PROCEEDINGS

OF THE

Iowa Academy of Science

FOR 1919

VOLUME XXVI

Thirty-third Annual Session, Held at Cedar Falls,
April 25 and 26, 1919

Published by
THE STATE OF IOWA
Des Moines

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IOWA ACADEMY OF SCIENCE

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First Vice-President—Professor Nicholas Knight, Cornell College.

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1918-1919.

President—Professor S. W. Beyer, State College.

First Vice-President—Professor T. C. Stephens, Morningside College.

Second Vice-President—Professor R. M. McKenzie, Parsons College.

Secretary—James H. Lees, Iowa Geological Survey.

Treasurer—Professor A. O. Thomas, State University.

EXECUTIVE COMMITTEE.

Ex-officio—S. W. Beyer, T. C. Stephens, R. M. McKenzie, James H. Lees, A. O. Thomas.

Elective—Professor D. W. Morehouse, Drake University; Professor Maurice Ricker, West Des Moines High School; Mr. Fred J. Lazell, Cedar Rapids.

PAST PRESIDENTS

Osborn, Herbert	1887-1888	Hall, T. P.	1896
Todd, J. E.	1888-1889	Franklin, W. S.	1896-1897
Witter, F. M.	1889-1890	Macbride, T. H.	1897-1898
Nutting, C. C. (2 terms)	1890-1892	Hendrixson, W. S.	1898-1899
Pammel, L. H.	1892-1893	Norton, W. H.	1899-1900
Andrews, L. W.	1893-1894	Veblen, A. A.	1900-1901
Norris, H. W. (1 term)	1894-1896	Summers, H. E.	1901-1902

PAST PRESIDENTS—Continued.

FINK, BRUCE	1902-1904	BEGEMAN, L.	1911-1912
SHIMEK, B.	1904-1905	BENNETT, A. A.	1912-1913
AREY, M. F.	1905-1906	KINNEY, C. N.	1913-1914
BATES, C. O.	1906-1907	CONARD, HENRY S.	1914-1915
TILTON, JOHN L.	1907-1908	KELLY, HARRY M.	1915-1916
CALVIN, SAMUEL	1908-1909	STEWART, GEORGE W.	1916-1917
ALMY, FRANK F.	1909-1910	ROSS, L. S.	1917-1918
HOUSER, GILBERT L.	1910-1911	BEYER, S. W.	1918-1919

MEMBERS OF THE IOWA ACADEMY OF SCIENCE

LIFE FELLOWS.

BEYER, S. W.	Iowa State College, Ames
CLARKE, DR. J. FRED	Fairfield
CONARD, HENRY S.	Grinnell College, Grinnell
ERWIN, A. T.	Iowa State College, Ames
FITZPATRICK, T. J.	State University, Lincoln, Neb.
GREENE, WESLEY	State Horticultural Society, Des Moines
HOUSER, G. L.	State University, Iowa City
KAY, GEORGE F.	State University, Iowa City
KUNTZ, ALBERT	St. Louis University, St. Louis, Mo.
LEES, JAMES H.	Iowa Geological Survey, Des Moines
NORTON, W. H.	Cornell College, Mount Vernon
PELLETT, FRANK C.	Hamilton, Ill.
RICKER, MAURICE	New York City
ROSS, L. S.	Drake University, Des Moines
SEASHORE, C. E.	State University, Iowa City
SHIMEK, B.	State University, Iowa City
SUMMERS, H. E.	Iowa State College, Ames
SYLVESTER, R. H.	Public Health Center, Des Moines
THOMAS, A. O.	State University, Iowa City
TILTON, JOHN L.	Simpson College, Indianola
WILLIAMS, MABEL C.	State University, Iowa City
WYLIE, R. B.	State University, Iowa City

FELLOWS.

AITCHISON, ALISON E.	Teachers College, Cedar Falls
ALBERT, HENRY	State University, Iowa City
ALMY, F. F.	Grinnell College, Grinnell
AREY, MELVIN F.	Teachers College, Cedar Falls
BAKER, J. A.	Iowa Wesleyan College, Mount Pleasant
BAKER, R. P.	State University, Iowa City
BAKKE, A. L.	Iowa State College, Ames
BALL, E. D.	Iowa State College, Ames
BATES, C. O.	Coe College, Cedar Rapids

FELLOWS—Continued.

Begeman, Louis..Teachers College, Cedar Falls
Bond, P. A...State University, Iowa City
Brown, P. E..Iowa State College, Ames
Brumfiel, D. M...State University, Iowa City
Buchanan, R. E..Iowa State College, Ames
Cable, E. J...Teachers College, Cedar Falls
Carter, Charles ....Parsons College, Fairfield
Chaney, George A..Des Moines
Chaney, Ralph W...State University, Iowa City
Coffin, Charles L..Penn College, Oskaloosa
Condit, Ira S..Teachers College, Cedar Falls
Coover, W. F..Iowa State College, Ames
Cratty, R. I..Iowa State College, Ames
Davis, W. H...Teachers College, Cedar Falls
Doty, H. S...Simpson College, Indianola
Dox, A. W..Iowa State College, Ames
Evvard, John M...Iowa State College, Ames
Ewing, H. E...Iowa State College, Ames
Fay, Dr. Oliver J..1213 Equitable Bldg., Des Moines
Fordyce, Emma J..High School, Cedar Rapids
Gaessler, Wm. G..Iowa State College, Ames
Galpin, Sidney L...Iowa State College, Ames
Geauque, H. A...Simpson College, Indianola
Getchell, R. W..Teachers College, Cedar Falls
Goodell, F. E...West High School, Des Moines
Guthrie, Joseph E..Iowa State College, Ames
Hadden, David E..Alta
Hayden, Ada..Iowa State College, Ames
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Higbee, F. G...State University, Iowa City
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Jewell, Susan G...Tabor College, Tabor
Kelly, H. M...Cornell College, Mount Pleasant
Keyes, Charles R...Des Moines
King, Charlotte M...State College, Ames
Kinney, Charles N...Drake University, Des Moines
Knight, Nicholas. ....Cornell College, Mount Vernon
Kunerth, Wm...Iowa State College, Ames
Lamb, Alvin R...Iowa State College, Ames
Lazell, Fred J..Cedar Rapids
McClintock, Jno. T...State University, Iowa City
MacDonald, George B...Iowa State College, Ames
McKenzie, R. Monroe...Parsons College, Fairfield
Martin, John N...Iowa State College, Ames
Melhus, I. E..Iowa State College, Ames
Miller, A. A..914 College Street, Davenport
Morehouse, D. W...Drake University, Des Moines

FELLOWS—Continued.

Mueller, H. A. .... St. Charles
Norris, H. W. .... Grinnell College, Grinnell
Nutting, Charles C. .... State University, Iowa City
Oleson, O. M. .... Fort Dodge
Orr, Ellison .... Waukon
Overn, O. B. .... Luther College, Decorah
Pammel, L. H. .... Iowa State College, Ames
Pearce, J. N. .... State University, Iowa City
Pearson, R. A. .... Iowa State College, Ames
Plagge, H. J. .... Iowa State College, Ames
Reed, Charles D. .... U. S. Weather Bureau, Des Moines
Reilly, John F. .... State University, Iowa City
Roberts, Marie M. .... Iowa State College, Ames
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Sanders, Dr. W. E. .... 613 Equitable Bldg., Des Moines
Sieg, L. P. .... State University, Iowa City
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Spencer, Clementina S. .... Coe College, Cedar Rapids
Spinney, L. B. .... Iowa State College, Ames
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Stanton, E. W. .... Iowa State College, Ames
Stephens, T. C. .... Morningside College, Sioux City
Stevenson, W. H. .... Iowa State College, Ames
Stewart, George W. .... State University, Iowa City
Stiles, Harold .... Iowa State College, Ames
Stoner, Dayton .... State University, Iowa City
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Thompson, George E. .... Iowa State College, Ames
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Woodward, S. M. .... State University, Iowa City

ASSOCIATES.

Abbott, Roy L. .... Cedar Falls
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Baldwin, F. M. .... Ames
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Brown, Howard C. .... Charles City

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McGaw, F. M.........Mount Vernon
McKinley, Lloyd.........Iowa City
McCandlish, Andrew.........Ames
Marsh, Herbert.........Wesley
Maxwell, H. L.........Mount Vernon
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Millen, F. Eric.........Ames
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Moon, Helen.........Vinton
Morbeck, George C.........Ames
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Mullin, Catherine.........Iowa City
Overholt, Sigel.........Kirkman
Paige, F. W.........Fort Dodge
Paul, Matilda.........Iowa City
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Pieterpol, Henry W.........Pella
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Rees, Marie.........Ames
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Smith, John E.........Ames
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Tisdale, Wilbur E.........Iowa City
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Volkmer, Albert W.........Cedar Rapids
Wait, G. R.........Iowa City
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Wehman, H. J.........Iowa City
Werner, Herbert R.........Ames
Wester, C. W.........Cedar Falls
Whipple, Elizabeth S.........Wapello

ASSOCIATES—Continued.

Whipple, Mrs. Velma La Breck....Mount Pleasant
Wilcox, A. C....Mount Vernon
Willey, Florence S....Ames
Wilson, Ben H....Mount Pleasant
Winter, C. L....Le Mars
Yocum, L. Edwin....Ames
Vorhees, J. F....Cedar Rapids
Zuker, W. B....Des Moines

HONORARY FELLOWS.

Arthur, J. C....Purdue University, Lafayette, Indiana
Macbride, Thomas Huston....State University, Iowa City, Iowa
Osborn, Herbert....State University, Columbus, Ohio
Todd, J. E....State University, Lawrence, Kansas
Trelease, William....State University, Urbana, Illinois
Udden, J. A....State University, Austin, Texas

CORRESPONDING FELLOWS.

Anderson, J. P....Front and Main Streets, Juneau, Alaska
Andrews, L. W....440 W. 61st Place, Chicago, Illinois
Bain, H. Foster....Rangoon, Burma, India
Ball, C. R....Department of Agriculture, Washington, D. C.
Barbour, E. H....State University, Lincoln, Nebraska
Bartsch, Paul....Smithsonian Institution, Washington, D. C.
Boyd, Mark F....School of Medicine, University of Texas, Galveston, Texas
Brown, F. C....Bureau of Standards, Washington, D. C.
Bruner, H. L....Butler College, Indianapolis, Indiana
Carver, G. W....Tuskegee, Alabama
Cook, A. N....State University, Vermillion, South Dakota
Dieterich, E. O....Physical Laboratory, B. F. Goodrich Co., Akron, Ohio
Dodd, Lawrence E....Bureau of Standards, Washington, D. C.
Dodge, H. L....State University, Norman, Oklahoma
Drew, Gilman....Orono, Maine
Eckels, C. W....State University, Columbia, Missouri
Edwards, John W....Chattanooga, Tennessee
Faris, Ellsworth....University of Chicago, Chicago, Illinois
Finch, Grant E....State Normal School, Dillon, Montana
Fink, Bruce....Miami University, Oxford, Ohio
Franklin, W. S....Massachusetts Institute of Technology, Boston, Mass.
Fraser, Charles N....Marine Biological Station, Nanaimo, B. C.
Gabrielson, Ira N....U. S. Department of Agriculture, Portland, Oregon
Gillette, C. P....Agricultural College, Fort Collins, Colorado
Gossard, H. A....Agricultural Experiment Station, Wooster, Ohio
Hance, James H....Denison University, Granville, Ohio
Hansen, N. E....Agricultural College, Brookings, South Dakota
Haworth, Erasmus....State University, Lawrence, Kansas
Hitchcock, A. S....Department of Agriculture, Washington, D. C.
Hume, N. H....Glen St. Mary, Florida
Jenner, E. A....State Normal, La Crosse, Wisconsin
Job, Thesle T....Loyola Medical College, Chicago, Illinois
Learn, C. D....Agricultural College, Stillwater, Oklahoma
Leighton, M. M....State University, Urbana, Illinois

CORRESPONDING FELLOWS—Continued.

LEONARD, A. G.........................State University, Grand Forks, North Dakota
LEVERETT, FRANK ....U. S. Geological Survey, Ann Arbor, Michigan
MILLER, B. L.......................................Lehigh University, South Bethlehem, Pa.
NEWELL, WILMON...............................State Plant Board, Gainesville, Florida
PECK, MORTON E....................................Willamette University, Salem, Oregon
POMEROY, J. C...Military Academy, Charleston S. C.
PRICE, H. C..Evergreen Farm, Newark, Ohio
SAVAGE, T. E...State University, Urbana, Illinois
SIRRINE, EMMA.........................Department of Agriculture, Washington, D. C.
SIRRINE, F. A...79 Sound Avenue, Riverhead, New York
SOMES, MELVIN P...Box 378, Kalispell, Montana
VAN HYNING, THOMPSON..........................State Museum, Gainesville, Florida
VAN TUYL, F. M...School of Mines, Golden, Colorado
WEBSTER, R. L.......................................Cornell University, Ithaca, New York
WENTWORTH, E. N.............................Agricultural College, Manhattan, Kansas

CORRESPONDING ASSOCIATES.

BENNETT, WALTER W...Laurel, Nebraska
BETTS, GEORGE H.........................Northwestern University, Evanston, Illinois
BUCHANAN, L. L...........................Bureau of Entomology, Washington, D. C.
CASE, CHAUNCEY...Warren, R. D. 5, Ohio
DERSHEM, ELMER...State University, Urbana, Illinois
DEWEY, ARTHUR H..State College, Penn.
FEES, L. V...Box 1117, Denver, Colorado
FOSTER, CLARENCE L.....................................Yachow, Szechuan, West China
GIDDINGS, L. A..High School, Salt Lake City
GEISER, S. W........................Johns Hopkins University, Baltimore, Maryland
HEHNER, NELSON E.........................U. S. Bureau of Mines, Minneapolis, Minn.
HOFFMAN, W. A.........U. S. Department of Agriculture, Monticello, Florida
HORSFALL, JOHN L...State College, State College, Pa.
HOWELL, JESSE V...Lawton, Oklahoma
HUGHES, SALLY P..510 W. 124th St., New York City
JEFFS, ROYAL E...State University, Norman, Oklahoma
KENOYER, L. A...Christian College, Allahabad, India
KUZIRIAN, S. B..Jamaica, New York
LINDSEY, ARTHUR W..Decatur, Illinois
LOCKHART, WM. O.......................................State University, Knoxville, Tenn.
LORENC, F. A...Loma, Nebraska
PALMER, E. LAURENCE..............................Cornell University, Ithaca, New York
QUIGLEY, T. H...State University, Gainesville, Florida
ROGERS, W. E...Lawrence College, Appleton, Wisconsin
SAWYER, M. LOUISE.......................................Knox College, Galesburg, Illinois
SCHOEWE, W. H..School of Mines, Golden, Colorado
SCHRIEVER, WILLIAM...State University, Norman, Oklahoma
SHIPPEE, VERNON C..................Crook County High School, Prineville, Oregon
SHIPTON, W. D..............................Washington University, St. Louis, Missouri
SIMPSON, MARJORIE..........................De Pauw University, Greencastle, Indiana

CORRESPONDING ASSOCIATES—Continued.

Stuhlman, Otto, Jr. .... University of West Virginia, Morgantown, W. Va.
Swenson, L. G. ....
....Chemical Laboratory Smelting and Refining Company, Detroit, Mich.
Thone, F. E. A. .... Scripps Institution, La Jolla, California
Weigle, O. M. .... Westminster College, Fulton, Missouri
Williams, A. J. .... State University, Norman, Oklahoma

TITLES OF PAPERS PRESENTED

PROCEEDINGS OF THE THIRTY-THIRD ANNUAL SESSION

Held at Cedar Falls, April 25 and 26, 1919

The meetings of the thirty-third session of the Academy were held at the State Teachers College on April 25 and 26, 1919. The opening meeting was called to order by President Beyer at 1:30 Friday afternoon in the recitation room of Chemistry Hall. After a short business session, Doctor Beyer delivered the Presidential Address on "Some Problems of Conservation," after which the Academy passed to the reading of papers of general interest. Following these the Academy separated into sections of Zoology, Botany, Geology and Physics for further reading of papers.

At 6:45 the Academy convened for a special war film exhibit, following which President Emeritus Macbride addressed the Academy on the work of Scientists in the war. It was moved and carried that brief outlines of the work of the different branches of science be prepared by members to be chosen and that these be printed in the Proceedings. Following this meeting the members attended a reception tendered the Academy by President and Mrs. Seerley.

On Saturday morning the sections resumed their work and at 11:00 o'clock the Academy met for its final business session.

REPORT OF THE SECRETARY.

Members of the Academy:

It is scarcely necessary for me to remind you that this has been an abnormal year in all lines of activity, to explain several features of the year's work in the Academy. I strongly suspect that the decrease in the number of papers to be presented at this meeting may be traced to this abnormality and to the diversion and distraction of men's thoughts. We have, with difficulty, been able to direct our minds along the customary channels of reasoned scientific procedure and the results of the year's activity may perhaps reflect this situation to some extent. It is but a passing phase, however, and before long we shall find ourselves settled back into more normal fields of productive effort.

You have all been wondering what has become of the, supposedly, forthcoming volume of the Proceedings, toward whose value and importance you contributed so materially. The Secretary has had the same feelings many times and would be greatly pleased could he put a copy into the hands of each of you at this moment. His inability to do so must be charged to the aforesaid abnormal state of public activity. As a matter of fact it has been almost impossible for the printers to get employees competent to do the quality of work which our Proceedings demand. The volume is practically all in type, however, and work has been begun on making it up into page form. Progress promises to be more rapid very soon.

In this connection may I make mention of one part of the editorial work on the Proceedings. There are a good many calls in the course of each year for a list or index of the publications of the Academy. This demand led to the preparation of an index to the twenty-five volumes so far issued, including the one now in course of publication. A word of explanation may make its use a little easier. It was necessary, of course, to make it as brief as possible to avoid making the volume too bulky. The plan followed has been to give each title complete under the author's name, also a complete or in some cases slightly condensed title under the most prominent word. In addition cross references are given where necessary. Each author's titles are listed under his name in chronological order. It is probable that a number of extra copies will be printed to supply the demand. It is hoped that this index will prove useful to the members of the Academy and to the public as well.

The subject of the Corresponding Fellowship list and its relations to the Academy has been discussed before you several times in the past. It is to be presented again for what it is hoped will be its final settlement. There seems to be some misapprehension regarding the standing of this class of members. The constitution originally provided that workers in science in other states might be elected as corresponding fellows, also that fellows removing to another state might be classed as corresponding fellows. As a matter of fact only one person on our present list of corresponding fellows was elected as such under the first provision, namely Doctor Udden. All the others have been transferred under the second provision. Further, the records show that six of these were associates for periods ranging from one year to five years, without payment of any dues, and then, without becoming fellows, were transferred to the list of corresponding fellows and have been receiving without cost cloth bound copies of our Proceedings for twenty years, while in some instances our active members have had to be content with board bound copies. Now there is no honor either to the Academy or to the members in their being transferred to the corresponding list, and there is no reason why they should be exempt from payment of dues. That this has been the general opinion is evidenced by the fact that there are on our books two amendments providing for payment of dues by these members. It will be well to keep the historical situation in mind in voting on the amendments relating to corresponding fellows and associates which are to be brought before you.

The American Association for the Advancement of Science is urging upon scientific societies the nation over the desirability of affiliation with itself and thus of unification of the scientific forces of America for improved opportunities for their work and better appreciation of their efforts. Article 7 of the revised constitution, to be presented for adoption at the St. Louis meeting, reads as follows: "National and local scientific societies may, by vote of the council, become associated with the Association. Those associated societies which the council shall designate as affiliated societies are represented on the council and on the sectional committees as provided in articles 4 and 5." (Science, N. S. Vol. XLIX, p. 113, Jan. 31, 1919.) Such affiliated academies are left absolutely free as to their own work and organization and if all members of such an academy become members of the Association part of the Association membership fee of three dollars is returned to the academy for its expenses. Thus the Association becomes in effect an association of the various societies which unite with it. It would seem that such affiliation on the part of the Iowa Academy of Science should be mutually helpful to both parties in the agreement and I would commend the plan to your consideration.

It seems to your Secretary that the time has come when there must be a somewhat decided change in the editorial policy of the Academy or else there must be an equally decided change in the personnel of the editorial staff. The Academy has grown to such proportions and the number of papers presented annually for publication has become so large that the task of editing the Proceedings and preparing them for the printer has become a very arduous one for a volunteer editor, so to speak, and particularly, perhaps, for one who has an increasingly large amount of similar work to do in his regular capacity. It is realized, without any self-laudation, that there are advantages in having this work done by one at the seat of government and more or less intimately connected with that government. Our Proceedings are in a way public and official documents, since the State provides for their publication and it is perhaps somewhat more convenient for a public official to attend to their publication. The work has also been a very pleasant and enlightening one and it is not at all with the wish of shirking an unpleasant duty that these statements are made. But the necessity for a change is nonetheless urgent. This change must take the form, as previously suggested, either of the chosing of another editor who shall have more time to devote to the work, or the assumption of more responsibility by the authors of the papers to be published. This latter alternative will be easy if each author will do his share. By this I mean that in the first place he exercise the greatest care in the preparation of his manuscript. I wish that each one of you might have on your desks the little booklet issued by the United States Geological Survey entitled Suggestions to Authors. This contains many hints and discussions which are of value to writers on any subject whatever and it is accepted as standard by the Iowa Geological Survey except in a few points wherein the Survey's practice of long standing has been different. The general use of such a book as this would tend much to lighten the work of the editor. You will all agree I am sure that it is not fair for a writer to send in a paper which must be read twice by the editor before it can be sent to the printer, or one which must be sent back to be typewritten or to be couched in more grammatical form. And yet such cases are not unknown to the editorial sanctum. In the second place papers must be brief. I have mentioned this repeatedly and will pass it by here with the statement of fact.

Heretofore the editor has followed the practice of reading the galley proof, then sending it, with copy, to the author, and later reading the page proof. This plan places the responsibility for the correctness of the paper with the author, but means a great deal of work for the editor. One way in which the authors can assist will be by reading the page proof, thus leaving only one proof reading for the editor. Even this leaves a great amount of work which must be done by the editor.

In the matter of illustrations also there is room for improvement. If authors will carefully plan the arrangement of the illustrations in their papers and will see that they are economically and suitably grouped a great deal of unsatisfactory work will be spared the editor and the authors will be better pleased with the results. This point also has been called to your attention before and may be dropped with the suggestion.

In concluding this discussion it may not be out of place to state that several of our sister academies employ secretaries who devote their whole time to the work and who are paid by the State for their services while our Academy has always been served by secretaries who have done its work in addition to their regular duties. The same is true of the other officers of the Academy and it should be realized that the office of Treasurer, particularly, involves a great amount of work extending entirely through the year. This comparison is made, not for any purpose of disparagement, but merely to show under what different circumstances the work of our society is carried on.

In conclusion let me felicitate the Academy upon its steady growth and its maintenance of the high ideals which are its goodly heritage. Let me also thank the members for their kindly response to whatever calls have been made upon them for service or assistance in prosecuting the work of the Academy.

Respectfully submitted,

JAMES H. LEES,
Secretary.

TREASURER'S REPORT.

RECEIPTS.

Cash on hand, April 22, 1918	$ 27.30	
Transfer and entrance fees	62.00	
Annual dues from members	195.00	
Sale of Proceedings	3.00	
Total		$287.30

EXPENDITURES.

Honorarium to Dr. E. A. Birge, lecturer at the 32d Meeting	$ 50.00
Postage and clerical work for Treasurer	17.00
Stationery for Treasurer	2.50
Stationery and postage for Secretary	18.17
To Miss Newman, sending out Vol. XXIV	10.00
Honorarium to Secretary	25.00
Postage to A. L. Bakke, sending out questionnaires	4.05

To Robert Henderson, State Printer	9.00	
To J. M. Jamieson, State Binder, binding 1917 report	120.00	
Balance on hand, April 25, 1919	31.58	
Total		$287.30

A. O. Thomas,
Treasurer.

Report correct.

Harold Stiles,
R. W. Getchell,
Committee.

REPORT OF COMMITTEE ON SECRETARY'S REPORT.

Cedar Falls, Iowa, April 26, 1919.

To the Iowa Academy of Science:

Your committee appointed to consider the suggestions of the Secretary wishes to report as follows:

First—That the members of the Academy be instructed to take full responsibility in the preparation of typewritten papers and of illustrations that will stand such reduction as may be necessary to fit the page; and that they also take full responsibility with reference to the correction of the galley and the page proofs.

Second—We wish the finances of the Academy permitted adequate compensation of the secretary and also for the Treasurer for their services. We recognize, however, that such labor must for the present continue to be a labor of love, for the welfare of science in Iowa and recommend the adoption of this expression of our appreciation for that labor so admirably performed. We further recommend that the honorarium of the Secretary be changed from Twenty-five to Fifty Dollars for the year, that all expenses be paid as heretofore, and also such expenses of both Secretary and Treasurer as may be necessary in attendance upon a meeting of the Executive Committee to plan for the welfare of the Academy if such meeting is held between the sessions of the Academy.

Third—We are glad to express more than approval of the plan for the publication of an index to the Proceedings of the Academy. Such an index will assist very materially those who wish to consult the numerous valuable papers published in the Proceedings.

Fourth—We approve the suggestion that the Iowa Academy become affiliated with the American Association for the Advancement of Science under such provisions as are at present reported requisite and recommend that the necessary steps be taken to accomplish that affiliation.

Fifth—We understand that the Fellows of the Academy have been informed of proposed changes in the constitution with reference to honorary fellows and others not residing in the state, so do not report on those recommendations.

Respectfully,

John L. Tilton,
(For the Committee.)

The Committee on the Secretary's report gave its report and a motion was made and carried that the report be considered by sections. After a rereading of section one, it was moved and carried that the Executive Committee have power to reject articles which were unsatisfactory and that responsibility be put on authors. On section two it was moved and carried that a vote of thanks be given the Secretary and Treasurer and that the matter of the honorarium to the Secretary be left with the Executive Committee. Section three was adopted. After a discussion of section four it was moved and carried that the matter of affiliation be left with the Executive Committee and that the committee be instructed to prepare a program for affiliation with the A. A. A. S., provided that such affiliation modifies the internal organization of the Academy, such program to be presented to the Academy. Otherwise, the Executive Committee is to have power to act. It was then moved and carried that the report as a whole be adopted.

The proposed amendments to the constitution were then read. The first amendment was discussed and on motion was laid on the table. The matter of enforcement of the present provisions of the constitution was left with the Secretary and Treasurer. The second amendment was discussed and was carried. The amendments are found below.

PROPOSED AMENDMENTS TO THE CONSTITUTION.

Professor Pammel proposes the following change to section 4 as amended. (See volume XXIII, p. 14.) From the sentence regarding entrance fees and annual dues strike out the words "and corresponding fellow." From the sentence regarding arrearage strike out the words "and corresponding fellows."

Professor Stewart, for the committee on the eligibility of Associates residing outside the state to be elected as Fellows, proposes the following addition to section 3: "An Associate moving to another state becomes thereby a Corresponding Associate. A Corresponding Associate may be elected a Corresponding Fellow in the manner provided for the election of Fellows."

REPORT OF THE COMMITTEE ON NECROLOGY.

The Committee on Necrology begs leave to call attention to the deaths of Dr. Byron D. Halsted, a charter member, formerly of Ames and later of Rutgers College; Mr. Glenn I. Tenny of Des Moines, who enlisted in the army and lost his life in the services of our country; and Mr. R. B. Dodson, of the Physics Department of the State University at Iowa City. Appropriate sketches will appear in the Academy Proceedings.

L. H. Pammel,
C. C. Nutting,
Committee.

REPORT OF THE MEMBERSHIP COMMITTEE.

The Membership Committee presented the following report, which was adopted and the persons were declared elected.

For Transfer from Associate to Fellow—R. E. Conklin, Miss M. Louise Sawyer, W. F. Coover, H. R. Werner, Otto Walter, E. L. Palmer, F. S. Mortimer, G. C. Morbeck, Wm. Diehl.—9.

For Transfer from Associate to Corresponding Associate and Thence to Corresponding Fellow—Elmer Dershem, Urbana, Ill., M. P. Somes, Kalispell, Mont., I. N. Gabrielson, Corvallis, Oregon, Charles M. Fraser, Nanaimo, B. C.—4.

For Election as Fellow—Harry A. Geaque, Indianola.

For Election as Associates—C. N. Ainslee, Sioux City, Rev. Chas. Snyder, Sioux City, Dr. Grant J. Ross, Sioux City, Dr. Thomas P. Haslam, Sioux City, A. F. Allen, Sioux City, Delmer C. Cooper, Sioux City, A. J. Anderson, Sioux City, James A. Coss, Sioux City, Arthur H. Locke, Sioux City, Winfield Scott, Cedar Falls, E. Lyle Peck, Centerville, K. Bird, Des Moines, F. W. Emerson, Oskaloosa, Mrs. Sadie B. Allen, Waterloo, Tom McMillen, Mount Pleasant, George E. Crane, Mount Pleasant, James T. Whiting, Mount Pleasant, Wm. H. Gran, Mount Pleasant, Hugh Robinson, Mount Pleasant, C. E. Smith, Mount Pleasant, C. W. Cruikshank, Mount Pleasant, W. O. Lockhart, Cedar Falls, Chas. B. Crofutt, Mount Vernon, Evelyn Ensign, Storm Lake, Waldo S. Glock, Vinton, Fred Cox, Iowa City, Matilda T. Paul, Iowa City, Mrs. Lillian Nims, Osage, Jacob Trieschman, Mount Vernon, Miss Elizabeth P. Moulton, Cedar Falls, Edward J. Hornick, Dubuque, F. C. Mortensen, Cedar Rapids, Rev. Herbert Marsh, Wesley, Chester A. Momyer, Jr., Algona.—34.

The names of Professors James Edward Todd and Johan August Udden, Corresponding Fellows of the Academy, were proposed for election to Honorary Fellowship, as provided by the Constitution. They were unanimously elected. Both gentlemen have since accepted the election.

Professor Kinney opened a discussion on salaries of science teachers in the colleges and it was finally moved and carried that the chair elect a committee, of which Professor Kinney should be chairman, to formulate for the Academy a statement on the question and that the statement should be sent to the presidents of the Iowa Colleges.

The President later appointed as the additional members of this committee, G. W. Stewart, F. F. Almy, S. W. Beyer and James H. Lees.

Other special committees appointed by the President were the committee on legislation, consisting of John L. Tilton, Chairman, C. C. Nutting, D. W. Morehouse, Nicholas Knight, James H. Lees; also a committee on conservation, consisting of W. H. Davis, Chairman, B. Shimek, H. E. Jaques, G. B. MacDonald and G. A. Chaney.

REPORT OF COMMITTEE ON CONSERVATION.

The writer was appointed a committee on conservation at the Iowa City meeting of the Iowa Academy of Science. Soon after the appointment of the committee the writer had an interview with Governor Harding to appoint the members of the Conservation Board. The writer asked the Governor to appoint a member of the Academy, preferably the President. Owing to the strenuous war work of the Governor it was impossible for him to appoint this Conservation Board until late in November or early in December, 1918.

The Governor appointed Hon. J. F. Ford of Fort Dodge, Hon. Joseph Kelso of Bellevue, and much to my surprise asked me to accept appointment on this Board. Mr. E. R. Harlan, the other member of the Board was named by the legislative act. The Board organized in December by electing the Iowa Academy representative as chairman and Mr. E. R. Harlan secretary. The Board is representative in that there are two good and capable business men in the same, Messrs. Kelso and Ford. In our transactions a great many financial matters come up and the experience of these men is worth much to the state. Mr. Harlan looks after the secretarial work with the assistance of Mr. Mott. The whole park matters have been thoroughly systematized. Everything is in good working order.

We have acquired out of the hunters' license fees the Devil's Backbone park in Delaware county, which is to be dedicated on October 1, 1919. We have also had donated to us an area near Farmington of one hundred acres with a lotus lake of forty acres. There was donated to us an area in Keosauqua of one hundred sixty acres to which we added by purchase considerable more land. We have also added to our park area by gift from the Brandt sisters a tract of fifty-seven acres known as the Wild Cat Den, Muscatine county. We have asked the citizens of Muscatine and Davenport to raise by subscription $5,000 so that the whole of the area can be acquired, enough to make about two hundred and twenty acres. We would then have a park extending from Wild Cat Den to Mississippi river on Pine creek. Other gifts are in sight.

The Conservation Board proposes three types of parks: *Highway parks* of twenty-five acres distributed in various counties convenient to a good highway; *Lake parks,* areas on lakes; and *State parks,* more or less unique places of larger area having some scientific, historical or recreational interest. The last legislature appropriated $100,000 annually and provided the State Historical Museum with an assistant secretary to assist in the park matters. Mr. E. R. Harlan secured the service of an excellent man, Mr. Mott, to do this work.

L. H. Pammel,
Chairman of Committee.

ACTIVITIES OF MEMBERS OF THE IOWA ACADEMY DURING THE WORLD WAR

ROSTER OF MEN IN SERVICE.

AVIATION.

Grissel, Earl.

Lindsey, A. W., Flying Cadet, Balloon Division.

CHEMICAL WARFARE SERVICE.

Ressler, Ivan L., Sergeant Co. I, 3d Bn.

COAST ARTILLERY.

Belanski, Charles H., Private, Park Battery C., A. A. P.

ENGINEERS,

Corson, George E., Sergeant Co. A., 211 Engineers.

Jordan, R. H.

FIELD ARTILLERY.

Buchanan, Lee L., 1st Class Private, Battery F, 337th Regiment

Helmick, Paul, 330th Regiment.

Smith, Donald M., Private, 17th Battery, F. A., C. O. T. S.

Thone, F. E. A., 2d Lieutenant.

Wait, G. R., Private.

Wentworth, Edward N., Captain, 164th Brigade.

INFANTRY.

Doty, H. S., Line Sergeant, 6th Co., 2d Bn., I. C. O. T. S.

Hartzell, Albert, Corporal, Co. F., 1st Tr.

Hoersch, Victor A., 1st Lieutenant, Co. L, 9th Infantry.

Horsfall, J. L., Sergeant, 99th Div. Training School.

Moore, W. A., Sergeant, Co. 11, Infr. Repl. & Tr. Trps.

Snider, Frank J., Corporal, Co. A, I. C. O. T. S.

Stainbrook, M. A., Service Supply.

Torrance, D. M., Private, Co. 50, 13 Bn., 163 D. B.

MEDICAL CORPS.

Baker, Norval E., 1st Lieutenant, 88th Division.

Bennett, W. W., Sergeant, Instructor Military School of Roentgenology.

Clarke, James F., Lieutenant Col., Director Hospital Unit R.

Glomset, Daniel J., Major, Base Hospital No. 15.

Hagen, Wayne, Sergeant, Co. B, Medical Detachment, Fort Des Moines.

Maxwell, H. L., Sergeant, Base Hospital, Camp Dodge.

NAVAL AVIATION.

Tenney, Glenn I., Died.

NAVY.

Lockhart, W. O., 2d Class Seaman, U. S. N. R. F., Co. J, 22d Regiment.

Palmer, E. L., 2d Class Seaman, U. S. N. R. F.

PERSONELL.

Ritchey, Geo. E., Sergeant, Headquarters Detachment.

PSYCHOLOGY.

Sylvester, R. H., Captain.

QUARTERMASTER CORPS.

Wolden, B. O., Private, School for Bakers and Cooks.

S. A. T. C.

Geiser, S. W., Co. 20, 2d School Inst. S. A. T. C., Upper Iowa.

S. O. T. C.

Smith, Orrin H., Private, Fort Sheridan.

SANITARY CORPS.

Dox, Arthur W., Captain.

Hinman, Jack J., Jr., Captain.

Lamb, Alvin R., 2d Lieutenant.

SIGNAL CORPS.

Fortsch, A. R., Corporal, 3d Service Co.

Schriever, Wm., Sergeant, 29th Service Co.

BRANCH OF SERVICE NOT DESIGNATED.

Hughes, U. B.

Diehl, Wm. W.

Thompson, L. D.

Wilcox, A. C.

GEOLOGISTS.

