brown. Thorax dorsally and anterior part of the abdomen dark brown, abdomen gradually darker posteriorly and quite black at the apex. Face with a distinct shining callus in the middle, front with an elongate shining black callosity. Antenna, first segment black somewhat elongated, second and third segments brown, basal extension of the third segment slender, elongate, somewhat curved and not quite reaching half of the length of the segment. Legs black except that each tibia is white with a very dark apex. Wing dark, nearly black, posteriorly less intensely colored. Figure 3.

Holotype female from Tukeit, British Guiana, July 17, 1911, and ten paratype females taken between July 16 and August 16, 1911, in the same locality, in the American Museum of Natural History. Three paratype females from the same locality taken July 17, 1911, in my collection.

This is a peculiarly colored species for a Dichelacera, but it has the proper characters and aside from color, looks like a member of the genus. Its uniform dark color at once distinguishes it from other species with which it is associated.

Dichelacera ochracea n. sp.

Length of the female 11 millimeters. General color pale yellowish all over without conspicuous markings of any kind. Front yellowish pollinose, frontal callosity shining brown, nearly square with a short extension above. Face yellow pollinose without denuded central callus, palpi yellow, antenna largely yellow, annulate portion of the third segment dark, nearly black. Thorax pale yellow with much golden pubescence, dorsally a uniform band between the attachment of the wings and the scutellum clear brown. Legs pale yellow without distinct markings although the tarsi are a shade darker than the tibia, especially apically. Wing shaded; from some views it appears to be uniform all over but with the insect pinned on a white support or with opaque light the disk of the wing is seen to be less colored than the other parts. Included in the less colored are the second basal and axillary cells, and parts of the marginal, first submarginal, fourth and fifth posterior and all of the discal except its apex. Abdomen dorsally pale yellow and mostly golden haired, bases of the first four segments, especially the third, and all of the last three segments brownish.

Allotype female from Mallali, British Guiana, April 31, 1907, in the United States National Museum. Paratype female from Port of Spain, Trinidad, in my collection.

This is a difficult insect to characterize on account of the lack of contrasting colors, but it is very distinct from other species of the genus known to me.

Dichelacera caloptera n. sp.

Length of the female about 12 millimeters. Front gray pollinose, frontal callosity as wide as the front, shining black, about as high as broad, angulate above; face with a prominent shining callus, palpi yellow. Antenna yellow except the annulate portion of the third segment which is dark, basal extension of the third segment slender, reaching half the length of the segment. Thorax yellow dorsally with a black band between the wing attachments scutellum black; front femur yellow with a brown apex, front tibia yellow basally, otherwise brown, front tarsus dark brown, middle leg all yellow except the tarsus which is pale brown, hind femur yellow, brown at the apex, hind tibia and tarsus dark brown nearly black. Wing clear black with a pale yellowish area which includes the second basal cell and basal parts of the discal, first, fourth and fifth posterior, first submarginal and a small area in the marginal cell. See Figure 4. Abdomen dorsally, first segment pale, following segments each dark on the anterior half and pale on the posterior half.

Length of the male 12 millimeters. Colored like the female and easily associated with it.

Holotype female from the State of Colima, Mexico, collected by L. Conradt, and allotype male from Venodio, Mexico, Rusche collector, in the United States National Museum. A paratype female from Venodio, Mexico, Rusche collector, in my collection.

Ohio State University, Columbus, Ohio.

SPRINGS OF MINIMUM INERTIA.

H. C. Lord.

In certain forms of apparatus where springs are employed to indicate the instantaneous value of a varying force it is of the utmost importance that they should be as light as possible in order that the inertia should be reduced to a minimum. In designing such a piece of apparatus the writer found it necessary to investigate mathematically the conditions which must be fulfilled in order that the spring might be of minimum weight. In the course of this investigation certain unexpected and very interesting results were reached which not only are of general application, but also lead to simple formulae of design. Such springs may be grouped into two classes, namely, those whose action depends upon bending and those whose action depends upon torsion. Evidently, in either kind, the maximum allowable fiber stress and the maximum deflection to which the beam will ever be subjected must be reached simultaneously with the maximum load for, were it otherwise, the spring could have some metal removed and still be strong enough to resist the stress. We will take, therefore, as the quantities entering into this investigation the following:

f = the maximum allowable fiber stress.
P = the maximum load.
Δ = the maximum deflection.
Z = the modulus of the section.
I = the moment of the inertia.
E = Young's Modulus.
w = the weight per cubic inch.
W = the total weight.
b† = the breadth.
d = the depth.
L = the length.

†In beams of constant strength, and depth constant, b is breadth of base.

SPRINGS DUE TO BENDING.

All springs of this type take the form of some sort of a beam and we will then have the following formulae from the fundamental principles of strength of materials.

$$(1)\quad f=\frac{PL}{ZN} \qquad\qquad (2)\quad \Delta=\frac{PL^3}{KEI}$$

In the above equations N and K are constants which determine the method of loading and the manner in which the beam is supported.

BEAMS OF RECTANGULAR SECTION.

In this case—

$$Z=\frac{bd^2}{6}, \qquad I=\frac{bd^3}{12}, \qquad \text{and} \qquad W=wbdL$$

These give when substituted in equations (1) and (2),

$$(3)\quad f=\frac{6PL}{Nbd^2} \qquad\qquad (4)\quad \Delta=\frac{12PL^3}{KEbd^3}$$

Square equation (3) and divide the result by equation (4) and we have,

$$(5)\quad \frac{f^2}{\Delta}=\frac{3PKE}{N^2bdL} \qquad \text{whence} \qquad (6)\quad bdL=\frac{3PKE\,\Delta}{N^2f^2}$$

In equation (6) bdL is simply the volume of the spring and hence if we multiply this by its weight per cubic inch, we will have its total weight, whence

$$(7)\quad W=wbdL=3w\left(\frac{K}{N^2}\right)\left(\frac{E}{f^2}\right)P\,\Delta$$

In either of the cases of a beam fixed at one end and loaded at the other, supported or fixed at both ends and loaded in the middle, the quantity $(K/N^2)=3$, whence the weight will be given by

$$(8)\quad W=9\left(\frac{wE}{f^2}\right)P\,\Delta$$

It will be noticed that the dimensions of the beam have entirely disappeared from equation (8) or in other words the weight is entirely independent of the section of the beam. To put this in other words a spring in the form of a ruler laid flat wise would weigh exactly as much as one in the form of a ruler laid edgewise provided only that in both cases the same load produced the same deflection with the same fiber stress. At first sight this seems almost absurd and to contradict our experience, but a moment's consideration shows that the reason of our doubt is that in applying the formulas for strength and flexture, the length of our beam is almost invariably given in advance and we forget that a short flatwise ruler will be as stiff as a long narrow one edgewise.

In an exactly similar manner we may investigate the case of a beam of constant strength and of constant depth, or one of constant strength and constant breadth and we will find that the expression for the weight of the beam is identical in both cases. In the case of the hollow cylinder there are two limiting cases, first, where the walls are very thin, and second, where the cylinder became a solid rod. The following table gives the results.

Beam of constant strength loaded at one end fixed at the other........................	$W = 3\left(\frac{wE}{f^2}\right) P \Delta$
Hollow cylinder walls very thin.............	$W = 6\left(\frac{wE}{f^2}\right) P \Delta$
Rectangular Beam.........................	$W = 9\left(\frac{wE}{f^2}\right) P \Delta$
Round rod..................................	$W = 12\left(\frac{wE}{f^2}\right) P \Delta$

It is to be noted that in the above expressions for the weight of the several types of beams that if we take the weight of the beam of constant strength equal to one the weight of the others will be 2, 3, and 4. Attention should be called to the great superiority of the beam of constant strength when the depth is made constant, the plan, in that case, being a triangle. In this case not only is the total weight the least of the cases considered, but the weight is nearly all concentrated at the fixed end, while the free end which moves is the vertex of the triangle and consequently of almost no weight.

We will now give the formulas for design for a few cases which will sufficiently illustrate the method so that the designer can readily apply the same process to any case that he might have in hand. Introducing the values of K, N, I, and Z in equations 1 and 2 we find after reduction the following:

BEAM OF CONSTANT STRENGTH, DEPTH CONSTANT, FIXED AT ONE END.

(a) $bdL=6(E/f^2)P\Delta$
(b) $bd^2=6PL/f$
(c) $\Delta=6PL^3/(bd^3E)$ Check

RECTANGULAR BEAMS FIXED AT ONE END.

(a′) $bdL=9(E/f^2)P\Delta$
(b′) $bd^2=6PL/(f)$
(c′) $\Delta=4PL^3/(bd^3E)$ Check

SOLID ROUND ROD, FIXED AT ONE END.

(a″) $\pi r^2L=12(E/f^2)P\Delta$
(b″) $r^3=4PL/(\pi f)$
(c″) $\Delta=4PL^3/(3\pi Er^4)$ Check

At first sight it might seem that the three equations in each of the above cases were independent of one another, but that is not the case as the expression for the volume was obtained from a combination of the other two. The equation for the flexture is introduced to serve to check the computation. In the first two cases there are three unknowns, b, d, and L; so that any one of them may be assumed and the other two computed which gives great flexibility in design; in the third case, however, there are but two unknowns and hence but a single solution of the problem. As an illustration, let us assume—

$P=100$ lbs.
$\Delta=0.1''$
$f=40{,}000$ lbs. per square inch.
$E=29{,}000{,}000$ lbs. per sq. in.

First Case. From (a) $bdL=1.0872$, from (b) $bd^2=0.015L$. Let us assume $d=\frac{1}{4}''$ and we will then have $L=4.26''$, $b=1.02''$. Second Case. From (a′) $bdL=1.631$, from (b′) $bd^2=0.015L$ and as above assume $d=\frac{1}{4}''$ and we will have $L=5.21''$ and $b=1.25''$. Third Case. From (a″) $r^2L=0.6922$, from (b″) $r^3=0.003181L$, whence $r=0.2942$ and $L=8.002$.

SPRINGS DEPENDING UPON TORSION (COILED SPRINGS).

Under this class we will consider those springs which are wound in the form of a helix and in which the action is such as to stretch or compress the spring along the axis of the helix. In his "Mechanics applied to Engineering," Goodman, neglecting the angularity of the helix, gives for the maximum fiber stress and the total deflection

$$(9)\ f=\frac{8PD}{\pi d^3} \qquad (10)\ \Delta=\frac{8nPD^3}{Gd^4}$$

In the above D equals the mean diameter of the coil, d the diameter of the wire, n the number of turns, G the coefficient of rigidity, and the other quantities as before. A moment's consideration shows that we will have for the length of the wire and the total weight

$$L=\pi nD \text{ and } W=(1/4)\pi^2nwd^2D$$

From Equations 9 and 10 we find

$$\Delta/f^2=\pi^2nd^2D/(8PG)=W/(2wPG)$$

From this it follows that

$$W=2wPG(\Delta/f^2)$$

From this it follows that the weight of the spring depends only upon the material, the applied load, the coefficient of rigidity, the maximum deflection and the allowable fiber stress in shear; and is entirely independent of the size of wire, diameter of the helix and number of turns. The formulas for design may now be easily derived:

$$(a''')\ nd^2D=8PG\Delta/(\pi^2f^2)$$
$$(b''')\ d^3/D=8P/(\pi f)$$
$$(c''')\ \Delta=8nPD^3/Gd^4)$$

As before, we have two independent equations containing the three unknowns, n, d, and D, so that we may assign to any one of them an arbitrary value and then compute the others and use the third equation as a check.

As an illustration, let us assume $P=100$ lbs., $G=12{,}000{,}000$, $f=50{,}000$ and $\Delta=\frac{1}{2}''$. We will then find that $nd^2D=0.1945$, and $d^3/D=0.00509$. If then we assume that the spring is to have twenty turns of wire, we find from the above that $D=0.513''$, $d=0.1377''$, and if the spring is to be wound close, its length will be $2.8''$. The following formula is useful in computing the length of the helix (L), $L'=n\ (d+s)$ where s is the width of the open space, which is small in the springs considered.

The Emerson McMillin Observatory, Ohio State University,
May 15th, 1920.

XII. THE GREAT MAGEIK LANDSLIDE.

Robert F. Griggs.

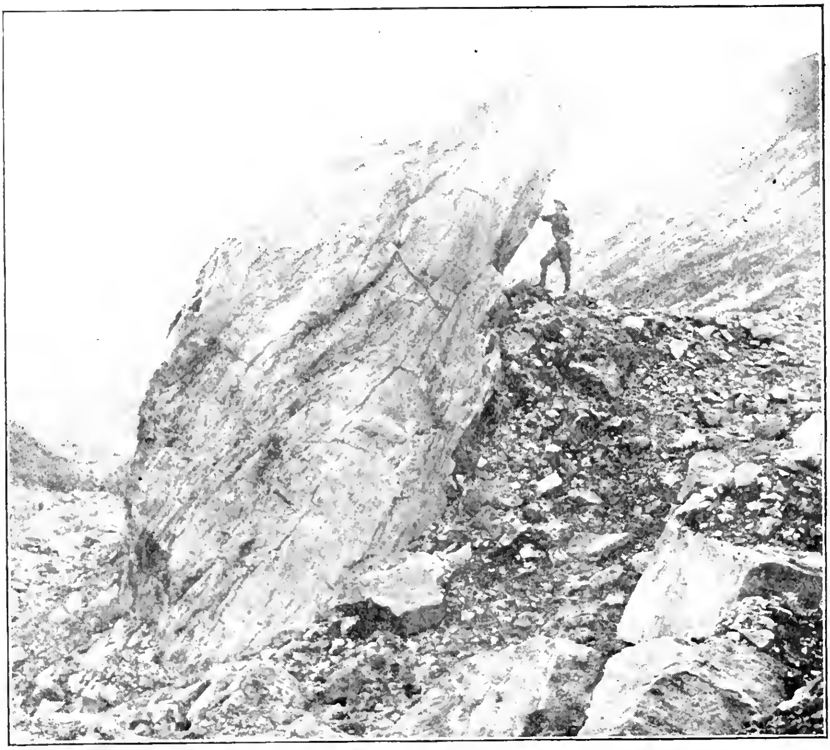
When in our exploration of the Katmai District we entered the upper reaches of Martin Creek, we came upon a most curious terrane, a third wonder almost worthy of being ranked with the Ten Thousand Smokes and the crater of Katmai. The valley was filled with a stupendous mass of broken up rocks, piled together in the utmost confusion, so different from any of the common physiographic features that its interpretation for a time seemed an insoluble riddle.

The upper portion of this Valley, for five miles from its head out on to the flat plain, where it is more than a mile wide, is covered with a great mass of debris. Piles of broken rock, chunks of soil, masses of peat and plant remains are everywhere jumbled together in indiscriminate heaps. The bowlders comprise several sorts of rock; fragments of an old lava flow, tuff from an ancient eruption, and blocks of sandstone are all mixed together.

BOWLDERS AS BIG AS A HOUSE MORE THAN A MILE FROM THEIR SOURCE.

Rocks ten feet across are abundant, and in some places compose the bulk of the terrane, while much larger bowlders are frequently encountered, some of them as large as a good sized house. Many measure more than 30 or 40 feet. The largest single stone observed was 75 feet long, 35 feet wide and 20 feet high, lying half hidden in the surrounding debris. (See page 326).

The mass is spread so thinly over the valley floor as apparently to change but little the original contours. Its general surface is fairly flat, conforming with that of the broad open U-shaped valley in which it occurs, but it is thickly studded with curious conical mounds of detritus which contribute much to its puzzling appearance. (See page 352). In the lower part of its course it forks, sending a branch down both of the two streams that drain the valley. One of these branches is especially noteworthy for it terminates in an extremely narrow tongue, closely confined to the slight trench of the stream. Although scarcely a hundred yards wide, this tongue is a mile long.



Photograph by Robert F. Griggs

ONE OF THE LARGER ROCKS OF THE SLIDE, SURROUNDED BY SMALLER DEBRIS.

The largest bowlder observed, which was 75 x 35 x 20 feet, was not favorably situated for a photograph.

DIFFERENCES FROM A GLACIAL DEPOSIT.

When I first saw this terrane from a distance, I supposed, from its obvious flow structure, that it was a rock-covered glacier, and it was only on nearer approach that it was seen to contain no ice. But it shows so many resemblances to a glacial deposit, that for a time I supposed it must be some freak of glacial action, for I could not at first imagine any agency other than ice which could move huge bowlders with as great ease as fine sand. In places also its surface is pitted with characteristic circular puddles, exact miniatures of the "Kettle-hole Ponds," so familiar to students of glacial deposits. (See page 343). Since these could be readily accounted for by the melting away of an embedded block of ice or snow after the mass reached its present position, their occurrence gave color for a time to the glacial theory.

But it has several important characteristics which show at once that it was not the work of any glacier. It has no moraines, no ridges of any kind at its end or edges, nor is there any sign of the push and shove everywhere characteristic of ice work. There is none of the piling up and gradual overthrow of masses of resistant solid material caused by the steady downward creep of the irresistible ice, but, on the contrary, the mass gives evidence of having possessed a high degree of internal fluidity permitting it to spread out in a thin layer over the ground. Although lacking any resemblance to morainic ridges, the terminal edge is perfectly clear cut and distinct, sharply contrasting with the surface of the original soil beyond. In some places the margin is a steep convex bank, about three feet high. (See page 328). But in others there is merely a thin veneer of debris spread over the ground. (See page 329).

The effect on the bushes that lay in its path, also seen particularly well along the margin, likewise affords clear and positive evidence that it is no glacial moraine. An advancing glacier slowly overwhelms the trees that stand in its way, gradually pushing them over by piling debris against their trunks. But here the willows and alders were broken sharp off, clear up to the very margin of the flow. The line of destruction is as sharp as the edge of the debris itself. (See page 345).

There are many places where one may observe clean-broken stumps protruding through their covering of debris, within a few feet of similar bushes standing untouched beyond the margin of the drift. These bushes were not simply bent over before the advancing debris, nor were they uprooted by its force. they were snapped off sharp as though struck by a flying rock. (See page 328).

In the terminal portion of the mass there are few of the rocks so characteristic of the upper portion. On the contrary, the terminus is composed more largely of fine materials, among which are great chunks of black peat soil. In some places these masses of peat are scattered irregularly through the debris, but in others they are thrown into rude rows. (See page 351).