Two geologist members were engaged in Y. M. C. A. work for the Army, one in France, one in America. Three were on the staff of the U. S. Geological Survey and were detailed to the War Department for topographic mapping, while two men prepared data on oil and gas production, as well as doing map work. Three members prepared bulletins on as many of the training camps. Another was Assistant Director of the U. S. Bureau of Mines for the period of the war. Iowa clays were examined by geologists of the State College to find substitutes for imported fire clays. Several geologists served as instructors in the S. A. T. C. at different schools and aided in various ways in the preparation of soldiers and civilians alike for their part in winning the war.

CHEMISTS.

Several chemists were able by their technical training to render distinct service in specialized work, as for instance the treatment of underwear to render it vermin proof, the preparation of chemicals needed in warfare, the inspection of ordnance, the analysis of water for the Camp Dodge supply. Others were of service in directing the four-minute men and in similar patriotic service.

BIOLOGISTS.

Several of the biologists of the Academy were directly engaged in furthering increased food production in various ways—in fighting injurious insects and plants, in doing specialized laboratory work, in stimulating the raising of special crops. One member was in Red Cross work in England, another by his studies produced a poison gas detector and a number were engaged in S. A. T. C. instruction in various capacities. In addition a number were in the army.

BOTANISTS.

During the war an active campaign was carried on looking toward the extermination of the barberry. The U. S. Government detailed several members of the Academy for this work in Iowa. Also work was done trying to eliminate the loss of crops by the destruction of weeds. Some members of the Academy were engaged in trying to save and utilize wood and fuel and some work was done in connection with the utilizing of walnut and other timber for gunstocks and aeroplanes.

Other members were actively engaged in assisting by their technical knowledge the increase of food production so necessary during and after the war. One member, whose intimate acquaintance with the foreign-born element of our population gave him ready access to their sympathies, made a great number of patriotic speeches. Another was county chairman for the U. S. P. S. R., and another was a captain in the R. O. T. C. and later an instructor in the S. A. T. C.

MEDICINE.

Several medical members did valiant work fighting the "flu" on the home front. Others lectured before the soldiers and the S. A. T. C. and one was director of the Iowa Child Welfare Research Station.

PHYSICISTS.

The war work of the members of the Academy who are physicists differed widely. One of our members gave a series of lectures at the naval camps on "The Earth, Magnetism and the Compass," and "The Ocean Tides;" one was senior instructor in charge of all technical instruction at a Signal Corps Officers Training School: one was "Assistant District Educational Director" of District No. 8, under the Committee on Education and Special Training of the War Department; two were members of the Committee on Location of Invisible Aircraft of the National Research Council, one as chairman; one was a captain in the army and assistant engineer engaged in experimental work in connection with the flight of airplane bombs; one was captain and later major in the army and devoted himself to the ordnance features of airplane service; one was a non-commissioned officer in the Signal Corps and an active participant in experimental work in the development of the wireless equipment of airplanes; another was employed as special agent to assist in locating men in different branches of the service; and those remaining on duty in the colleges were actively engaged in S. A. T. C. instruction. It is impracticable to discuss the individual successes of the members. They found themselves utilized in a highly specialized capacity, as teachers, as executives in connection with education and with army and navy research, and virtually as development engineers in the employ of the army and navy. In fact, experience during the war showed that the physicist possessed the appropriate training and the suitable attitude of mind for a development engineer. The profession of physicist has more than ever become recognized as having an important function in the development of applied science.

PSYCHOLOGISTS.

The members of the Psychology department of the State University were engaged in devising acoustic instruments for use by listeners in locating submarines, also an instrument for measuring acuity of hearing at all pitch levels. In addition there were developed methods of selecting listeners for locating submarines and airplanes and tests for diagnosing fitness for radio service.

Several members of the Academy were active in making patriotic addresses and aiding in the liberty loan drives. Others served in army Y. M. C. A. work, in Red Cross work and among the great group of workers who were striving to advance the production and distribution of food supplies.

LIST OF MEMBERS AND VISITORS IN ATTENDANCE.

Roy L. Abbott, Cedar Falls, Alison E. Aitchison, Cedar Falls, Henry Albert, Iowa City, F. F. Almy, Grinnell, M. F. Arey, Cedar Falls, J. A. Baker, Mount Pleasant, F. M. Baldwin, Ames, S. W. Beyer, Ames, E. D. Ball, Ames, L. Begeman, Cedar Falls, P. A. Bond, Cedar Falls, E. J. Cable, Cedar Falls, R. W. Chaney, Iowa City, Ira S. Condit, Cedar Falls, J. A. Coss, Sioux City, R. I. Cratty, Ames, Eva Cresswell, Cedar Falls, W. H. Davis, Cedar Falls, A. H. Dewey, Iowa City, H. L. Dodge, Iowa City, A. R. Fortsch, Iowa City, S. W. Geiser, Fayette, R. W. Getchell, Cedar Falls, D. J. Glomset, Des Moines, C. Bert Gose, Indianola, J. E. Guthrie, Ames, S. F. Hersey, Cedar Falls, J. L. Horsfall, Dubuque, H. E. Jaques, Mount Pleasant, Geo. F. Kay, Iowa City, H. M. Kelly, Mount Vernon, C. N. Kinney, Des Moines, Nicholas Knight, Mount Vernon, Wm. V. Knoll, Iowa City, James H. Lees, Des Moines, T. H. Macbride, Iowa City, Anson Marston, Ames, T. W. McGraw, Mount Vernon, D. W. Morehouse, Des Moines, Elizabeth P. Moulton, Cedar Falls, F. S. Mortimer, Iowa City, G. W. Newton, Cedar Falls, C. C. Nutting, Iowa City, O. B. Overn, Decorah, E. L. Palmer, Cedar Falls, L. H. Pammel, Ames, L. Chas. Raiford, Iowa City, O. B. Read, Cedar Falls, John F. Reilly, Iowa City, Ivan L. Ressler, Ames, M. Louise Sawyer, Grinnell, Carl E. Seashore, Iowa City, W. H. Schoewe, Iowa City, Winfield Scott, Cedar Falls, D. M. Smith, Ames, John E. Smith, Ames, Orrin H. Smith, Mount Vernon, Clementina S. Spencer, Cedar Rapids, T. C. Stephens, Sioux City, George W. Stewart, Iowa City, Harold Stiles, Ames, Dayton Stoner, Iowa City, F. A. Stromsten, Iowa City, A. O. Thomas, Iowa City, George E. Thompson, Ames, John L. Tilton, Indianola, Olive Tilton, Cedar Falls, Mrs. F. May Tuttle, Osage, G. W. Walters, Cedar Falls, C. L. Webster, Charles City, H. R. Werner, Ames.

IN MEMORIAM

DR. BYRON D. HALSTED.

L. H. PAMMEL.

It was my privilege to be called to the chair of botany just vacated by Dr. Byron D. Halsted in February, 1889. It was not my good fortune to meet him until some months later at one of the meetings of the American Association for the Advancement of Science. In those days Doctor Halsted was a familiar figure at the meetings of the American Association and the Society for the Promotion of Agricultural Science. Of this society, he was, I believe, one of the charter members and secretary for some years. Dr. Halsted was also a charter member of the Botanical Society of America. He was, if I am not mistaken, a charter member of the new Iowa Academy of Science. The botanical career of Doctor Halsted has been given in journals of recent date.

Doctor Halsted was a voluminous writer on a variety of botanical matters. While at Ames he turned his attention to economic botany, especially fungi and the diseases of plants. These subjects too engaged his attention for many years, while connected with the New Jersey Agricultural Experiment Station and Rutgers College. Here he made an interesting study of diseases of vegetables like the egg plant, tomato, sweet potato and bean. Owing to failing health, the late years of his life were spent in a study of breeding of tomatoes and sweet corn. Those who are familiar with this type of botanical work pronounce it excellent.

His work at Ames, on fungi, embraced studies on the downy and powdery mildews and rust. It was, however, largely fragmentary, consisting of few notes and observations. I do not mean to say that Dr. Halsted's work was of a low order; it was not. For instance in the two bulletins issued by him while at Ames, forty or fifty subjects were treated in each of the bulletins. The work could not, therefore, be exhaustive. His papers on some disease treated in one of the Reports of the U. S. Department of Agriculture were much more exhaustive and comprehensive. His treatment of diseases of truck plants while in New Jersey indicated that he could conduct a large piece of work well. At Ames he became interested in a study of the storing of reserve food products in apple twigs. The results of his investigation were embodied in a bulletin of some size.[1] This work was later extended in a publication, Memoirs of the Torrey Botanical Club.

Doctor Halsted was a most delightful correspondent, and a most charming man to meet, naturally somewhat reticent in conversation, but intensely in earnest and sincere about his work and affairs of life. Doctor Halsted was a fine teacher according to the testimony of those who had worked with him. I found, on coming to Ames, that the respect for him by his students was universal. On the occasion of his death the faculty of Iowa State College at one of its regular meetings expressed appreciation as follows:

"Dr. Pammel submitted the following resolution in regard to the death of Dr. Byron D. Halsted, who was a member of the faculty of Iowa State College from March 1, 1885, to December, 1889.

"I am sure the older members of the faculty and students will remember Dr. Byron D. Halsted, who was a member of the faculty of Iowa State College. Dr. Halsted died at New Brunswick, N. J., on August 22, 1918, as a result of paralysis. It would seem proper for this faculty to adopt resolutions.

"*Be It Resolved*, therefore, by the faculty of Iowa State College that we appreciate the scientific labors of Dr. Byron Halsted; that as an editor of the American Agriculturist, teacher at Iowa State College and Rutger's College, and as an investigator in many lines of botanical work, he furthered the agricultural and scientific interests of the state and nation: that we honor his fidelity as an American citizen and his faithfulness in the discharge of every public and family duty. We feel proud of the fact that Dr. Halsted was associated with this institution and we shall always cherish the memory of this noble Christian and exemplary citizen. Moved the adoption of this resolution and that a copy be sent to the family and to Rutger's College."

He entered Bussey Institute in 1874, being the first student Doctor Farlow had. To students in mycology he will be remembered for his discovery of the downy mildew (*Plasmopara Halstedii*) in 1875, which was named after him by Dr. G. W. Farlow, who only a few months after the death of Doctor Halsted, also passed away.

Dr. Halsted was registered in the Lawrence Scientific School. His thesis, "The Classification and Description of American Characeæ," was presented at his examination for graduation in 1878, and was published in the Boston Society of Natural History, volume

[1]Bulletin Ia. Agrl. Exp. Sta. 4.

20, pages 169 to 290, March 5, 1879. He received the Doctor of Science degree at commencement 1878, being the first person to receive this degree at Harvard.

Doctor Halsted had a long, active career. He was born at Venice, Cayuga county, New York, June 7, 1852, educated in the secondary schools of that state, later graduated from the Michigan Agricultural College, receiving the B. S. degree in 1871 and the M. S. degree in 1874, and later the D. Sc. degree from Harvard. I believe his was the first degree to be given in this country. He then became associate editor of the American Agriculturist, and then Professor of Botany of the Iowa Agricultural College, following Dr. C. E. Bessey. Later he was called to Rutger's College, New Jersey, where his active career was ended on August 27, 1918.

Doctor Halsted will live in the memory of his students and friends in the botanical world and the educational institutions with which he was connected. His work was well and faithfully done and he had the highest esteem of his fellow men.

Papers Presented at the Thirty-third Meeting of the Academy

THE ADDRESS OF THE PRESIDENT

SOME PROBLEMS IN CONSERVATION

SAMUEL WALKER BEYER

The credit for directing the attention of the public to the almost universal waste of the Nation's resources must be accorded to the late President Theodore Roosevelt. The great President was not only the originator of the movement but continued to be its most aggressive and enthusiastic apostle and promoter. The idea first found definite expression in his address before the Society of American Foresters, March 26, 1903, in which he emphasized the necessity of forest preservation and pointed out the close relationship between the forests and stream flow.

Later at the Jamestown Exhibition, June 10, 1907, he restated his views covering all the natural resources of the nation. To quote: "The conservation of our natural resources and their proper use constitute the fundamental problem which underlies almost every other problem of our national life. Unless we maintain an adequate material basis for our civilization we cannot maintain the institutions in which we take so great and so just a pride; and to waste and destroy our natural resources means to undermine these material bases."

Continuing he gives Gifford Pinchot due credit, in which he says: "So much for what we are trying to do in utilizing our public lands, for the public; in securing the use of the water, the forage, the coal, and the timber for the public. In all four departments my chief adviser, and the man first to suggest to me the courses which have actually proved so beneficial, was Mr. Gifford Pinchot, the chief of the National Forest Service. Mr. Pinchot also suggested to me a movement supplementary to all of these movements, one which will itself lead the way in the general movement which he represents and with which he is actively identified, for the conservation of all our natural resources."

The epoch making event along conservation lines was the White House Conference which took place in the White House, May 13 to 15, 1908. All of the Governors or their representatives, with their advisers and the leading scientific men of the nation met with the Judges of the Supreme Court, the Congress, and the

President of the United States and his cabinet. The Conservation movement was officially launched and has been under way ever since. The term conservation has become a household word. In fact during the period of the war, conserve and conservation were the most overworked words in our language.

While conservation was on the lips of many of us and in the minds of all of us during the war, there never has been a period in the history of the world when inroads in the natural resources were so great. War is waste with a capital W, just as truly as it is what General Sherman denominated it, with a capital H, waste in material things as well as in human life.

During war times the winning of battles outweighs all other considerations. We are now in the period of reconstruction and the stress of haste in repairing and restoring the losses entailed by the war tempts many of our people to continue wasteful practices permitted during the war. It is high time that thoughtful consideration be given to the elimination of wasteful methods and the extravagant use of the nation's resources; to re-establish our industries and our commercial activities on a pre-war basis and re-dedicate our best efforts toward real conservation.

Conservation Defined—While the speeches and writings of the great apostle of conservation are full of the spirit of conservation, the subject is never treated academically. In his special message to Congress transmitting the report of the National Conservation Commission, he says: "The policy of conservation is perhaps the most typical example of the general policies which this Government has made peculiarly its own, during the opening years of the present century. The function of our Government is to insure to all its citizens, now and hereafter, their rights to life, liberty, and the pursuit of happiness. . . ."

"We have realized that the right of every man to live his own life, provide for his family, and endeavor, according to his abilities to secure for himself and for them a fair share of the good things of existence, should be subject to one limitation and to no other. The freedom of the individual should be limited only by the present and future rights, interests and needs of the other individuals who make up the community." Conservation does not mean hoarding, but the wise and intelligent use of our resources now, with reasonable forethought and consideration for the rights and happiness of the generations which are to follow. This definition is generally accepted as correct in principle, when applied to a nation, but has little force from the standpoint of the individual.

The natural resources are readily divisible into two distinct classes accordingly as they are not renewable, or are renewable. The first class comprises the mineral products including the mineral fuels and the metals, which are not renewable and whose exhaustion is certain to come in time. The best that conservation can hope to accomplish is to defer the date of exhaustion.

The second class includes the soil and its products, the forests, and the waters.

The natural resources belonging to the first class are relatively unimportant in Iowa. It is true that a considerable area is underlain by coal of workable thickness and there are lesser areas of gypsum, iron ore, and lead and zinc. The production of these mineral products is quite insignificant when compared with the products of the soil. While the actual and potential value of the waters, clay, shale, stone, sand and gravel quantitatively are much more important than the mineral products before listed, they too are relatively unimportant in the inventory of natural resources for Iowa and will receive but passing notice in the present paper.

In dollars and cents coal is the most valuable of the mineral resources now being developed. The state has been notably lax in permitting most wasteful methods in mining, in the preparation, storage and use of coal. In most of the Iowa coal fields, less than seventy per cent of the seam mined is actually hoisted to the surface and scarcely more than two-thirds of this will grade as lump coal. As a rule only one seam is developed in coal basins where two or more workable seams are present, and this without regard to its position to the remaining seams which may be destroyed for all time through removing the coal from the single seam.

The methods now in use are even more wasteful in the handling and consumption of coal. The ordinary hot air furnace and steam boiler are very low efficiency mechanisms. Problems worthy of the best efforts of the mining engineer, the gas engineer, and the mechanical engineer have to do with fuel conservation.

Similar problems present themselves when the other mineral resources of the state are considered. Limestone and shale when properly blended and heated to a high temperature and then reduced to a fine powder become Portland cement. Immense quantities of impalpable dust are wasted in the process; in fact worse than wasted, because this dust becomes a nuisance in the vicinity of the plant, destroying the vegetation, defacing buildings and improvements, and defiling the atmosphere. This same dust carries most of the potash found in the shale, and should be saved.

Mr. George P. Dieckmann, Chemist of the Northwestern States Portland Cement Co., advises me that the dust loss in the modern Portland cement plant is calculated at five per cent of the raw mix. This means a loss of about fifteen tons in the manufacture of 1000 barrels of cement. The total daily capacity of the four Portland Cement Plants in Iowa is about 20,000 barrels, with a dust loss of about 300 tons per day. The amount of potash carried is about 4 per cent, of which more than one half is water-soluble. Mr. Dieckmann has done enough experimental work to demonstrate that some 90 to 95 per cent of the potash may be recovered electrolitically. Nothing has been done as yet to save this important resource in the Iowa plants.

While the value of the normal mineral output amounts to a few tens of millions of dollars, the value of the products of the soil finds expression in hundreds of millions and is after all the real basis of the wealth of the state. The conservation of the soil and its fertility is our greatest material problem to-day. Soil losses are chiefly mechanical and chemical, and while all soils are undergoing constant changes through natural agencies, the losses are greatly stimulated through unwise or careless agricultural processes.

The removal of the natural vegetation subjects the land to undue wash by rain and running water and careless methods of farming, or cultivation of the land during the wrong season of the year may greatly aid such soil wastage. Oftentimes the erosive work of running water is sufficient to more or less completely remove the soil through gullying and sheet erosion, rendering the land untillable for the time being or indefinitely. Up to the present time not much of our Iowa land has been lost in this way. Most Iowa farmers are sufficiently alert to note the "hand writing," and have adopted or are adopting methods to reduce soil erosion to a minimum.

The chemical waste of soils or loss in soil fertility is less obvious and the tillers of the soil are much slower to recognize such losses and to appreciate the fact that corrective measures must be discovered and put into effect. Our agricultural Experiment Stations are pioneers in the work of soil conservation and are doing excellent service in bringing the matter of soil waste to the attention of the farmers and suggesting corrective measures. The Iowa Station has made a careful inventory of the leading elements which determine soil fertility in Iowa, of which nitrogen, phosphorus, potassium, carbon, lime, and sulphur are the most important. According to the Station authorities: "The Missouri loess, which is richest in phosphorus and potassium on which corn makes the heaviest draft of all grain crops, contains in its surface soil enough phosphorus for 90 crops of corn and enough potassium for 1,782 crops, if only the grain is removed. If the stover also is removed, there is enough phosphorus for only 66 crops and potassium for only 477 crops. . . . In the Iowan drift, the poorest soil in both phosphorus and potassium, there is enough phosphorus in the surface soil for only 75 crops of corn and potassium for 1,170 crops if the stover is returned to the soil. If the stalks are removed, the phosphorus would supply only 56 crops and the potassium 313 crops." These elements have required hundreds of years in their accumulation, and in farming, as ordinarily practiced, are being rapidly withdrawn. In fact the average farmer is overdrawing his account in terms of soil fertility and the practice if persisted in must ultimately lead to bankruptcy.

The most important of all of the ingredients of the soil, and the medium through which plants take the so-called essential foods is water. It is a truism that the habitability of any continent depends on its water supply. Mr. McGee's epigram is "no water, no plants; no plants, no people." In the arid and semi-arid regions the chief problem was and is to put water on the land and for a time putting on water was considered to be the only problem. After expensive and sometimes ruinous experience it was discovered that drainage was quite as important as irrigation in these regions.

Up to this time the prompt removal of the water is the problem receiving most attention in the humid regions, while every intelligent farmer knows that crop production could be increased if the rainfall in humid areas was more equally distributed throughout the growing season, and in a relatively few instances some effort has been made to supplement this deficiency by irrigation. In our inland states, Iowa and its immediate neighbors, irrigation is applied in a very limited way to gardens only. In order to extend the service to general farming operations the available water supply must be conserved. All of the water available for this purpose is meteoric in origin, that is, comes as rain and snow. The Mississippi Valley is in the region of the prevailing Westerlies, and practically all of the water received as rain and snow comes directly or indirectly from the Gulf of Mexico. Small amounts may come from the Atlantic Ocean.

The moisture laden winds from the Gulf travel inland, become a part of the great cyclonic movements which travel across the continent from west to east and supply the Mississippi Valley with an abundance of water making it the granary of the world. The moisture received as rain or snow is distributed as follows: runs directly off—the run-off, collects into ponds and lakelets, or escapes through drainage lines, and eventually returns to the Gulf from which it came. A second and much larger portion soaks into the ground. The larger part of the water which enters the ground is pumped to the surface through the force of capillarity and by plants and returned to the atmosphere as vapor. A lesser part descends through the force of gravity and becomes a part of the "permanent" ground water supply. The water supply system for the Mississippi Valley region comprises a central pumping station, the Gulf of Mexico, the great cyclonic movements constitute the distributing system and the lakes and lakelets serve as a reserve supply.

The productivity of the valley region is dependent primarily upon the adequacy of the water supply, that is a sufficient amount of water properly distributed in time and space. No evidence is available to show that man can vary the first factor, the total rainfall. The distribution can be varied both in time and space through drainage and irrigation and methods of cultivation, as far as farm crops are concerned. The natural distribution of water is variable. The porous soils and subsoils tend to equalize such variability. Water so held is available when within the reach of plant roots with the aid of capillarity. The zone of perpetual groundwater is the reservoir. The height to which capillarity can lift varies inversely as the diameter of the capillary tubes. In arid and semi-arid regions the ground water level may be so low that capillarity fails to bring the water within the reach of plants, while in humid regions the level may be so high as to drown many plants.

The ground water level is not a constant but varies with the seasons or through a term of years. The ground water level is important from an agricultural standpoint. Where it is too high drainage may be required and where it is too low irrigation may be necessary.

The recognized indicators of the level of ground water in the order of their dependability are: (a) the water in an outlet-less pond or lake, the water being an extension of the ground water and rising and falling with the season. (b) Swamp and bog levels give the approximate level of ground water but are less sensitive to changes in climatic conditions. (c) Hillside seeps or springs mark the line of outcrop for the ground water and are conspicuous along many streams which are in the channeling stage. (d) Artificial trenches and excavations for agricultural, industrial and sanitary purposes give a reliable record of the ground water level. Along this line the ordinary dug or shallow well is most important on account of its almost universal distribution

In 1909 and 1910 the U. S. Department of Agriculture started an inquiry to determine the stability of the mean ground water level. Questionaries were sent to 33,000 reporters and replies were received from about half the number. The important questions were: "Dates of making wells; Original depth of water in wells; and Present depth of water in wells." The data received were carefully weighed and tabulated. It is obvious that only the general conclusions can be considered here. The outstanding facts obtained are: (a)[1] "The depth of the water level beneath the surface varies from place to place, but is in over 60 per cent of the wells, and in most states on the average for all wells, within capillary reach of the surface soil." (b) "A clear quantitative indication that the sub-soil water level is, and has been since the settlement of the country, lowering at a considerable rate." Incidentally information was obtained bearing on the general subjects of water supply and drainage.

The ground water must be looked upon as a reserve supply from the standpoint of farm crops and is subject to overdraft during periods of drouth. The data further show "that its upper level is not far from the limit of its availability for crop growth." The universal lowering of the ground water level is a matter of grave concern. The records show that the average lowering for the entire country is about nine feet and for Iowa some twelve and a half feet during the fifty years proceding 1910. The rate of lowering was highest during the early stages but appears to be proceeding at a diminishing rate. If such recedence continues the result is obvious. It will be only a matter of time when the great reserve supply is out of reach of some of our useful plants. It is time to take an inventory of our water resources and endeavor to

[1]Bul. No. 92, p. 184. Bureau of Soils.

discover ways and means by which waste or unintelligent use may be reduced to a minimum. In other words practice economy in the use of our most vitally important natural resource.

Up to the present time there is no evidence to support the view that the country is undergoing a change toward aridity, that rainfall is gradually becoming less. Neither do the facts show that cultivation increases the rainfall and that deforestation reduces it. According to McGee[2]: "The chief cause of lowering of the sub-soil water—the waste of storm and thaw waters through surface run-off—is remediable, and with the advance and diffusion of intelligence is bound to be remedied."

This waste is responsible for the mechanical and chemical soil losses, destructive floods and resultant property damage; the silting up of streams, destroying their navigability, and the contamination of water supply. Additional water losses and consequent lowering of the ground water come through the cultivation of the land; drainage, industrial operations, especially mining, and water consumed by man and domestic animals; the latter being almost negligible.

The really great loss through storm and thaw can be effectively reduced through proper drainage and cultivation. Tile drainage lowers the ground water but reduces the direct run-off and is especially effective in reducing the wasting of the land. Open ditches lower the subsoil water and increase the run-off, in addition to interfering with general farming operations. The ditch always destroys the land for agricultural purposes and the spoil banks too frequently are worse than useless as they become the breeding grounds for all manner of foul weeds. In general from two to eight acres of land per mile are rendered non-productive. Tiling equalizes the run-off while the open ditch increases the inequality between flood and low water.

In north central Iowa the numerous ponds and lakelets originally present were Nature's method of conserving the ground water level, stabilizing stream flow and reducing soil waste. The wholesale destruction of these natural devices through the open ditch, or tile drains with catch basins, has more or less completely removed these natural safeguards.

In the great mountain regions of the United States the Federal Government has taken over large tracts of land as forest reserves on the theory that it was necessary to exercise protective control

[2]Bul. No. 92, pp. 178 et seq. Bureau of Soils.

in order to safeguard the great rivers which head in these regions, for purposes of navigation, irrigation, and power.

The United States Geological Survey has investigated a number of projects along this line. The White Mountains, New Hampshire, may be cited as fairly representative of methods employed and results obtained. The work was divided into two parts,—geologic and hydrometric—and was assigned to some of the most competent and experienced men on the Survey. "The examination included a general geologic study directed to the consideration of the relation between control of the forest lands and the protection of the streams rising on these watersheds, and an intensive hydrometric investigation directed to the consideration of the relation between land control and stream regulation." "The results of the former study are largely negative, . . . the hydrometric investigation . . . yielded what is believed to be indisputable evidence of an actual and measurable relation between forest cover and stream regulation." In a word it was demonstrated that deforestation accentuates the rapid melting of snow, the amount of run-off, floods and soil removal, while forestation operates in the opposite direction.

Through deforestation, the vegetation cover is reduced, the immediate run-off increased, and floods in the tributary streams cause soil removal and transfer to the larger streams, with flatter grades, where sedimentation occurs, obstructing transportation and interfering with power development.

In conclusion the main thesis of this paper is to direct attention to the importance of water conservation from an agricultural viewpoint in Iowa. The mean annual rainfall, about thirty-five inches, is adequate when properly distributed in time and space. There is no convincing evidence to show that agricultural operations or deforestation exert any measurable influence on the amount and distribution of rainfall. Hydrometric measurements made by the U. S. Geological Survey prove beyond any reasonable doubt the dependence of the run-off curve on the vegetative covering. Correct drainage installation puts the ground in condition to receive the rain as it falls, reduces run-off to a minimum and avoids drowning of growing crops; proper cultivation prevents the too rapid escape of soil moisture thus ensuring an adequate supply to bridge over periods of drouth. Through drainage and cultivation the intelligent farmer aids in bringing about the correct distribution of water in time and space. Forested areas, natural and artificial reservoirs, tend to equalize stream flow, and thereby reduce floods, and reduce water losses through evaporation. Lakes and ponds tend to modify temperature ranges, hold up the ground water level, and serve as reserve to be redistributed by the great cyclonic movements that obtain their chief supply from the ocean. This redistribution may not find expression in actual rain or snow, but in an increase in relative humidity, thereby reducing evaporation losses.

It is the opinion of the writer that a hydrometric survey would demonstrate the wisdom of preserving large tracts of land in their natural state. Such reserves might include many of our lake groups and broken lands in the north central Mississippi Valley. They would be worth while based on agricultural considerations only. Such reservations might serve incidentally as parks and play grounds but primarily as stabilizers of stream flow and water supply, conservers of the soil, and would aid the Mississippi Valley to maintain its position as the *Granary of the World.*

THE BIRDS OF MARSHALL COUNTY, IOWA, II[1]

IRA N. GABRIELSON

77. *Coccyzus americanus americanus.* Yellow billed Cuckoo. A common summer resident from May 9 to October 7. The yellow-bill seemed to be much more common than the black-bill. Nests were found May 30, 1914, two eggs; June 25, 1914, four eggs; August 3, 1914, two eggs; June 26, 1915, three fledged young. Of these the May 30 nest was in a bushy little elm which had been broken off and sprouts had grown out. This nest was about six inches from the ground and was later destroyed by high water. The nest of June 25, 1914, was on a broken over elm about twelve feet from the ground. The one found August 3, 1914, was in a willow tree about ten feet from the ground, and the one on June 26, 1915, was in a gooseberry bush about two feet from the ground.

78. *Coccyzus erythropthalmus.* Black-billed Cuckoo. The black-billed cuckoo was a less common summer resident than the yellow-bill. My earliest record is May 22 and the latest September 18. On June 2, 1914, a nest of this species containing four eggs was discovered by Harry Mann who guided me to the spot. It was built within two feet of the ground and was destroyed by a sudden freshet June 8.

79. *Ceryle alcyon.* Kingfisher. A common summer resident from March 28 to October 24. Fledgling young were a common sight in July or August. The writer watched a pair carrying food into a hole during the last week in June, 1914, but neglected to note the date. These nest holes were not uncommon along Iowa river.

80. *Dryobates villosus villosus.* Hairy Woodpecker. A tolerably common permanent resident most frequently recorded during the winter months. The writer has two nesting records. On June 5, 1915, a pair were watched carrying food into a hole high in an elm tree on Linn creek. The young birds could be heard calling almost continuously. On June 28, 1915, one of the boys at a boy scout camp cut down a willow and after the tree had fallen the discovery was made that it contained a brood of three nearly fledged Hairy Woodpeckers that were killed by the fall.

81. *Dryobates pubescens medianus.* Downy Woodpecker. The downy woodpecker was found to be a common permanent resident.

[1]Continued from volume XXV of these Proceedings.

In 1914 during the warm balmy days of early February, the downies commenced the flight evolutions so noticeable in mating season. Cold weather followed this warm spell and this behavior was not again noted until early April. The writer failed to note the nests found. Consequently the only breeding record found in his notebooks is a nest of four fully fledged young found in the Marshalltown cemetery June 2, 1915. The nestlings left the nest at about noon of June 3.

82. *Sphyrapicus varius varius.* Yellow-bellied Sapsucker. A common spring migrant between April 6 and May 22 and a tolerably common fall migrant from September 7 to October 15. These birds come back to the same trees year after year and make their peculiar square punctures for the sake of the sap. In the cemetery the various conifers seemed to be favorites and along the streets maple *(Acer)* was more often attacked than others.

83. *Melanerpes erythrocephalus.* Red-headed Woodpecker. An abundant summer resident and breeder from April 29 to October 4 and a rare and irregular winter resident. During the winter of 1913-1914 a little band of at least eight birds wintered in the cemetery at Marshalltown. (Wilson Bul., Vol XXVI, p. 104.) One or more of these were seen on every visit to this locality during the winter months. Eight, seen on March 17, 1914, was the greatest number found on one day until the migrants arrived May 1. In 1915, a single bird appeared in the same place on April 1 and remained there alone until April 29 when a large number of migrants arrived. This bird had probably wintered somewhere in the vicinity.

On May 31, 1913, the writer watched a pair at work on a nesting hole, and on June 7 found five eggs in this nest. They nested commonly along the streets of Marshalltown as well as in the woodland along the river. Several nests were seen in telephone poles. On June 24, 1914, two nests were found containing young, and the parents were observed to catch and carry crickets to them. On June 10, a nest was discovered in a stump about six feet high. This nest was located near the entrance to the Iowa Soldiers' home where hundreds of people daily passed within ten feet of it. The birds did not seem to mind them as they passed in and out to feed the young without hesitation.

These woodpeckers have very versatile feeding habits. It is no uncommon sight to see them in company with the grackles catching grasshoppers and other ground living insects. They also are expert at flycatching and often feed in this manner. I frequently saw them take cherries or mulberries to a roof or tree, lodge them in a crevice or crack and proceed to pick them to pieces. One was seen to catch a cicada on the wing one day, but this probably was an accident. On August 10, 1914, while beating a bunch of hazel bushes I disturbed a cicada which flew off buzzing loudly. It had not gone more than twenty or thirty feet when a red-head seized it and carried it off. The woodpecker was apparently just flying past, and the cicada unluckily flew in its path as the bird did not appreciably alter its course. The woodpecker certainly was not pursuing the insect as it was flying along in regular woodpecker fashion and not flying as the red-head does when fly-catching on the wing.

84. *Centurus carolinus.* Red-bellied Woodpecker. This species was not found during the summer months but appeared in small numbers from August 22 to May 23, being observed in greater numbers in April and November than any other months. It is possible that it bred rarely, but the writer never found it. One was taken April 4, 1913. One wintered in 1913-1914 in company with a band of red-headed woodpeckers. (See Wilson Bul., Vol. XXVI, p. 104.)

85. *Colaptes auratus luteus.* Flicker. The flicker was a permanent resident found in abundance March 8 to October 2 and in small numbers during the remainder of the year. Like the red-headed woodpecker they nested commonly along the streets of Marshalltown in trees or telephone poles. Nests with young were examined on June 24, 1914, and June 2, 1915. On July 3, 1915, several broods of young flickers were noted flying about the lawns, but still being fed by the regurgitative method.

86. *Antrostomus vociferus vociferus.* Whip-poor-will. A locally common summer resident from May 3 to September 10. Along Iowa river above Clay Bluffs and at Mormons Ridge they could be heard calling every evening in June and July. On June 27, 1915, Hartly Vogt found a nest containing two newly hatched young. This was below Marshalltown on Iowa river. Other nests were reported at Clay Bluffs.

87. *Chordeiles virginianus virginianus.* Night Hawk. A common summer resident from May 12 to September 26, nesting regularly on buildings in Marshalltown. On June 30, 1914, a nest containing two partly grown young was found on a building and a second nest was seen in the same sort of a situation on July 17, 1915. The young sat among the gravel stones on the roof and were hard to distinguish as long as they remained motionless.

In the fall flocks of considerable size are often seen sweeping back and forth over the country. On August 19, 1914, fifty-eight birds were counted in such a flock.

88. *Chætura pelagica.* Chimney Swift. An abundant summer resident from April 22 to October 1. The only nest seen was one found in June, 1914, in the chimney of a small cottage. It contained two young at the time of my visit.

89. *Archilochus colubris.* Ruby-throated Hummingbird. A tolerably common summer resident from May 7 to September 27. During September flocks of from four to six were frequently found in a small swamp north of the cemetery at Marshalltown. I never found the nest of this species in the county. On June 25, 1915, at Mormons Ridge a pair were found about a group of three or four oaks. Their behavior indicated that they had a nest in the vicinity, but it could not be found. On June 30 this pair was accompanied by a third,—evidently a young bird, as they flew about this grove.

90. *Tyrannus tyrannus.* Kingbird. An abundant summer resident from May 2 to September 1. The kingbird nests more often in the groves about farmyards than anywhere else. This is another common species whose nests the writer neglected to note in the majority of cases. One nest containing four eggs was found June 6, 1913, and on July 4, 1915, a pair were discovered building a nest. This nest contained three eggs when visited again on July 16.

91. *Myiarchus crinitus.* Crested Flycatcher. The crested flycatcher is a common migrant and tolerably common breeding species from May 3 to September 7. A pair regularly built among some giant cottonwoods in the Iowa river bottom but the nest was not examined owing to its height. On June 20, 1914, a nest containing eggs was pointed out to be me by a small boy. This nest was closely watched and the results of the study have been reported elsewhere.[2]

92. *Sayornis phœbe.* Phœbe. A common summer resident from March 28 to October 12. A pair of phœbes nested every year in a vault in the Marshalltown cemetery. This pair had a completed nest May 4, 1913, as did another pair nesting under a bridge. On April 9, 1914, this pair was back again and starting to carry building material into the vault. No note was made of the 1915 dates. A new nest was constructed each year and from the number of fragmentary nests found in this vault they had been breeding there for

[2]Gabrielson, Ira. N., The Home of the Great Crest: Wilson Bul., Vol. XXVI, No. 4, December, 1915.

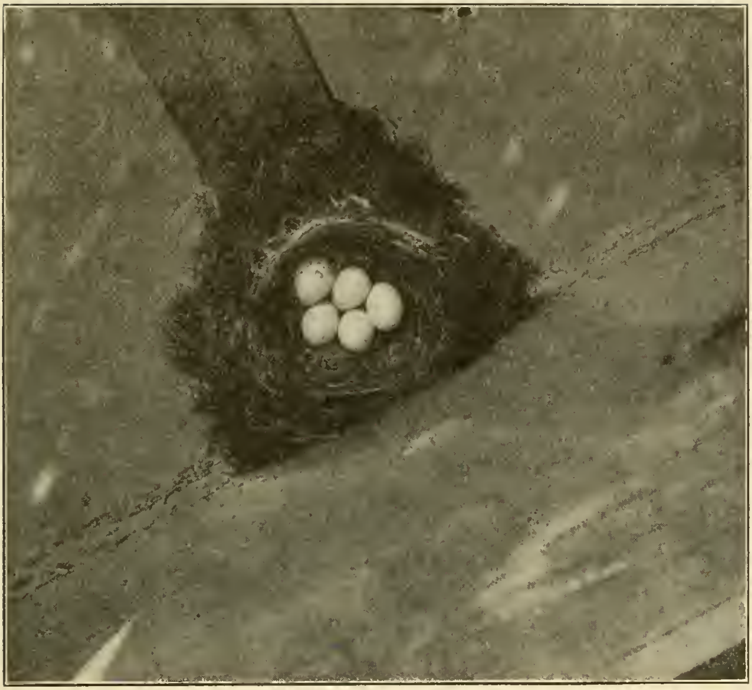


FIG. 1.—Nest and eggs of the Phoebe (*Sayornis phoebe*).

at least four or five years. On July 5, 1914, a nest was found containing five which hatched July 8. At least two broods were raised each season in this locality.

93. *Nuttallornis borealis.* Olive-sided Flycatcher. A rare spring migrant May 2 to May 22. It was not noted in the fall. My first record for the region was a female collected May 2, 1913. It was recorded on May 10, 12, 17 of that year, May 3, 1914, and May 22, 1915. Single birds were recorded on each of these dates except the last when two were seen.

94. *Myiochanes virens.* Wood Pewee. The wood pewee was a locally common summer resident wherever suitable conditions were found. Its earliest appearance was May 9 and the latest record is September 13. The plaintive whistle of this bird was regularly heard about the woodlands, but only one nest was discovered. This one, containing three eggs, was found at Mormons Ridge on June 30, 1915. It was saddled on a branch of an elm tree and was about fifteen feet from the ground.

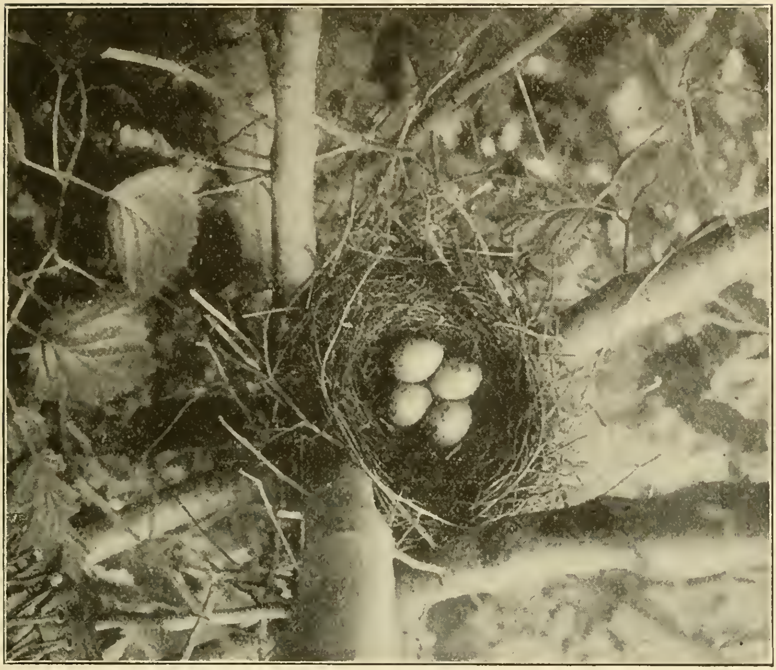
95. *Empidonax flaviventris.* Yellow-bellied Flycatcher. The small flycatchers of this group are all seemingly rather uncommon about Marshalltown. The yellow-bellied flycatcher was found only twice. On May 24, 1913, the writer collected two of this species. These birds were identified by Mr. H. C. Oberholser. On May 14, 1915, on the morning after a terrific hailstorm two more of these flycatchers were found among a number of birds picked up dead. Others were occasionally seen which might have been this species but none were positively identified.

96. *Empidonax trailli alnorum.* Alder Flycatcher. This species also appears to be uncommon. My first record is a specimen taken on September 12, 1913, and identified by Mr. H. C. Oberholser. Two more birds seen in the same spot on September 13 presumably were of this species as was another noted September 22, 1913. On May 22, 1915, one was taken and a number of others noted and on June 30 at Mormons Ridge a nest was found containing one egg. This nest was hung in some low bushes hanging over a little stream formed by a spring. The old bird was very tame and allowed us to approach within a few feet.

97. *Empidonax minimus.* Least Flycatcher. A common migrant from May 2 to June 2 and August 21 to September 20. Also an uncommon summer resident. A pair was seen about Mormons Ridge from June 25 to July 20, but no nest was found and no others were noted in the summer months.

98. *Otocoris alpestris praticola.* Prairie-horned Lark. The prairie-horned larks were common permanent residents. They were more in evidence in March than any other season of the year. They commence to sing freely about March 1 (earliest date Feb. 28, 1914) and are quite conspicuous in the fields and meadows for the next two weeks. A brood of fledglings in the spotted plumage was noted July 8, 1915. A nest evidently of this species was described to me by a schoolboy in April, 1915, but it had been destroyed at the time of my visit. My winter specimens were all identified as this subspecies by H. C. Oberholser.

99. *Cyanocitta cristata cristata.* Blue Jay. A very common permanent resident. They nest commonly in Marshalltown in the trees along the streets but are so quiet that they are not often discovered. One nest found May 30, 1913, contained four eggs. It was situated low down in a hawthorne tree and was the only nest actually inspected.



. FIG. 2.—Nest and eggs of the Blue Jay *(Cyanocitta cristata)*.

One pair of birds were seen industriously filling a large crack in a maple tree by wedging acorns in it. This particular piece of industry brought them no return as the fox squirrels discovered the store and promptly devoured it.

100. *Corvus brachyrhynchos brachyrhynchos*. Crow. Another abundant permanent resident. They nested commonly along the river but their nests were usually so high up as to be inaccessible. The writer frequently saw them carrying sticks in March. On March 22, 1913, three partly completed nests were found. A female was found incubating a set of four eggs on May 10, 1913. On May 12 three young were found. This nest was visited May 17, 24 and 30 and photographs were taken of the young on each visit. On the 30th they had left the nest. On the third visit (May 17) the nestlings were of a dirty color with great blue pin feathers partly covering the body. On May 24 they were completely feathered out and were gone by the 31st. The old birds were never seen or heard during the various visits to this nest after May 10 when one was flushed from the nest.

There was a great deal of complaint against the crow but few evidences of serious depredations came to my notice in this region. Corn fields or vegetable gardens lying along the timber are more or less subject to attack and two cases where serious loss was occasioned were investigated. Both were near the woodland along Iowa river. On August 5, 1914, they were found to be pecking open watermelons as fast as they ripened. There were certainly several hundred melons damaged, in this field. Scarecrows had no effect in preventing their visits.

On August 10, 1914, and on several subsequent dates the writer found a flock of several hundred crows frequenting a corn field of thirty acres. A careful count of the ears showed that about forty-five per cent of the ears had been more or less damaged.

An interesting performance by a flock of crows was witnessed on December 1, 1913. I was standing in a dense clump of willows when my attention was drawn to a huge flock of crows some distance away and high in the air. Instead of flying in straggling crow fashion they were in a compact and orderly group and while I was watching they went through curious evolutions cawing noisily all the time. These evolutions were unlike any I had ever seen in gathering at a roost or on any other occasion. The flock wheeled, split and circled in opposite directions and then united again. This maneuver was repeated several times intermingled with others. The entire performance lasted from five to ten minutes after which the flock broke up and the birds flew off in various directions.

101. *Dolichonyx oryzivorus.* Bobolink. During 1913 and 1914 the bobolink appeared only as a rare migrant being noted only on May 17 and 24 in 1913 and May 10 and September 7 in 1914. In 1915 the species appeared in some numbers and bred in the fields from which they had been absent the two previous years. In 1915 they were first seen on May 22 and the last date was September 5. Singing males were noted frequently, but only one nest was actually found. This was discovered on June 9, 1915, and contained five eggs.

102. *Molothrus ater ater.* Cowbird. The cowbird is an abundant summer resident from March 31 to November 4 except in the month of September for which month I have no records. A

male and female were taken April 25, 1913. The eggs of this parasite were found in the nests of the following species:

1. Red-winged Blackbird.
2. Larksparrow.
3. Field Sparrow.
4. Cardinal.
5. Dickcissel.
6. Scarlet Tanager.
7. Red-eyed Vireo.
8. Yellow Warbler.
9. Ovenbird.
10. Redstart.
11. Wood Thrush.

103. *Xanthocephalus xanthocephalus.* Yellow-headed Blackbird. Although the yellow head breeds abundantly in northern Iowa it was noted only once in Marshall county. This was on May 8, 1914, when a flock of four were seen along Iowa river. It was reported by several observers as having bred in former years in a small swamp near the Country Club.

104. *Agelaius phœniceus predatorius.* Red-winged Blackbird. An abundant migrant and common breeding species from March 14 to November 18. All my skins were examined by Mr. H. C. Oberholser who pronounced them *predatorius.*

One nest found May 24, 1913, and two on May 30, 1913, were built on or near the ground on bogs about the Goose ponds. One found on June 8, 1915, was built in a bunch of weeds on the Soldiers' Home grounds. Several discovered on June 30, 1915, were built in cattails in a small swamp. On July 14, 1915, one was found built in the clover in the center of a large clover field. All others discovered in this locality were built in the small willows that border Iowa river and other streams. These different locations are mentioned in order to show the adaptability of this species in this region where normal nesting sites are not plentiful. The earliest date on which eggs were found was May 24 and the latest July 14.

This species was the worst sufferer from the sudden flooding of the lowlands on June 8, 1914. Sixteen eggs of this species were picked out of one small mass of drift after the water went down and many nests lower down stream were known to have been flooded.

105. *Sturnella magna magna.* Meadowlark. Both the eastern and western meadowlarks were common about Marshalltown and the writer was never able to decide which was the more abundant. Both species were often singing at the same time and the contrast was striking. In behavior the two species are much the same. The Meadowlark was found commonly from March 14 to October 25. One was collected March 28, 1914.

Although all the meadowlark nests found happened to belong to the other species, there is no doubt that *magna* breeds. It was present and in song until well into July, and adults were frequently seen carrying a beakful of insects.

106. *Sturnella neglecta.* Western Meadowlark. A common summer resident from March 15 to November 1 and a rare winter resident. Two birds spent the winter of 1914-1915 about a straw stack on the farm of Mr. Henry Friese. These birds fed around the stack and in the barnyard and spent the night in holes in the stack. Two were seen on February 10 and 11 north of town by W. Robinson. A nest containing two eggs was found May 14, 1914. No more were laid and these two hatched May 21. On May 24, 1914, Harry Mann guided me to a nest containing seven eggs and I took some photographs of it. These eggs hatched sometime after May 24 and before June 8 as after the water receded from its high level after the freshet the seven young and an adult were found drowned in the nest. The water had come high enough to cover the nest with about four inches of water.

107. *Icterus spurius.* Orchard Oriole. A rare and local summer resident. Previous to 1915 a single bird noted on August 27, 1913, was the only record for the county. On June 15, 1915, a singing male was found in a small orchard. Two pairs of birds later nested in this orchard and built four nests, two of which never contained eggs. One containing two eggs was located June 21, 1915. On July 4 this nest contained three young which left the nest on July 7 although not yet able to fly. The second nest, containing five eggs, was found on July 10. All nests were swung between upright limbs of apple trees.

It is probable that other nesting pairs occur in similar places throughout the county, but they are very local and one misses them entirely unless he happens to visit the particular grove in which they nest.

108. *Icterus galbula.* Baltimore Oriole. The Baltimore oriole was an abundant summer resident from April 29 to September 7. The great elms found so commonly along the streets in Marshalltown were favorite nesting sites for these birds and scarcely a block of the trees could be found which did not contain one or more nesting pairs of this species. One partly completed nest was found May 10, 1913. It contained one egg on May 24 but was abandoned. On June 8, 1914, a nest containing several young was found low down in the cemetery and June 24, 1914, another containing four young was found within ten feet of the ground.

These were exceptional, however, as the nests were usually swung far out on the branches of the tallest trees.

109. *Euphagus carolinus.* Rusty Blackbird. The Rusty blackbirds were a common migrant from March 14 to May 11 and August 27 (?) to November 14. They usually associated with the immense flocks of red wings and grackles which roamed the country in fall and consequently their fall movements were difficult to detect.

110. *Quiscalus quiscula æneus.* Bronzed Grackle. An abundant summer resident from March 26 to November 8. In spring and fall migrations the grackles appeared in immense flocks often mingled with other species of blackbirds. They showed a marked preference for the groves about farm buildings and the writer never found them nesting in any other situation except for a few pairs found in the cemetery and on the lawns about town where conifers could be found. A nest containing four eggs was found on June 6, 1913. Twenty nests which were or had recently been occupied were found in one grove on May 31, 1915, and five occupied nests were seen in another grove on July 5, 1915. No detailed record was kept of others, but the birds were found nesting in practically every coniferous grove visited in this region.

As soon as the young are able to fly they commence to gather in flocks which roam the timber for a time and then begin to appear on the meadow lands. The first flocks of this kind were noted on July 5, 1914, and on June 22, in 1915.

111. *Hesperiphona vespertina vespertina.* Evening Grosbeak. This species is included on the statement of Leonard Kellogg who reported seeing one in the Marshalltown cemetery on December 23, 1916. His description of the apperance and behavior of the bird are clear and accurate and I have no hesitation in adding it to the list.

112. *Carpodacus purpureus purpureus.* Purple Finch. The purple finch was a tolerably common spring and fall migrant from April 13 to May 19 and October 17 to November 23. It also appears as an uncommon winter resident. An adult male was found lying dead on the ice of Linn creek on January 13, 1914, and brought to me. A flock of four were feeding in a clump of ironwood trees *(Ostrya virginicana)* and one was collected. Its crop contained twenty-six seeds of ironwood.

113. *Acanthis linaria linaria.* Redpoll. Although the writer searched every winter for the redpoll he failed to find it. In the fall of 1916 Leonard Kellogg wrote that he had found them at

Marshalltown. On February 20, 1917, two specimens were received in the flesh from Vern Evans. These birds were collected on February 11, 1917. On March 3, L. Kellogg again wrote concerning their numbers and enclosed a copy of his notes. These show that the birds were present in varying numbers from November 25, 1916, to March 3, 1917.

114. *Astragalinus tristis tristis.* Goldfinch. The goldfinch was a common permanent resident, being most abundant from March 30 to November 1. There were several small springs along the river which usually remained open through the winter and flocks of goldfinches regularly remained there through the cold months. The only nest found was in a small cottonwood tree planted between the sidewalk and street. The nest was about ten feet from the ground and was not examined. The female was incubating when it was discovered July 29, 1914. On September 18 and 19, 1913, four goldfinch fledglings barely out of the nest were seen. These birds still had the nestling down about the head and could not fly over a few yards.

115. *Spinus pinus.* Pine Siskin. The only record for this species was from May 8 to 23, 1914. From the 13th to the 18th they were present in thousands all along the river. This flight was reported in the Wilson Bulletin (Vol. XXVII, p. 288, March, 1915).

116. *Calcarius lapponicus lapponicus.* Lapland Longspur. The Lapland longspurs were recorded only twice, November 22, 1913, and December 5, 1914. They probably were regularly present in the open farming country but the writer was unable to make regular trips to favorable regions to look for them. On November 22 one was taken out of a huge flock. On December 5 only two were seen one of which was collected. This later bird was too badly damaged to make a skin.

117. *Pooectes gramineus gramineus.* Vesper Sparrow. A tolerably common resident from March 30 to October 16. I never found the nest of this species but include it among the breeding birds from observation of several broods of fledglings in July, 1915. The first of these was of a brood of four just from the nest on July 8. Several other broods of young were seen on the 13th and 15th.

118. *Passerculus sandwichensis savanna.* Savannah Sparrow. A tolerably common migrant from April 3 to May 22 and October 6 to 25. It was never found in any numbers except on October 6 and 17, 1913, when it was common.

119. *Ammodramus savannarum australis.* Grasshopper Sparrow. A common summer resident from April 24 to September 24. The weak insect-like trill of this species was one of the most common bird songs heard along the country roads. The only nest seen was one from which the parent was flushed on June 4, 1914. This nest was in a field of timothy and contained six eggs.

120. *Passerherbulus lecontei.* Leconte Sparrow. A single bird, taken on October 8, 1913, is the only record I have for the county. Of three sparrows flushed from a tiny clump of willows in a depression in an oat field, one was collected and proved to be of this species.

121. *Chondestes grammacus grammacus.* Lark Sparrow. A common summer resident from April 8 to October 8. The lark

FIG. 3.—Nest and eggs of the Lark Sparrow (*Chondester g. grammacus*). Nest contains also two Cowbird eggs.

sparrow was more in evidence in late April and early May than at any other season. Eugene McKibben found a nest and guided me to it on May 29, 1913. The nest contained four lark sparrow and two cowbird eggs. Another nest was pointed out to me on June 8, 1914. This nest had been discovered a few days previous to this and had been washed from its position by heavy rains.

122. *Zonotrichia querula*. Harris Sparrow. A common migrant from May 3 to May 17 and from October 3 to 27. One peculiarity in the migration of this species impressed me. At Sioux City on Missouri river it regularly appeared about the middle of March, while at Marshalltown I searched carefully for them each year and failed to find them until May when they appeared in numbers.

123. *Zonotrichia leucophrys leucophrys*. White-crowned Sparrow. A rare spring migrant from May 4 to May 15. Four seen on May 14, 1913, is the greatest number noted on any one day. Two were taken on May 10, 1913. I failed to find it in the fall. It was recorded May 10, 12, and 14 in 1913, and May 4, 13, 14, 15, 1914. Single birds were seen on all dates except those mentioned above. The records of May 13, 14 and 15 were probably of the same bird as a single individual was noted about a little spring for three successive mornings during a cold stormy period. It was not seen in 1915.

124. *Zonotrichia albicollis*. White-throated Sparrow. An abundant migrant from April 9 to May 23 and from September 21 to November 12. During both spring and fall migration the white throated sparrow was one of the most abundant species found among the migrating hosts of sparrows. Between April 20 and May 14 they were usually at their maximum numbers. October 1 to 20 was the corresponding period of abundance for the fall period.

125. *Spizella monticola monticola*. Tree Sparrow. An abundant winter visitor from September 27 to April 14. The months of October, November, March and April were the periods of greatest abundance as many migrated farther south to spend the winter.

126 *Spizella passerina passerina*. Chipping Sparrow. An abundant summer resident from April 7 to October 12. In April the chipping sparrow was one of the most abundant migrating birds, appearing in enormous numbers with some of the migration waves. June 6, 1913, a nest containing four eggs was found and also one containing two nearly fledged young. The first was built in a spirea bush on a lawn in Marshalltown and the second in one of the lower branches of a large white pine. June 17, 1915, a nest

containing two eggs was found in a small spruce in the Marshalltown cemetery.

127. *Spizella pallida.* Clay-colored Sparrow. The clay-colored sparrow was a tolerably common migrant from May 1 to 16. In the fall it was noted only once, September 22, 1913. It probably occurred regularly in the fall but was overlooked in the great flocks of migrating sparrows.

128. *Spizella pusilla pusilla.* Field Sparrow. An abundant summer resident from April 5 to October 18. The field sparrow nested commonly about bushy pastures and along the roadsides. Two nests found May 31, 1913, contained four eggs each; two

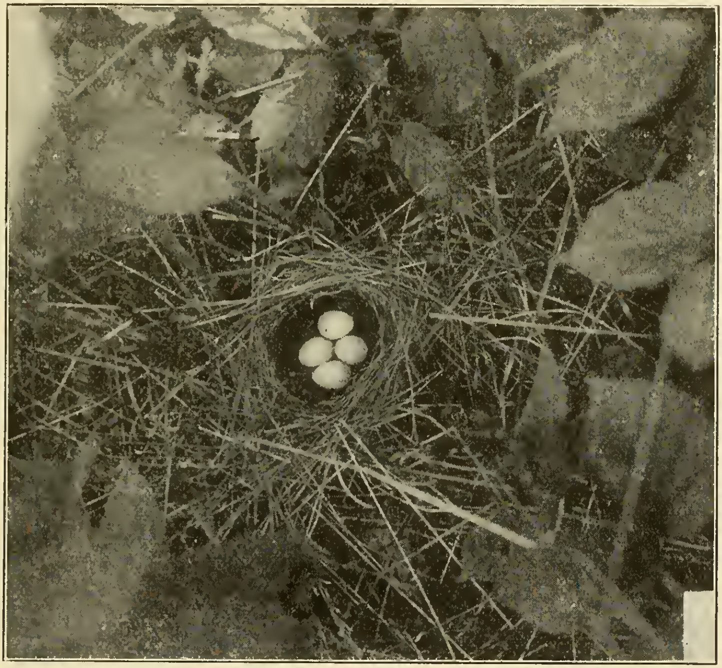


FIG. 4.—Field Sparrow (*Spizella p. pusilla*) nest in a hazelbush.

found in newly mown hay along the roadside June 25, 1914, each contained four eggs; a nest discovered May 7, 1915, contained two field sparrow eggs and two of the cowbird. One located June 28, 1915, had four eggs. All of these except the two cut down in the hay were built low down in hazel bushes. These two in the hay land had been built in weeds.

129. *Junco hyemalis hyemalis.* Junco. A common winter resident from September 22 to May 7. The periods of greatest abundance were October and early November during the fall migration and March and April in the spring. The great majority passed farther south to spend the winter but large flocks remained about the weed patches along the river. Next to the tree sparrow it was probably the most abundant winter bird.

130. *Melospiza melodia melodia.* Song Sparrow. An abundant summer resident from March 15 to November 12. No nests of this species were found in the county, and I neglected to record dates on which young birds were seen.

131. *Melospiza lincolni lincolni.* Lincoln's Sparrow. A tolerably common spring migrant from April 7 to 25 and a more abundant fall migrant, September 12 to October 18. This species was probably common at times but owing to the difficulty of picking it out among the great flocks of sparrows it often passed undetected.

132. *Melospiza georgiana.* Swamp Sparrow. A common migrant from April 4 to May 22 and September 12 to October 25. Sometimes appeared in large flocks, but usually it was inferior in numbers to song, field, fox, chipping and white-throated sparrows in the great migration flocks.

133. *Passerella iliaca iliaca.* Fox Sparrow. A common migrant from March 14 to April 15 and September 23 to October 30. In the spring the fox sparrow was usually abundant for only a few days. In 1913 and 1915 it did not arrive until April 1 and 2 respectively, and the last one seen was on April 13 in both seasons. In 1914 a few came on March 14 and small numbers were seen on every trip up to April 7, when they became common. The last one was noted on April 15.

134. *Pipilo erythrophthalmus erythrophthalmus.* Chewink. A common summer resident from April 4 to October 14. The chewink was never found in great numbers, but a pair or two were seen on nearly every trip. No nests were found but on the camping trip at Mormons Lake, adults were frequently seen followed by young birds.

135. *Cardinalis cardinalis cardinalis.* Cardinal. The cardinal was an increasingly common permanent resident. One nest was found May 24, 1913. This nest was built in a hawthorne tree in a dense thicket and contained one cardinal egg and two of the cowbird. Several pairs remained along the river and it was no uncommon thing to see from three to five birds in a day's tramp. A brood of fledglings begging for food was found August 22, 1914.

136. *Zamelodia ludoviciana.* Rose-breasted Grosbeak. An abundant summer resident from April 26 to September 27. From May 12 to 14, 1914, three grosbeaks were picked up dead on the streets of Marshalltown and brought to me and I found a fourth one. Examination indicated that they had been killed by striking something. This was the mating season and the males were furiously chasing each other through the tree tops. The telephone wires are placed along the streets beside the trees, often running between the branches, and it is probable that these wires were responsible for the destruction of these birds.

A completed nest was found May 14, 1915. The earliest date that I have for a nest with eggs was May 22, 1914 (one egg) and the latest was June 25, 1914, of a nest containing newly hatched young.

137. *Passerina cyanea.* Indigo Bunting. A common summer resident from May 3 to September 26. This species and the red-eyed vireo were the two conspicuous summer songsters of the region. Both sang persistently through the long hot summer days. A nest with two eggs was found by flushing the female from it on June 30, 1915, at Mormons Ridge. This nest was built in a tangle of vines and bushes along a fence.

138. *Spiza americana.* Dickcissel. A common summer resident from May 3 to August 21. A partly completed nest was found June 25, 1914, in a big thistle. On July 4 this nest contained four eggs and July 18 the young birds left the nest when I approached to examine it. A nest containing four young and a cowbird egg was found July 13, 1914, and one with three young on August 6, 1914. These nests were built in hazel bushes in open pasture.

139. *Piranga erythromelas.* Scarlet Tanager. An uncommon summer resident from May 3 to July 29. At times the scarlet tanager was quite common during May but was never found in numbers at any other time. A nest containing two eggs and one cowbird egg was found on June 26, 1915, at Mormons Ridge. It was a loosely woven structure of grass and roots and was about twelve feet from the ground in a small elm tree.

140. *Progne subis subis.* Purple Martin. An abundant summer resident from April 3 to September 7. They usually did not appear until about the middle of April and the bulk were gone by August 20. A large colony nested in the Court House tower and several smaller colonies were scattered about town in bird houses. No nests were actually opened and so no dates for egg laying can be given.

141. *Petrochelidon lunifrons lunifrons.* Cliff Swallow. A rare spring migrant but common in the fall. I have only two records in spring, May 11, 1914, and May 22, 1915, but from August 3 to September 20 they are quite numerous in the great swallow flocks found over the meadowland. A farmer living north of Marshalltown informed me that a colony nested on his barn in 1914 and came back in 1915, but their nests were destroyed "because they made such a mess." The remains of one nest were still on the barn at the time of my visit on July 20, 1915.

142. *Hirundo erythrogastra.* Barn Swallow. The barn swallow is a common summer resident from April 23 to September 28. Almost every farm had one or more pairs of this swallow nesting about the buildings. Usually the nests were plastered on beams or rafters high up in the big hay barns and were consequently inaccessible. One containing four young was inspected June 29, 1915, at Mormons Ridge. The barn swallow was one of the most numerous species in the great fall flocks.

143. *Iridoprocne bicolor.* Tree Swallow. A tolerably common migrant from April 3 to May 29 and July 5 to September 28. One of the less common species, being greatly exceeded in numbers by the barn and bank swallows, and slightly outnumbered by the rough-winged swallow.

144. *Riparia riparia.* Bank Swallow. A common summer resident from April 15 to September 28. Many banks along the river were honeycombed with the nesting holes of this species. No attempt was made to dig any of them out and so definite nesting data are not available. In the spring migration this was the most abundant species and in the fall it equalled the barn swallow in numbers.

145. *Stelgidopteryx serripennis.* Rough-winged Swallow. A common summer resident from April 23 to September 7. Ranked third in abundance among the swallows. Bred in the same situations as the bank swallow. A pair were noted feeding fledglings on July 10, 1915.

146. *Bombycilla cedrorum.* Cedar Waxwing. An irregular migrant sometimes appearing in great numbers. In 1913 they did not appear until May 10 and were then present in large flocks until June 7. In 1914 they appeared with the early robins, the first being noted on March 12. They were noted in small numbers until March 29. The only other spring record for 1914 was a flock of five seen on May 17. In 1915 a flock was noted on April 1 and the species was not again found until May 13, when a few appeared

and remained until May 23. The only summer records that I have are of a single bird August 10, 1914, and a pair July 27, 1915. Only scattered records were made during the fall as follows: September 18 and 19, 1913; September 17, 1914; October 8, 1913, and November 27, 1914.

147. *Lanius borealis.* Northern Shrike. The northern shrike was seen only twice, once March 29, 1913, and the second time March 30, 1914. Curiously enough both records were made in the same clump of dead trees. On the first occasion my attention was called to the bird by a rather pleasing but unfamiliar song. It is probably a more common visitor than my records show since I did not get out much in the winter into the open country.

148. *Lanius ludivicianus migrans.* Migrant Shrike. A tolerably common summer resident from April 5 to November 13. While never found in great numbers, the nest of this species was the most easily located of any breeding species. A solitary hawthorne found along a country road was almost certain to hold a nest. A nest containing five nearly fledged young was found May 29, 1913; a fully fledged family of four young was seen July 16, 1914; five nestlings were seen on May 23, 1915; a nest with three eggs found June 4, 1915, contained six eggs on June 8. One found June 21, 1915, contained five eggs and held five young on July 5 when visited. These nestlings were about five days old at this time.

149. *Vireosylva olivacea.* Red-eyed Vireo. Common summer resident from May 10 to September 22. The red-eyed vireo shared with the indigo bunting the honor of being the most persistent songster through the long hot summer days. Plenty of vireos' nests could be found after the leaves had fallen but the only occupied one ever discovered was one on Mormons Ridge June 29, 1915. When found the vireo was incubating three cowbird eggs. She subsequently left the nest and a close examination revealed the fact that it was a double nest which contained one cowbird egg in the bottom chamber. Thus four cowbird eggs had been laid in this vireo nest.

150. *Vireosylva philadelphica.* Philadelphia Vireo. A vireo shot for a warbling vireo on September 7, 1914, proved, when examined carefully, to be a Philadelphia vireo. This and another bird, September 18, 1914, are the only records I have for the county. Its close resemblance to the warbling vireo makes it difficult to determine its exact status in the region. It must, however, be credited as a rare migrant on the basis of the present data. This specimen secured on September 7 was identified by H. C. Oberholser.

151. *Vireosylva gilva gilva.* Warbling Vireo. A common summer resident from May 3 to September 18. It was found commonly about the town as well as in the timber. A complete nest was found June 28, 1915, at Mormons Ridge, but no eggs were found in it. All through June and July of 1914 two pair frequented a little patch of hazel and scrub oak, but the nests were never found, although the writer searched many times. In July one pair was seen feeding young in this patch so it is certain that they bred there.

152. *Lanivireo flavifrons.* Yellow-throated Vireo. An uncommon migrant from May 3 to May 22 and August 28 to September 22. It probably appeared more frequently than my notes show, especially in the fall.

153. *Lanivireo solitarius solitarius.* Blue-headed Vireo. A tolerably common migrant from April 29 to May 22 and August 20 to September 24. The blue-headed vireo was never abundant but was found regularly every season. Ten noted on September 18, 1914, was the greatest number ever found in one day.

154. *Vireo belli belli.* Bell's Vireo. The only definite record I have for this species is a single bird noted one morning on a busy street in Marshalltown. It was feeding in a small tree near the sidewalk and allowed me to approach within a few feet and watch it as long as I chose. Others were seen and heard which were supposed to be this species, but identification was not positive. This bird is most certainly more abundant than my records show.

155. *Mniotilta varia.* Black and White Warbler. The black and white warbler is a common migrant from April 29 to May 22 and from August 21 to September 18. It was most commonly noted in the spring migrations, probably because of the greater ease with which small birds can be detected at that season.

156. *Vermivora chrysoptera.* Golden-winged Warbler. The golden-winged warbler was a rare migrant both spring and fall. One was taken May 24, 1913, in a large patch of hawthorns. A second bird was seen on three successive days (May 11, 12 and 13, 1914) about a small spring in the Marshalltown cemetery (Wilson Bul., Vol. XXVI, p. 152, Sept., 1914). The third was a bird taken September 7, 1914.

157. *Vermivora rubricapilla rubricapilla.* Nashville Warbler. A common spring migrant from May 3 to May 17. In the fall it appeared only in 1913. Beginning September 20, a greater or less number could be found regularly in a little willow thicket back of the Marshalltown cemetery. They remained here until October 14.

158. *Vermivora celata celata.* Orange-crowned Warbler. A common spring migrant from May 1 to May 22 and uncommon in the fall, September 20, 1913, and September 26, 1914, being the only records I have. In the spring they were occasionally present in great numbers.

159. *Vermivora peregrina.* Tennessee Warbler. An abundant spring migrant from May 1 to May 24 but noted in the fall only on September 22, 1913, when it appeared to be common. In the spring the Tennessee warbler usually outnumbered all others except the myrtle. It appeared in great numbers with every migration wave in early May.

160. *Compsothlypis americana usneæ.* Parula Warbler. A rare migrant of which I have only three records in the county. One, taken May 4, 1914, out of a tall boxelder, was the first bird noted. A second was seen May 9, 1914, and a third September 18, 1914. The last two were noted in the same place, a dense growth of willow and other shrubs in a swampy little pasture.

161. *Dendroica tigrina.* Cape May Warbler. A rare migrant. The only record I have is of male and female seen feeding about a grape vine in the Marshalltown cemetery on June 2, 1915. They were very tame and were watched through the glasses for a long time at close range.

162. *Dendroica æstiva æstiva.* Yellow Warbler. The yellow warbler was an abundant summer resident from May 3 to September 26. It nested commonly in the bushes along the roadside and about homes in town and country. On June 7, 1913, a nest containing three eggs was found and one containing three eggs and a cowbird egg was seen on July 4, 1915. Between these dates many others were found containing eggs, or young.

163. *Dendroica coronata.* Myrtle Warbler. An abundant migrant from April 12 to May 15 and September 9 to October 24. The myrtle warbler was by far the most aboundant migrant in both spring and fall. In the spring they keep to the timber with the other warblers but in the fall they are found most abundantly in the cornfields or along the country roads in the hedges and bushes.

164. *Dendroica magnolia.* Magnolia Warbler. A common spring migrant from May 4 to May 29. In the fall it was found only twice, September 10, 1913, and September 12, 1914.

165. *Dendroica cerulea.* Cerulean Warbler. A very rare migrant. The only specimens seen were a pair found just back of the Marshalltown cemetery May 13, 1914. They were feeding high up in a boxelder tree. One was collected.

166. *Dendroica pennsylvanica.* Chestnut-sided Warbler. A tolerably common spring migrant from May 9 to May 24. It was not noted in the fall. The Marshalltown cemetery was a favorite resort for this species and I saw more there than in all other places combined.

167. *Dendroica castanea.* Bay-breasted Warbler. A rare spring migrant. It was noted on May 14 and 19, 1913, and May 18 and 21, 1914. A total of seven birds was noted on these four days. It was not recorded in the fall.

168. *Dendroica striata.* Black-polled Warbler. A common spring migrant from May 3 to May 25, most abundant from the 17th to the 25th. In the fall it was noted only twice, a single bird on August 23, 1913, and two on September 7, 1914.

169. *Dendroica fusca.* Blackburnian Warbler. The Blackburnian warbler was a tolerably common spring migrant from May 3 to May 22. It was not usually found in any numbers, three being the greatest number noted on any one date. A single bird taken on August 10, 1914, and another the following day are the only fall records.

170. *Dendroica virens.* Black-throated Green Warbler. A tolerably common spring migrant from May 4 to May 22. Only individual birds were noted on most dates, but on May 10, 1913, over fifty singing males were counted. In the fall it was recorded on September 19, 1913, and September 7, 1914.