The lateral edges, several miles back from the terminus, have a different character still more distinct from the moraine ridges of a glacier. For here the edge may be said to be concave, instead of convex. That is to say, instead of piling up, the

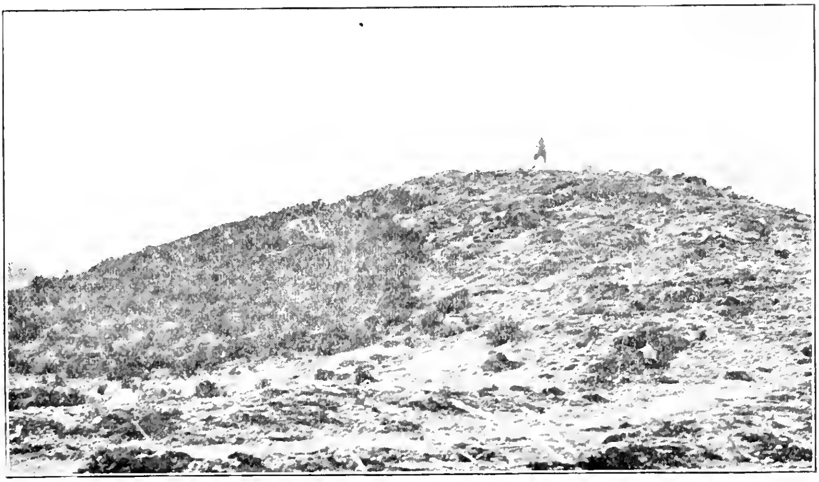
Photograph by Robert F. Griggs

TERMINAL EDGE OF MAGEIK SLIDE.

Although obliterating the alder thickets wherever it touched them, it showed no tendency to form ridges resembling moraines. At this edge the slide covered the ground only four or five feet deep. The black chunks are masses of peat.

debris slumped away from the highest level it reached, leaving a hollow rather than a ridge. This is particularly well shown along the foot of one of the encircling mountains, so located as to have stuck squarely out into its path. Here it ran over the barrier, clearing the vegetation and soil from the rock to a height of nearly 100 feet above the present level of the debris. But instead of piling up against the obstruction, as a glacier would have done, it slumped away again, leaving the hillside almost free from debris, and forming a deep hollow all around its base, in which has gathered a considerable body of clear green water, the "Horseshoe Pond." (See pages 330 and 336).

Even more significant than the absence of moraines along the margin of this terrane is the fact that it branches. In addition to the two main forks, there is, near the terminus, a manifest tendency for the edges to splay out into minor branches. Parts of two of these little branches are well shown on page 345. A forking glacier is, to be sure, no impossibility; but a mass of ice can be divided only when it meets an insuperable obstacle capable of withstanding the enormous power of its advance.



Photograph by Robert F. Griggs

A THIN EDGE OF THE SLIDE, WHERE IT RAN UP THE SIDE OF A LITTLE HILLOCK.

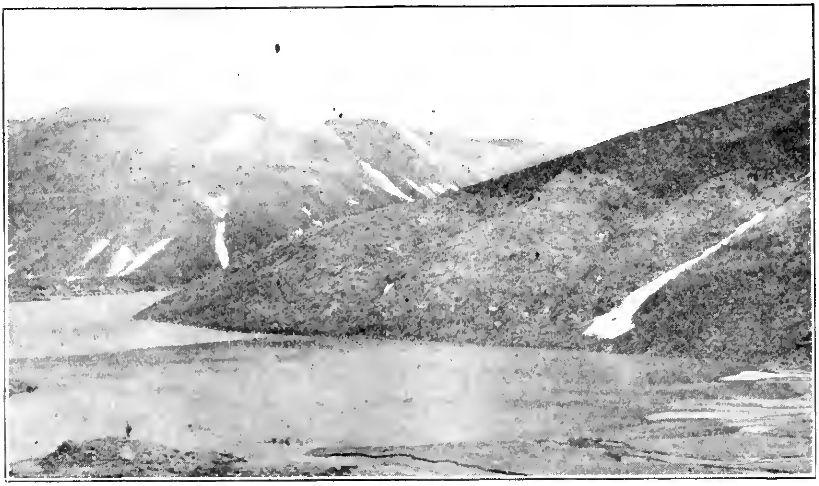
The grass land at the left was not touched by the slide. The covering of debris is so thin that it scarcely alters the contour of the hill.

In this case no such obstacle existed, for the terrane lies in a broad open valley which happened to be occupied by two streams flowing in separate courses to their confluence below.

Originating on a branch at an angle to the general course of the main valley, it ran straight across the valley and then, turning the corner, continued for more than two miles down the beds of the two streams. The height of the divide which thus served to split it is so slight that it seems altogether inconsequential. As one studies the situation in the field, he is astonished that such a mass of heterogeneous solids should have had the capacity of adjusting itself so completely to slight differences in the gradient of its bed.

EVIDENCE OF SUDDENNESS OF FORMATION.

Another striking difference from a glacier lies in the fact that the terrane under consideration bears unmistakable evidence of having been formed suddenly. There are numerous fragments of the original vegetation which were not destroyed



Photograph by Robert F. Griggs

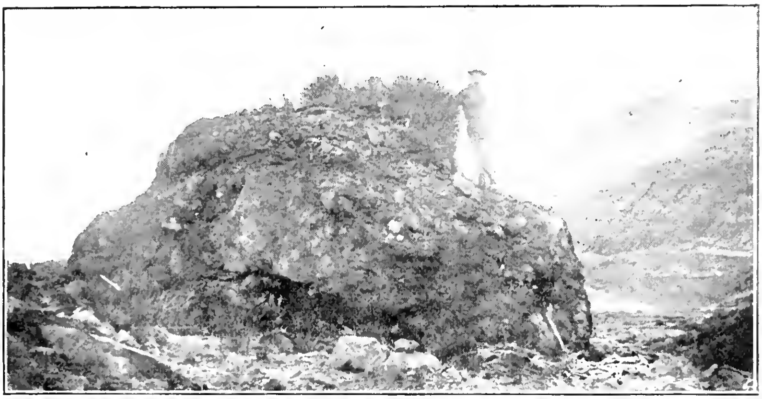
A HILL SCOURED OFF BY THE SLIDE.

The flying rocks scoured off the soil nearly a hundred feet up this hillside, yet before movement ceased the mass slumped away again, leaving a deep depression now filled with water, forming the Horseshoe Pond.

by the catastrophe. Some of these, indeed, still remain alive and have begun to grow again. (See page 331). Such a thing would hardly have been possible in a glacier, for its action is a typical example of the working of the old adage, "The mills of the Gods grind slowly, but they grind exceeding fine." The transportation of such a bowlder as that shown on page 331, from the mountain top down into the valley by a glacier would require a number of years, during which all traces of vegetation would in all probability have been ground up in the repeated overturning to which glacial bowlders are usually subject. These fragments of vegetation were evidently carried "right side up with care" all the way down the mountain to their present resting place.

INDICATIONS OF THE DATE OF ITS OCCURRENCE.

Along with indications of suddenness of formation is other evidence which fixes rather closely the date at which this curious mass of debris reached its present position. By all the criteria of physiography it is very young—indeed, infantile. Two streams traverse its surface for some miles, but have scarcely

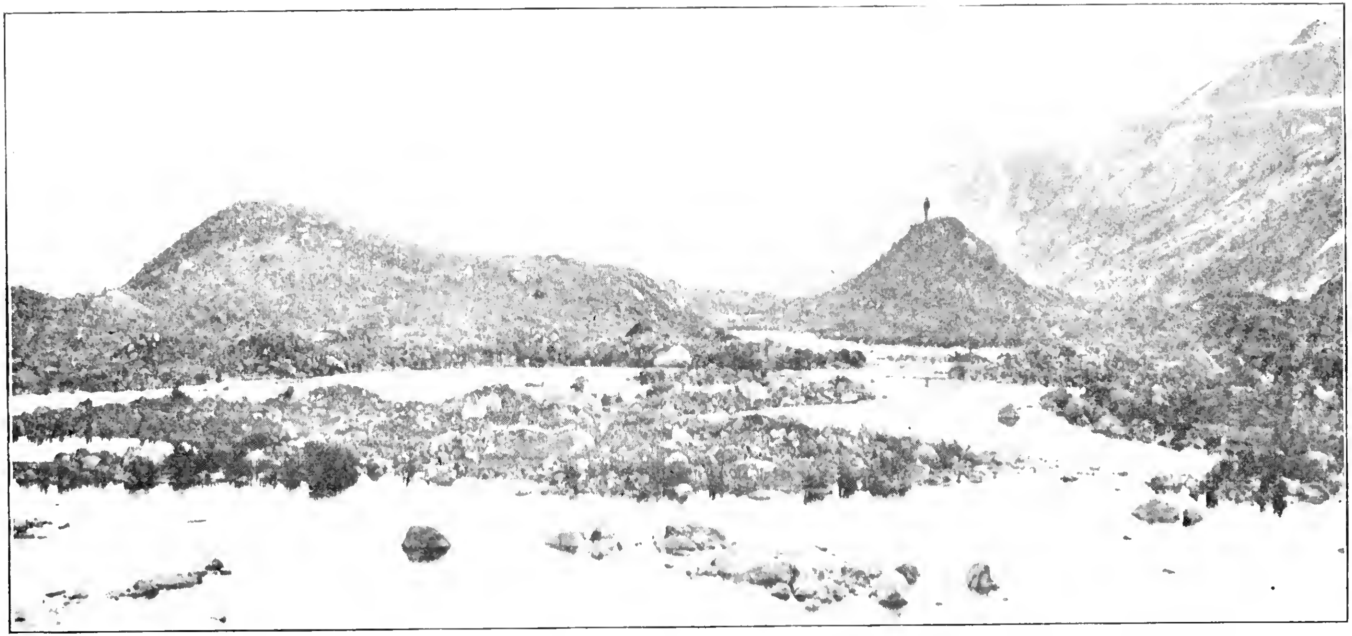


Photograph by Robert F. Griggs

ORIGINAL VEGETATION PERSISTING ON A ROCK IN THE SLIDE.