171. *Dendroica palmarum palmarum.* Palm Warbler. A common spring migrant from April 28 to May 17. On May 3, 1914, and May 4, 1915, great numbers of this species were present along the river. It was not noted in the fall.

172. *Seiurus aurocapillus.* Oven-bird. An abundant migrant and common summer resident which first appeared May 3 and was last seen September 21. On May 28, 1914, Hartly Vogt found a nest containing two eggs and two cowbird eggs. Singing males were common during June and July, 1915, on Mormons Ridge.

173. *Seiurus noveboracensis notabilis.* Grinnell's Water-Thrush. A common migrant from May 2 to May 24 and August 22 to September 19. It occasionally appeared in large numbers along the river and smaller streams.

174. *Seiurus motacilla.* Louisiana Water-Thrush. A tolerably common spring migrant from May 3 to May 22. It was not noted in the fall. Its favorite haunts were the willow thickets back of the Marshalltown cemetery where a few could usually be found if anywhere in the country.

FIG. 5.—Nest of Oven-bird (*Sciurus aurocapillus*) containing Cowbird eggs.

175. *Oporornis philadelphia.* Mourning Warbler. A tolerably common spring migrant from May 11 to May 24. Occasionally it was common but more often one or two individuals were all that could be found on a single trip.

176. *Geothlypis trichas trichas.* Maryland Yellow-throat. An abundant summer resident whose earliest arrival date was May 3 and which was last seen October 14. Although it was very abundant in the breeding season the writer succeeded in finding only one nest. This one containing four eggs was discovered July 14, 1915, at Mormons Ridge. It was built in a densely matted field of red clover and was about twelve inches from the ground.

177. *Wilsonia pusilla pusilla.* Wilson's Warbler. A common migrant from May 4 to May 22 and August 22 to September 26. This species was present in abundance from May 17 to 21, 1913, and was common again on May 22, 1915. In the fall it was usually less in evidence.

178. *Wilsonia canadensis.* Canada Warbler. The Canada warbler was an uncommon spring migrant, being seen at that season on only four dates, May 21 and 23, 1913, and May 22 and 23, 1914.

In the fall it was a tolerably common migrant from August 21 to September 19. On August 22, 1914, a large number were seen feeding in a willow thicket.

179. *Setophaga ruticilla.* Redstart. An abundant migrant and locally common summer resident. Its earliest spring appearance was May 3, and the latest record was September 19. Usually this species ranked with the myrtle, yellow and Tennessee warblers in abundance during migration. A nest discovered June 26, 1915, at Mormons Ridge contained one egg. An egg was laid on June 27, and a third on June 28, after which the female commenced to incubate. A female was found incubating two cowbird eggs in another nest a short distance away. Both of these nests were built in hazel bushes about three feet from the ground.

180. *Dumetella carolinensis.* Catbird. An abundant summer resident from May 3 to September 26. It was no trouble to discover a catbird's nest as practically every gooseberry bush and plum thicket along the river contained one. They also built commonly in bushes and vines about the houses in Marshalltown. The earliest nesting date that I have is of a nest containing one egg May 22, 1914, and the latest a nest containing four eggs, July 14, 1915. A nest containing three nearly fledged young was noted August 3, 1914.

181. *Toxostoma rufum.* Brown Thrasher. An abundant summer resident from April 20 to September 29. Like the catbird this species nested so abundantly that it was not difficult to find their nests. Two nests found on May 22, 1913, were built on the ground. One was placed beneath a pile of drift material left by the river and the other was beside a small bush. Many small, exceedingly dense hawthorne trees or bushes, which were dwarfed by browsing animals, were scattered over the pasture lands along the river. Many of these, only a foot or two in height and consisting of masses of twigs and broken branches, were favorite nesting sites for the thrashers. A nest containing one egg, discovered on May 14, 1914, and one containing two eggs found on June 28, 1915, were the earliest and latest nesting dates.

182. *Troglodytes ædon parkmani.* Western House Wren. The house wren was an abundant summer resident from April 24 to October 8. It nested commonly about Marshalltown in boxes provided for it. At least two broods a year were raised. Three curious nest locations were noticed. One in the pocket of a hunting coat has already been described (Wilson Bul., p. 152, Vol. XXVI, Sept., 1914). On June 5, 1914, a nest was found built inside one of the

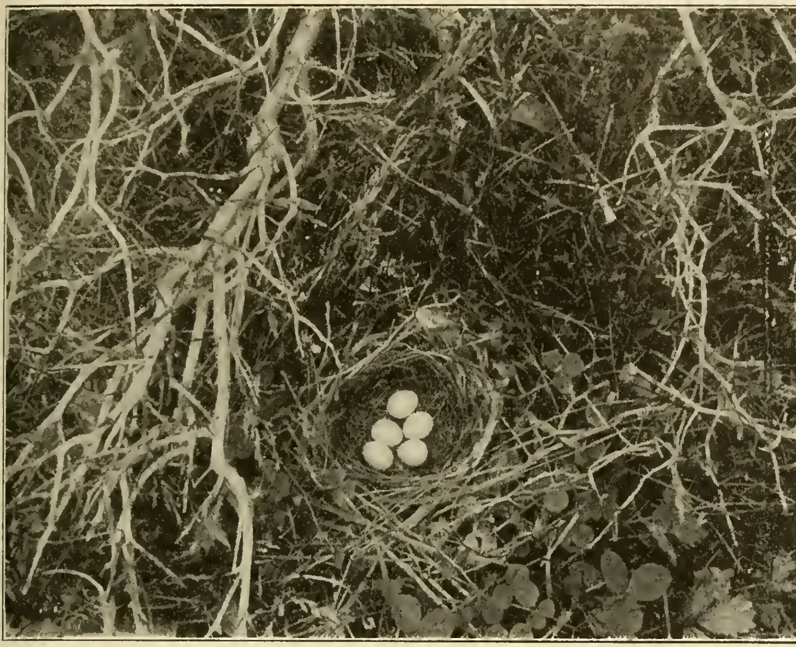


FIG. 6.—Nest of Brown Thrasher (*Toxostoma rufum*). Built on the ground beneath a pile of brush.

seat cushions of an old buggy. The birds had entered through a small opening in one corner of the cushion. Another nest found the same day was built in an old overshoe hanging on a porch in Marshalltown.

183. *Nannus hiemalis hiemalis.* Winter Wren. A tolerably common migrant from March 31 to April 21 and September 22 to October 23. Five birds noted April 17, 1914, was the greatest number seen on any date, one or two being the usual number.

184. *Cistothorus stellaris.* Short-billed Marsh Wren. A pair of short-billed marsh wrens were noted at close range May 22, 1915, and one was collected. These two birds are the only record for the county but it probably occurs regularly in small numbers as it breeds in several localities north of Marshall county.

185. *Telmatodytes palustris iliacus.* Prairie Marsh Wren. A tolerably common migrant from May 3 to May 23 and August 5 to October 18. It would probably nest if any suitable nesting sites were available. Possibly there are a few such places scattered through the western part of the county and the species may breed there. However, my records show it only as a migrant.

186. *Certhia familiaris americana.* Brown Creeper. A common winter resident from October 5 to April 30. It is most abundant in October and April.

187. *Sitta carolinensis carolinensis.* White-breasted Nuthatch. A common permanent resident. The writer never saw the nest but during his stay on Mormons Ridge, from June 28 to July 2, found young birds still showing nestling down to be very common. They had evidently been hatched nearby.

188. *Sitta canadensis.* Red-breasted Nuthatch. An uncommon migrant. I have the following records: March 31, 1913, one in the Soldiers' Home grounds; April 6, two birds seen on the Country Club grounds; May 1, 1913, a single bird at the Country Club; a single bird November 18, 1913, in the Marshalltown cemetery; and on April 12, 1914, two in the City park.

189. *Bæolophus bicolor.* Tufted Titmouse. This species seemed to be a rare permanent resident, at least the records are well scattered throughout the year. I have no evidence of its breeding. The records are as follows: April 5 and 12, 1913, a pair seen at the Country Club; January 25, 1914, two taken from a little clump of willows along the river (Wilson Bul., Vol. XXVI, p. 104); September 18, 1914, a single bird seen near the Goose ponds, and February 28, 1915, a pair in the Soldiers' Home grounds.

190. *Penthestes atricapillus atricapillus.* Chickadee. An abundant permanent resident. A pair was noted feeding young on May 30, 1914, and a brood of six young were found May 22, 1915.

191. *Regulus satrapa satrapa.* Golden-crowned Kinglet. The golden-crowned kinglet was an abundant spring migrant from April 6 to April 17. Each year they were abundant on one day and scarcely seen at any other time. April 6, 1913, the trees were full of them, but they were not seen on any other date; the same was true in 1915, the date of their appearance being April 8. In 1914 a single bird was seen on April 9, one on April 11, and two on April 12. The great flight came on April 17 after which they were not seen again. In the fall they appeared from September 22 to November 24 in 1913, but were not noted at all in 1914.

192. *Regulus calendula calendula.* Ruby-crowned Kinglet. An abundant migrant from April 3 to May 17 and September 9 to October 27. It was much more common than *R. satrapa* in both spring and fall migrations.

193. *Hylocichla mustelina.* Wood Thrush. A common summer resident from May 2 to October 2. One pair were watched building on May 19, 1914. The female was incubating on this nest on May

26. A nest with four eggs was found June 2, 1915, and one with two eggs and three cowbird eggs was seen June 8, 1915. A pair of wood thrushes were seen feeding a fledgling cowbird on June 27, 1914. A brood of three young were following a pair about in the cemetery June 30, 1914.

194. *Hylocichla fuscescens fuscescens.* Wilson Thrush. A common spring migrant from May 2 to May 17. In the fall it was less commonly noted, September 9 and 10, 1913, and September 5 and 7, 1914, being the only dates on which it was seen.

195. *Hylocichla aliciæ aliciæ.* Grey-cheeked Thrush. Migrant from May 3 to May 22. It is impossible to say how common it was as it appeared at the same time as the olive-backed thrush and it was impossible to distinguish the great majority of individuals seen. It was not noted in the fall.

196. *Hylocichla ustulata swainsoni.* Olive backed Thrush. Migrant from May 3 to May 24 and from September 5 to September 29. The remarks under the gray-cheeked thrush apply to this species also.

197. *Hylocichla guttata pallasi.* Hermit Thrush. A common migrant from April 9 to April 29. In the fall it was noted only twice, October 14, 1913, and October 24, 1914. A bird brought to me by Hartley Vogt on April 15, 1913, was picked up dead.

198. *Planesticus migratorius migratorius.* Robin. An abundant summer resident from March 9 to November 12. It is also reported as a rare winter resident. A flock of thirteen was reported on December 4, 1913. On February 15, 1915, two birds were reported and I saw one on February 16. These birds apparently came north with the bluebirds and pintails which appeared immediately on the breaking up of the ice. A pair were noted carrying nesting material on April 18, 1913. The writer failed to record many data on the nesting period of this species as most of the nests were built high up in the trees along the streets and in the parks. On one occasion five occupied nests were counted in one block in Marshalltown. Nests with eggs were found on May 30 and June 5, 1915, and one nest containing young was examined June 9, 1915.

199. *Sialia sialis sialis.* Bluebird. A common summer resident from February 14 to November 1. The bluebirds came on February 14, 1915, following a thaw and freshet which took the ice out of the river. Cold weather again set in but these birds remained about feeding on sumac *(Rhus glabra)* berries. No more arrived, however, until March 19. The first birds appeared on March 8, 1913, and March 4, 1914. Bluebirds had partly completed nests

April 27, 1913. Two nests with eggs were found on May 8, 1913. A nest containing four newly-hatched young was seen on May 12, 1913, also a nest with four eggs on June 24, 1914, and a nest with two young and two eggs on June 28, 1915. Birds were seen carrying nesting material as early as March 29, 1913.

INTRODUCED SPECIES

200. *Phaisianus torquatus.* Ring-necked Pheasant. A number have been released at various times at Mormons Ridge on the State game preserve located there. A few were seen in June and July, 1915, while the writer was camping on the ridge.

201. *Passer domesticus.* English Sparrow. An abundant permanent resident. There were one or two albinos living about the streets in Marshalltown. At least one of them mated with a normal bird and reared a family all the members of which seemed to be normal.

On the morning of September 5, 1914, after a terrific hailstorm 155 dead English sparrows were reported to have been picked up under a tree where a large flock roosted. Their nests were built indiscriminately in the trees and vines or in crevices and crannies about buildings and bridges.

HYPOTHETICAL LIST

1. *Colymbus auritus.* Horned Grebe. On August 22, 1913, at Goose ponds, the writer shot what was probably an immature bird of this species. Circumstances prevented either the saving or the identifying of the bird before it spoiled.

2. *Larus franklini.* Franklin's Gull. A farmer told the writer of seeing a flock of small black-headed gulls over the Goose ponds in the spring of 1914. They were probably of this species.

3. *Mergus serrator.* Red-breasted Merganser. One of the high school boys described a "duck" which he saw on the open water below the Marshalltown mill on February 8, 1915. The writer accompanied him to the place but the bird was gone. From his description it was undoubtedly a merganser and probably of this species.

4. *Archibuteo lagophus sancti-johannis.* Rough-legged Hawk. On February 7, 1914, the writer saw a large hawk which he took to be this species, but did not get close enough to make the identity sure. It undoubtedly occurs in severe winters.

5. *Polioptila cærulea cærulea.* Blue-gray Gnatcatcher. On May 3, 1914, a bird which almost certainly was of this species was

seen at the cemetery. However, it kept to the top of the highest trees and it is thought best to place the species in the Hypothetical List for the present.

U. S. Department of Agriculture.

THE RESISTANCE OF STREPTOCOCCI TO GERMICIDAL AGENTS

HENRY ALBERT

During the past year and a half, streptococci have assumed an unusual role as causes of disease. They have been the cause of most of the serious infections of war wounds. They were almost entirely responsible for the severe epidemics of pneumonia and empyema which occurred in many places, especially military camps during the winter of 1917-18, and together with the pneumococcus were apparently the cause of most of the fatalities during the recent epidemic of influenza.

This unusual prominence of the streptococci was gained in part by wide distribution of virulent forms and probably also in part, by an increase in the virulence of the organism.

It is therefore a matter of great importance to determine if it is possible to destroy these chained cocci as they occur both in the normal body and in connection with the lesions of disease, without at the same time causing any great injury to the living tissue.

To date but few tests of this kind have been made. This is due to the fact that streptococci are difficult to cultivate and require special, not easily prepared media, for their recognition in plates. The more important contributions to this subject to date have been made by Lingelsheim[1] and by Post and Nicoll[2].

The purpose of the research here reported was to determine the germicidal effects of various chemical agents on streptococci with the hope of finding the most effective germicides in the presence of albuminous fluids such as are represented by the various fluids of the body.

TECHNIC

1. Exactly 5 c. c. of each of a number of dilutions of the germicide are measured into as many tubes. The same pipet may be used for the whole series by beginning with the lowest dilution. Tubes should be marked and placed in regular order in the racks.

2. With a sterile pipet, from 0.1 to 0.5 c. c. (to be varied as may be necessary) of a twenty-four-hour broth culture of the organism is added to each of the above test tubes at intervals of

ten minutes. Nutrient bouillon is used, being made with Liebig's beef extract and Witte's peptone in the usual manner and giving a reaction of exactly 1.0.

3. One-fourth minute after the "germicide" tube has had the culture added, a subculture is made from each tube in the series of dilutions by transplanting one loopful to a tube of 10 c. c. sterile broth. (The loops used were of No. 23 U. S. standard gage platinum wire, each loop being 4 mm. in diameter.)

4. Immediately after the broth tube, inoculated with a loopful of the culture treated with the germicide, has been made, 1 c. c. of this broth culture is plated with 10 c. c. of blood agar. It is mixed in a test tube before being poured into the Petri dish.

5. At 1-2, 1, 2, 5, 10, 30 and 60 minute intervals cultures are made in the same way as in Direction 3.

6. The cultures should be incubated at 37°C. for twenty-four to seventy-two hours. "Record" growths usually develop in forty-eight hours.

CONTROLS

1. From 0.1 c. c. to 0.5 c. c. (as used in the foregoing) of the same twenty-four-hour broth culture of the micro-organism used in the experiment should be placed in exactly 5 c. c. of plain broth.

2. One "standard" loopful of the foregoing diluted culture should be transferred to a 10 c. c. broth tube. This will be the "broth control."

3. One c. c. of the "broth control" should be transferred to a 10 c. c. tube of blood agar. The agar tube should be poured into a Petri dish. This will be the "agar control."

4. The cultures should be incubated at 37°C. for twenty-four to seventy-two hours. Record growths after the same period of incubation as used for the experiment.

As a rule, aqueous solutions of the germicide were used. To test the effect of the germicide on the micro-organism in the presence of albuminous material, we also used blood, serum water and dilute serum water. The blood used was defibrinated sheep blood. The serum water was prepared by mixing one part of beef blood serum with three parts of distilled water and sterilizing the mixture on three successive days in the Arnold steam sterilizer. Dilute serum water was prepared in the same way, except that one part of blood serum was used to ten parts of water.

Blood agar was prepared by the addition of 10 per cent of defibrinated sheep blood to plain agar and by the process of adjusting the temperature to 0.5 reaction, with phenolphthalein as the indicator. From 10 to 15 c. c. of the blood agar were poured into each Petri dish.

FINDINGS

The results of our experiments have been placed in Tables 1 and 2. Table 1 shows the effects of various germicides in reducing the number of streptococci or entirely destroying them after periods of exposure varying from one-fourth minute to one hour. Table 2 indicates the shortest time in which all streptococci of a given culture were killed by various germicides as well as a list of those germicides which failed to kill all the streptococci at the end of one hour.

The letters "h" and "v" in the column under "Types of Streptococci" refer to "hemolyticus" and "viridans" respectively. The plus and minus signs in the column under "G" refer to the presence or absence of growth in the broth tubes. The figures in the column under "No." refer to the number of bacteria living in a given volume (as explained in the discussion of the technic), after the disinfectant had been permitted to act for a given length of time, as represented in Table 1. The number of bacteria was determined by the number of colonies that developed on the blood-agar plates. In order that the figures may be made comparable, they have been reduced to a basis of a control of 1,000 colonies.

TABLE NO. 1 SHOWS THE EFFECTS OF VARIOUS GERMICIDES IN REDUCING THE NUMBER OF STREPTOCOCCI OR ENTIRELY DESTROYING THEM AFTER PERIODS OF EXPOSURE VARYING FROM ONE-FOURTH MINUTE TO ONE HOUR.

Reagent	Dilution	Type of Strepto-coccus	G	¼ No.	G	½ No.	G	1 No.	G	2 No.	G	5 No.	G	10 No.	G	30 No.	G	60 No.
Alcohol	50%	v	+	5	+	0	+	0	+	2	+	2	—	0	—	0		
Alcohol	25%	v	+	260	....	......	....	......	....	......	....	......	....	......	+	45	—	7
Alcohol	50%	h	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0
Alcohol	75%	v	+	2	+	10	+	2	—	0	—	0	—	0				
Alcohol	95%	h	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0
Boric acid	4%	v	+	840	...	......	....	......	....	......	....	......	....	......	+	400	+	115
Phenol	5%	v	....	......	...	......	+	80	+	87	+	87	+	15	—	0	—	0
Chloramin-T	0.2%	h	+	400	+	200	—	0	—	0	—	0	—	0	—	0	—	0
Chloramin-T	0.1%	h	+	700	+	500	+	300	—	0	—	0	—	0	—	0	—	0
Chloramin-T	0.05%	h	+	900	....	......	+	700	....	......	+	200	+	100	—	0	—	0
Chloramin-T	0.2% in serum water	h	+	1,000	+	650	+	350	+	95	—	0	—	0	—	0	—	0
Chloramin-T	0.2% in blood	v	+	950	+	950	+	600	+	900	+	900	+	950	+	900	+	950
Chloramin-T	1% in serum water	h	+	380	+	40	—	0	—	0	....	0	....	0	....	0		
Chloramin-T	0.5% in serum water	h	+	390	+	200	+	300	....	......	+	130						
Dakin's solution	100%	v	—	3	....	......	....	......	....	......	....	......	....	......	—	6	—	6
Dichloramin-T	0.5%, 1%, 2%	h	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0
Ethylhydrocuprein hydrochlorid	1:500	v	....	......	....	......	+	200	....	......	....	......	....	......	+	200	+	500
Glycerin	10%	v	+	89	....	......	....	......	....	......	....	......	....	......	+	62	+	89
Hydrogen peroxid solution	1%	v	....	......	....	......	+	810	+	370	+	860	+	430	—	20		

Iodine	1:2,000	h	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0
Iodine	1:1,000 in diluted serum water	h	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0
Iodine	1:10,000 in diluted serum water	h	+	721	+	735	+	714	+	1,078	+	1,330	....	......	+	749	+	1,050
Menthol	1:1,000	v	....	......	....	......	+	880	....	......	....	......	....	......	+	600	+	140
Mercuric chlorid	1:1,500	v	....	......	....	......	+	620	+	150	....	......	—	0	—	0	—	0
Mercuric chlorid	1:65,000	v	....	......	....	......	+	910	+	840	+	840	—	385	—	7	—	7
Quinin sulphate	1:350	v	....	......	....	......	+	405	....	......	....	......	....	......	—	18	—	27
Sodium benzoate	......	......	....	......	....	......	+	840	....	......	....	......	....	......	+	800	+	392
Sulphuric acid	1:150	v	....	......	....	......	—	37	—	37	—	0	—	40	—	12	—	12
Thymol	1:750	h	—	0	—	0	—	0	—	0	—	0	—	0	—	0	—	0
Thymol	1:1,000	h	+	25	+	8	—	0	—	0	—	0	—	0	—	0	—	0
Thymol	1:1,000	v	+	540	+	290	+	110	+	161	+	23	+	2	+	2	+	0
Thymol	1:2,000	h	+	225	+	100	—	0	—	25	—	0	—	0	—	0	—	0
Thymol	1:750 in serum water	h	+	100	....	......	—	14	—	6	—	0	—	0	—	0	—	0
Thymol	1:750 in blood	h	+	210	+	260	+	250	....	......	+	260	+	210	+	200		

h=Streptococcus hemolyticus
v=Streptococcus viridans
+=Growth (bacteria not all killed).
—=No growth (bacteria all killed).
Figures represent number of bacteria of a total of 1,000 not killed as indicated by number of colonies which developed.

TABLE NO. 2 INDICATES THE SHORTEST TIME IN WHICH ALL STREPTOCOCCI OF A GIVEN CULTURE WERE KILLED BY VARIOUS GERMICIDES AS WELL AS A LIST OF THOSE GERMICIDES WHICH FAILED TO KILL ALL THE STREPTOCOCCI AT THE END OF ONE HOUR.

Reagents	Dilution (in water) unless otherwise specified	Type of strepto-coccus	Shortest time tried in min. in which all strep-trococci were killed	Streptococci not all killed in 1 hour
Alcohol	50%	h	one-fourth min.	+
Alcohol	50%	v	ten min.	
Boric acid	1–25	v		+ numerous
Carbolic acid	1–200	v	thirty min.	
Chloramin–T	0.2%	h	one min.	
Chloramin–T	0.1%	h	two min.	
Chloramin–T	0.2% in serum water	h	five min.	
Chloramin–T	0.2% in blood	h		+ numerous
Dakin's solution	100% and all sol. below	v		+ few
Dichloramin–T	0.5%	v and h	one-fourth min.	
Ethylhydrocuprein hydrochlorid	1–500	v		+numerous
Iodine (Tr.)	1–2000 in water	h	one-fourth min.	
Iodine (Tr.)	1–2000 in dilute serum water	h	one-fourth min.	
Mercuric bichloride	1–1500	v	ten min.	
Quinine sulphate	1–350	v		+ few
Sulphuric acid	1–150			+ few
Thymol	1–750	h	one-fourth min.	
Thymol	1–750 in serum water	h	five min.	
Thymol	1–750 in blood	h		+ numerous

SUMMARY AND CONCLUSIONS

1. Streptococci are probably the most important disease-producing bacteria.
2. The frequency with which streptococci are found in the mouth, throat and in connection with wounds, enables them to be acted on quite directly by germicidal agents.
3. As yet very little work has been done in testing the effect of germicides on streptococci.
4. The most efficacious of the germicides tested are as follows: alcohol, 50 or more per cent; chloramin-T; dichloramin-T; iodin; mercuric chlorid and thymol.
5. Certain commonly employed germicides as boric acid and

hydrogen peroxid solution were found to be of very little value.

6. Iodine is very effective even in a high dilution and in the presence of a moderate amount of albuminous material. In a solution of 1:2,000, it destroyed all streptococci suspended in water and in a solution of 1:1,000, all of them suspended in an albuminous solution within one-fourth minute. It would seem that it would be advisable to use very much more dilute solutions of iodine than are ordinarily employed, especially since the more concentrated solutions are both irritating and destructive of tissue cells.
7. The presence of albuminous fluid very markedly reduces the germicidal effect of a number of agents, of which chloramin-T and thymol may be mentioned as examples.
8. There does not seem to be a "specific" germicide for streptococci.

Acknowledgement is here made to the effect that most of the technical work of this piece of research was done by Miss Margaret Taylor.

It is planned to continue this investigation with the hope of finding one or more germicides which will destroy streptococci without having any or at least only relatively slight harmful effects on the tissue cells.

Bacteriological Laboratory,
The State University.

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THE CORRELATION OF ART AND SCIENCE IN THE MUSEUM

HOMER R. DILL

What is it that makes the museum a success? I believe this question may be satisfactorily answered by a careful study of the people who visit museums. Go to some good museum and stroll quietly about among the groups of spectators and listen to their remarks; note carefully the types of exhibits that attract their attention, occasion their comment, and hold their interest. If you are interested and wish to follow up your investigation, go again and as often as you are able. You may thereby get some suggestions for building a museum for the public that never would occur to you otherwise. If you are connected with a museum and have been rash enough to make exhibits of your own it is possible that your pet ideas may receive a distinct shock from the frank criticism of some innocent spectator. Nevertheless, heed well what you may hear, for it is the impression that an exhibit makes on the spectator that counts. No matter how well a group is executed, if it does not tell this spectator the story it was designed to tell, it is a failure.

I remember well my visit to a certain museum where there is an anthropological exhibit. In one of the groups an Indian is represented drilling ivory, using his bow and a piece of metal for the purpose, while close at hand his squaw is engaged in tanning a skin. The group was interesting, and, to my mind, there was no question as to what the Indians were doing. As I was about to leave the exhibit, however, a young lady stopped directly behind me and remarked, "Oh, see the Indian fiddling while his wife is getting supper." After that remark it was obvious that the impression made by the group was misleading. One of the museum attendants informed me later that he had heard people say the same thing a number of times and this despite the fact that the group was well labeled. Labels, we must remember, are only secondary, and are seldom read unless the spectator's interest has first been engaged by the exhibit.

True it is that the public will ask foolish questions and make absurd remarks. All of these, however, should be duly considered.

The exhibitor must keep in mind the fact that his work is to be seen through the eyes of the public and that many things clear to his mind, or to the minds of others in the same work, may not be at all clear to those whom he would instruct by means of his exhibits.

Art students often visit our museum for the purpose of drawing and designing from the mounted specimens. One young lady, a college senior, asked me how we managed to kill the mammals and birds in just the positions in which we wanted them for our exhibits. On another occasion we had placed a miniature model of a bison group in the large case that was to be used for the group itself when finished, stating the facts plainly on a label. During the few days that the model was on exhibition a number of people remarked that they did not see why we used such a large case for such a tiny model.

If it is your fortune to have a competitor, listen to his criticisms, even though they be bitter, for he will seek out every fault and point out much that would be overlooked by a more kindly critic. In short, let us have that sense of the value of criticism which prompts the successful moving-picture actor to drop into some theater to see himself on the screen and hear what people have to say about him.

During a visit to the Panama Pacific Exposition in San Francisco, I had an experience which verified a thing that for many years I have believed to be one of the most important features in exhibit work. The first day of my visit found me in the Agricultural Hall standing before an elk group mounted by Mr. James Clark. As I was admiring the work I noticed a dignified old gentleman, of the Oliver Wendell Holmes type, standing nearby. He remarked that it was a fine piece of work. Two days later I was again in the same hall and almost unconsciously I worked my way around to the elk group when to my surprise I found my friend of the previous visit. Smiling he said, "I have interests that bring me to this building, and while I am here I often drop over to admire these animals. Although I know nothing about taxidermy, I do love a work of art whether it is in the form of a picture, statuary, or mounted specimen." On the last day of my visit I once more passed through the Hall of Agriculture, and there, by the elk group, among other spectators, was the old gentleman. I stopped to speak with him, and we agreed that it was the art in the group that made it worth seeing many times.

The same spirit was apparent, on a broader scale, among the great crowds of people who came to the exposition to see the sights. The Joy Zone did not attract the largest number of people, nor were the state exhibits in the buildings overcrowded. It was the esthetic, the beautiful, the artistic, that caught and held the masses. They strolled about the courts admiring the architecture, the beautiful flowers, the colors, and the good music. Twenty, or even fifteen years ago such conditions may not have existed, but I believe that the average intelligent person who visited the great exhibit will say that, aside from any special thing in which he may have been interested, it was the whole exhibit in its artistic aspect that made the most favorable impression.

It is true that we cannot divide the public into those classes which do, and those which do not, appreciate art. Among the educated people we often find individuals who are entirely lacking in this respect. This is particularly true of individuals who have specialized along scientific lines. On the other hand, we occasionally find, in the most common families, individuals who are artistic and who, in so far as their opportunities admit, are appreciative of art.

The following experience convinces me that even the savage may have latent in him some real esthetic instinct. At one time it was my good fortune to know an old Indian guide named Pete. One day I received a letter from a friend, asking me to see if I could engage Pete as a guide for a hunting party, and with him make a canoe trip of fifty miles and join the company. It was on this occasion that I really got acquainted with Pete. The first day was quite uneventful. Pete seldom talked. I remember my pleasure in watching the graceful, rhythmic play of the guide's muscles as our canoe glided along, the silence broken only by the regular "put-put" of our paddle blades as they cut the water. About sun-down we made camp at a sharp bend in the stream, a site which afforded an unusual view of nearly a mile of mirror-like water, bordered on either side by the rich reds and yellows of a Canadian autumn. As I sat by the camp-fire watching a flock of loons swim past, leaving a tiny ripple that soon melted from sight, and enjoying the beautiful picture, I happened to glance at Pete. He was sitting on the end of a log smoking, and apparently vacantly gazing out over the same scene. "What you see, Pete?" I asked. "Me like to see um nice woods, nice water, all same me like to chase um deer, shoot um deer, eat um deer," was his reply. I understood. Pete loved the esthetic, as well as the hunt that meant a day's sport and a good square meal.

The next day we came to a carry, where Pete informed me that by taking the canoe and our baggage on our shoulders and making an overland trip of a mile, we could save many miles of paddling. So we proceeded through the crisp morning air and at noon we stopped in a hard-wood grove to eat our lunch. The stillness in this grove was oppressive. There was not a sound, until all at once from some distant thicket there came to our ears the clear flute-like notes of a hermit thrush. Pete heard it and a soft smile spread over his wrinkled, copper-colored face as he remarked, "Um bird, he hain't got no cold."

What had been this man's experience that had caused the veil to be lifted, even though slightly, so that this glint of light shone through. It is true that he or his ancestors knew nothing of books. Could it be that the art that is in nature had accomplished this?

Since the successful introduction of the habitat groups into some of the larger museums, there has sprung up all over the country, a desire to have something of the kind in the smaller museums as well; and the work has been undertaken oftentimes without the slightest knowledge of how such work should be done, and in violation of all the laws of art and science. The result is that some of the most hideous productions have been placed on exhibition. There may be some excuse for a poorly mounted specimen in a serial collection, but there is no excuse for attempting to make habitat groups without some special knowledge of the work. No scientist can do the work without a supplementary knowledge of art; nor can an artist do any thing worth while without scientific training in the technique of such work and a real knowledge of the subject to be handled. Beautiful pictures painted from fancy have no more value in a museum than have inartistic groups. Such exhibits ought not to be tolerated for many reasons. They have no educational value; they fill up space that might be used for something worth while; they often waste rare specimens which cannot be replaced, and which on account of improper treatment eventually go to pieces.

No intelligent person questions the importance of having a museum on a scientific basis. The information propagated by a museum should be absolutely dependable. Every setting for a group should tell a true story. A museum, however, can be strictly scientific, and yet fail utterly in its mission. The dreary, monotonous exhibits of the old-fashioned institutions have demonstrated this. The few people who went to the collections were fatigued by their visits. It is true that a part of the weariness caused by these old exhibits was physical, owing to the poor arrangement of the specimens which made it necessary for the spectator to get into many unnatural positions in order to see the objects and read the labels. I believe, however, that the major part of the fatigue and discomfort came from a mental rather than a physical strain.

A friend of mine who is a hunter and naturalist, once asked me to go with him through one of the older museums in the East. We met by appointment and spent the entire day looking over the various collections. When night came my friend asked to be excused from an engagement for that evening saying that he believed he would go to bed as he was completely exhausted. Now this same friend on a previous occasion tramped miles with me in the woods, climbed trees for birds' eggs, crawled hundreds of yards flat on his stomach after young ducks, and yet when night came was not seriously fatigued.

In these days when all wild life is rapidly disappearing, when the specimens that we are placing in our exhibits may be the last of their kind to be secured, there is brought home to all of us the importance of permanently preserving them, of being sure that we have taken every precaution for their safety. In these days of experiment and investigation, I believe there is no excuse for a museum man who does not keep up with the times, and permanently and artistically preserve for future generations some of the phenomena of nature that will soon be gone forever.

In early days all kinds of museum material could be collected with little difficulty. Grease-burned skins, museum metal-disease, and other things that now try the soul of a curator were, if not unheard of, at least not generally known. Today the matter of permanently preserving museum material is one of the most serious things that confronts us. Any of the people who lived in the Middle West fifty years ago, can remember the great flocks of passenger pigeons. We have records to show that they were sold in the market for one cent each, and yet today it is impossible to find a perfect skin. How many pigeon skins could a man get if he were to make a standing offer of $50 per skin? What would one have to pay for the skin of a California condor, an ivory-billed woodpecker, a heath hen, or a Carolina parakeet, and what would be the condition of these skins if he did succeed in finding them? Recently we succeeded in getting three passenger pigeons that had been mounted thirty to thirty-five years ago. These birds we remounted and placed in an exhibit in our museum. The skins were all badly grease-burned and the oldest went to pieces so that it was necessary to cement the twenty odd parts on a modeled form. From this one skin we took over an ounce of oil besides the fat that was removed by the use of alkalies. How many of us are sure that some of the valuable skins that we are putting into our collections today are not in the same condition? It is not an infrequent thing to have people ask how long these specimens that we are preparing today will last. We like to say, "Indefinitely," and in most cases we can. But the question, "How do you know?" has been a little difficult to answer satisfactorily. We know that the animal oils or fats in skins contain acids that slowly destroy the tissue. In our laboratory experiments we have demonstrated that these oils are readily turned to soap by the use of soda, borax, and talc. The soap and glycerine formed by the process are slightly antiseptic and are not injurious to the skin, but if so desired, they may be removed by washing the skins in water.

We believe that, after the oils have been removed, the skins should keep. Now for the proof!

It was during the summer of 1915 that I visited the Deseret Museum, Salt Lake City. In that interesting collection taken from the cliff-dweller's huts in southern Utah, I unexpectedly found the proof. This material to which I refer, is said by good authority to be from one thousand to fifteen hundred years old. Among the many notable things are two deer skins and the skin of a small blue-bird, all in a perfect state of preservation, even the feathers on the bird being intact. These specimens were dug from the loose soil forming the floors of the huts. This natural soil (according to geologists who are informed on the subject) contains crude soda, potash, and magnesium, and these ingredients have preserved the skins by their action on the oils, the process, although crude, being the same that we are using in our laboratory today. The cliff-dwelling Indian had no idea of permanently preserving the skins when he buried them there. We go to nature for our art; we scrutinize every little detail to make our exhibit a success; and now we find that she has set the pace even in the matter of preserving material. To answer further the question of how long organic material may be preserved we have but to visit the tar pits at Rancho La Brea and see the perfect skeletons two hundred thousand years old.