By some freak this grass, with the soil in which it grew, was transported, "right side up with care," for two miles down to the valley from its original position at the top of the cliff.

begun to erode their beds. They spread out in most irregular fashion over the uneven surface of the debris, without having even so much as scooped out a channel for themselves. (See page 332). The bowlders in their beds are still angular, like the rest of the material, in sharp contrast to the rounded cobbles of typical streams. The surface is so fresh that, despite the large content of soil in places, new vegetation has only just begun to take hold. Considerable numbers of fragments of the overwhelmed bushes lie embedded in the debris in such fashion as to leave no doubt that they are contemporaneous with it. Such pieces of wood must, of course, rot away in the



Photograph by Robert F. Griggs

DRAINAGE OF THE SURFACE OF THE SLIDE.

The several swift streams which cross its surface have not even cut beds for themselves in the gravelly debris
The water simply spreads out irregularly over the uneven surface.

course of a few years, but as yet they show few signs of decay. These circumstances combine to make it certain that the material was thrown into position very recently.

On the other side, it is certain that the terrane goes back to the time of the eruption by reason of the fact that its surface is in many places covered with the layers of ash from Katmai. Because of local irregularities in deposition, I have not been able to satisfy myself whether all layers of ash are present or only the upper strata. But it is significant that close beside these spots covered with stratified ash are others which show no sign of ash or in which it is mixed with the debris in such fashion as to indicate that while the mass in the main must have reached its position before the end of the eruption, yet there were minor movements after the ashfall. This combination of circumstances appears to fix pretty definitely the formation of the terrane as co-incident with the eruption.

The presence of the original vegetation on its surface and other features suggests the similarity of the terrane to a landslide. Fragments of the original ground surface were similarly transported in the great landslide at Frank, Alberta, as described by McConnell and Brock,* who report, "One large bowlder still retains on its upper surface a coating of moss and a fragment of rotten log lying quite undisturbed." But here again there are important differences which at once distinguish this from the ordinary landslip. Its surface has neither the hummocky billows nor the crescentic ridges so characteristic of landslides in general. Instead it possesses a peculiar type of surface different from anything I have ever seen in regions of ordinary physiography.

Everywhere the surface of the terrane shows a marked tendency to be studded with the most curious conical piles of detritus. Some of these are astonishingly perfect in form. In others the conical form is less perfect. Nevertheless, it is so unusual and so strongly impressed on the topography as to excite the wonder of everyone who beholds it. The pictures on pages 349 and 352 give a good idea of the general character of these cones.

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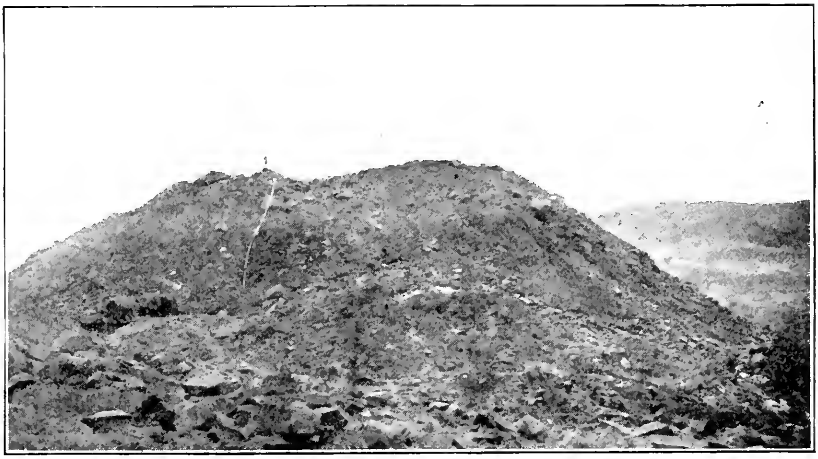
*McConnell, R. G., and Brock, R. W. Report on the Great Landslide at Frank, Alberta, 1903. Ann. Rept. Dept. Interior, Canada, 1903. p. 10.

SIMILARITY TO THE "ROCK STREAMS" OF COLORADO.

Our difficulties in interpreting this feature were evidently very similar to the experience of Cross and Howe, who first described the "Rock Streams" of Colorado which closely resemble the present terrane, for in their first account of them* they say: "Probably masses of the same character occur in many other localities, but they are less sharply defined from other debris and hence, so far as we can ascertain, they have never attracted sufficient attention to be particularly described.



Photograph by D. B. Church

ONE OF THE LARGEST OF THE ROCK PILES.

The man against the sky line gives the scale. In this case the pile departs somewhat from the conical shape, but was evidently formed in the same manner as the more perfect cones.

The most striking of these masses, and those to which attention was first directed, closely resemble debris covered glaciers at the heads of the basins or cirques in which they occur. * * * All the accumulations just described impress one with a sense of motion, looking as if they had flowed as do viscous masses and were still advancing from the head walls of the cirques downward. So noticeable was this that in the field they were spoken of as "Rock Glaciers," and upon the map receive the name of "Rock Streams." * * * The larger rock streams, however,

*Silverton Folio. (U. S. Geol. Survey Folio 120, p. 25), 1905.

must owe their origin to glaciers; no other agencies could transport such vast quantities of rock so far from their sources." This same opinion was held by Chamberlin and Salisbury* who say, "the loose debris on steep slopes sometimes assumes a sort of flowing motion and descends the slope with some such form and at some such rate as a glacier," illustrating such "talus glaciers" by a picture of one of the Silver Basin "Rock Streams."

This view is further strengthened by the strong resemblance of the gouged out mountain side from which they originate to a glacial cirque. But in the landslides of the Katmai district any inclination to interpret the hollows at the heads of the flows as glacial is at once disposed of by the obviously fresh unweathered surface of the rock, which of itself shows that they were never occupied by a glacier whose disappearance would have involved a considerable lapse of time and the consequent weathering of the surface of its cirque.

After further study, however, Howe reached the same conclusion concerning his rock streams that was independently forced upon the writer in his field examination of the Mageik Slide, for in this final review of the situation, four years later, he concludes:† "There can be little doubt that the detritus of which the Rock Streams are composed flowed down the valley sides or basin floors; not, however, 'at some such rate as a glacier' but with a sudden violent rush that ended as quickly as it started. A study of the San Juan Rock Streams carried on through a number of field seasons has failed to show that they are now in motion or that they have come to their present position as a result of slow glacier-like movement."‡

If the evidence was sufficient to justify Howe in deciding that the comparatively old features he observed were a special class of landslide, it is much clearer in the fresher Mageik Landslide, for when glacial action is eliminated and the destructive action on bushes is observed, little doubt of its nature can remain.

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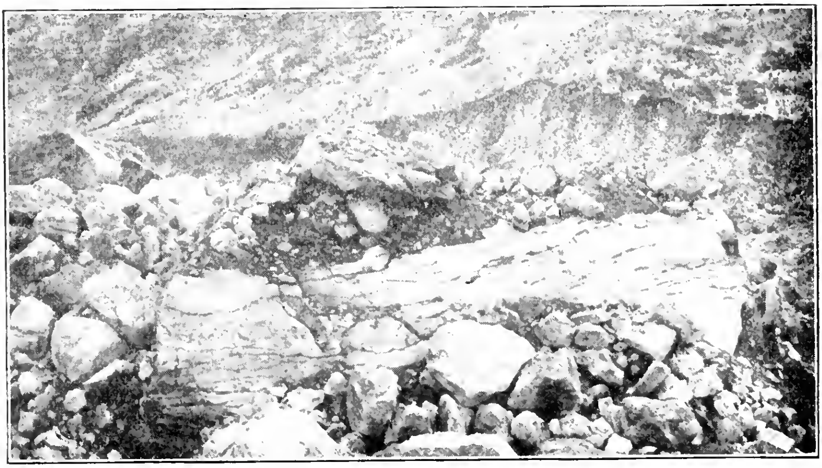
*Geology, Vol. I, 2nd ed., 1905. pp. 232-233.

†Howe, Ernest. Landslides of the San Juan Mountains, Colorado. U. S. G. S., Professional Paper 67, p. 54. 1909,

‡In this connection I would take occasion to express my obligation to several of my geological friends, Dr. Whitman Cross, of the United States Geological Survey; Dr. Rollin D. Salisbury, of the University of Chicago; Dr. R. A. Daly, of Harvard; and Dr. J. E. Carman, of the Ohio State University, who by their counsel have aided me in the preparation of this paper.

GEOLOGICAL STRUCTURE FAVORABLE FOR LANDSLIDES.

An examination of the geological structure of the area where the slide occurred reveals conditions favorable for the development of the conditions of unstable equilibrium prerequisite to landslides. Massive lava flows several hundred feet thick have been poured out on a platform of sandstone dipping away from the vents. The strata are bent up against the volcanoes all around, as though they had been blistered up by the injection of a laccolith beneath.



Photograph by D. B. Church

DETAIL AT THE EDGE OF THE MIDDLE SECTION OF THE SLIDE.
The man at the right gives the scale. The mountain side was deeply plowed up by the flying rocks. Note the absence of any marginal ridge and the high percentage of solid rock in the detritus.

The lava flowing down the inclined surface of the sandstone often congealed before reaching the bottom. As it hardened, joint planes perpendicular to the sloping surface developed, changing the solid flow, to a certain extent, into a series of slanting columns. Closely adjacent to the part of the cliff that fell away, colossal columns are still standing, apparently so ready to topple over that the marvel is that they survived the shock which set off their neighbors. (See page 349).

Through the joint cracks water doubtless reached the original surface and, working along, may have greatly facilitated movement by lubricating a bed for the unstable mass above.

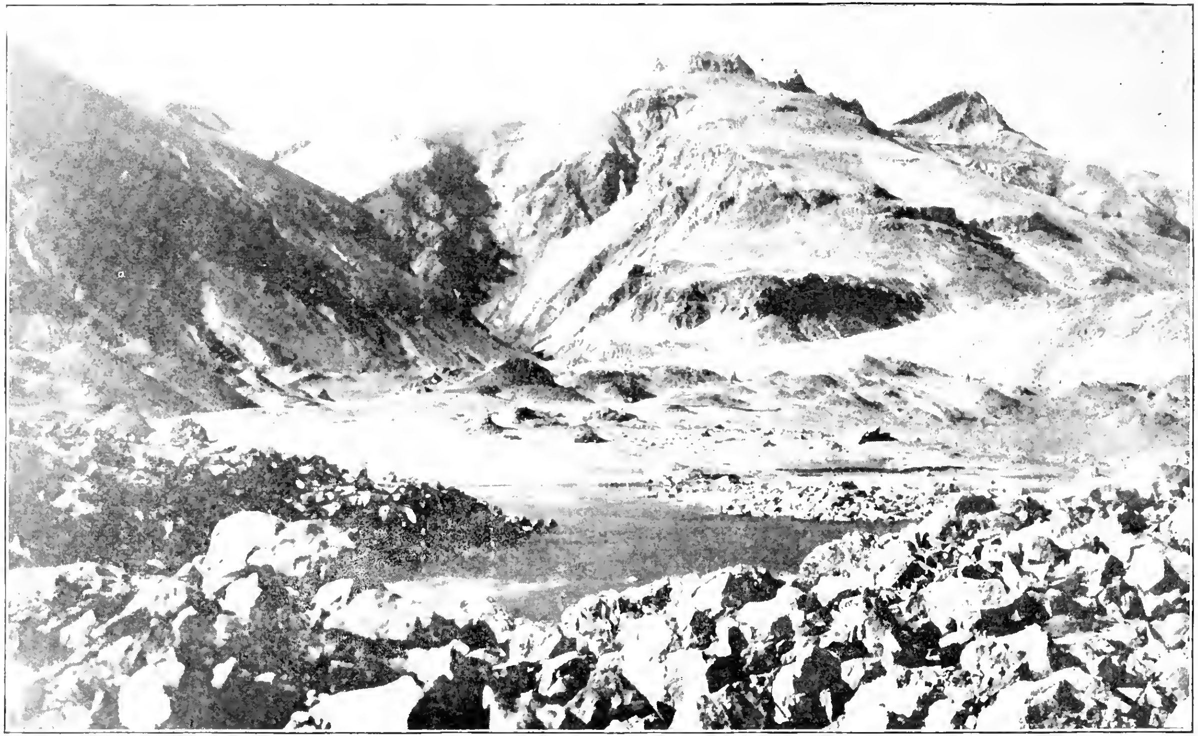
Of the immediate cause which set off the fall, one is left to speculation. Undoubtedly there were earthquakes in connection with the eruption, but they do not seem to have been particularly violent. It is not impossible that there may have been a further uptilting of the strata by the injection of new magma below. Unstable equilibrium from such a cause would be the simplest, if not the only, explanation of the continual succession of avalanches which have coursed almost without intermission down the slopes of Falling and Noisy Mountains since their discovery. It is interesting further to note that while the cliff at the head of the Mageik Landslide was quiet during our observations in 1917, it was subject to frequent, heavy rock falls in August, 1919. There is, however, little if any independent evidence of recent uplift except such as is furnished by the actively falling cliffs themselves.

DIMENSIONS OF THE SLIDE.

The top of the cliff from which the rock started stands at an elevation of about 3,000 feet. The height of its present perpendicular face is some 750 feet. The width of the area that fell away is about 2,000 feet. We have no means of knowing how much further down the valley it may have projected before the fall. As it stands now, since the fall, its face is a great concave cirque, evidently gouged out of the face of the mountain. Its bright new surface of unweathered columnar lava contrasts strikingly with the duller cliffs round about.

The cliff from which the rock started stands on a branch to one side of the main valley. From this point it swept down half a mile of steep slope and then across the flat valley for nearly two miles to the opposite mountain side. Then, deflected partly by the mountain wall and partly by an obstructing spur part way across, it turned a 60° angle and continued down the valley, in a broad flat sheet a mile wide, more than two miles further. Beyond this point a relatively minute tongue continued on in the bed of a stream for another mile before coming to rest.

The total length from the cliff to the extreme tip is about five and a half miles, divided as follows: Upper steep portion about half a mile, descending about a thousand feet; middle section about one and three-quarters miles, descending 400 to 500 feet to an altitude of about 800 feet; broad lower end about



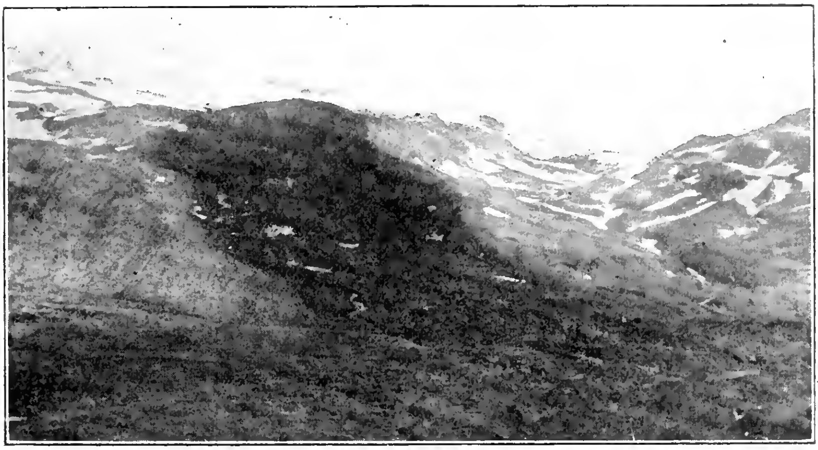
Photograph by D. B. Church

A PORTION OF THE ROCK SLIDE FROM THE SLOPES OF NOISY MOUNTAIN.

The cones of detritus in the middle distance are everywhere the characteristic feature of the surface of the slides. In the foreground is Katmai River, which spreads out irregularly over the angular bowlders of the slide.

two miles, reaching an altitude of about 500 feet; and the narrow terminal tongue a mile long but hardly 100 yards wide, coming down just below the 400 foot contour.

The upper portion, just below the cliff, has somewhat the character of an ordinary talus slope. But its bowlders are of a very great size, many of them 30 to 40 feet in diameter and its general contours are concave in sharp contrast with the ordinary cone of talus. Along with the large size of its bowlders goes a certain roughness and irregularity of surface not found in the typical talus.



Photograph by Robert F. Griggs

THE CLIFF FROM WHICH THE SLIDE ORIGINATED.

The steep slope of its upper course contrasts with the low gradient of the flat valley covered by the lower section. The Slide has been darkened to make its outlines more evident.

The irregularities of the upper surface perhaps foreshadow the conical mounds that appear so plentifully in the middle section, but there are no such features on the steep portion of the slope.

In the second portion that occupies the flat valley above the bend are the largest and most perfectly developed cones. Here, also, is a much higher percentage of large rocks and less soft stuff than the lower portion below the bend, for the cones gradually become smaller and less numerous as one approaches the tip, although some cones and some very large bowlders occur clear down to the end.

The area covered by the debris may be provisionally stated as approximating four square miles. Of the quantity of material that fell away we are not in a position to make even a very intelligent guess, since we know neither the original contours of the cliff, nor can we tell how deeply the debris covers the ground. From the statements of the thickness of other slides given below, it appears conservative, however, to estimate the average thickness as ten yards. On this basis the cubage of the mass would be in the neighborhood of 120,000,000 yards.

CONE STUDDED SURFACE BELIEVED TO BE CHARACTERISTIC OF VERY VIOLENT LANDSLIDES.

No features of this great landslide are more striking, or arouse more universal speculation as to their nature and significance than the remarkable conical piles with which its surface is so thickly studded. The general texts on physiography in common use make no mention of such topographic forms. As several of our most experienced geologists with whom I have discussed the matter have assured me that nothing similar has come within their experience, I am inclined to think that they have not been adequately described previously. They are not, however, unique, nor are they confined to this particular landslide.

From field study of other landslides of the Katmai District, and from an examination of the literature, I am inclined to the opinion that this curious type of cone studded topography is not accidental, but is a characteristic feature of extremely violent landslides generally.