Is it not the correlation of art and science that will make the museum a success? A man who studies science to the exclusion of everything else is likely to become cold, unsympathetic, and narrow. The more he specializes the more he isolates himself from his fellows. The man who studies art and nothing else becomes insipid and impractical. But when we combine the two we get art that is useful and science that is broad; we get individuals who can do something worth while; we get the sort of art and science that men like Akely, Knight, and Fuertes have combined in their work. I believe that such a union of art and science is bound to remove the objectionable features of the museum. When we have said good-bye to the T-perches, polished bases, the poorly-lighted cases and dingy walls; when we have given some thought to the decoration of the exhibit rooms; when we have museum men who do their work seriously and for the love of doing a thing well; when we send men into the field who have the power of keen observation, the technique, and the artistic ability faithfully to record the facts that can be obtained only from live animals in their natural environments—then we have secured a means of conveying scientific facts to the public in adequate form. Such exhibits, combining with accurate, scientific information the best that there is in art, will reach not only the student but the layman as well. They will reach where books seldom go to the improving of men's minds and to helping them to higher conceptions and new appreciations of nature and her manifold and marvelous works.

Vertebrate Museum,
The State University.

VARIATIONS IN THE BRANCHES OF THE CŒLIAC ARTERY IN THE RABBIT

H. R. WERNER*

It has been noted in some mammals, and no doubt this is true for most species, that there is considerable variation from what is ordinarily understood as the normal condition in the origin and arrangement of certain arteries and veins. Such variations have been reported concerning the origin of groups of vessels, such as the arteries which arise from the systemic aorta and supply the head, neck and fore limbs. Similar conditions have been observed in the post cava and the venous system in general in some mammals. Even the blood vessels in man, both arteries and veins, are subject to a great many variations, or, what are sometimes called, abnormalities.

Students in their work in physiology in this department use approximately one hundred and twenty-five rabbits each year and it has been a matter of very general occurrence to find rabbits in which the arrangement of the arteries did not conform to that which is considered the normal condition. (See Baldwin, this volume, as to carotid variation.)

The origin and arrangement of the branches of the cœliac artery presented a most interesting state of affairs and it was therefore attempted to make a careful record of such variations and note the frequency with which they occurred.

The supply of rabbits consisted of the types which are ordinarily obtained from the average breeder. Many of the animals, however, which were used for our purpose, were secured from the Animal Husbandry Department of Iowa State College and came from their stock supply. Five specially injected rabbits for these observations were about three-quarters Belgian. Both male and female individuals were used.

The arterial system of the rabbits was injected with a red injection mass through the femoral artery, while in a few cases the cœliac artery or one of its branches was injected separately. The blood vessels of rabbits which had just been killed also were studied, in which case the contained blood within the vessels made a careful study comparatively easy.

*Deceased, Feb. 14, 1920.

In selecting rabbits for this investigation the matter of any variation did not mark them as especially desirable, but of the one hundred or more rabbits used in the laboratory, twenty were selected because of their superior injection and these were used for comparison in addition to the five especially prepared specimens.

THE PREDOMINANT ARRANGEMENT OF THE COELIAC BRANCHES

While the relative number of variations are tabulated later in this paper, I shall consider first that condition which is predominant and may therefore be called the normal arrangement of the cœliac branches. (Figure 7:1 and 2; Figure 8:3.)

Where the abdominal aorta (AA) emerges through the diaphragm it gives off the cœliac artery which extends toward the right to the lesser curvature of the stomach. Figure 7:1 and 2, C.) The following branches are given off from the cœliac artery. Between 7 and 9 mm. from the origin of the cœliac there arises the *splenic* artery (S). About half way between the abdominal aorta and the origin of the splenic artery there is given off, on the anterior border of the cœliac, a small branch, the *inferior phrenic* artery (P), which supplies the diaphragm. Bensley in his Practical Anatomy of the Rabbit claims there are several inferior phrenic branches, but in no case have I been able to locate more than one vessel, which is very small. Quite frequently no vessel corresponding to the inferior phrenic was found arising from the cœliac. It is quite possible that where the inferior phrenic artery was not found this may have been the result of imperfect injection, or, what is more probable, it may have arisen from the abdominal aorta directly. While the latter is a very frequent variation in the inferior phrenic in some animals, I was unable to identify it as coming off the aorta in the rabbit. The small size of the vessel, however, may have precluded a proper injection. While the inferior phrenic artery is shown in figure 7:2 and 8:3 and 6, in which cases it was seen, it will not enter further into the discussion in this paper. Between 7 and 9 mm. from the origin of the splenic artery the *left gastric* artery (LG) arises, figure 7:2. The cœliac from this point continues as the *hepatic* artery (H) and gives off, at the junction of the duodenum and the pylorus, the *gastroduodenal* artery (GD). The hepatic artery continues through the lesser omentum to the liver where it divides and supplies the various lobes.

The *splenic* artery arises from the ventral border of the cœliac, curves to the right then to the left and then to the right again, very much like a letter S, on the dorsal surface of the fundus of the stomach. It gives off one (figure 7:2, and 8:3, 5, 6, 7) or often two or more (figure 8:4, 8) large vessels, the *short gastric* arteries (SG), to the left portion of the greater curvature of the stomach. The splenic artery after a short distance then gives rise to one or more very small vessels which supply a portion of the pancreas (figure 8:3). One or more of these vessels are often given off before the short gastric. The splenic now passes to the hilus of the spleen where it gives off to the spleen, one or more branches which in turn break up into a great many smaller branches. The splenic continues into the greater omentum and then toward the right to the greater curvature of the stomach as the *left gastrœpiploic* artery (LGE) where it supplies the walls of the stomach and finally anastomoses with the *right gastrœpiploic* artery (RGE) from the other side.

The *left gastric* artery (LG) arises from the cœliac, dorsal to the cardia of the stomach, between 5 and 7 mm. from the origin of the splenic, divides immediately into three branches all of which divide in a radiating fashion on the surface of the stomach. Two of these branches supply the ventral surface of the stomach and are separated by the œsophagus. The one to the left sends small branches to the œsophagus while the most extreme right branch of the right vessel anastomoses across the lesser curvature of the stomach with the *right gastric* artery. The third branch supplies the dorsal stomach wall.

The *hepatic* artery (H) is a continuation of the cœliac. It continues to the right and cephalad and after giving off several small branches to the pancreas it gives rise to a vessel which extends to the posterior; the *gastroduodenal* artery (a. gastroduodenalis). This vessel, which is dorsal to the pyloric stomach, divides into two branches, the larger one of which supplies the duodenum and pancreas, being known as the *superior pancreatico-duodenal* artery (a. pancreaticoduodenalis superior), while a recurrent branch, the *right gastrœpiploic* artery (a. gastrœpiploica dextra), passes through the greater omentum toward the left to the greater curvature of the stomach and anastomoses with the left gastrœpiploic artery. The hepatic artery now enters the lesser omentum on its way to the liver but gives off a small branch, the *right gastric* artery (RG), which passes to the pylorus and anastomoses with the right branch of the left gastric artery across the lesser curvature of the stomach (figure 7:1 and 2).

VARIATIONS FROM THE NORMAL BRANCHING

In discussing the variations from the normal, one branch will be considered at a time and in the same order as presented above.

The *splenic* artery presents peculiarities in the number and arrangement of its branches mainly concerning the short gastric arteries. There may be one, two or more of these branches coming off at the same place or at intervals from the splenic. By far the most common arrangement is where but one or two branches come off together as shown in all the figures. While there are variations in the number and arrangement of the splenic branches they need no further discussion. I would mention a possible variation, however, which I was unable to note in the rabbits studied, that is, the possibility of the splenic artery arising directly from the abdominal aorta. In one case, the splenic, while originating on the cœliac, came off at the base. Cases where the origin of the splenic was on the aorta have been noted in this laboratory while Piersol mentions the same condition as a possible variation in man.

The *left gastric* artery and its branches present by far the most interesting variations. From a condition which has been designated as the normal (figures 7:1, 2; 8:3), in which case the vessel immediately divides into three main branches, the following variations have been noted and figured. In figure 8:4 the dorsal branch, which is always shown in the figures as a short unbranched vessel, comes off the right branch instead of having its origin in common with the right and left branches. This condition is shown in figure 8:6 also. In figure 8:5 and 7 its origin is on the left branch. In figure 8:8 two vessels are shown, one from the right branch and the other from the left. It is interesting to note how far removed these origins may be from the normal as shown in figure 8:5 and 8. The right and left branches show considerable variation in their origin. In figure 8:5 and 6 the origins on the cœliac are quite far apart. The origin of the branch which anastomoses with the right gastric artery also varies considerably as shown in figure 8:5, 6, 7 and 8.

The *hepatic* artery, which in the normal condition is a continuation of the cœliac, after giving off the left gastric artery, is shown in figure 8:6 and 8, in what appears to be a continuation of the right branch of the right gastric artery. The facts are, however, that the hepatic artery, in this case, does not give off the gastroduodenal artery after the left gastric, but the hepatic and the gastroduodenal arteries are given off before a part or all of the left gastric, while in figure 8:6 and 8 the three or more origins of the left gastric are scattered over a comparatively long area. Probably the most interesting hepatic arterial variation is that shown in figure 8:7 where a second hepatic artery (HE) comes off the right branch of the left gastric artery.

The variations in the *gastroduodenal* artery have already been mentioned. It may come off the cœliac in common with the hepatic (figure 8:8) and a part or all of the left gastric, or it may branch off the hepatic some distance beyond the left gastric, which is the normal condition. The range of variations here is quite considerable.

The *right gastric* artery may have its origin on the hepatic, the latter being normal or abnormal, or it may, as is shown in figure 8:4, 5, 7 and 8, come off the gastroduodenal.

FREQUENCY OF VARIATIONS

If the branches of the cœliac artery and their ramifications in different rabbits were compared with any considerable degree of detail, each particular case, no doubt, would stand by itself. But with the details as shown in figures 3 to 8 as the criterion for the degree of minutia, it will be interesting to compare the branches as a whole and note the frequency of such variations.

The following table of twenty-five rabbits will show that the total number of variations is greater (68 per cent) than the normal condition, which is only 32 per cent. The frequency of the next most numerous is 24 per cent. If we consider that the modifications listed under 2 and 3 in the table, especially 2, in which case the right gastric artery comes off the hepatic and which is the normal condition, we find that the total frequency of case 1 in the table and the modifications of 2 and 3 (2, a and 3, a) is 68 per cent of the total.

TABLE SHOWING THE FREQUENCY OF VARIATIONS

	Number	Percentage Normal	Percentage Abnormal
1. Rabbits showing (normal) condition, as Fig. 3	8	32	
2. Rabbits showing condition, as Fig. 4	1		4
(a) As Fig. 4 except right gastric comes off the hepatic	3		12
3. Rabbits showing condition, as Fig. 5	1		4
(a) As Fig. 5 except right gastric comes off the hepatic	6		24
4. Rabbits showing condition, as Fig. 6	4		16
5. Rabbits showing condition, as Fig. 7	1		4
6. Rabbits showing condition, as Fig. 8	1		4
Total	25	32	68

It appears from the facts at hand that it is perfectly logical to accept the condition as shown in figures 7:1, 2; 8:3 as the normal, both on account of its more frequent occurrence and again because it seems to be the condition around which abnormalities vary.

As to the causes for these variations, it is beyond the realm of this paper to determine. It is, however, of considerable anatomical and developmental importance to throw some light upon the subject on account of its frequency in mammalian animals. McClure ('00) has discussed in detail abnormalities in the post cava of the cat, as well as variations in the venous system of Didelphys. Hunt ('18) shows some interesting variations in the carotid of the cat. Piersol in his Human Anatomy points out similar conditions in the cœliac as well as in many other vessels in man. Besides these, there are hosts of cases where other variations have been noted in other mammals.

McClure ('00) has suggested the possible causes for these abnormalities in the post cava of the cat as domestication, inbreeding, disease, drugs and shocks. Concerning some of these there seems to be some disagreement. Slomaker ('00) finds abnormalities in the circulatory system of the common gray rabbit where domestication as a cause is eliminated. McClure, later ('06), working with Didelphys, disproves at least one of his earlier conclusions as to the cause. He says, "It is generally conceded that variations in the venous system occur with greater frequency among domesticated animals than among those living in the wild state; an idea, however, which is most certainly erroneous, as shown by the conditions met with in Didelphys." It is my opinion that none of these five causes suggested by McClure have any influence, or if so, they can hardly be accepted as a determining element.

The most general explanation, in many cases, as to the causes of such variations is reversion. But Pearl ('08) has shown that if we accept this explanation as to the cause we are simply begging the question, while it raises a very important question concerning natural selection. He says, "They all (abnormalities*) point to the same conclusion; namely, that onotogeny may take an entirely new course, which in all probability has never appeared in the racial history before, and yet immediately reach an adaptive end result." "Natural selection by individual elimination clearly fails to explain such adaptive morphogenesis." He states further, "It is suggested that some form of internal selection offers a possible explanation for such causes."

*Writer's word in parenthesis.

The whole question as to the cause or causes seems at present to be without a solution. It seems, therefore, that the entire problem of abnormalities or variations waits upon the further knowledge of embryology and a solution of the factors which govern and regulate embryonic development.

DEPARTMENT OF ZOOLOGY AND ENTOMOLOGY,
IOWA STATE COLLEGE.

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EXPLANATION OF SYMBOLS USED IN ALL FIGURES

AA	abdominal aorta (aorta abdominalis)
AN	anastomoses
C	cœliac artery (a. cœliaca)
D	duodenal artery (a. duodenalis)
DU	duodenum
GB	gall bladder
GD	gastroduodenal artery (a. gastroduodenalis)
H	hepatic artery (a. hepatica)
L	liver
LG	left gastric artery (a. gastrica sinistra)
LGE	left gastrœpiploic artery (a. gastrœpiploica sinistra)
OE	œsophagus
P	inferior phrenic artery (a. phrenica inferior)
PA	superior pancreaticoduodenal artery (a. pancreaticoduodenalis superior)
RG	right gastric artery (a. gastrica dextra)
RGE	right gastrœpiploic artery (a. gastrœpiploica dextra)
S	splenic artery (a. lienalis)
SB	splenic branch (r. lienalis)
SG	short gastric artery (a. gastrica brevis)
SP	spleen

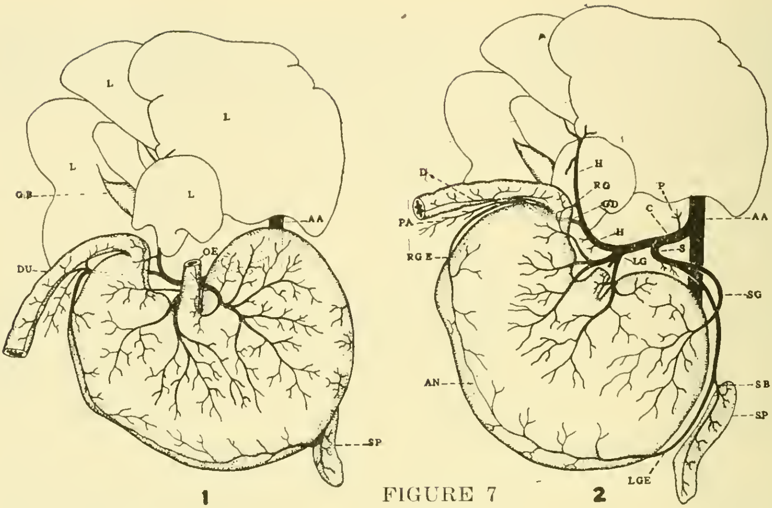


FIGURE 7

Fig. 1. Cœliac artery in the rabbit showing stomach in natural position, the liver turned up and the duodenum and œsophagus cut.

Fig. 2. Same as Fig. 1 with the stomach turned to the right and the spleen somewhat displaced posteriorly showing the branches of the cœliac artery and their distribution.

FIGURE 8

Fig. 3 Cœliac artery showing normal branching. Similar to Figs. 1 and 2.

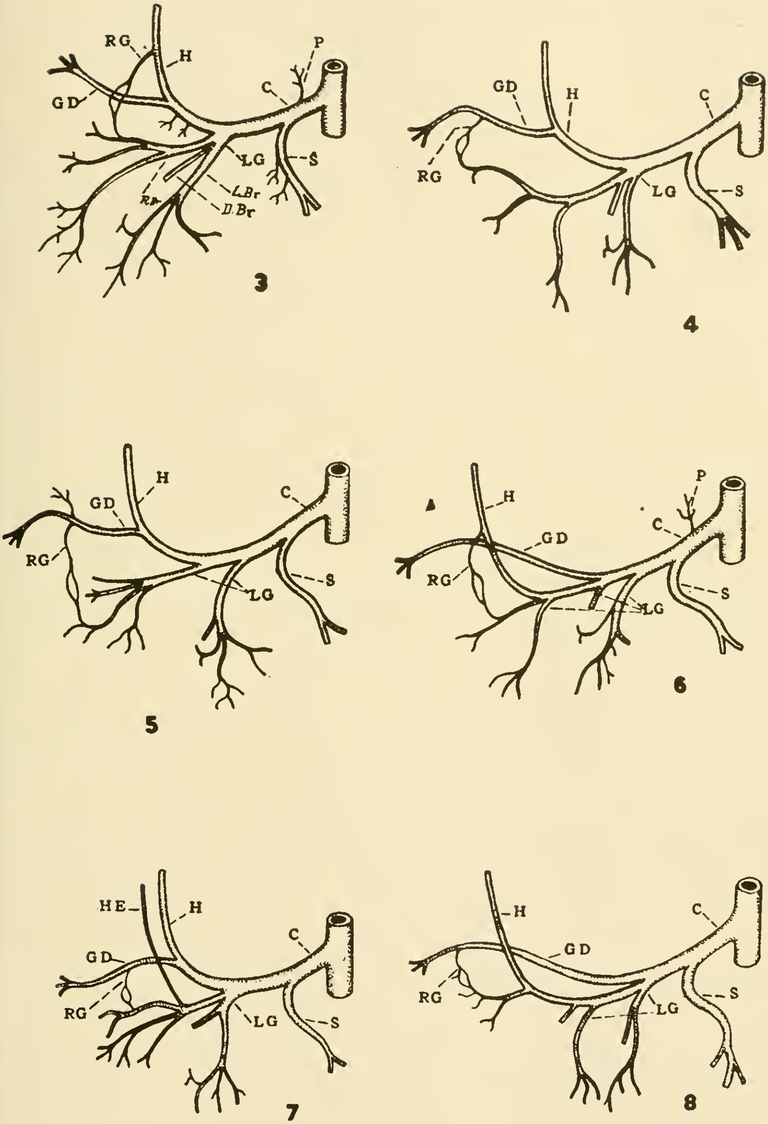
Fig. 4 Right gastric artery arising from the gastroduodenal, while the dorsal branch of the left gastric comes off the left branch.

Fig. 5 Left gastric showing two origins with a dorsal branch coming off each one. Right gastric arising from the gastroduodenal artery.

Fig. 6 Left gastric artery showing four separate origins with the gastroduodenal coming off the cœliac and hepatic arteries.

Fig. 7 A second hepatic artery (HE) coming off the right branch of the left gastric and the right gastric coming off the gastroduodenal.

Fig. 8 Various origins of the left gastric arising over an area of one and a half inches on the hepatic artery, with the right gastric coming off the gastroduodenal artery, while the latter arises from the cœliac.


RG
H
P
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C
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S
L.Br
D.Br
3
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C
RG
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S
4
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GD
C
RG
LG
S
5
P
H
GD
C
RG
S
LG
6
HE
H
C
GD
RG
LG
S
7
H
C
GD
RG
S
LG
8

FIGURE 8

VARIATIONS IN THE CAROTID ARTERIES OF THE RABBIT

FRANCIS MARSH BALDWIN

That the blood vessels of any group of mammals in general are subject to great variations is well known. Such minor variations as have been observed within any group have usually been ignored or at most, resolved to conform to the type. Using the rabbit as a basis of study in mammalian anatomy during the past two years the writer has had an opportunity to make some interesting observations on the variations of the carotid arteries. Of one hundred and fourteen specimens dissected in the laboratory, twenty-three, or about twenty per cent were found to differ from the usual condition described in the texts. Of these, eleven individuals possessed marked differences, as shown in the illustrations in figure 9, which are numbered 1 to 12.

In the majority of cases, the common carotid artery (figure 1, C. C.) passes forward from the superior thoracic aperture along the side of the trachea. Its branches include the superior thyroid artery supplying the thyroid gland, and the superior laryngeal artery. The latter arises at the level of the thyroid plate (larynx) and passes to the sternohyoid and sternothyroid muscles. A short distance cephalad the common carotid artery gives off a very small internal carotid artery which passes dorsad, and disappears beneath the auditory bulla. From this point forward the vessel is the external carotid artery, which gives off successively the occipital, the lingual, the external maxillary, the superficial temporal (one of the terminal branches), and the internal maxillary (the other terminal branch) arteries, in the order named.

The occipital artery passes to the posterior portion of the head from the dorsal wall of the external carotid artery at a point just cephalad to the internal carotid.

The lingual artery arises from the ventral wall of the external carotid artery at a point about at the level of the occipital, and passes forward into the tongue.

The external maxillary artery is given off just cephalad of the lingual branch, and passes to the medial surface of the ventral border of the mandible. It gives branches to the submaxillary gland and the muscles of mastication.

The internal maxillary and the superficial temporal arteries form the two terminal branches of the external carotid artery. The former passes in the direction of the orbit and gives off the inferior alveola branch to the mandible; the latter passes to the temporal region and gives off the transverse facial artery to the cheek and face.

To simplify the presentation of differences found, it is convenient to use the following captions:

The Internal Carotid-Occipital differences—A common difference in the relationships just noted is a condition where the internal carotid artery and the occipital branch arise from the common carotid as a single trunk, the innominate (figures 2, 3, 7 and 12 IN.), which subsequently divides. Interesting gradations in respect to the division are found, from the condition (figure 8) where the two arteries arise separately from the common carotid artery, and where there is no innominate formed, to that where a long innominate is formed as shown in figure 7. The order of the division is of interest also since in some cases (figure 2), the occipital branch is morphologically the most posterior, in others (figures 9 and 12). the internal carotid artery occupies such a position. In the first condition there is no crossing of the two, the occipital passes dorsad to the muscles of the head and neck, and the internal carotid artery passes directly mesad under the auditory bulla. In the second condition, there is a crossing, the occipital branch usually passing laterad of the deeper lying internal carotid trunk, although here again there seems to be some variability, since in one case (figure 4) the opposite is the case.

The External Maxillary-Lingual differences—While there has been noted no case where the sequential order in which these two arteries are given off from the external carotid artery, the relative differences in distances from one another in their origin is worthy of study. In two individuals (figures 6 and 7) the interval between the two is very considerable, being very nearly a centimeter. From this extreme gradations occur, the distance between their points of origin on the carotid gradually approximating one another as is shown in figures 3, 2 and 5 respectively. Finally there is formed in some cases, a common trunk, an innominate, before the division takes place, as shown in figures 4, 9 and 12. It is apparent that this approximation may take place in either direction, that is, the lingual may move cephalad to effect the junction with the maxillary, as shown in figure 9, or the maxillary may move caudad as represented in figure 4. In the condition shown in figure 5, both arteries have been slightly displaced from the usual position of either. In one case (figure 6), it is interesting to note that the external maxillary is given off as a branch of the internal maxillary artery some distance cephalad of the latter's junction with the superficial temporal. In this case it occupies the relative position of the inferior alveola branch, and might easily have been taken for the latter on superficial examination, the inferior alveola branch in this case being somewhat more cephalad than usual. In two cases, however, figures 4 and 5, where the maxillary and lingual branches are closely approximated, the inferior alveola branch is considerably more caudad than is ordinarily the case.

The Internal Maxillary-Superficial Temporal differences—In some instances these two vessels differ conspicuously in size, and where this condition is most marked, one may be considered a branch of the other. In conditions shown in figures 2 and 3, the superficial temporal is a small side branch passing dorsad while the larger internal maxillary artery continues forward. In other cases (figure 9) the opposite is true, the smaller internal maxilliary artery is a branch of the larger superficial temporal trunk, and in this case its point of origin from the temporal is well cephalad.

In two cases represented by figure 7, the relationship of these terminal branches of the external carotid artery are of interest since they together with the external maxillary artery form a three parted fork, the external maxillary artery turns abruptly ventral, the superficial temporal passes dorsad, and the internal maxillary bends mesad. In size there is very little difference between the three vessels, any one of which could be considered a terminal branch of the external carotid artery.

The Superficial Temporal-Occipital differences—In three cases the occipital artery originates as a branch of the superficial temporal. In one individual (figure 9) it passes dorsad from what may be considered the base of the superficial temporal or its innominate. In figure 5 it is but a little more cephalad, while in figure 10 it is shown passing away from the temporal well cephalad to the latter's junction with the other arteries.

Other differences—In one case shown in figure 11, all the arteries pass forward away from the common trunk in such a way as to form a sort of corona radiata. In such a condition the external carotid artery is practically eliminated, since the common carotid artery is broken up immediately into five terminal branches. In the condition shown in figure 12 the common carotid artery can be considered as terminating in three innominate trunks; one giving rise to the internal carotid and occipital branches, one forming the external maxillary-lingual branches, and the third, the internal maxillary-superficial temporal branches. In the condition shown in figure 10, the external carotid artery is very short, terminating in four branches, one of which is an innominate which forms the superficial temporal and occipital branches.

In two cases, the inferior alveola artery which normally is considered a branch of the internal carotid artery, shows a tendency to branch well down on the external carotid trunk. This condition is indicated in figures 4 and 5. On the other hand, the external maxillary artery which normally is a branch of the external carotid, in two individuals (figures 3 and 6), branches well cephalad from the internal maxillary artery.

Summary—Variations in the relative positions and points of origin of the several vessels along the common carotid artery result in the formation of several innominate arteries. Those of especial interest are the occipital-internal carotid, the external maxillary-lingual, the internal maxillary-superficial temporal, and the superficial temporal-occipital arteries, represented in figures 2, 4, 9 and 10, respectively.

After the common carotid artery gives rise to the internal carotid or to the innominate (internal carotid-occipital), the remaining trunk, the external carotid artery, may terminate in a number of ways; it may end as a single trunk (either the internal maxillary or the superficial temporal); it may be bi-parted (as normally) or by two innominates as in figures 9 and 12; it may be three-parted formed by the two maxillaries and the temporal as in figure 7; it may be four-parted, formed by the two maxillaries, the temporal and the lingual as in figure 8 or by the lingual, the two maxillaries and the innominate as in figure 10; or it may be five-parted, formed by the two maxillaries, the lingual and the temporal and the occipital.

The inferior alveola artery which normally is a branch of the internal maxillary, is in two cases (figures 4 and 5), well down on the external carotid artery.

The external maxillary artery in one case (figure 6) is given off as a branch of the internal maxillary some distance cephalad to the latter's junction with the temporal. In several cases both the lingual and the external maxillary arteries pass out of the external carotid artery at the level of the internal maxillary and superficial temporal arteries as in figures 8, 10 and 11.

The occipital artery varies considerably in its origin. It may be a branch from the internal carotid artery as in figures 2, 3, 7 and 12; it may branch as an independent twig from the external carotid artery as in the normal condition as shown in figures 4, 6, 8 and 11; or it may be a branch from the temporal as in figures 5, 9 and 10.

In one case, figure 3, the lingual and the external maxillary arteries may be regarded as branches from the internal maxillary, since their points of origin are well cephalad to the point at which the temporal branch is given off.

Department of Zoology and Entomology,
Iowa State College.

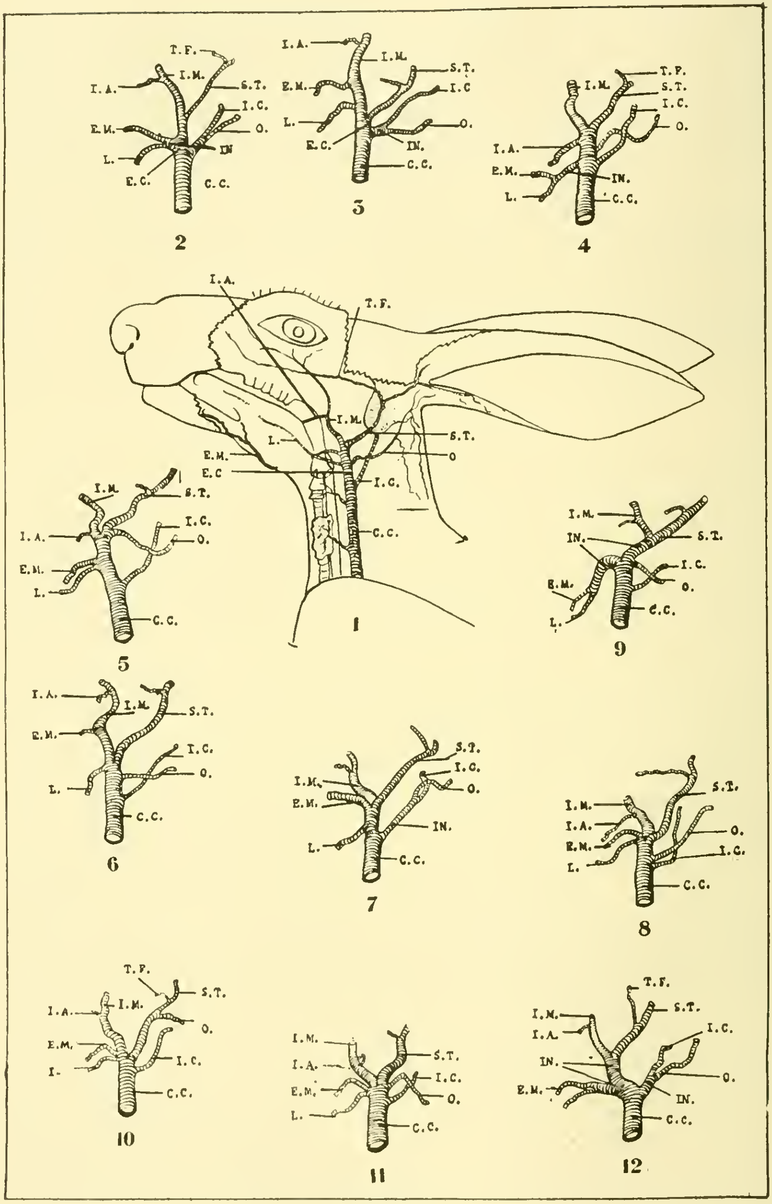

FIGURE 9

EXPLANATION OF FIGURE 9

Fig. 1. Branches of the common carotid artery (left side) showing order and distribution in the majority of cases.

Fig. 2. Variation in which the occipital and internal carotid arteries

leave the common carotid artery together as an innominate artery. The superficial temporal is much smaller than the internal maxillary and can be regarded as a branch of the latter.

Fig. 3. The innominate of the internal carotid and occipital and the superficial temporal are close to each other, while the lingual, external maxillary and inferior alveola may be regarded as branches from the internal maxillary.

Fig. 4. The external maxillary and lingual arteries arise as an innominate from the common carotid. The occipital and the internal carotid arteries are in the reverse sequence from the condition shown in Figs. 2 and 3, and the former passes mesad to the latter. The inferior alveola is a branch from the external carotid.

Fig. 5. The occipital leaves the superficial temporal close to the latter's base; the external maxillary and the lingual arteries arise close together from the external carotid while the inferior alveola is at the base of the internal maxillary.

Fig. 6. The external carotid artery in this case terminates in three branches: the lingual, superficial temporal and internal maxillary, the external maxillary and inferior alveola being branches of the latter.

Fig. 7. The external carotid artery terminates in three branches: the external maxillary, the internal maxillary and superficial temporal. Note the comparatively long innominate which divides to form the occipital and internal carotid arteries.

Fig. 8. The lingual and external maxillary arteries originate close to the junction of the internal maxillary and superficial temporal arteries.

Fig. 10. The occipital artery is a branch of the superficial temporal which leaves the latter well cephalad.

Fig. 9. The external carotid terminates in two innominate arteries, one giving rise to the lingual and external maxillary arteries, the other forming the internal maxillary and superficial temporal arteries. The occipital branch is small and comes off of a point of junction of the two innominates.

Fig. 11. All the branches of the common carotid are close to one another forming a sort of corona radiata at its termination.

Fig. 12. The common carotid artery breaks in this case into three innominate arteries: the external maxillary-lingual, the internal maxillary-superficial temporal and the internal carotid-occipital arteries.

ABBREVIATIONS

C. C.—Common Carotid Artery.
E. C.—External Carotid Artery.
E. M.—External Maxillary Artery.
I. A.—Internal Alveola Artery.
I. C.—Internal Carotid Artery.
I. M.—Internal Maxillary Artery.
I. N.—Innominate Artery.
L.—Lingual Artery.
O.—Occipital Artery.
S. T.—Superficial Temporal Artery.
T. F.—Transverse Facial Artery.

AN ECOLOGICAL STUDY OF DRY RUN, A TYPICAL PRAIRIE STREAM

I. THE FISHES

E. LAURENCE PALMER

Dry Run, a tributary of Cedar river in Black Hawk county, Iowa, furnishes an excellent unit for studying the ecology of a prairie stream. It is rather exceptional in that for a greater portion of the year a natural barrier is formed where the stream flows underground for the last two miles of its course. This study is concerned only with the west branch which joins a brook of similar size near the grounds of the Cedar Valley Fair Association. While this paper deals only with a description of the creek and the distribution of its fish inhabitants, it is the plan to submit subsequent articles dealing with other forms found.

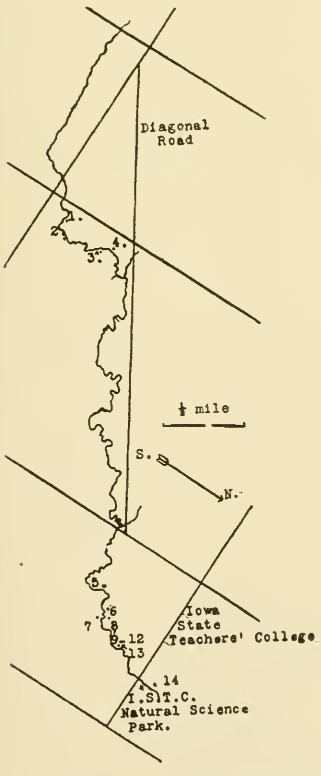

Fig. 10.—Map showing course of Dry Run for the upper three miles.

The upper part of the west branch of the stream follows quite closely what is known as "The Diagonal Road," figure 10. After passing the northern end of this road, the stream bed continues on in the same direction through the Natural Science Park of the Iowa State Teachers' College. The stream is about five miles long from the source to the "springs." The upper three miles have water throughout the year. The tilt of the strata of earth beneath the stream is contrary to the direction of the current. This causes, in part, the marked variation in the

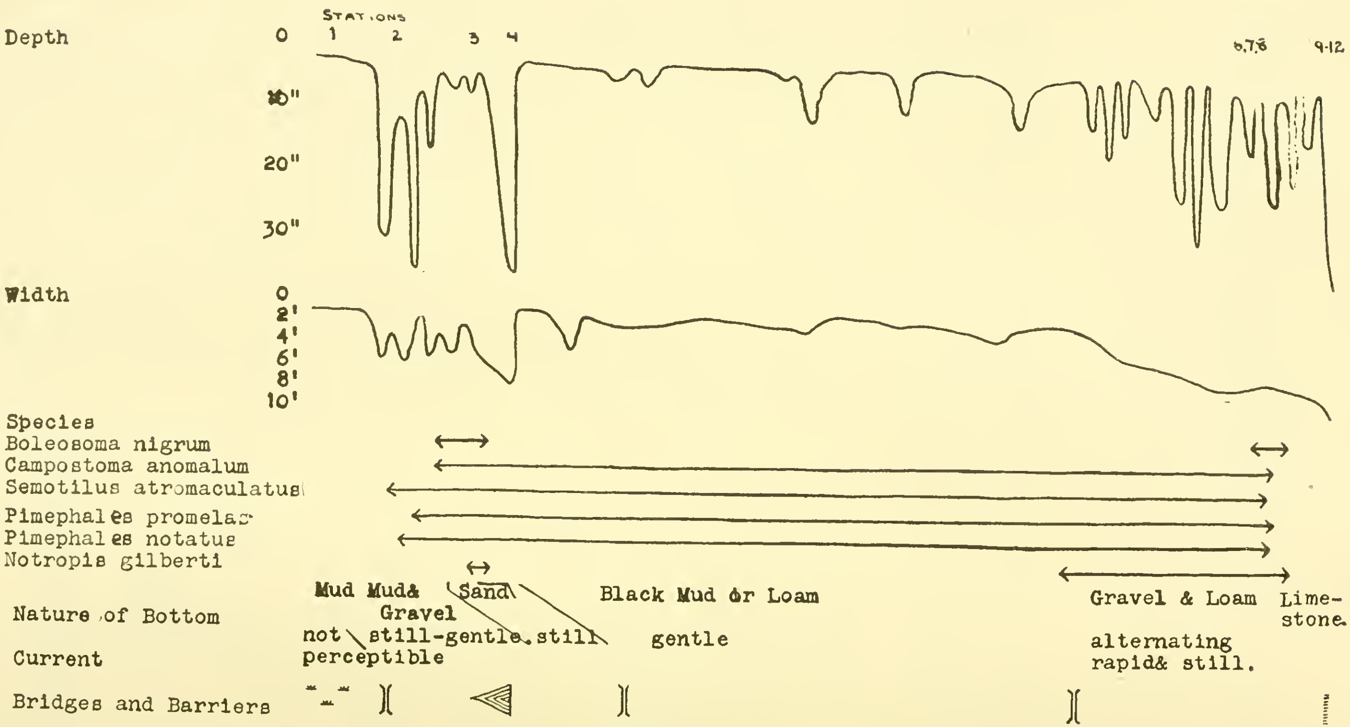

Fig. 11—Graph of Dry Run showing width, depth, current, species distribution, etc.

type of bottom found and, as will be shown, accounts in part for the disappearance of the stream in the lower part of its course. No little interest was attached to this phase of the study, as it was believed that it had a bearing on a serious epidemic connected with the water supply of Cedar Falls.

From the source to the junction of the two branches, the west branch may be conveniently divided into five units, figure 11. 1. The marshy area represented in the map above Station 1. 2. The spring and pool area extending from Station 1 to Station 4. 3. The slow-flowing mud-bottomed area extending from Station 4 to the mouth of a small tributary at the north end of "The Diagonal Road." 4. The gravel, mud and limestone-bottomed area extending from the end of the "diagonal" to the quarry, at 10. 5. The limestone area extending from the quarry to the "springs" two miles away.

The work of making the survey extended over two years. With the assistance of two of the author's students, Mr. Victor Peterson and Mr. George Hendrickson, the course of the stream was carefully surveyed. At regular intervals measurements of the depth and width were made and any exceptional variations recorded. From the figures, the graphs for the course and depth and width were compiled. The figures given for depth and width are those found when the stream is at its very lowest during protracted periods of dry weather. It is planned that in a subsequent article the figures for the stream in time of flood will be given. The depth between stations 6 and 9 is so variable, due to showers, that no attempt was made to standardize it. Each photograph is taken looking towards the stream from the place indicated by the corresponding figures on the map.

The west branch of Dry Run rises in a marshy area southwest of the rural school shown in the map. This area extends to Station 1 on the map and in it the water scarcely flows. Dense growths of sedges practically hide the course of the stream. The bottom is a soft black mud and in the summer during dry weather this area appears only as a region of wet mud. No fishes were found in this area in spite of the fact that wherever there was a little water this was seined with a scoop net.

The region from Station 1 to Station 4 is interesting because there is always much more water here than one would expect to find from a study of the lower stretches of the stream. Beginning just above the clump of willows shown in figure 12 a series of springs appears in the bed of the stream. The uppermost of these are shallow and not well defined, but at the base of the willows we find a large pool of cool water nearly six feet wide and three feet deep. Just below this is the bridge shown in figure 13 and from there down to Station 3 there appears a series of pools and shallow water.

Fig. 12.—Looking east showing clump of trees above spring at head of Dry Run.

Fig. 13.—Looking west just below spring at head of Dry Run.

The bottom through this area is mostly soft mud and gravel, but there appear at intervals a few large bowlders such as are shown in figure 13. Below this area of pools and shallow water the stream has been dammed up evidently to furnish a supply of drinking water for stock. This makes a pool about a hundred yards long and at its lower extremity seven feet wide and a yard deep. The bottom of this pool is very soft black mud except for a stretch of sand which appears at its head. The fishes found in this region from Station 1 to Station 4 include *Boleosoma nigrum* Rafinesque, the "Johnny Darter"; *Campostoma anomalum* Rafinesque, the "Stone Lugger" or "Stone Roller"; *Semotilus atromaculatus* Mit-

FIG. 14.—Mr. Peterson and large Snapping Turtle caught in pond near head of Dry Run.

chill, the "Horned Dace" or "Creek Chub"; *Pimephales promelas* Rafinesque, the "Flathead" or "Black-Head Minnow"; *Pimephales notatus* Rafinesque, the "Blunt-nosed Minnow"; *Notropis gilberti* Jordan and Meek, "Gilbert's Minnow." In other words, all of the species reported for the entire stream were found in this short stretch of stream. The large spring mentioned contained an especially large number of specimens of *Semotilus,* some of them being at least nine inches in length. With the exception of *Boleosoma* and *Notropis,* the other species were distributed quite uniformly throughout the length of the region. *Notropis* was found only over the sand stretch mentioned at the head of the backwater formed by the dam, while *Boleosoma* was found here and for a short stretch above. It surprised the author to find *Boleosoma* in water as quiet, shallow and warm as that just above the backwater. While seining the backwater a large snapping turtle (*Chelydra serpentine* L.) was caught. This may have accounted in part for the absence of any great number of fish in the pool. At any rate, the results of seining the pool showed a dirth of specimens compared to what was found in the spring-fed pools above. This pool would have served as an excellent duck pond for the adjacent farm, but if it should be so used care should be taken to remove any other turtles which may be there.

Below the dam, the stream is very small and insignificant. Apparently there is less water flowing here than in the stretch between the springs and the backwater above the dam. The stretch

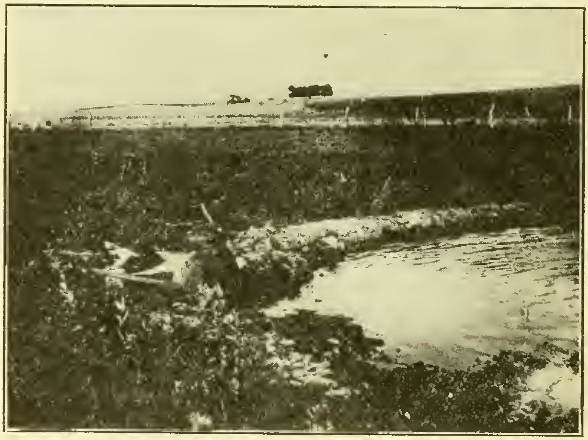

Fig. 15.—Dam built near head of Dry Run to form pond evidently to furnish drinking water for stock.

of sand may account for this, as some of the water may go below the surface and appear again elsewhere. Certainly so far as variety of habitats and of bottom and species are concerned the region from here to the north end of the "Diagonal Road" is very uninteresting. The bottom is uniformly composed of soft black mud which probably prevents the water from entering lower strata of earth freely. Three small tributaries in the upper stretches of this area scarcely augment the size of the stream, they are so small. The graph shows that all of the species reported for the stream with the exception of *Notropis* and *Boleosoma* are reported from this area. What few pools appear are pools because of their increased width rather than because of increased depth and do not furnish anything interesting as to the distribution of the fishes. A rather large tributary which appears near the north end of the "Diagonal" changes the character of the stream considerably—particularly as to size. This tributary rises in a rather extensive boggy area to the west of this end of the road.

Probably the most interesting stretch of stream is that from the end of the "Diagonal" to the quarry shown in figure 20. For the

FIG. 16.—Characteristic view of Dry Run as it nears outcropping of limestone.

most part, the most marked change is in the nature of the bottom. The brook changes from a stream of uniform depth and rate of current flow to a stream of pools and rapids. Wherever the water flows rapidly instead of the mud bottom we find gravel and sand.

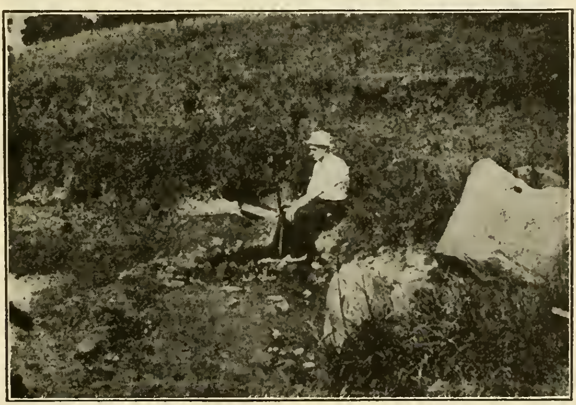

FIG. 17.—Large sink hole in limestone in which water disappears completely during dry weather.

Figure 16 shows the lower end of one of the upper pools in this stretch. The banks on either side of the stream here are higher and in at least three places springs enter the stream from these banks.

FIG. 18.—Same sink hole as seen in Figure 17 after a heavy rain.

FIG. 19.—Water flowing into uppermost quarry after a heavy summer rain.

The springs are not, however, well defined. Beginning at Station 6 a very interesting thing happens. From here on the bed of the stream is limestone. At Station 6 the stream disappears completely in dry weather. The author has never seen the stream dry up completely above this point, although he has watched through a number

FIG. 20.—Usual appearance of uppermost quarry. Water disappears in region shown in lower left hand corner.

FIG. 21.—View of walls of uppermost quarry. Notice great difference in texture of strata. Layers 2 and 7 are harder than the others.

of exceedingly dry seasons. The sink hole shown in figure 17 is circular and about five feet across. It is surrounded by large bowlders and is filled with smaller loose fragments of limestone. When the water is low the underground passage is so large and open that one can hear the water falling over the stones underground. A short distance downstream is a long shallow basin filled with loose limestone. After a rain, the stream rises and, flowing beyond the sink hole, as shown in figure 18, enters this basin. If the rain is not too great all

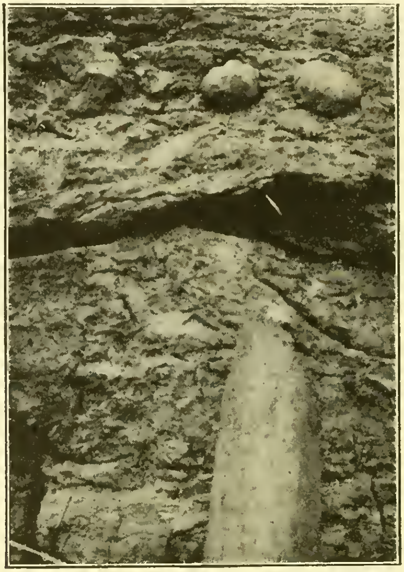

Fig. 22.—Showing fossils found in limestone in wall of quarry. These are harder than surrounding stone, are not so easily dissolved and so help to support layers forming underground passage for water.

Fig. 23.—Limestone ledge just below uppermost quarry showing harder ledge below.

of the stream disappears here. During a normal summer the stream rarely flows beyond these two sink holes. During a wet season or in the spring the stream flows beyond this into the quarry shown in figure 20. Sometimes after a very heavy rain in the summer the water will flow over into this quarry. This is shown in figure 19. Except in time of high spring flood the stream runs its course under-

FIG. 24.—Limestone ledge seen in Natural Science Park of Iowa State Teachers College. This shows the same layer seen in Figure 23 only higher from the creek bed and illustrates the tilt in the strata of rock contrary to the flow of the stream.

ground from the quarry on. Figures 19 to 24 show the irregularity of the limestone underlying the stream bed. These layers are interspersed with fossils such as are shown in figure 22. It is believed that the water dissolves the softer limestone and these harder fossils prevent the harder layers from settling together. This causes numerous large underground waterways. The water evidently settles through these until it strikes some harder, more continuous layer or until it encounters some strata of finer material which prevent the rapid passage of the water. At any rate, the water does not come to the surface again. Near the river end of the course of Dry Run about two miles from the quarry a number of springs rise, as shown in figures 25 and 26. Undoubtedly these springs are not associated with the water which disappears near the quarry, as the tilt of the strata of rock would send the water in the opposite direction. The east branch of Dry Run does not dry up so readily and often continues upon the surface well into the summer. A study of this stream would prove profitable to see whether or not the species found are identical with those in the west branch. The fact that it maintains a connection with the river through a greater period of time would lead one to expect a more varied list of fish inhabitants.

Fig. 25.—"The Springs" approximately two miles from uppermost quarry and sink hole. This water is not the same as that entering the sink holes.

The species of fish found in the stretch from the sink holes to the north end of the Diagonal include all forms found in the stream. This is probably due to the great variation in the type of bottom and consequent variation in food supply. *Campostoma, Semotilus* and the two species of *Pimephales* are found universally, while *Boleosoma* and *Notropis* are limited to regions possessing a gravelly bottom for the most part. Of these latter two species, *Boleosoma* is the more restricted in range. It was found near the lower extremity just above and below the sink holes. Very often pools which dried up left specimens of *Boleosoma* stranded. These pools furnish an excellent place for collecting minnows and crayfish for bait and figure 27 shows how well fishermen are rewarded with crayfish after making a single haul of the seine.

Undoubtedly a study of the aquatic insects and smaller aquatic organisms will shed further light on the reason why *Boleosoma* and

FIG. 26.—Water from one of the large springs just before it enters Cedar River.

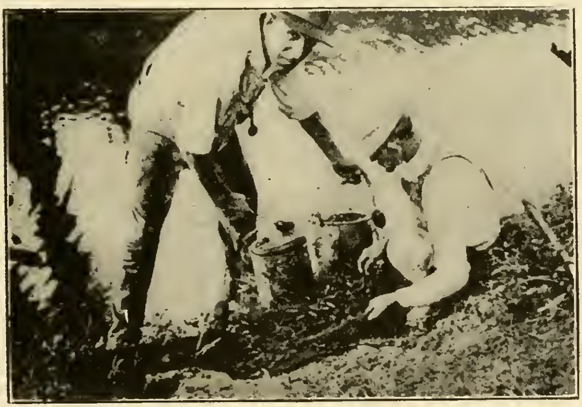

FIG. 27.—Fishermen collecting crayfish in one of the pools left just above the uppermost quarry. This pool vanishes in dry weather.

Notropis are restricted in their distribution. Certainly, the fact that they are confined to or near regions possessing a gravelly bottom would indicate that this has something to do with their distribution. The abundance of fish at the headwaters would indicate that there is an abundance of fish food there and would indicate that possibly a farm fish pond might be established there with the use of a little judgment. There are surely plenty of opportunities for finding out more interesting things in connection with this stream.

Department of Botany,
Iowa State Teachers' College.

ANIMAL TRACKS, FOOD AND DISPOSITION. IS THERE ANY RELATION?

E. L. PALMER

"He that runs may read" but he that runs may also be read and the reading of the tracks of birds and animals may lead to some very interesting observations. When speeding all animals move essentially alike so the following conclusions are based upon the method of locomotion adopted by the animal when moving slowly. This is shown in the first line of tracks under those given for each species.

A study of the tracks shown in the plate will make it plain that there are apparently three types based upon the behavior of the limbs,—particularly the hind limbs. The rabbit, squirrel and deer-mouse all move the hind limbs in unison while the front may or may not work together. In these animals the hind limbs are also plantigrade. The cat and the shrew move the hind limbs alternately as they do also their fore limbs. When speeding, however, their hind limbs are moved simultaneously. The cat at least is digitigrade. The rat and the muskrat vary from each of these types. In these animals, the hind limbs may or may not be moved in unison and there is apparently no attempt to follow any definite plan of behavior for the fore limbs. This probably accounts in part for the peculiar irregularly rolling gait which these animals show.

Possibly the above classification might not be of interest but when we consider the food habits of each of these animals we find that they readily classify themselves into the same groups. The rabbit, squirrel and deer-mouse are essentially plant eaters. The cat and shrew are out and out carnivors while the muskrat and rat are plainly omnivorous. In connection with the food habits it would appear logical to expect different methods of locomotion. Carnivors are called upon to use caution in approaching their prey while this would be unnecessary on the part of herbivors. Sudden movements such as would arise from using the hind limbs simultaneously would jeopardize their chances of securing their prey by surprise. Herbivors do not need to exercise caution in securing a meal but do need to be able to move rapidly in escaping from an enemy. It would seem natural then to expect that movements on their part might readily

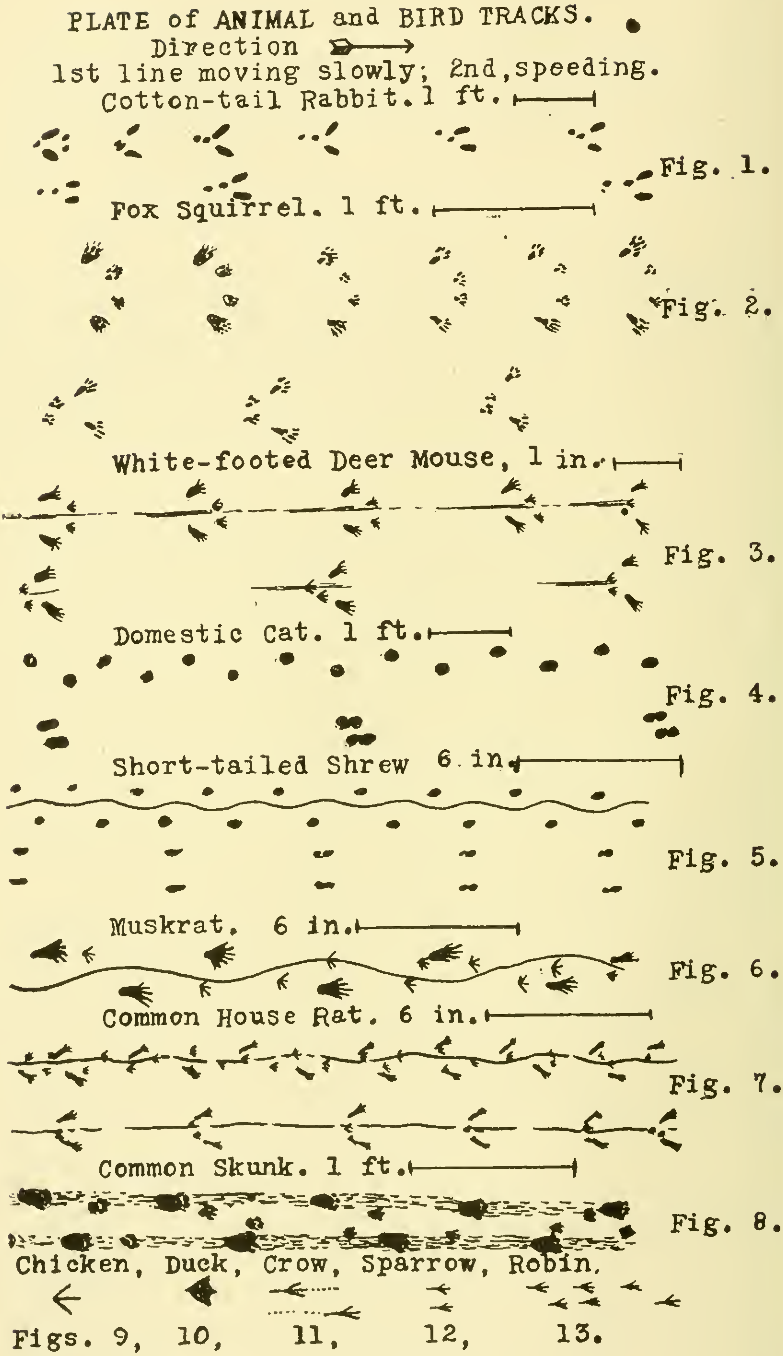
PLATE of ANIMAL and BIRD TRACKS.
Direction
1st line moving slowly; 2nd, speeding.
Cotton-tail Rabbit. 1 ft.
Fig. 1.
Fox Squirrel. 1 ft.
Fig. 2.
White-footed Deer Mouse, 1 in.
Fig. 3.
Domestic Cat. 1 ft.
Fig. 4.
Short-tailed Shrew 6 in.
Fig. 5.
Muskrat. 6 in.
Fig. 6.
Common House Rat. 6 in.
Fig. 7.
Common Skunk. 1 ft.
Fig. 8.
Chicken, Duck, Crow, Sparrow, Robin.
Figs. 9, 10, 11, 12, 13.

FIGURE 28

resemble that employed by a majority of animals when speeding. An examination of the tracks shown in the plate would show this to be so. The omnivorous muskrat and rat seem to combine these types of locomotion as well as their types of food. The skunk, which is an animal-eater, nevertheless confines its food to the smaller forms like insects, crayfish and the like and does not need to exercise the caution in their apprehension which animals who capture forms more nearly their own size need to show. The gait does not then clearly resemble the carnivorous type. An examination of the skunk's tracks also shows that the animal persistently drags its feet. This certainly would indicate lack of caution which has undoubtedly arisen from the facts that its food is easily obtained and that for obvious reasons it need show little fear of its enemies. From this it would seem that besides the relation between the types of locomotion and food there might also be a relation between types of track and the animal's disposition. Very probably, however, the disposition is largely governed by the ease with which the animal can secure a living and the liability of its capture by its enemies.

Bird tracks as well as animal tracks indicate something of the food habits and disposition. The chicken and duck, which are not perching birds, do not show the track of the hind toes. The chicken at least would find this toe a disadvantage in scratching for food and one might expect all scratching birds to be of this type. The aquatic habit of the duck is of course shown in the web. The other birds shown in the plate indicate that they are perching birds by the presence of the hind toes which enable the bird to cling more securely to its perch. It is interesting to note that the crow drags its toes in a careless manner. Possibly if it were not gregarious but had to depend entirely upon its own alertness in detecting foes these tracks might not possess this characteristic. The sparrow, which is an out and out seed eater, differs quite markedly from the omnivorous robin in the method of locomotion. Besides mixing its diet the robin combines hopping, skipping and jumping. Very probably, however, the clear distinctions evident in the tracks of mammals will not be noticeable in the tracks of birds.

Unquestionably there can be exceptions cited to the general observations made above. The ungulate animals like the horse and cow certainly do not move their limbs like the rabbit and squirrel but their great size serves as a protection from a majority of the carnivors. The red squirrel is largely carnivorous but this is not a habit common to the group. Most of its near kin are essentially herbivorous. It retains the method of locomotion common to its kin. It might also be remarked that while it is highly carnivorous, at least for a squirrel, it preys largely upon helpless forms and does not need to use great caution in capturing them. The meadow mouse, which is largely herbivorous, commonly uses its hind limbs alternately but the nature of its habitat might readily account for this as it would be difficult for an animal which lives under low hanging herbage or obstructions of any kind to go by means of hopping. Aside from these exceptions, however, it would certainly seem that in those smaller forms which live in the open in places not remarkably secluded there must be some relation between the types of tracks, food and disposition.

Department of Botany,
Iowa State Teachers College.

SOME INTERESTING INSECT HABITATS IN THE TROPICS

DAYTON STONER

The particular habitats to which reference is made in this paper include a few of the most striking and unusual ones observed in the West Indian Islands Barbados and Antigua. Observations were made and collecting was done by the writer at these places in May, June and July, 1918, at which time he was a member of the University of Iowa Barbados—Antigua Expedition.

The housing conditions on both Barbados and Antigua are in many respects entirely different from those which ordinarily obtain with us. Scarcely ever is a glass window to be seen; window and door screens are practically unknown although every bed in the homes of the white people and the better class of negroes is furnished with a mosquito net. While flies and mosquitoes are common they are not particularly troublesome. At night the lights in our quarters attracted many kinds of insects, especially moths of which the majority were Sphingids and Noctuids. From the entomological point of view this free ingress of insects proved extremely profitable.

On both Barbados and Antigua there are, especially in the cities, high walls of brick and masonry about many of the houses and lawns of the well-to-do. The Dockyard at English Harbor is protected on the land side by such a wall. Many of these walls are capped with a formidable array of heavy, broken glass bottles set in cement; some of them are so placed as to hold a considerable amount of water. While the sun is hot and the water in the bottles evaporates quickly when exposed directly to its rays, evaporation takes place much less rapidly in shaded places. Under such circumstances these containers may hold water for many consecutive days for, during the rainy season, scarcely a day goes by on Barbados that a shower does not occur. These receptacles therefore afford breeding places for mosquitoes, the filaria mosquito *(Culex fatigans)* and the yellow fever mosquito *(Stegomyia fasciata)* occurring on both Barbados and Antigua. While not a considerable number of these pests may breed in such places they only add to a situation which is none too good.

At Antigua a colony of the large brightly colored pentatomid, *Vulsirea nigrorubra* Spinola, was found upon a small tree with shining green leaves about the size of a cherry leaf. This particular kind of tree which was growing along one of the trails leading up Monk's Hill seemed to be uncommon in the region for only one or two others were discovered in our wanderings about the island. The adult insects are shining blue-black with bright crimson markings and venter, and average from one-half to five-eighths of an inch in length. The brilliant contrasty colors of the insect stand out strikingly against the leaves rendering the insect quite conspicuous. The nymphs, of which several from one-half to two-thirds grown were taken, display more of the crimson color and show up even more distinctly than the adults. Whenever a branch or twig upon which one of the insects was resting was disturbed it immediately dropped to the ground where it hid beneath the dried leaves. All the other pentatomids discovered on the island, seventeen species in all, were found upon weeds, grasses or low bushes; in fact this was the only strictly arboreal form collected on the entire trip. Of the more than sixty specimens of *V. nigrorubra* secured, but one was taken in the sweep net, the others coming from the colony on this little tree.

On the salt marshes near English Harbor, Antigua, the dark greenish tiger beetle *Cincindela trifasciata* var. *tortuosa* is found in great numbers. On account of its protective colors the insect is very difficult to see and on account of its agility on the wing is extremely difficult to catch.

At Calais beach on Barbados and again at Half Moon bay on Antigua considerable numbers of the almost pure white tiger beetle *Cincindela suturalis* var. *hebræa* were collected. At both these places are typical white coral sand beaches and the beetles are quite common. The flight of this species seems not to be so rapid as that of the preceding form and often one may bring the insects to earth with a well-aimed handful of sand. I believe that previous to our visit on Antigua this form had not been recorded from the island.

In the wooded districts about Antigua the white ants (Isoptera) are very abundant and the covered galleries which look somewhat like grayish vines extend over the branches and trunks of many of the trees. While the insects themselves are blind they seem to have an aversion for the light and so construct these galleries in which they travel from place to place. The runways are made of tiny particles of bark which are scraped from the trees by the insects and then glued together to form a hollow structure which is quite fragile although it resists weathering very well. The nests are placed either in the trees themselves or at the bases and are more formidable structures than the galleries. Termites also are found on Barbados although they are not so common as at Antigua.

The Scotland district towards the northeastern extremity of Barbados is extremely rough and in many places the vegetation is very dense. On making the ascent from Bathsheba to Hackleton's Cliff which is about two miles from the rough coast line, one passes through a typical tropical jungle with little huts scattered here and there and a few small plots cultivated by the blacks. In these plots banana trees are not uncommon. On June 7 while examining the large reddish brown leaves at the base of one of the bunches of bananas a large yellow and black Calandrid (*Metamasius hemipterus* Linn.) was found in some numbers. As the bunches of fruit develop and become larger the leaves which formerly covered the blossom roll back thus exposing the fruit more or less. It is at the bases of these leaf rolls that the insects are usually found—one beetle to a roll but sometimes several individuals to a single bunch of bananas. If the tree be jarred or shaken the beetles drop to the ground and lie perfectly quiet for some little time. The general color of the insect is very like that of the partly dead leaves within whose coil it finds food and shelter. This beetle was not found in other situations.

One of the most interesting and, to the writer, unusual situations in which to find insects and other terrestrial arthropods was in the

Fig. 29. Epiphytes growing on manchineel trees, Antigua, British West Indies.

great "cistern epiphytes" *(Bromelia sp.)*, which grow, sometimes in great numbers, on the manchineel and other trees in the wooded districts of Antigua and to some extent of Barbados. These air plants, known locally as "wild pineapples," are the most completely epiphytic of the entire group to which they belong and are mechanically but not physiologically attached by their roots to the branches of the trees. Nutrition is brought about by absorption through the leaves which are ordinarily from two to four and one-half feet long

Fig. 30. Epiphytes and cacti in a tropical jungle, Antigua, British West Indies.

and about two inches wide. Upon carefully removing one of these "pines" from the limb to which it is rather loosely attached one usually finds more or less water held at the bases of the channeled leaves where they overlap to form a sort of pitcher. On turning the pine upside down cockroaches, spiders, scorpions, ants and beetles are pretty sure to be dislodged and in most instances mosquitoes also. Both the larvæ and adults of the latter are often found in the same plant and apparently the pest breeds in these natural reservoirs. No doubt, too, the cool moist air here is most welcome to all these arthropods during the heat of a tropical day.

The State University of Iowa.

GRASS-HOPPER CONTROL WORK IN IOWA.

H. E. JAQUES.

Grass-hopper depredations to farm crops have been of frequent occurrence in Iowa, and figure to a certain extent in the loss account of almost every year in at least some part of the state. Attacks during the summer of 1918 seem to have been the most extensive of recent years. Early in June the young nymphs were seen in great

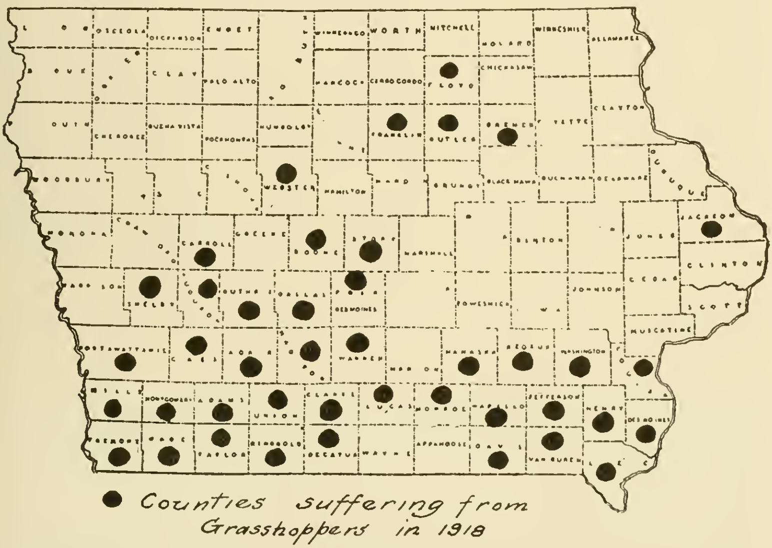

FIGURE 31

numbers in many of the counties in the southwestern part of the state and a few weeks later they had reached the same stage in the southeastern part of the state. As this indicates, complaints of serious damage came first from the southwestern counties; but before the summer had passed grass-hoppers in numbers to demand control were scattered well over the state. It is known that their damage was serious in at least forty-two counties, as shown by the appended map.

As the grass-hopper is not restricted in its choice of food plant, the nature of its damage depends very largely upon what is available in the way of fresh green crops. For the whole state, it seems safe to conclude that the major part of the damage of 1918 was done to the second crop of clover, the seed crop suffering severely and being a total loss in many fields. Severe loss was sustained in many oat fields due to the habit of the hopper in cutting off the spikelets of maturing grains and dropping them to the ground. Corn suffered in a limited way through attacks on the silk previous to the time of pollination. Outlying garden patches also came in for their share in the loss.

A large percentage of the damage may be charged to four of the somewhat limited number of species of grass-hoppers found in the state. Early in the season the Two-striped Grass-hopper (*Melanoplus bivitatus*) seemed most abundant. Associated with it was frequently found the Lesser Migratory Grass-hopper (*Melanoplus atlanis*). This latter one is the only grass-hopper in Iowa which is distinctly migratorial in its nature. A little later in the season the Differential Grass-hopper (*Melanoplus differentialis*) was perhaps the dominating species, while still later the Red-legged Grass-hopper (*Melanoplus femur-rubrum*) was by far the most abundant in many localities. With these could always be found stray members of the Carolina Grass-hopper (*Dissosteira carolina*) and a few other species.

Two methods of control were successfully employed throughout the summer—the poison bran mash, and control by catching with the hopper-dozer of grass-hopper catching machines. The poison bran formula most frequently used consisted of a mixture of:

Wheat bran	25 pounds
Paris green or some other arsenical	1 pound
Cheap molasses or syrup	2 quarts
Lemons	6 fruits
Water	about 2 gallons

The bran and arsenical were mixed dry. For small quantities a washtub served well, while a wagonbox or large trough was used when a large quantity was mixed. In the latter case a scoop and a hoe proved to be the most successful tools for the mixing. The lemons (other fruits may be substituted) were cut in a food-chopper and mixed with the syrup and water. This liquid mixture was then thoroughly worked into the bran, the amount of water being regulated to make a crumbly mass that would break up when scattered.

The poison bran mash was sown broadcast over the infested fields, making the quantity mixed from twenty-five pounds of bran cover about five acres, giving a cost of about forty cents per acre for materials. It was frequently sown by hand, the sower carrying a bucket of the mixture on foot, or on the rear of a wagon or auto truck. The endgate seeder was also successfully used. Occasionally favorable results were not apparent, but in a very large percentage of cases the owners of the infested fields were well pleased with the outcome. Some have estimated that as many as ninety per cent of the hoppers were destroyed by one treatment. The poison bran was used successfully throughout the infested region. As far as is known Adair and Union counties did the most thorough work in this way. Several thousand acres were treated in Adair county. A visit to Adair county during the summer of 1919 found only a few grass-hoppers, and the farmers for the most part were highly pleased with the results of the poison bran as used in the previous year.

The question is frequently raised as to the danger to farm animals in putting out the poison bran. The only report of loss that came to the attention of the writer is from Mahaska county, where the bran mash was used in a cornfield seriously attacked by grass-hoppers. So many were killed that the neighbors' chickens feeding on the dead grass-hoppers met a like fate, but the corn was saved.

While the poison bran treatment is almost always successful, the inexperienced observer does not see the results so readily as with the catchers, so that it has been more difficult in some cases to make the appeal with the poison bran than with some catching device.

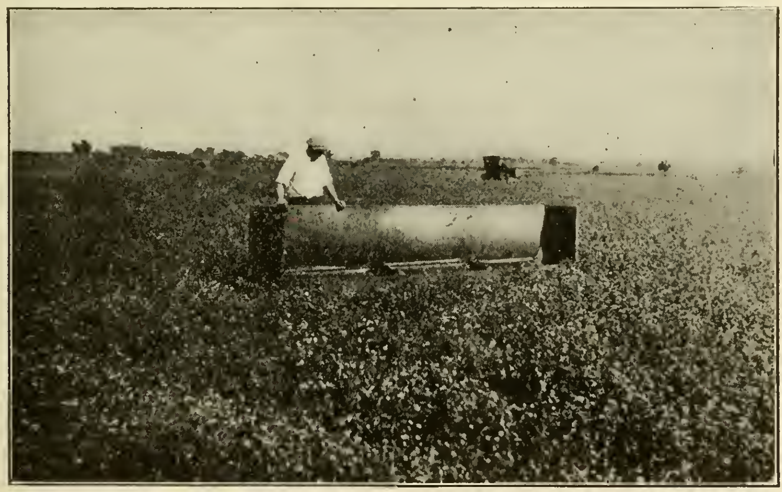

FIG. 32.—Krebill's Hopper-dozer.

During the summer referred to, hopper-dozers similar in construction to the model recommended by the U. S. Department of Agriculture were made and used with excellent results in many of the infested areas. Lee county, through the aggressive efforts of the county agent, Mr. J. S. Clare, probably did more with the hopper-dozer than was done in any other county of the state. More than twenty machines were made and successfully operated in that county.