Noisy Mountain, in the second valley of Katmai River, above the Canyon, had a slide in every way similar to the present. There is a gouged out cliff beneath which is a great tumbled mass of debris spread out over the valley floor, damming the river and forming the upper Katmai Lake. This, too, is thickly covered with the same regular cones. (See page 338).

Falling Mountain at the margin of the Valley of Ten Thousand Smokes is a gouged out cliff in every way similar to the other two. But in this case the enormous quantity of rock that has obviously fallen away from the mountain is for the most part covered up by subsequent deposits. Nevertheless, several very perfect cones like those of the other slides protrude from the deposits that fill the valley level full elsewhere.

The first time I ever observed such topography was on the lower slopes of Augustine Volcano in Cook Inlet in 1913. They were so striking as instantly to arouse speculation as to their origin. (See cut below). At first I supposed they must be some sort of an expression of volcanic forces. But a little examination made such a hypothesis untenable, because of the heterogenous character of the debris of which they were composed, and because of the clear evidence that they never possessed craters nor any semblance of a radial structure.

Photograph by Robert F. Griggs

CONICAL PILES OF DETRITUS ON THE FLANK OF AUGUSTINE VOLCANO.

The similarity to the topography of the Mageik Slide, and of the slide from Noisy Mountain, illustrated on page 338, is obvious.

SIMILAR CONES DESCRIBED IN OTHER SLIDES.

In their discussion of the slide at Frank, Alberta, McConnell and Brock* say, "Peculiar conical mounds built of loose rocks up to three feet in diameter were noticed at several points. The origin of these mounds is uncertain, but some of them may represent portions of ridges which have been partly destroyed by flying rocks." These are clearly distinguished from other cones which they thus describe: "Diminutive cones with crater-like depressions in the center, due to the

*McConnell, R. G., and Brock, R. W. op. cit.

escape of imprisoned air, are common features of the mud flats." Cones of this latter type are to be expected in any terrane that has undergone sudden movement requiring subsequent readjustment in accordance with the specific gravities of the different portions of the mixed up mass. They are well known features of earthquakes. But in these, as in all other cones thrown up around a vent of any sort, there are clear indications of a radial structure underlying the circular outline, while in the mounds under discussion there is absolutely no suggestion of a radial structure or of an axial throat terminating in a crater at the apex. On the contrary, these cones are made up of materials of all sizes mixed together in the most hit or miss fashion. The large bowlders occur near the periphery or near the axis indifferently. The position of the large stones often furnishes the most positive proof that there could never have been a crater at the top. (See page 349).

Similarly in their figures of the great landslide at Elm, in Switzerland, Buss and Heim* show very plainly the same cone-studded surface, although they seem not to have discussed it.

Again, at Bandai San, Sekiya and Kikuchi,† (See page 353), figure and describe such cones in very striking fashion.

A HYPOTHESIS TO ACCOUNT FOR THE CONICAL PILES.

The occurrence of such numbers of regular cones scattered over the surface of these landslides naturally aroused immediate speculation as to their nature and the causes that had brought them into being. But it was a long while before any theory at all suggested itself. And now, even after they have been studied in the field for two years, I cannot do more than offer a hypothesis, admittedly supported by very little evidence, which may perhaps aid in interpreting them.

The only previous attempt to explain them which I have seen is that of McConnell and Brock, cited above. It is evident from their statement that they do not place much weight on their hypothesis, and indeed a glance at the abundant cones shown in the pictures reproduced herewith will make it evident that it would be difficult to account for the cones on the Mageik

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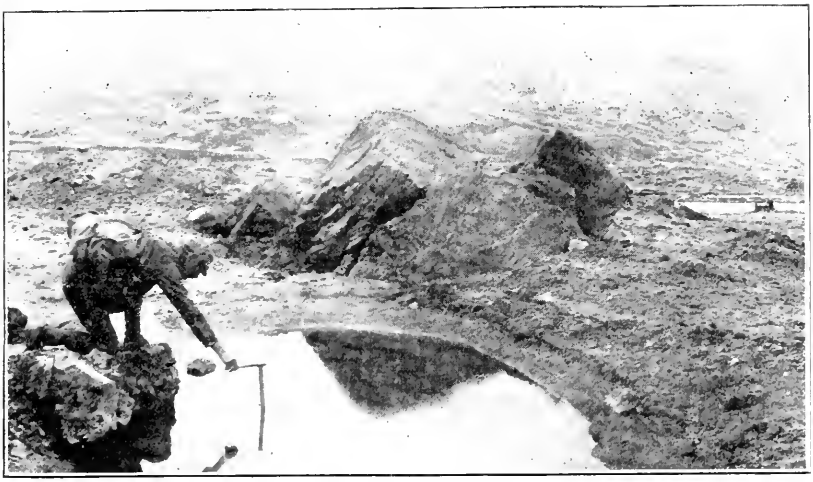
*Buss, E. and Heim, A., Der Bugsturz von Elm. Zeischer Deutsch Geol Gesell. 1882, pp. 74, 435.

†Sekiya, S., and Kikuchi, Y. The Eruption of Bandai San. Journ. Col. Sci. Imp. Univ., Tokyo. 3:91-172. 1889.

Slide as remnants of former ridges which have been destroyed for the most part by flying rocks. They are too numerous. Nor could one suppose that if such ridges had been present originally, every one of them would have been destroyed. Such a hypothesis would, moreover, leave us with the problem of accounting for the disappearance of both the material of the erstwhile ridge and the rock which demolished it. The cones show, furthermore, no tendency to fall into transverse lines.



Photograph by Robert F. Griggs

A DIMINUTIVE "KETTLE HOLE" POND NEAR THE TIP OF MAGEIK SLIDE.

This may have been caused by the melting away of a chunk of ice or snow.

Some conspicuous cones are to be found in places where the general mass of the slide, the portion strewn evenly on the ground, forms a surprisingly thin veneer often less than a yard, sometimes hardly a foot, in thickness. In such places the total bulk of the smooth portion of the slide is less than that of the mounds with which it is covered. When I thus discovered large mounds standing isolated in very thin portions of the slide, it began to appear that the material composing the mound must have traveled together as a unit into its present position. In other words, *the cones seem to represent discrete masses of material which travelled together throughout the motion of the mass and so settled down in the same* *place when the motion ceased.* The conical form is, of course, merely due to the subsequent rattling down of the shattered fragments to form slopes standing at the angle of repose for such materials.

The thin layer of debris spread evenly over the ground represents, on this view, the more fluid material, the lubricating matrix, which bound together the more solid portions of the slide sufficiently to permit the whole to act as a homogeneous mass expending its energy as a unit, rather than as a bunch of separate rocks, each dependent on its own individual momentum to overcome the friction that opposed its movement.

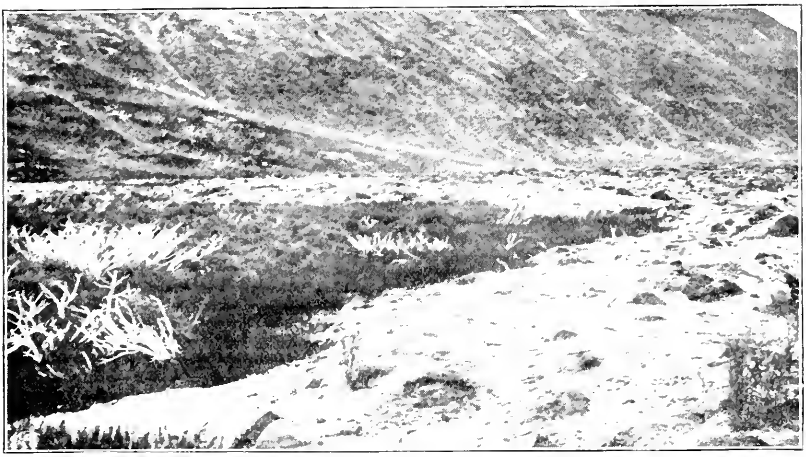
Whether this hypothesis has any basis in fact or not could probably be determined only by observation of such a slide in action, but one further circumstance was observed which lends it some probability, namely, this: Some of the cones are composed of the same sort of material throughout. When that material is lava bowlders, the fact is not particularly striking, but one finds occasionally a cone composed exclusively of broken up sandstone. Since there is in the slide, taken as a whole, only a very small percentage of sandstone, a good sized mound of it seems to be most reasonably interpreted as the remains of a single large block which though thoroughly broken up, was not scattered by its journey down the valley. (See page 352.)

THE SURPRISING LIQUIDITY OF THE SLIDE.

In almost every feature of this remarkable mass that one examines, he sees clear evidence of a liquidity that is nothing short of astounding in view of the materials of which it is composed. From whatever aspect one considers the phenomenon thoughtfully, his speculations are sure to be brought back to the problem of accounting for this surprising behavior.

If the slide had been composed entirely of soft material like much of that at the terminus, its liquidity would be easy of comprehension. For in the spring of the year, when the eruption and in all probability the slide also occurred, such material becomes thoroughly saturated with snow water and is so nearly liquid that nothing but an initial impulse is needed to send it rolling off the hillside at any time. In climbing the mountain directly above the slide we found considerable ground where we sank nearly to our knees during the period when the snow was going off. Much of the material of the terminal portion of the slide itself has this same consistency so that we had to pick our way over it with some care.

But the greater part is composed of no such material. In places it is made up exclusively of angular bowlders. (See page 347.) It is this portion of the slide whose "liquidity" is so difficult to understand. Indeed, that a mass composed of solids of such heterogenous sizes and angular shapes could, by any means, have been made to behave like a liquid seems incomprehensible.



Photograph by Robert F. Griggs

PART OF THE TERMINUS. THE TWO BRANCHES SHOWN INDICATE THE TENDENCY OF THE SLIDE TO "SPLAY" OUT AT THE TIP.

The standing bushes beyond the reach of the slide contrast with the broken sticks protruding from the debris here and there.

If we might be permitted to suppose that these rocks rode down on top of the mud which continued to flow on down the valley after the rocks stranded, explanation would be easier. But such a supposition seems to involve difficulties as great as that which it would explain. (1) It is difficult to see how so much of the mud could have thus flowed on, leaving so little in the interstices between the stones which it carried. (2) Being derived supposedly from the soil on top of the cliff, it is difficult to see how it could get beneath the flowing mass. That much of it did not do so, but remained on top, is shown by the persistence of fragments of vegetation which survived the catastrophe. (3) The soil on the mountain top was a very thin layer as compared with the great thickness of rock which fell away. The quantity is altogether too small to suffice to lubricate the bed of the coarse rock. The evidence seems to require, therefore, that we hold that this striking liquid character was inherent in the whole mass.

We are not in a position to analyze the situation sufficiently to permit of an explanation of the matter, but some considerations may be adduced which may make it seem less impossible. An ordinary liquid like water buoys up any solids immersed in it, and the buoyancy thus imparted to them is equal to the weight of the liquid which they displace. Examination of the slide indicates that during the period of its fluidity it had similar properties. The position of certain of the rocks imbedded in the mass can indeed hardly be explained on any other basis. In some cases a bowlder, several feet in diameter, surrounded entirely by finer material, was carried up to the very edge in such fashion that by no stretch of the imagination could it be considered as having slid or fallen into place, but must have floated into position. Since, moreover, the specific gravity of this liquid was much greater than that of water, its power of flotation must have been correspondingly increased. This becomes especially significant when it is recalled that the specific gravity of the liquid approached closely to that of the stones which it carried. Thus, while the density of the liquid may have been only twice as great as water, its power of flotation, which is measured by the difference between the specific gravities of the load and liquid, was very great. When, in addition to this, it is remembered that the transporting power of a liquid increases with the sixth power of its velocity, and that the slide probably had a velocity much higher than that of any ordinary stream, its curious behavior may perhaps be better understood.*

On looking up the literature on my return from the field, I find my opinion confirmed by eye-witnesses of the Elm landslide, which was evidently closely similar to the present one.

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*Sekiya and Kikuchi, as quoted below, give the velocity of the slide at Bandai San as 48 miles per hour, while the flood current of a great river seldom exceeds 7 miles per hour. In other words, the transporting power of a stream with the velocity of the slide would be more than 100,000 times as great as that of an ordinary flood. It is doubtful if the numerical comparison would hold where the conditions are so different. No attempt should be made to apply it numerically, but the statement gives a lively idea of the possibilities in this direction.

Sir William M. Conway* in describing this event says: "In this last phase of the catastrophe 10,000,000 cubic meters of rock fell down a depth (or an average) of 450 meters, shot across the valley and up on the opposite slope to a height of 100 meters, where they were bent 25° out of their first direction and poured, almost like a liquid, over a horizontal plain covering it uniformly throughout a distance of 1500 meters and

Photograph by Robert F. Griggs

IN PLACES THE SLIDE IS COMPOSED OF SHARP ANGULAR BOWLDERS.

That a mass made up exclusively of such materials could by any means have been made to behave like a liquid seems incredible, yet the evidence that it did so is unequivocal.

over an area of about 900,000 square meters to a depth of 10–20 meters. The internal friction of the mass and the friction between it and the ground were insignificant forces compared with the tremendous momentum that was generated by the fall. The stuff flowed like a liquid."

*Conway, Sir Wm. Martin. The Alps from End to End. 1900. pp. 176-183, as quoted by Howe. op. cit.

The slope of the bed down which the slide coursed is of the form most favorable to reducing friction and so assisting the motion, for it approximates Shiele's Tractrix, or "Antifriction Curve," such as is used in a toboggan slide. As in a toboggan slide, starting with a nearly perpendicular drop and gradually changing into an inclined plane of ever decreasing pitch whose friction absorbs the acceleration due to gravity and keeps the toboggan moving at a nearly constant rate to the end of its course, so in the Mageik Slide there was first an almost vertical drop of 750 feet, then half a mile of steep hillside, followed by a flat valley of gradually decreasing grade until in the last mile the descent was only about 200 feet. It is thus evident that, aside from the bend in its course, the form of its bed was such as to offer a minimum of resistance to its movement.

COMPARISON WITH OTHER LANDSLIDES.

The dimensions of the Elm Landslide as given above were: Average fall 450 meters, length 1500 meters, area 900,000 square meters, depth 10–20 meters, volume 10,000,000 cubic meters.

The Frank Slide covered 1.03 square miles, to an average depth of 15 yards. The amount of material moved is estimated at 36,000,000 cubic yards.†

The Rossberg Slide is said to have been 4300 yards long, 349 wide, 35 deep, and to have totalled 51,000,000 cubic yards.‡

The Colorado landslides are especially notable because of the great number that have occurred in a restricted area in the vicinity of Silverton. The largest single area covered with landslide material is Silver Mountain Landslide, which covers ten square miles, being therefore considerably larger than the Mageik Slide. But this is believed to be a compound of several slides that occurred at different times. Moreover, it is not of the violent type, but an ordinary landslide which is believed to have been in continuous slow movement for a long time. Of the "Rock Streams" proper, the largest in the Silverton area is somewhat less than a mile long, and therefore very much smaller than the others that have been cited.

Of the other landslides in our area, two are so large as to deserve notice in this series of comparisons. The Katmai

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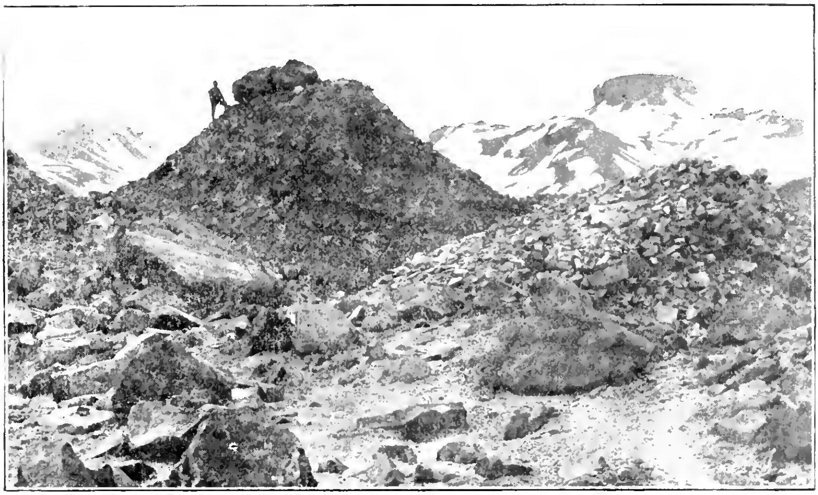
†McConnell, R. G., and Brock, R. W. op. cit.
‡Goldau und Seine Gegend. Neues Jahrbuch, 1875.

Slide, which dammed Katmai Canyon, causing when it broke the Great Flood, has been estimated by Maynard from his survey to contain, 88,000,000 cubic yards, which though far inferior to the Mageik Slide, is nearly twice as large as any of the other records quoted above. The Noisy Mountain Slide looks much bigger than the one in Katmai Canyon, but the survey has not yet been carried into that area, so that it is impossible to give any estimate of its dimensions.



Photograph by Robert F. Griggs

ONE OF THE CONICAL PILES OF THE SURFACE OF THE SLIDE.

The rock on top shows clearly enough that the mound was not built up around a crater. In the distance is a leaning pillar of columnar lava suggestive of the conditions of the cliff which fell to form the Slide. In the foreground is much white ash from the eruption, which does not appear on the mound, probably because of readjustment of the surface after the close of the ashfall.

As each of the slides cited above was considered a very remarkable event, it is evident that those of the Katmai District are to be ranked as among the most notable examples of their class on record. They are, however, by no means the greatest of such phenomena that have been reported. Aside from records of slow-moving landslips of the ordinary type with which we have no concern, there are accounts of other catastrophes belonging to the same violent type of landslide as ours, which so far exceed the slides we have described as to quite dwarf them by comparison.

THE GOHNA LANDSLIDE.

On September 6, 1893, an enormous mass of rock fell 4000 feet from Mount Maithana, in the Himalayas, into the Bhirai Gunga, at its foot. The violence of the fall is attested by the formation of great clouds of dust which darkened the neighborhood for miles around and on falling covered the ground like snow. The falls lasted for three days and continued in rainy weather for many months. The fallen material formed a great dam stretching along the river for two miles, filling the channel to a depth of 900 feet; the length across the gorge was 600 feet in the bottom and 3000 feet at the top, the thickness of the dam up and down stream was 11000 feet at the bottom and 2000 feet at the top. Above the dam a great lake, with a maximum depth of 777 feet, accumulated, and was later released in one of the greatest floods of record. Although the surface covered by the debris was only 423 acres, it is evident that the amount of material far exceeds any of the slides discussed above.