The case of Mr. Otto Krebill, living west of Donnellson, will illustrate the success of this work. Early in June, having just finished cutting his first crop of clover, he found many young grass-hoppers appearing in the meadow. A hopper-dozer of the type already referred to was built and put into operation. Not wishing to go to the expense of metal pans, matched flooring was used and a lining of tarred building paper applied. This, however, did not prove to be the success that had been anticipated, as the kerosene soon reacted on the building paper. A pan carefully constructed of good lumber may be made sufficiently water tight.

Another improvement was made, however, which proved to be of considerable value and was copied by many makers of hopper-dozers throughout the state. Mr. Krebill observed that the junior mem-

Fig. 33.—Krebill's meadow.

bers of the tribe, on many occasions could not leap the nine inches in height necessary to get over the front of the pan. Accordingly, a twelve-inch board was placed in a diagonal position with one edge attached to the top of the pan and with the other edge resting on the projecting runners. This permitted the young nymphs to gain entrance to the pan by a series of two or three jumps and proved to be a valuable idea.

The entire meadow was gone over twice the first day and large quantities of hoppers were taken. About two weeks later it was

FIG. 34.—Blossoming time in Krebill's meadow.

FIG. 35.—A badly damaged field. Heads all gone, leaves going.

found that many new nymphs had hatched. The hopper-dozer was used again as before and this operation was repeated the third time at another period of two weeks. As a result of this protection, at blossoming time Mr. Krebill had one of the finest pieces of second-growth clover seen in the state during the summer. The accompanying illustrations show views taken in his meadow, also a view taken the same day in a neighbor's field which had been unprotected. In the latter case the clover heads were almost entirely gone. Much of the clover was stripped to a stem and the meadow was being turned under with a complete loss of seed or second crop of hay.

Mr. Krebill had in all fourteen acres of clover, which yielded sixty-five bushels and forty pounds of clover seed, an average of about four and seven-tenths bushels per acre. The ten acres which were best, netted over fifty-seven bushels or an average of five and seven-tenths bushels per acre. This clover seed was sold at $19 per bushel. As might be expected, Mr. Krebill is very enthusiastic over the success of his control work and says that the hopper-dozer was worth more than $1,000 to him. Other farmers have named amounts equally large as representing the worth of the hopper-dozer to them.

In many cases the use of the hopper-dozer did not get under way until late in the season. Many suggestions were made that the device could be mounted on wheels after the clover had reached a good height, but so far as our observations went all of the machines were mounted on runners made of two by fours laid flat. Although this mashed the clover down, it was found that it came up again, and if the precaution was taken to run the hopper-dozer in the opposite direction around the field from which the mowing machine would be operated, no trouble was experienced in cutting the crop. Some have tried hitching the hopper-dozer between two autos with good success, the greater speed being especially valuable after a large percentage of the grass-hoppers have their wings.

Reports of taking one to two bushels of grass-hoppers to the acre have been common. The question was frequently raised if the large number of hoppers being caught could not be used for some practical purpose. Accordingly grass-hopper catcher machines built after the design first described by Dr. E. D. Ball in a bulletin of the Utah Experiment Station and later shown in Circular Number 75 of the University of Montana, were constructed and tried in several counties of the state. The machine captures the hoppers alive in a screened cage, the device being operated by horses hitched at the ends, the same as the hopper-dozer. The device has about the same efficiency as the hopper-dozer and can be operated more easily on hilly ground, but costs about twice as much to build.

Mr. E. J. Rice, of Ft. Madison, was one of the men who gave the hopper-catcher a thorough trial. He caught and dried 1,400 pounds of grass-hoppers. A bulletin suggested sacking the hoppers for twenty-four hours in order to kill them. Mr. Rice writes, "It takes three or four days to kill the hoppers by sacking them, then plenty of nerve to empty the sack." After first using a cement feeding floor unsuccessfully, Mr. Rice succeeded in drying the hoppers on an open spot in a pasture field at some distance from the house. Dried grass-hoppers are reported to contain 75 per cent protein. The writer has been using some of the hoppers prepared by Mr. Rice as winter chicken feed, and has secured a high egg-laying record. Chickens eat the dried hoppers greedily. The plan followed was to feed a mixture of nine parts of dried bran with one part of dried grass-hoppers in a self-feeder, along with the regular daily ration of corn, etc.

Later experiments conducted during the summer of 1919 showed that grass-hoppers caught with the hopper-dozer with either kerosene or gasoline as a killing agent may be dried even more successfully than those caught alive and that in feed value they are in every way the equal of those caught without kerosene.

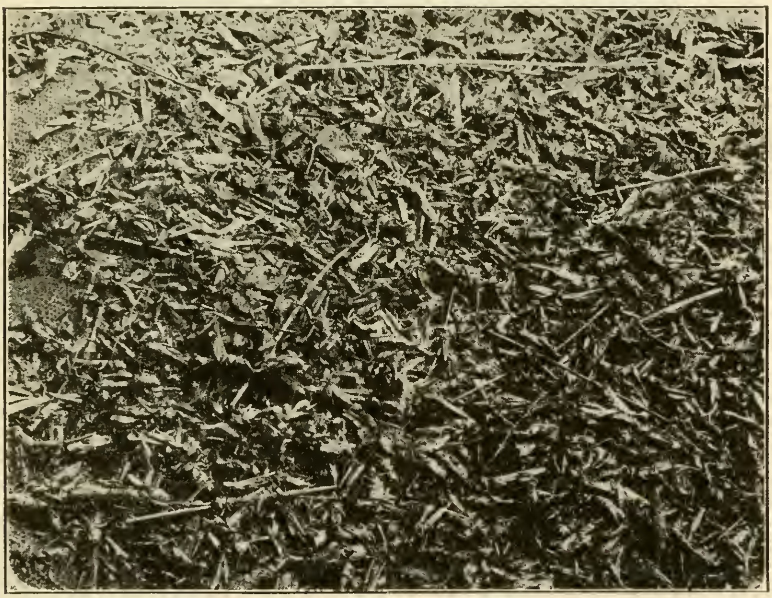

FIG. 36.—Grass-hoppers drying on burlap.

The catch should be thoroughly drained and then spread out in quite thin layers in the sunshine, on bare ground or closely cut grass. Thorough drying requires one to three days depending upon the intensity of the sun, wind, etc. If stack covers, other tarpaulin or large pieces of burlap are available the hoppers may be spread on these, which offers a chance to keep them clean and to take them up

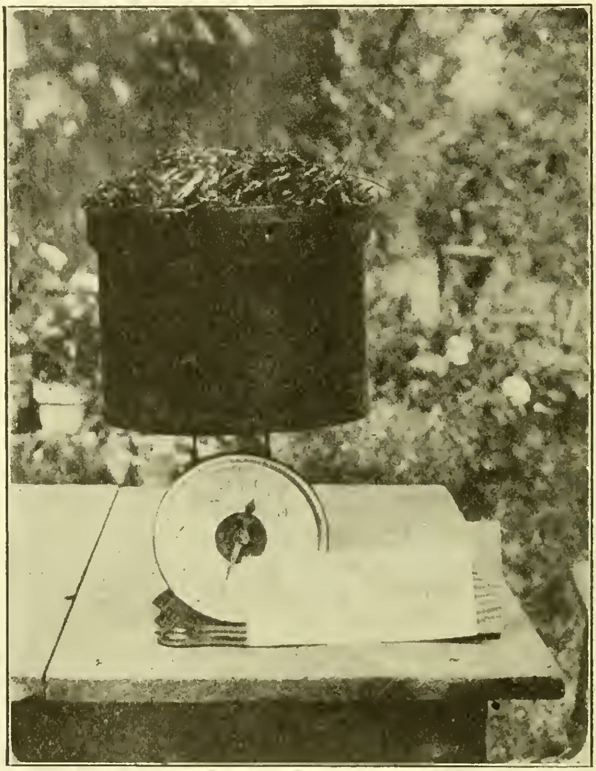

Fig. 37.—One peck freshly caught grass-hoppers. Net weight ten pounds.

quickly with the minimum loss. It is well to stir the drying hoppers with a garden rake once or twice a day to facilitate drying. The kerosene evaporates and in no way interferes with the use of the hoppers as feed. Gasoline was found to work slightly less satisfactorily in the machine and to offer no advantage over the kerosene when it came to drying.

A bushel of grass-hoppers as caught in the hopper-dozer weigh when thoroughly drained forty pounds. A lot of grass-hoppers caught at Salem, Iowa, August 27, 1919, many of which were adults, were carefully weighed both before and after drying. It was found that in drying the weight was reduced to about 31 per cent of the

FIG. 38.—One peck dried grass-hoppers. Net weight two pounds.

original weight, but that they expanded enough in bulk to make a bushel weigh only eight pounds when thoroughly sun dried.

A total of one thousand insects taken at random by handfuls from different lots caught at Salem revealed that a bushel of forty pounds contained about 85,340 individual insects.

This one thousand were separated for species with the following results.

Red leg grass-hopper (Melanoplus femur-rubrum) male......	294
Red leg grass-hopper (Melanoplus femur-rubrum) female....	239
Differential grass-hopper (Melanoplus differentalis) male....	12
Differential grass-hopper (Melanoplus differentalis) female..	10
Differential grass-hopper, Nymphs (Melanoplus differentalis)	194
Dicromorpha viridis male..................................	18
Dicromorpha viridis female................................	6

Arphia zanthoptera	3
Tettix sp	1
Crickets, all species	142
Xiphidium spp	62
Orchelimum, sp	11
Tree crickets, Œcanthus spp	8
Total	1000

Many farmers of the state testify to the value of the poison bran and hopper-dozer in protecting crops from grass-hopper damages. Likewise, the feed value of the hoppers thus caught in crop protection has been demonstrated beyond doubt. The catching alone offers big returns, but when the hoppers may be turned into direct value as a substitute for tankage, the control work becomes of even greater worth.

Department of Biology,
Iowa Wesleyan College.

NOTES ON THE CERCOPIDÆ WITH DESCRIPTIONS OF SOME NEW SPECIES

E. D. BALL

No additions have been made to the records of Iowa *Cercopidæ* since the writer presented his papers on this group in 1895 and 1897; in fact, only one new species has been added to the United States list since that time.

There have, however, been a number of rather surprising additions and extensions of distribution and some of them point to the probability of two more species being found in Iowa and the distribution of two others being extended beyond what appeared at that time to be their probable limits.

The *Cercopidæ* are a strikingly distinct group from the fact that their larvæ produce a frothy secretion inside of which they develop. This froth or spittle appears to serve the double purpose of concealment and absolute protection from all parasitic forms, as no parasites of *Cercopidæ* have been found. The food plants and larvæ of quite a number of species are as yet unknown and among them are the four mentioned below.

Tomaspis bicincta. This is the only representative found in the United States of a tropical group large in numbers and in size. It is found in the southern states and up the Atlantic coast to Massachusetts. The only record for Iowa is the single specimen taken by the writer at Ames in 1893. This was thought at the time to be a specimen that had been blown up from more southern locations. The writer last season (1918) took a single specimen at Madison, Wisconsin, along the margin of a marsh, in a situation practically identical with that in which the Ames specimen was found. Both specimens were apparently fresh and it now seems probable that it will be found in suitable localities throughout the state where search is made. Nothing is known of its food plant or larvæ.

Philaenus parallelus Str. This species was described recently from examples from northern Wisconsin. There is a single example from central Illinois, collected by the late Charles Hart, in the collection of the Illinois State Laboratory. Last season (1918) the writer took five examples from a marsh at Balsam lake, Wisconsin. They were all beaten from a single species of sedge growing in open spaces between clumps of wild cranberries. They were all adults and no traces of the larvæ could be found. The Illinois record suggests that this species also will be found in suitable situations in Iowa when more collecting is done.

Lepyronia gibbosa Ball. This species was described from the sand hills of northwestern Nebraska. The writer took it in eastern Colorado and western Nebraska. In all cases it was taken from very sandy areas and was next reported from sand dunes along the Mississippi in Illinois by Hart and later it was found in similar situations along the coast in Massachusetts. Last season the writer took this species quite commonly in sand hills along Wisconsin river. From these records it seems certain that this species will be found in sandy areas in this state.* It is probable that the larvæ of this species when found will prove to be subterranean, like that of *Philaronia abjecta* and *Aphrophora permutata,* as it is doubtful whether it could maintain a froth above ground in such locations.

Philaronia bilineata Say. This is an abundant species in the Rocky mountain region. The writer reported collecting it in northwestern Iowa in the former paper and suggested that as the limit of its range in the state. It has been found to be common in the northern Appalachians and to extend across the United States in the northern tier of states, coming down into Wisconsin to about the Iowa line. Careful collecting will undoubtedly show that it extends across our northern border. The writer has taken them by hundreds in low, slightly alkaline meadows in Wyoming, but was not able to find a sign of froth or a larva. It will probably be found to have a subterranean habit like the other representative of the genus.

Philaronia bilineata var. *reticula* n. var.

Resembling typical *bilineata,* but with the entire dorsal surface pale smoky, set off by a narrow median line, all the elytral nervures, especially emphasized on the reticulate ones, and the basal half of the costal margin creamy white.

Described from a pair from Kimball, Nebraska, collected by the writer.

Philaronia bilineata var. *nigricans* n. var.

Resembling *bilineata,* but with the whole dorsal surface dark smoky brown with the white stripe along the costal margin in sharp contrast. This stripe widens a little and curves inward just before

*Since presenting the above the writer has taken this species on a gravelly knoll near Little Rock, Lyon county, Iowa.

the apex of the elytra. The irregular apical nervures are partly light marked. The vertex and pronotum of the female are slightly lighter than the elytra.

Described from a pair from North Park, Colorado, collected by the writer.

Philaronia bilineata var. *orbiculata* n. var.

Resembling *bilineata* var. *nigricans,* but with the apical third of the elytra abruptly white except for the narrow apical margin which curves around and divides the light area into two oval spots. The narrow median line is definitely white on the scutellum.

Described from two examples from Rhinelander and Trout lake, Wisconsin, collected by the writer. Other examples are at hand from Ontario, Colorado and Wyoming.

Philaronia abjecta var. *provana* n. var.

Resembling typical *abjecta* in size and form, but with markings similar to var. *ustulatus* of *Philaenus leucophthalmus.* Dorsal surface pale tawny brown, darker in the males, a transverse, slightly irregularly oblique white band from just back of the apex of clavus to the costa, where it is definitely widened. The apical fourth of the elytra, extending forward to the apex of clavus and obliquely outward to the costa, subhyaline. These two light areas bound an irregularly triangular, darker "saddle," which is still darker along the margins.

Described from two pairs from Provo, Utah, collected by the writer from leaves of a *Helianthus* of the *grosseserratus* type.

Clastoptera obtusa var. *pallida* n. var.

Resembling typical *obtusa,* but with the ground color and all markings very pale and obscure. General color pale straw with most of the pattern in pale tawny.

Described from four examples collected by the writer at Ames, Iowa.

Clastoptera obtusa var. *borealis* n. var.

Resembling typical *obtusa* in size and pattern, but much darker. Ground color dark smoky brown with the vertex, anterior half of the pronotum, except for a narrow tranverse band, and the oblique saddle definitely set off in light creamy or white in sharp contrast.

Described from two examples from Nova Scotia from Dr. Brittain, one from Osceola, Wisconsin, collected by the writer, and one from West Virginia. This is the common form in the Rocky mountains and northern regions and extends down along the coasts as far as Washington and San Francisco. It was the only form at hand from California at the time the writer reviewed the genus. The western specimens have the band on the pronotum somewhat broken and the lower part of the face light, thus agreeing fairly well with the description of *lineaticollis* Stal and were so referred. Since that time dark smoky forms of the species that was known at that time as *delicata* Uhl. have been found in California and as Baker suggests they are undoubtedly the form that Stal described.

Clastoptera obtusa var. *juniperina* n. var.

Resembling *testacea* in ground color, but with the addition of a definite pattern of narrow dark lines on the nervures of the posterior part of the elytra, a band from the middle of the costa to just before the claval suture slightly irregular and curving around the bulla, a medium-sized callosity, a crescent at the apex of clavus and usually an arcuated transverse line setting off the anterior third of the pronotum, a line at the base of the scutellum and a very small spot at the extreme tip black. Sometimes a brown cloud extends obliquely across the clavus from before the middle of the scutellum towards the dark line in front of the bulla.

Described from four examples from Palisades, Colorado, taken by the writer.

This variety occurs only on the red cedar and has been found in all stages on that tree throughout the mountain regions of Colorado and Utah. The ground color and dark penciling render this globose species an almost perfect mimic of a dried strobile of this tree.

Clastoptera lineaticollis var. *lugubris* n. var.

Size and form of var. *delicata*, but lacking its definite marking. Dull smoky brown with faint indications of the transverse bands on vertex and pronotum. A dark smoky cloud just before the inflated portion of elytra and a large shining black callosity. Face shining black.

Described from a single female from Alameda county, California, in the collection of the writer. Other examples from the same locality vary in having broader bands and on the pronotum and the face with traces of light lines.

Clastoptera lineaticollis var. *brunnea* n. var.

Smaller and less definitely marked than *delicata*. Smaller than typical *lineaticollis* with less of a smoky and more of a bronzy cast, the lines and markings present, but obscure; face shining black.

Described from four examples from Alder and Rifle, Colorado, collected by the writer. The smaller size and shining black face will at once distinguish this variety from its lineate relatives.

Enocomia n. gen.

Broad short species superficially resembling, but not closely related to, *Clastoptera*. Resembling *Philaronia* in venation, but with a much shorter head and pronotum and a single spine on the posterior tibia.

Vertex very short, obtusely angled, disc sloping, ocelli almost equidistant from each other and the eyes. Front broadly transversely oval, the median third slightly longitudinally depressed. Pronotum very broad and short, anterior disc sloping, posterior disc horizontal, anterior margin more strongly produced than in *Philaronia*. Scutellum large, transversely convex, especially on the long acute apex. Elytra broadly oval as in *Clastoptera*, but not folded posteriorly, coriaceous and with the venation obscure on the disc as in *Philaronia*. Venation slightly irregular, variable, the outer anteapical cell broad, inner one long, acuminate anteriorly, apical veins slightly curved, prominent, several irregular supernumerary veins between the outer anteapical and the costa. Venation of under wing as in *Philænus* except that the third vein is forked back of the cross nervure. Posterior tibia with a single stout spine.

Type of the genus *Enocomia ampliata* n. sp.

This genus, which superficially resembles *Clastoptera*, appears to have affinities in venation and structure with both *Tomaspis* and *Philaronia*. It probably represents a group developed in the West Indian region.

Enocomia ampliata n. sp. (Figure 39, Fig. 1.)

Superficially resembling *Philaronia abjecta* var. *provana*, but much broader, almost as broad as in a *Tomaspis*. Length 7 mm., width 3 mm.

Vertex nearly twice wider than its median length, distinctly shorter than the pronotum, disc almost flat, strongly inclined; face straight in profile, line extended touching costa. Pronotum with the anterior two-thirds on the same inclined plane as the vertex then strongly rounding into the line of the convex scutellum. Elytra broad, coriaceous, venation obscure except towards the apex, outer anteapical narrow, curving around the end of the adjacent discoid cell; posterior veinlets distinctly curved. Posterior tibia weak, a single long spine before a rather weak terminal crown of spines.

Color brown, the vertex and anterior half of pronotum washed with yellow; face black, the anterior margin yellow; elytra with a pair of white spots just in front of the middle of costal margin from which narrow crescents extend in onto the claval areas, a similar pair of spots on costa half way to apex and large white areas occupying the first three cells and the bases of the ones adjoining.

Described from a single female from Port au Prince, Hayti, taken in February by R. J. Crew.

Enocomia ovata n. sp. (Figure 39, Fig. 2.)

Size and general appearance of a *Clastoptera*. Pale brown with eight or more spots. Length, 4 mm.; width, 2 mm.

Vertex short, obtusely rounding, two-thirds the length of the pronotum, disc strongly sloping, the margin thick. Front convex, the disc depressed. Pronotum broader behind than in *ampliata*, scutellum smaller, shorter and less convex than in that species. Elytra long-oval, coriaceous; venation indistinct, first anteapical cell large, apical cells short, almost rectangular.

Color pale testaceous brown, darker below, the margin of the vertex and apex of elytra lighter, eight or more round white spots as follows: A pair on costal margin before the middle, another pair on costa behind the middle, a pair just inside of these in the anteapical cells and usually one or two points on the disc.

Described from three examples from Jamaica, W. I. This is the smallest species in the Cercopid group outside of the genus *Clastoptera*. It is closely related to *ampliata*, but is much smaller and more compact.

Leocomia n. gen.

Resembling *Lepyronia* in general form, but with the elytra more rounding apically and the marginal vein of the under wing entire.

Vertex long, flat, parabolic in outline, the anterior margin thin, inclined to be foliaceous. Face very flat, profile straight and the extended line touching the costa. Head distinctly narrower than pronotum. Pronotum and scutellum as in *Lepyronia*. Elytra rounding posteriorly and nearly flat, similar to *Philaronia*. Venation similar to *Enocomia*, slightly more irregular, underwing with four apical cells as in *Enocomia*. Posterior tibia with two spines, both rather weak.

Type of the genus *Leocomia parabolocrata* n. sp.

This genus is intermediate in character between *Philaronia, Lepyronia* and *Enocomia*. The foliaceous vertex and flat elytra will serve to distinguish it from *Lepyronia*, which it most resembles, but from which it is widely separated by the venation of the underwing.

Leocomia parabolocrata n. sp. (Figure 39, Fig. 3).

Resembling a miniature *Philaronia abjecta*, but lighter in color and with a rounding vertex. Length, 4.5 mm.; width, 2 mm.

Vertex about two-thirds the length of the pronotum, parabolic in outline, disc flat, margin attenuate, in profile the whole head thin and shovel-like. Pronotum very slightly rounding in front, the lateral margin long and definitely oblique, continuing the outline of the head. Elytra coriaceous, long-oval in outline, not inflated nor compressed posteriorly. Venation obscure, similar to *E. ovata*, slightly irregular, the apical cells long and narrow.

Color testaceous, a rusty brown cloud on the vertex and pronotum omitting a median line and an area behind the eye.

Described from a single specimen from Port au Prince, Hayti, collected in February by R. J. Crew.

Lepyronia angulifera var. *minuenda* n. var.

Resembling *angulifera*, but still smaller and much lighter colored Length, female, 4.5 mm.; male, 3.5-4 mm.

Cinereous gray with a tawny cast, eyes and below darker brown. Males much smaller than the females and usually darker. Scarcely as large as a *Clastoptera*.

Described from six examples from Vera Cruz, Mexico, collected by Professor Herbert Osborn.

This minute variety may be specifically distinct from *angulifera*, but until more material of the latter species is available for study its normal range of variation cannot be told. The writer has held this material for many years thinking that this might represent a small variety of Stal's *sordida*, which was described from Mexico. Recently specimens of what is apparently that species have come to hand and are quite distinct.

Department of Entomology,
Iowa State College.

FIGURE 39

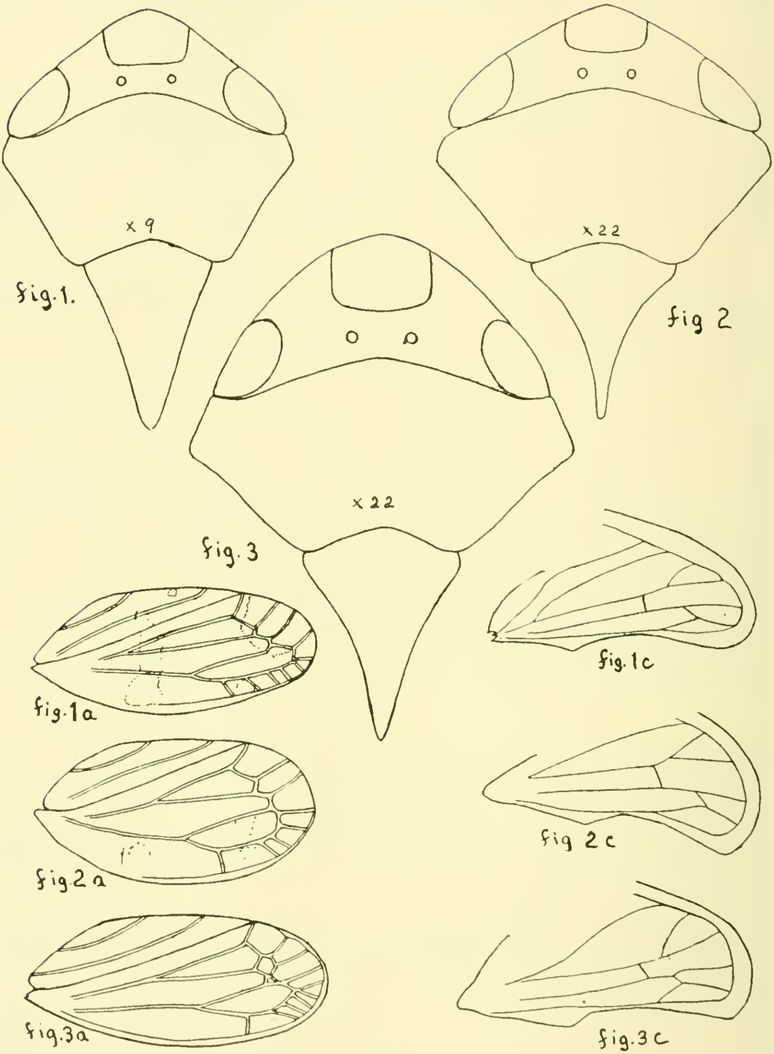

Fig. 1. Vertex and pronotum of *Enocomia ampliata* n. sp. (x9).
1a, Elytron (x5). 1c, Underwing (x5).

Fig. 2. Vertex and pronotum of *Enocomia ovata* n. sp. (x22).
2a, Elytron (x9). 2c, Underwing (x9).

Fig. 3. Vertex and pronotum of *Leocomia parabolocrata* n. sp. (x22).
3a, Elytron (x9). 3c, Underwing (x9).

THOMISIDÆ OF THE AMES REGION

I. L. RESSLER

The spiders of the family *Thomisidæ* are commonly called crab spiders. They are so-called because of the characteristic crablike attitude in which they hold the legs and because they can walk as readily sidewise or backward as forward. The first two pairs of legs are usually considerably longer and stouter than the third and fourth pairs. The tarsi are two-clawed. The eyes are small and arranged in two rows, both of which are almost always recurved.

Crab spiders are remarkable for the fact that their color resemblance is very similar to that of their environment. Many species which live among flowers assume the color of the flower on which they live. Others which live beneath the bark of trees, on unpainted fences and buildings, assume a dirty gray color which enables them to escape the notice, both of their prey and of their natural enemies. The spiders of this family do not build webs or snares, but lurk wherever there may be a place of concealment offered, and from that place pounce upon any unsuspecting prey that may come within their reach. Some crab spiders construct nests or retreats by rolling up or folding the leaves of plants. These nests are lined with silk.

The *Thomisidæ* are divided into several subfamilies, two of which, the **Misumeninæ** and the **Philodrominæ** are represented in our fauna.

Subfamily Misumeninæ

The tarsi of the first and second pairs of legs are never scopulate beneath, but may have a dense covering of hairs. The third and fourth pairs of legs are usually much shorter than the first and second pairs. The hairs of the body are rod-shaped and stand erect. The upper margin of the furrow of the cheliceræ is without teeth. Most of the *Thomisidæ* which the writer has collected fall into the various genera of this subfamily.

Genus MISUMENA

The spiders of this genus are white or brilliantly colored and are quite large. Both rows of eyes are recurved and the eyes of each row are equidistant from each other. Each eye is set on a small whitish tubercle. The area defined by the four median eyes is narrower in front than behind. Two species of this genus are in the Ames collection.

Misumena vatia Clerck. This is a very beautiful spider found chiefly on flowers. One of the most marked characteristics is the change in color that takes place when it migrates from one flower to another. The writer has collected it in the fall of the year on golden rod where the color was a light yellow. On various other flowers the color is white, and on brilliantly colored flowers there are bright red markings on a white or yellowish background.

Several full-grown females measuring from ten to twelve millimetres in length are in the collection. The general colors of these vary from milk-white to yellow, with frequently a bright red stripe on each side of the abdomen and some red in the eye region. The sides of the cephalothorax are always darker than the center. The legs are white with a slender light brown stripe on the upper side of the first and second pairs.

This species is very widely distributed throughout the United States.

Misumena aleatoria Hentz. This spider very closely resembles *Misumena vatia* in color and markings, although it does not have the red stripe on the sides of the abdomen. The chief characteristics of this species are the white transverse stripe between the two rows of eyes extending into lines over the chelicerae and around the sides of the head and the double row of brown spots on the dorsal side of the abdomen. Two females measuring five millimetres in length are in the collection.

Misumena aleatoria is distributed throughout the United States.

Genus CORIACHNE

The cephalothorax and abdomen are low and flat. The anterior row of eyes is straight while the posterior row is very much recurved. The four median eyes are smaller than the lateral eyes. The area defined by the median eyes is wider than long.

Coriachne versicolor Keyserling. The single female in the collection measures five millimetres in length. The general color is black and gray on a dirty white background. The abdomen is mottled irregularly with black and white spots. There is a dark spot on the thorax just in front of the dorsal groove while on each side there is a more or less connected row of dark spots. The legs are thickly covered with black spots which are larger near the joints.

This species is found on fences and stones, which it very closely resembles. In fact, the protective resemblance is so perfect as to make the animal difficult to detect. *Coriachne versicolor* is very widely distributed throughout the United States.

Genus XYSTICUS

The body is flat and rounded at the posterior end. The abdomen is about as long as the cephalothorax and is widest across the posterior half. The front row of eyes is very slightly recurved. The four median eyes are smaller than the lateral eyes and form a rectangle a little wider than long. The genus *Xysticus* is a very large one and embraces nearly one-third of our known Thomisidæ. They live under stones, leaves and the loose bark of trees. The general color is brown or yellowish. Five species are represented in the collection.

Xysticus cinereus Emerton. A single female measuring four millimetres in length was collected. The general colors are brown and white. The cephalothorax bears a light median band which is narrowed in the region of the dorsal groove and widened just behind the eyes. The usual brown cross stripes on a lighter background appear indistinctly on the abdomen. The femora are closely spotted with brown and have dark spots at the distal ends of the third and fourth pairs. The other segments are light with dark rings at the basal ends.

This spider had previously been reported only from the New England states by Emerton, but probably ranges throughout the eastern half of the United States.

Xysticus elegans Keyserling. A single male measuring seven millimetres in length is in the collection. The cephalothorax is reddish brown, darkest at the sides, with a light median stripe which is almost white at the edges. A narrow white line extends along the entire length of the cephalothorax on each margin. The abdomen is dark brown, lightest in the middle with several yellowish transverse stripes. The legs are almost uniformly brown on a yellowish background.

Xysticus elegans is very widely distributed throughout the eastern half of the country.

Xysticus ferox Hentz. Several females and a single male are in the collection. The females all measure about six millimetres in length and the male measures five millimetres. The cephalothorax has the usual yellowish stripe in the middle, with a scattering of brown stripes laterally and two dark spots at the posterior end. The sides of the cephalothorax are brown. The abdomen is brown on the dorsal side with several transverse white stripes. The sides of the abdomen are dirty white. The legs are thickly covered with small brown spots crowded together near the distal ends. The patella and tibia of the fourth pair of legs have a large dark spot on the upper side.

This spider ranges throughout a large part of our country.

Xysticus formosus Banks. This is a very common spider in the vicinity of Ames. The writer has collected a large number of males and females on low bushes. The females measure about five millimetres in length and the males about four and one-half millimetres. There is an extremely wide variation in the markings of the two sexes. In the female the cephalothorax is a yellowish brown with three black spots at the posterior end. The lighter central area of the cephalothorax is dark at the posterior end, lighter in front and whitish in the eye region. The abdomen is white, with a dorsal pair of black spots anteriorly and a double row of black spots on each side at the caudal end.

The male is much darker than the female. The thoracic markings are the same. Several black transverse stripes extend across the caudal end of the abdomen, a pair extend partly across the middle, and a pair of black longitudinal stripes are at the basal end. The ground color of the abdomen is white. The first and second pairs of femora are a uniform brown and the rest of the legs are yellowish.

This species is widely distributed throughout the United States.

Subfamily **Philodrominæ**

The tarsi of the first and second pairs of legs are scopulate beneath. The third and fourth pairs of legs are as long or nearly as long as the first and second pairs. The hairs of the body are plumose and lie flat. The upper margin of the furrow of the chelicerae has one or two teeth. Six genera of this subfamily are represented in our fauna, only one of which is represented in the Ames collection.

Genus PHILODROMUS

The cephalothorax is as wide as long, and is rounded at the sides. The anterior row of eyes is shorter than the posterior row. The abdomen is flat, longer than wide, and is pointed behind. There is very little difference in size between the two sexes. Most of the members of this genus are protectively colored to resemble their environment.

Philodromus minutis Banks. Several females measuring about two and one-half millimetres are in the collection. The cephalothorax is a light brownish yellow with the sides darkest. On the basal half of the abdomen there is a median brown stripe, while on the caudal half there is a pair of white stripes on either side.

Philodromus minutis is always found on low-lying bushes. Emerton previously reported this spider from the New England states but probably it is distributed throughout the eastern half of the country.

Philodromus ornatus Banks. A number ranging in length from two to three millimetres are in the collection. The general color is brown with a ground color of white. The cephalothorax is brown with a white central stripe. The abdomen is white with a pair of longitudinal brown stripes extending about half its length on the dorsal side. On the caudal half of immature individuals there are several dark chevrons, which may be faintly indicated in adults, although they are usually absent.

This spider is distributed throughout the eastern half of the country.

Philodromus pernix Blackwall. This is a very common spider in the vicinity of Ames. Mature individuals measure from six to eight millimetres in length. Both males and females are represented in the collection. The general color is gray and greatly resembles old unpainted wood. The under side of the abdomen is a dirty white. This same color can be seen dorsally at the caudal extremity of the abdomen. There is a long oval spot on the anterior half of the abdomen and a few dark chevrons appear on the posterior half. The legs are very finely mottled with dark brown spots which become larger near the joints.

This species is most commonly found around houses and fences and occasionally on plants. It is very widely distributed throughout the United States.

Zoology Department,
Iowa State College.

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NOTES ON THE OCCURRENCE OF WARTS ON COTTONTAIL RABBITS

J. E. GUTHRIE

About twelve years ago my attention was drawn to some interesting epithelial growths on the head of a cottontail rabbit which was sent to the college by Mr. J. Schuyler Long, who wrote from the Iowa School for the Deaf at Council Bluffs. The head and accompanying letter were referred to Professor H. E. Summers, then head of the Department of Zoology at Iowa State College. The letter reads: "I am sending you a rabbit's head. . . . It has several curious growths which resemble horns. I have killed a great many rabbits but never saw anything like it before. I should be pleased to hear . . . as to the explanation of this peculiar formation. The rabbit from which the head was taken was caught in a trap by one of our boys. In all other respects it looked like an ordinary rabbit and exhibited no other peculiarities, except that on two places on the body were growths similar in color and texture to these horns, but not pointed. They were about an inch square or a little less, and were raised about 3-4 to 1-2 inch out of the skin."

The accompanying figures are photographs of this rabbit head. It has at least ten large horns, pointed rather acutely, conical in shape and reaching as much as an inch in length. The under lip bore some smaller, softer, branching ones as seen in the view from underneath.

No dissection or other critical examination of the head was made at the time, the specimen being merely preserved for the museum. Apparently it represented a rare condition for the locality.

After a lapse of eleven years the subject was again brought up by a letter from Mr. J. W. Runnels of Stone Park, Sioux City. In January of 1918 Mr. Runnels sent in a wart similar to those borne by the Council Bluffs rabbit head, accompanied by the following note: "The enclosed was firmly attached to the skin of a rabbit just back of the left ear. Previous to this we have found several small ones on rabbits, which hunters call warts. Kindly inform me what they are and if they affect the flesh for food, also if they would eventually kill the animal."