THE GREAT SLIDE AT BANDAI SAN.

What appears to be the greatest landslide of which I have been able to find a record is a phenomenon not previously considered in connection with landslides at all, but as a peculiar sort of volcanic explosion—the eruption of Bandai San, in the province of Iwashiro, Japan, July 15, 1888, which covered an area of some 27 square miles with its detritus. Although this disturbance as described by Sekiya and Kikuchi* admittedly involved no magmatic extrusion, there seems no good reason to doubt the belief of the Japanese authors that it originated in a series of steam explosions in rock affected by some subterranean source of heat, i. e., was a phreatic explosion as defined by Daly.

Once set in motion, however, the mass behaved as a landslide and manifested all the characteristics of the Mageik Slide. It was this aspect of the phenomena, rather than the explosion, that caused the loss of life and damage to property, and hence it was this that occupies a major share of the account of the catastrophe. The following excerpts from the account are of more than usual interest in connection with our problem:

*Sekiya, S., and Kikuchi, Y. The Eruption of Bandai San. Jour. Col. Sci. Imp. Univ. Tokyo. 3:91-172. 1889.

"While darkness as aforesaid shrouded the region, a mighty avalanche of earth and rock rushed at terrific speed down the mountain slopes, buried the Nagase Valley with its villages and people, and devastated an area of more than 70 square kilometers."*

Recognizing that the main phenomenon of the eruption was not properly volcanic, the authors go on, (p. 106): "The main feature in the whole of this eruption was the deluge of rock and earth. Notwithstanding the violence of the phenome-

Photograph by Robert F. Griggs

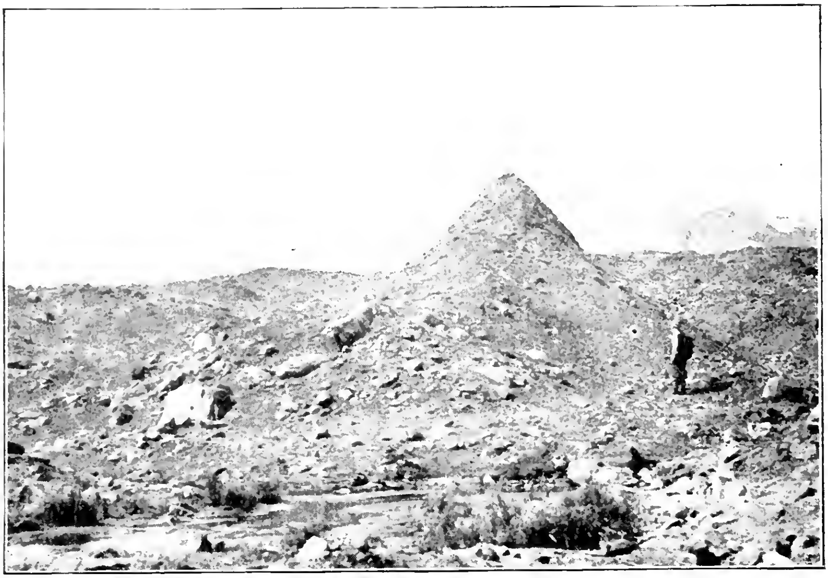
CHUNKS OF PEAT IN THE SLIDE DEBRIS.

Near the terminus of the slide are great masses of peaty soil. In some cases the chunks were thrown into rude windrows by the motion of the mass.

non, and the completeness with which the mountain was destroyed, the nature of the eruption was comparatively simple. The destructive agency was merely the sudden expansion of imprisoned steam unaccompanied by lava flows or pumice ejection. * * * by far the greater mass of Kobandai was just split into mighty fragments, which were thrown down much after the manner of a landslide. * * * If we suppose

*Op. cit. p. 104.

a mass of some 1.21 cubic kilometers, or 1,587 millions of cubic yards, which was the actual volume of the mountain destroyed, of sand to be suddenly precipitated from a lofty summit, it would flow down the sides in a torrent not very unlike that of water. That the earth and rock debris did flow down in this way we were convinced by examining the actual state of things on the spot, and more particularly by witnessing afterwards with our own eyes a very similar phenomenon, though on a vastly smaller scale.



Photograph by Robert F. Griggs

A CONE MADE UP ENTIRELY OF SANDSTONE.

Since sandstone forms only a very small percentage of the material of the slide as a whole, a pile like this composed exclusively of sandstone seems best interpreted as the remains of a single large sandstone block, which was much broken up, but not scattered, in its course down the valley.

"One day, while we were at work in the crater, a huge slice of the precipitous wall of rock that had been bared by the explosion, fell suddenly and crashed with a tremendous uproar down the steep incline beneath. This slab fell from a place about 300 meters high. The great masses of earth and rocks were shattered as they fell and broken up into pieces ever growing smaller as they descended. The behavior of this headlong mass resembled the rush of a headlong torrent. Although bowlders measuring 10 meters or more in diameter were mixed up with finer matter, as a whole the movement approximated to that of a fluid. No words can describe the fierceness and force of that impetuous downpour—it made surgings this way and that, and the bold leaps with which it would now and then bound over low ridges that hindered its progress, and shoot onward down the neighboring depression.

"In like manner probably, but on a vastly more gigantic scale, the stream of materials on the 15th of July ran down the slopes of Bandai San, dividing as it went into two principal branches."

It is to be noted that although this second flow was described as essentially similar to the first, there is in this case not the least hint of a volcanic disturbance connected with its cause. It is described as a typical rock fall, pure and simple, yet it is recognized as practically identical with the great eruption.

The eruption was accompanied by a great cloud of dust which, the authors carefully explain, was essentially different from the pumiceous ash of an eruption like Krakatoa, for it consisted merely of fragments of finely pulverized rock, *i. e.*, it was a typical dust cloud such as always accompanies a landslide. In every detail their description and figures show the features of a landslide. They go on (p. 110) as follows: "Among the various phenomena that constantly bewilder the eyes of visitors to the seat of the eruption, not the least striking are the numerous big bowlders, some of them measuring from five meters to ten meters each way, that are to be seen resting on the surface of the debris far away from the crater. These have evidently been carried along as part of the mud current, and not hurled through the air. Not less curious are the quantities of small cones, varying from a few meters up to 15 meters in height, which are scattered here and there over the surface, standing out of the debris like so many miniature Fujiyamas."

Their drawings of these innumerable cones studding the surface of the flow are perhaps even more striking than the photographs accompanying the present article.

The velocity of the Bandai San Slide was tremendous. Our authors estimate it as 77 kilometers, or 48 miles, per hour. It was accompanied by terrific wind blasts which overthrew houses and tore up trees by the roots. The minimum velocity of these winds was estimated by Mr. Y. Wada of the Imperial Meterological Observatory at 40 meters per second, or 90 miles per hour.

From these quotations it is evident that while the disturbance undoubtedly began with explosive phenomena, which were probably an indispensable factor in setting the mass of rock in motion, yet the behavior of the Slide, once started, was that of the typical violent landslide like that of Elm or those of the Katmai District.

With the perspective furnished by these comparisons, we are enabled to rank our landslides among similar phenomena that have occured elsewhere. It is evident that they are considerably larger than the best known landslides, but yet, if the eruption of Bandai San be rightly grouped in this class of phenomena, they must be counted pigmy affairs in comparison with some landslides that have occurred.

CADDIS-WORMS AS AGENTS IN DISTRIBUTION OF FRESH WATER SPONGES.

Frederic H. Krecker.

A freshwater sponge, which is probably *Spongilla fragilis*, is found in great abundance on the rocks and other solid objects in the region of the Bass Islands, Lake Erie. It is a green sponge which usually grows as a delicate incrustation on the objects to which it is attached; at times it assumes a cylindrical shape. While examining some material which had been dredged from what is known as Gibraltar Bar in Put-in-Bay, I noticed that the cases of a caddis-fly larva belonging to the *Rhyacophilidæ* were covered by *Spongilla*. The dredging had been done in five feet of water on a stony bottom.

The case of these *Rhyacophilidæ* is made of a parchment-like material in the form of a cone approximately 12 millimeters long. The broad end has an opening through which the larva is able to protrude its body and crawl about with its case. The cases examined were encrusted to a varying extent by the sponge. Several were entirely covered except for a small patch on the ventral side near the opening. On other cases merely a small spot was occupied. Between these extremes there were cases showing all intermediate stages. Professor Stephen R. Williams informs me that he has seen shells of aquatic snails similarly covered. His observations were made at Cedar Point, which is also on Lake Erie, but about twenty miles from Put-in-Bay, near Sandusky, Ohio.

Spongilla fragilis is of course a sessile animal without any very rapid means of distribution. On the other hand, a comparatively active animal, such as a rhyacophilid larva, in the course of its wanderings, would be likely to carry a sponge some distance from its point of origin and thus aid the more rapid spread of the species.

That a sufficient number of the caddis cases are invested with *Spongilla* to make the larvæ a factor in distribution is to be seen from the percentage of covered cases observed among those collected. In one mass of material dredged over a distance of twenty-five to thirty feet, there were twelve caddis-worm cases and eight of them were encrusted with sponges. In another haul there were three cases and one was covered. These results, compared with other more casual observations, indicate that from a third to a half of the cases bear the sponges.

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