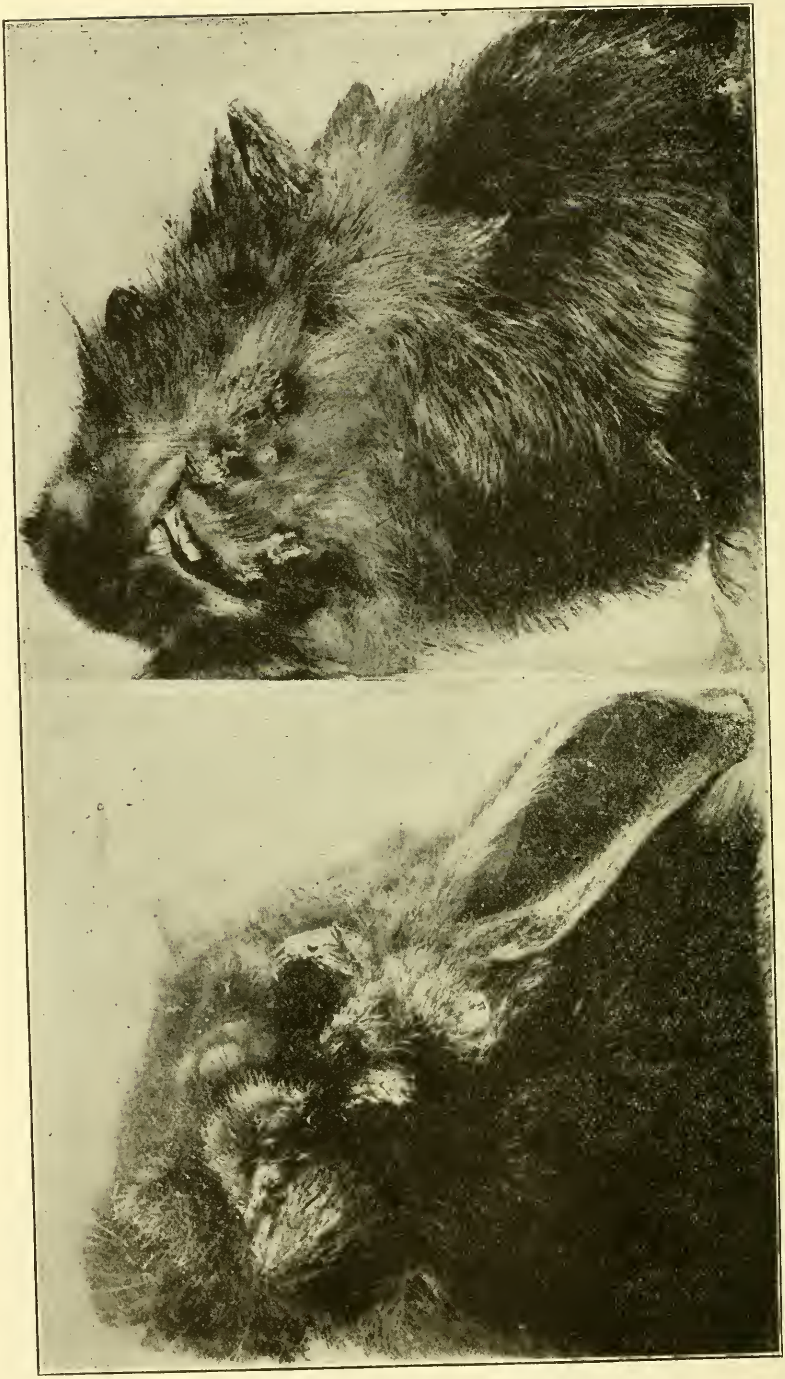

Fig. 40.—Head of "horned" cottontail rabbit.

Not having time then for the examination of the wart, and wishing more information on the cause, nature and effects, I sent the wart on to the Department of Animal Industry of the U. S. Department of Agriculture at Washington with a request for information. This was replied to by Dr. John S. Buckley, Acting Chief of the Pathological Division as follows:

"Replying to your letter of January 24, relative to a specimen of tissue taken from the head of a cottontail rabbit and forwarded to this office for examination, you are advised that histologic examination of stained sections of this material revealed the presence of a dense mass of hornified epithelium. Distributed at intervals through this tissue there were numerous dark pigment cells similar to those present in the skin of animals. These corneous developments are congenital malformations of dermal origin usually appearing as "horns" in the skin just behind the ears. In wild rabbits such growths are not infrequently encountered and are often referred to as "horns." Aside from some local irritation to the surrounding tissues, they possess little pathogenic significance."

Nearly a year later, on December 3, 1918, came a letter from Rev. C. Lilie of Persia, Iowa. Mr. Lilie says: "Should like to have some information regarding "warts" on cotton-tail rabbits. These "warts" appear on practically all older rabbits. They are but loosely connected with the outer skin, not showing at all below the skin. Some people claim that they indicate a disease, making the rabbit affected unfit for human consumption. Others say that they are produced merely by local irritation from sand burs, etc." Mr. Lilie's letter indicates what seems to be a pretty thorough infestation of the cotton-tails in the southeastern part of Harrison county.

Since that time I have made scores of inquiries among our students, but have found very few who had ever seen or heard of the occurrence of these growths. Two men of our faculty who have killed more rabbits around Ames than any others I know of, and have hunted elsewhere in the state as well, have told me that they have never seen anything of the kind. I talked with one student from one of the southeastern counties of South Dakota, and learned that in a day's hunting they usually find a few warted ones, and that they throw these rabbits away. He estimated the affected ones at about ten per cent of the cotton-tails. Another student reported having seen some warts around the ear bases of rabbits in Faribault county, in southern Minnesota.

Professor T. C. Stephens of Morningside College at Sioux City wrote that he had seen some reference to these warts in sportsmen's magazines in recent years, and that he had heard of one such rabbit being taken near Sioux City during the past winter, but that he had the impression that they were not common there. He kindly referred me to a paper on the subject by Edwin H. Barbour, in Proceedings Nebraska Ornithologists' Union, II, 1901, pp. 61-63, in which it is stated that four out of five rabbits taken in certain counties must be thrown away on account of these "horns."

I wrote to Dr. William T. Hornaday, a former Iowan, now Director of New York Zoological Park. As a hunter over many parts of this and other countries, a keen observer and a taxidermist, he would, I judged, be likely to know them if they were common. He replied, however, that: "In the matter of the so-called warts on cotton-tail rabbits I am obliged to confess ignorance and inexperience. I have seen nothing of the kind on any of our eastern rabbits, and the whole subject is new to me."

So far, I have been unable to obtain the paper by Mr. Barbour, but a letter from him states that "These horned rabbits are so abundant in southern Nebraska that it is wasteful. Hunters throw away the "spurred" rabbit. I have seen them with these spurs on all parts of the body, but they generally occur as a ruff around the nose and neck. These horns are sometimes three inches long. I was unable to find any mites in connection with these."

The whole subject of warts seems to be rather a mysterious one. So far as I have been able to find, the cause of the ordinary warts on the human skin is not well understood. It is stated that the blood from a wart will sometimes, but not invariably produce warts. Their appearance and disappearance on the hands and fingers of children seems difficult to explain. It is interesting to note that the only records so far obtained of the occurrence of warted rabbits in Iowa have been from the western border counties: from Council Bluffs in Pottawattamie, Persia in Harrison and Sioux City in Woodbury counties. The other regions that I have noted are southwestern South Dakota, southern Minnesota and southern Nebraska. It might be of interest to know whether there is any species of irritating bur or possibly some mite, tick or biting insect with a corresponding distribution. As to the statement that they are congenital, I have not yet been able to consult the evidence on which this is based. Perhaps it is sufficient.

In bringing this to the attention of the Academy at this time it is my hope to get further data* on the occurrence, effects and particularly the causes of this peculiar malady of our rabbits.

DEPARTMENT OF ZOOLOGY AND ENTOMOLOGY,
IOWA STATE COLLEGE.

*Professor W. H. Davis reported that he had been told of the taking of a cotton-tail rabbit at Cedar Falls during the present season which was said to have warts similar to those under discussion.

THE RELATION OF NATIVE GRASSES TO *PUCCINIA GRAMINIS* IN THE REGION OF IOWA, WESTERN ILLINOIS, WISCONSIN, SOUTHERN MINNESOTA AND EASTERN SOUTH DAKOTA

L. H. PAMMEL

During the summer and fall of 1918 the writer made, under the auspices of the Cereal Investigations of the U. S. Department of Agriculture, a study of the distribution of some of our native grasses and their relation to *Puccinia graminis*. The region embraced Iowa, western Illinois and Wisconsin, southern and western Minnesota and eastern South Dakota.

Dr. E. C. Stakman and F. J. Piemeisel[1] have given us the most complete list of the species of grasses on which *Puccinia graminis* and the various biologic forms occur. The paper is a most exhaustive one, recording the results of a large number of carefully conducted experiments. The paper shows in an interesting way the interrelations between the different host plants and the significance of the biologic forms of rusts on different grasses and cereals.

The authors state that the following hosts have been found infected in nature: *Agropyron caninum* (L.) Beauv., *A. cristatum*, J. Gært., *A. Smithii* Rydb., *A. spicatum* (Pursh) Rydb., *A. tenerum* Vasey, *Elymus brachystachys* Scribn. and Ball, *E. canadensis* L., *E. macounii* Vasey, *E. robustus* Scribn. and J. G. Sm., *E. virginicus* L., *Hordeum cæspitosum* Scribn., *H. jubatum* L., *H. pusillum* Nutt., *H. vulgare* L., *Hystrix patula* Moench., *Secale cereale* L., *Triticum compactum* Host., *T. dicoccum* Schr., *T. durum* Desf., *T. monococcum* L., *T. polonicum* L., *T. spelta* L., *T. turgidum* L., *T. vulgare* Vill.

Hosts easily infected artificially: *Agropyron elongatum* Host., *Bromus hordeaceus* L., *B. pumila*, *B. tectorum* L., *Hordeum spontaneum* K. Koch., *H. vulgare* (Abyssinian), *H. vulgare pallidum* Ser., *H. vulgare pallidum* subvar. *pyramidatum*.

The *Puccinia graminis compacti* occurs on the following hosts in the field: *Agropyron Smithii* Rydb., *Elymus canadensis*, *E. conden-*

[1]Biologic Forms of Puccinia graminis on Cereals and Grasses: Journal Agrl. Research, 10: 429-495, *pl.* 53-59.

satus Presl, *E. glaucus* Buckley, *E. Macounii* Vasey, *Hordeum jubatum* L., and *Triticum compactum* Host.

Hosts easily infected by artificial inoculation: *Agropyron cristatum* J. Gært., *A. elongatum* Host., *A. tenerum* Vasey, *Bromus tectorum* L., *Hordeum vulgare* L., *Triticum durum* Desf. (some varieties), *Triticum monococcum* L., *T. vulgare* Vill. (a few varieties.)

Weakly infected by artificial inoculation: *Agropyron desertorum* Schult., *A. intermedium* Beauv., *A. repens* (L) Beauv., *Secale cereale* L., *Triticum dicoccum* Schr., *T. durum* Desf. (some varieties), *T. vulgare* Vill. (most varieties tried).

The *Puccinia graminis secalis,* the authors state, can be summarized as follows: *P. graminis secalis* has been found on the following hosts in the field: *Agropyron caninum* (L) Beauv., *A. cristatum* J. Gaert., *A. Smithii* Rydb., *A. repens* (L) Beauv., *A. tenerum* Vasey, *Elymus canadensis* L., *E. robustus* Scribn. and J. G. Sm., *Hordeum jubatum* L., *H. pusillum* Nutt., *H. vulgare* L., *Hystrix patula* Moench., *Secale cereale* L., *Sporobolus cryptandrus* (Torr.) Gray.

In addition to the above, the following have been easily infected by artificial inoculation: *Agropyron elongatum* Host., *Bromus tectorum* L., *Elymus virginicus* L., *Hordeum spontaneum* K. Koch, *H. vulgare pallidum* Ser., *H. vulgare pallidum* subvar. *pyramidatum.*

The following have been weakly infected artificially: *Agropyron imbricatum* Roem. and Schult., *A. intermedium* Beauv., *A. sibiricum* Beauv., *Avena sativa* L., *Bromus purgans* L., *Triticum vulgare* Vill.

Inoculated but not infected: *Agropyron desertorum* Schult., *Agrostis alba* L., *A. stolonifera* Vasey, *Alopecurus geniculatus* L., *A. pratensis* L., *Anthoxanthum odoratum* L., *Arrhenatherum elatius* (L) Beauv., *Avena fatua* L., *Dactylis glomerata* L., *Holcus lanatus* L., *Koeleria cristata* (L) Pers., *Lolium perenne* L., *Phalaris canariensis* L., *Triticum compactum* Host.

Of the *Puccinia graminis avenæ* the authors make the following summary with reference to this biologic form. Hosts found naturally infected: *Avena sativa* L., *A. fatua* L., *Agrostis exarata* Trin., *Anthoxanthum puelli* Lecoq and Lamotte, *Dactylis glomerata* L. *Koeleria cristata* (L) Pers., *Panicularia pauciflora* (Presl.) Kuntze.

Easily infected by artificial inoculation: *Arrhenatherum elatius* (L) Beauv., *Alopecurus geniculatus* L., *A. pratensis* L., *Bromus tectorum* L., *Calamagrostis canadensis* (Michx.) Beauv., *Holcus lanatus* L., *Phalaris canariensis* L.

According to Stakman and Piemeisel *Puccinia graminis phlei-pratensis* are naturally infected as follows: Hosts on which *P. graminis phlei-pratensis* was found in nature: *Dactylis glomerata* L., *Festuca elatior* L., *F. pratensis* Huds., *Koeleria cristata* (L) Pers., *Phleum pratense* L.

Hosts heavily infected by artificial inoculation: *Alopecurus geniculatus* L., *A. pratensis* L., *Holcus lanatus* L.

Weakly infected by artificial inoculation: *Avena sativa* L., *A. fatua* L., *Arrhenatherum elatius* (L) Beauv., *Bromus tectorum* L., *Elymus virginicus* L., *Hordeum jubatum* L., *H. vulgare* L., *Lolium italicum* R.Br., *L. perenne* L., *Secale cereale* L.

The writer and Miss King,[2] in a paper on timothy rust report on the unsuccessful inoculation of timothy rust. The work was started in the fall of 1910; about fifty plants (several hundred leaves) of timothy were inoculated by sprinkling upon them water containing uredo spores of timothy rust. After a lapse of five days, uredo pustules made their appearance. In addition a large number of experiments were made with other grasses, foxtail *(Setaria glauca)*, barnyard grass *(Echinochloa crusgalli)*, blue grass *(Poa pratensis)*, barley *(Hordeum vulgare)*, brome grass *(Bromus inermis)*, wheat *(Triticum vulgare)* and red top *(Agrostis alba)*. In none of these cases was infection produced except in oats *(Avena sativa)*.

During the fall of 1911 inoculation experiments were carried on with timothy, English rye, other grasses and oats grown in the greenhouse.

"Inoculations were as follows: on October 3, 1911, three pots of young timothy plants, on the first leaf; pot with 200 young plants, inoculated with timothy rust; pot with 500 young plants, with timothy rust; pot with 200 young plants with red top rust. The method of procedure was as follows: a quantity of spores, placed in about 2 1-2 cc. of water, was distributed over the plants; the plants were then protected by bell-jars for 48 hours.

"On Oct. 9, no rust pustules were observed; inoculations were repeated upon the three pots of timothy plants.

"On Oct. 9, young seedling plants of the following grasses were inoculated with timothy rust; wheat, oats, barley, English rye-grass, Italian rye-grass, timothy, red top, meadow fescue.

"On Oct. 18, rust pustules were observed as follows: on English rye 2 sori, from timothy rust inoculation; on timothy 2 sori from timothy rust.

[2]Timothy Rust: Bull. Ia. Agrl. Exp. Sta. 131, 199-208, *f.* 1-4, 1912.

"On Oct. 23, English rye showed 3 sori from timothy rust, timothy showed 3 sori from timothy rust.

"On Oct. 23, timothy showed 1 sorus from stem rust of oats, inoculated Oct. 18.

"It is evident from these results that conditions were not present in the greenhouse to induce rust upon any of the plants except timothy, English rye and oats; it is difficult to account for the sudden appearance of timothy rust in the field, unless it was conveyed from some other host plants, because the disease was not observed here in 1909 or previous to the middle of June, 1910. Red top was abundant everywhere in proximity to the timothy and it was abundantly rusted. It is probable, therefore, when the conditions are favorable, that timothy rust will appear in epidemic form after having been in some way transferred from related host plants.

"*Puccinia phlei-pratensis* is evidently not the only rust on timothy. The question of the æcidium was discussed by us as follows:

"Ericksson and Henning do not connect this fungus with an æcidium or cluster cup stage. These writers made a large number of inoculation experiments upon barberry but without positive results except a feeble infection in one case. Arthur, who reported on cultures in Uredinæe in 1900 and 1901, says that *Puccinia poculiformis* from reed grass produces æcidia upon common barberry. Ericksson surmises that the æcidium stage of this rust has dropped out as part of the life cycle of the fungus." No æcidium was observed on barberry at Ames on the College campus in 1910 or 1911.

This refers to barberry on the campus. Barberry has since been found wild in several places, so that there probably was infection elsewhere in the vicinity.

THE RELATION TO OTHER HOST PLANTS

"The timothy rust has been reported by Dr. Ericksson and by Dr. Lindau upon fescue and timothy grasses. There is the possibility that this is only a form of the common grass rust. According to Johnson timothy rust transfers readily to *Avena sativa, Secale cereale, Festuca elatior, Dactylis glomerata, Arrhenatherum elatius* and *Poa compressa;* negative results were obtained on wheat and barley. Our own inoculation experiments indicated that it is transmitted to a few other host plants of the grass family. It certainly did not spread rapidly in the greenhouse. And while orchard grass was observed diseased with *Puccinia graminis* in the field a little distance from the timothy, red top was abundantly infected with *P. graminis* at the time when timothy rust was spreading rapidly among adjacent plants of timothy.

"*P. phlei-pratensis* is not the only rust found upon timothy; during the summer of 1910 a rust was found (by Miss King) upon the leaves of timothy which was growing adjacent to wild rye *(Elymus robustus)* which was abundantly affected by *Puccinia impatientis,* and which this rust closely resembled.

"Several interesting papers have been published on timothy rust. Ericksson and Henning[3] regarded this rust as a distinct species. A similar view is expressed by E. C. Johnson[4]. The writer and Miss King in the quotation above regard it as a form of *P. graminis* and this was likewise done by Torrey[5].

Stakman and Louise Jensen[6] state that the rust of timothy was transferred directly from timothy to *Avena sativa, Hordeum vulgare, Secale cereale, Avena fatua, Arrenatherum elatius, Dactylis glomerata, Elymus virginicus, Lolium italicum, Lolium perenne* and *Bromus tectorum.* The statement of E. C. Johnson is that, using *Avena sativa* as a bridging host, the timothy rust could be transferred to common barley. Stakman and Jensen found that wheat could not be infected without a bridging host.

E. C. Stakman and F. J. Piemeisel[7], in a paper on infection of timothy by *Puccinia graminis,* state that the ability of timothy rust to infect the barberry is still a matter of doubt. They say: "From its close similarity to *P. graminis avenæ,* however, it seems reasonable to suppose that it may possibly have developed from some form of *P. graminis.* Since *P. phlei-pratensis* resembles *P. graminis avenae* parasitically more closely than any other biologic form of *P. graminis* it would seem that infection of timothy with *P. graminis avenae* might be possible." "Until further, more extensive attempts are made to infect barberries with teliospores of *P. phlei-pratensis* and until the possibilities of developing experimentally a strain of *P. graminis* on timothy have been exhausted, work is more desirable than words, but the fact that *P. phlei-pratensis* can infect three of the cereals and a number of grasses and that timothy can be infected by *P. graminis avenæ* may possibly indicate that timothy rust, as Kern has previously suggested, may not be so far removed from *P. graminis* as has sometimes been supposed."

In a later paper Stakman and F. J. Piemeisel[8] find that there is very little if any difference between strains. "The rust failed to in-

[3]Die Hauptresultate einer neuen untersuchung uber die Getreide roste: Zeitsch f. Pflanzenk *4*: 66-73, 140-142, 197-202, 257-262.
[4]Timothy rust in the United States. Bull Bur. Pl. Ind. U. S. Dept. Agr. 224.
[5]Torreya 9 : 1-5.
[6]Jour. Agrl. Research *5*: 211-216.
[7]Jour. Agrl. Research *6*: 813-816.
[8]Jour. Agrl. Research *10*: 458.

fect barley in only a few cases." The statement signifies that this rust overwintered at St. Paul, Minnesota, in 1916-1917, a severe winter.

May not some of the inability to infect other grasses and the barberry be due to the condition of the *Dàrluca filum* which is a serious parasite of this host?

GRASSES ON WHICH PUCCINIA GRAMINIS OCCURS

It may be of interest to briefly discuss the grasses on which the various forms of *Puccinia graminis* have been found by investigators. The reference to rust in all cases is merely to the species and not to the biologic form. The grasses are distributed in the following tribes; PHALARIDEÆ: *Phalaris canariensis, Anthoxanthum Puelii;* AGROSTIDEÆ: *Agrostis alba, Sporobolus cryptandrus, Calmagrostis canadensis, Phleum pratense, Alopecurus pratensis, A. geniculatus;* AVENÆ: *Avena sativa, A. fatua, Holcus lanatus;* FESTUCEÆ: *Dactylis glomerata, Bromus secalinus, B. hordeaceus, B. pumila, Kœleria cristata;* HORDEÆ: *Agropyron Smithii, A. repens, A. tenerum, A. pseudorepens, A. Richardsonii, A. desertorum, A. cristatum, A. elongatum, Hordeum jubatum, H. cæspitosum, H. pusillum, H. vulgare, H. pammeli, Triticum vulgare, Secale cereale, Elymus Macounii, E. brachystachys, E. virginicus, E. glaucus.*

The following species—*Agropyron desertorum, A. cristatum* and *A. elongatum*—on which *P. graminis* has been reported by Stakman and Piemeisel do not occur in the region and hence will not be discussed.

Phalarideæ

Phalaris canariensis L. Canary grass is a naturalized plant in Wisconsin, Iowa, Illinois and Minnesota. It is, however, not abundant anywhere. I observed the plant in a few places, but no rust was observed on it. The ribbon grass *(Phalaris arundinacea L.)*, which is grown as an ornamental plant in some places was observed also at Manchester, within a few feet of a barberry bush, but no rust was observed on the grass anywhere in the region. It is common in the swamps and lake region of northern Iowa and along the Missouri river. In no case did I observe *Puccinia graminis* on it. *Anthoxanthum Puelii* L., sweet vernal grass, is not uncommon in lawn grass mixtures, but I have not observed *P. graminis* on it.

Agrostideæ

Phleum pratense L. This grass is generally naturalized from Kansas City, Missouri, north through Nebraska, Iowa, South Dakota, Minnesota, Wisconsin and Illinois. The *P. graminis* is common on it in the entire region, especially after July.

Alopecurus pratensis L. The meadow foxtail is frequently cultivated and has been for years in Iowa and Wisconsin but there is no evidence of its becoming naturalized, so far as I know, in any locality of the region. *Puccinia graminis* has been found on it in Iowa by the writer.

Alopecurus geniculatus L. is common throughout the region from Missouri to Illinois and Wisconsin and Minnesota and South Dakota. I have never seen any of the rust on it.

Sporobolus cryptandrus Gray. Sand rush grass, on which *P. graminis* has been reported, is a common grass in Iowa on sandy or gravelly soil in eastern Iowa, Muscatine, Louisa, Clinton and Allamakee counties to central Iowa, Story, Marshall, Emmet counties and western Iowa from Fremont, Woodbury, Dickinson and Lyon counties. It is common in La Crosse and Crawford counties, Wisconsin; Houston county, Minnesota, to western Minnesota; Big Stone Lake, Watertown, Brookings, Mitchell and Sioux Falls, South Dakota. In all this region I did not find a single instance of P. *graminis*. The *Puccinia Sporoboli* sometimes occurs in Iowa on this species and on *S. neglectus. S. asper. S. cuspidatus* and *S. vaginiflorus*.

Calamagrostis canadensis Beauv. The Blue-joint grass or red top is widely distributed in Iowa, from Keokuk to Lansing along the Mississippi, west to Fremont county on the south and in the north to Lyon county, Iowa, most abundant in low marshes or sloughs. It is common also in northcentral Illinois from LaSalle to the lakes and throughout Wisconsin and Minnesota; South Dakota at Watertown, Brookings, Mitchell and Sioux Falls. I made a careful search for *P. graminis* on this host, but was unable to find any of the rust.

Agrostis alba L. Red top is generally naturalized and common from Illinois to Kansas City, Missouri, north through Iowa, eastern Nebraska, where it is less common, northwestern Iowa, eastern South Dakota, except in low meadows and along streams, near lakes in northeastern South Dakota and common through Minnesota and Wisconsin. The *Puccinia graminis* is common on this species everywhere in Iowa, the uredo stage appearing during the middle and latter part of May. For instance, where the grass occurred near barberry bushes as in Forest City, Rock Rapids and Northwood

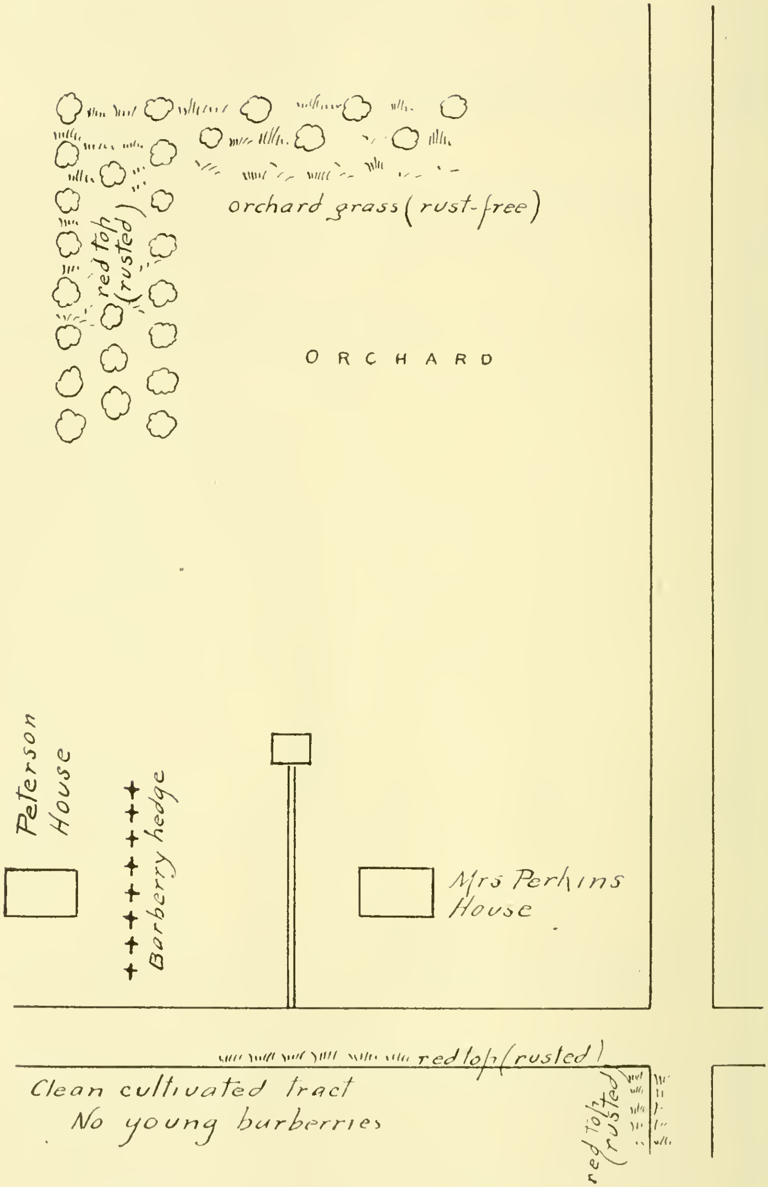

Fig. 41.—Barberry on the Perkins place, Burlington. Barberry hedge removed in May. (C. M. King.)

there was an abundance of the rust. This rust was observed at Hamilton, Walnut and LaSalle, Illinois; Keokuk, Burlington, McGregor, Postville, Lansing, Dubuque, Waukon, Humboldt, Pocahontas, Spirit Lake, Sibley, Rock Rapids, Forest City, Thompson and Sioux City, Iowa; La Crosse, Prairie du Chien, Wisconsin; Marshall, Graceville and Ortonville, Minnesota; Sioux Falls and Watertown, South Dakota.

Aveneæ

Avena sativa L., commonly cultivated throughout the region. *Puccinia graminis* is found everywhere in the region on this host. It was observed in the following localities: Forest City, Thompson, Garner, Concord, Algona, Rock Rapids, Little Rock, Sibley, Spirit Lake, Iowa; Graceville, Ortonville, Marshall, Minnesota; Watertown, Mitchell and Sioux Falls, South Dakota. The abundance of rust in Iowa was closely associated with the common barberry.

Avena fatua L., a commonly introduced and naturalized weed of South Dakota and western Minnesota, occasionally eastward as at Albert Lea, Minnesota, Northwood, Iowa, La Crosse, Wisconsin, and Sioux City, Iowa. The *P. graminis* is common on the host in Minnesota and Dakota and at Sioux City, Iowa.

Holcus lanatus L. Velvet grass has been cultivated as an experimental grass for many years in Iowa and I have seen it occassionally cultivated in Wisconsin, but it shows no tendency to spread in the region. The case is far different in the northwest, Washington and Oregon, where it is one of the common grasses. In Iowa, at least, I did not collect *P. graminis* on it. I have seen the rust on it in the past, however.

Arrenatherum elatius (L) Beav. Tall meadow oats grass, like the preceding grass, has been grown in an experimental way for many years in Iowa. It shows little tendency to persist although somewhat more so than *Holcus*. On the Pacific coast, especially in California, it is a common grass. I do not recall ever having seen *P. graminis* on it in Iowa.

Festuceæ

Dactylis glomerata L. This naturalized European grass is much more common in the southern portion of the area, than northward. It is abundant at Hamilton, Walnut, East Dubuque and Galena, Illinois; La Crosse, Wisconsin; Ottumwa, Burlington, Keokuk, Clinton, Dubuque, Manchester, Ames, Council Bluffs and Hamburg,

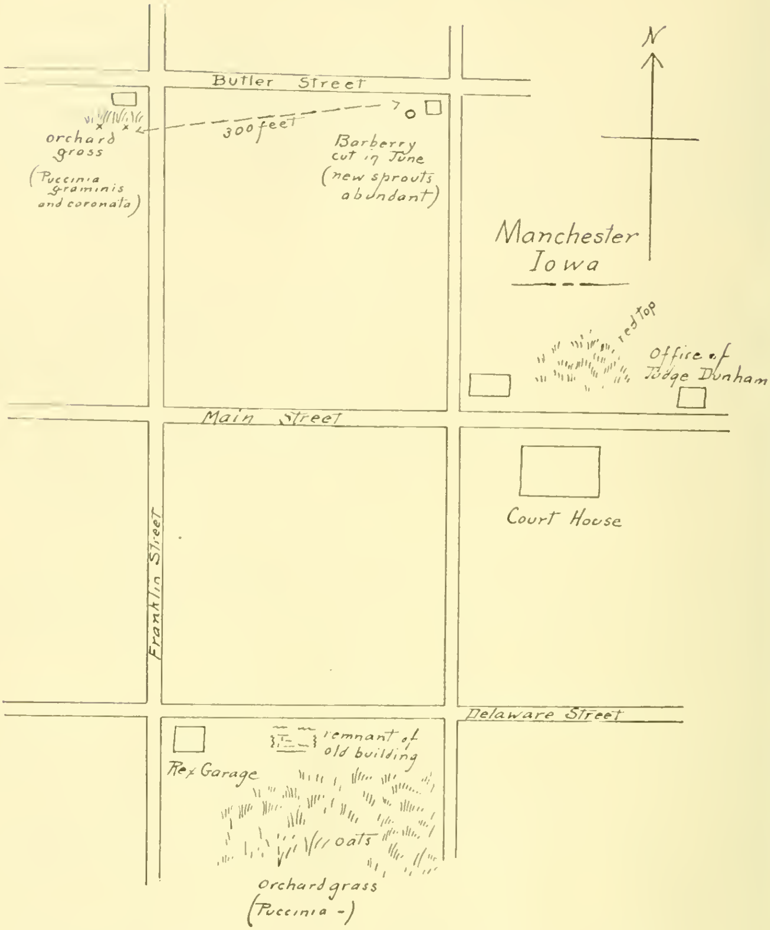

FIG. 42.—Rust and Barberry plants in Manchester. Infection on orchard grass, timothy and oats. (C. M. King.)

Iowa; as well as at Kansas City, Missouri. It is less common at Sioux City, Thorpe, Logan, Fonda, Pocahontas, Garner, Humboldt and Forest City, Iowa. It is also less common in the region to the north of these points in Minnesota. The *Puccinia graminis* was common in this grass at Manchester, Iowa, not far from the barberry bush. I also found this rust on the same grass at Thorpe in northwestern Iowa. I looked for it at many other points, such as Clinton, Dubuque, McGregor, Sioux City, Council Bluffs, Hamburg, East Dubuque, Iowa; LaSalle, Illinois; Sioux Falls, South Dakota, without finding it. I have found *P. graminis* and *P. coronata* on this host at Ames. Though this orchard grass at East Dubuque was growing in shade, and in moist places the weather and soil conditions for rust had apparently been favorable, yet the plants were free from rust.

Kœleria cristata Pers. The Kœleria is one of the most widely distributed of the native grasses in Missouri, Illinois, Iowa, Wisconsin, Minnesota and the Dakotas. It is common on gravelly knolls or in rocky situations from southern Iowa, Keokuk to Hamburg, north to Lyon county in the west and Allamakee county in the east. It is common everywhere in western Wisconsin along Mississippi river, north to Cass Lake in Minnesota, west to the Red river valley, Big Stone lake and Watertown, LaBolt, Brookings, Mitchell and Sioux Falls, South Dakota. In all of this region the *P. graminis* has never been observed by me. I examined many hundreds of plants during the past summer without finding a trace of the rust on this host. It must be a rare host in nature.

Bromus secalinus L. Cheat is closely associated with the cultivated small grain crops, especially wheat. At one time it was widely distributed in northern Iowa, and especially in northwestern Iowa. Since wheat culture was discontinued to a great extent, this grass has disappeared. For many years chess did not occur in central Iowa. Since winter wheat culture began in southern Iowa it has become common in places as at Burlington, Keokuk, Indianola, Hamburg, Council Bluffs and Whiting. It is common along Missouri river from Kansas City to Sioux City, and in western Wisconsin and eastern Minnesota. *P. graminis* was found once this season near Burlington, Iowa.

Bromus hordeaceus L. Soft chess is quite generally naturalized in Iowa, Missouri, Illinois and Minnesota, occurring in waste places. I have seen this grass for many years, but I have never seen any of the *P. graminis* on it. It is probable that in Missouri, Kansas and the west or in experimental plots the rust may occur. I did not see any of the rust this past season on that host in Iowa.

Bromus tectorum L. The awned brome grass was only a waif in central Iowa in 1892. Now, however, it has become one of the most common of the early spring grasses in central Iowa, at Ames. It has been reported from Mount Pleasant and other parts of southeastern Iowa. I also observed the weed at Sioux Falls, and Mitchell, South Dakota. It has for many years been a troublesome weed in Colorado, Utah and on the Pacific coast. The *P. graminis* has not been observed upon the grass in Iowa by me. With us the species is a winter annual. It is possible that in the south and west regions, Kansas, Oklahoma, Utah and the Pacific coast the rust occurs, and perhaps most frequently in experimental plots. The *Bromus pumilus* on which the rust has been found does not occur in this region as do *B. ciliatus, B. Kalmii, B. purgans, B. marginatus* and the introduced *B. inermis,* which is the most common of all the bromes in western Minnesota and eastern South Dakota. But not in a single instance, though the grass was growing in proximity to the barberry and near infested grasses of *Elymus robustus, Hordeum jubatum, Agropyron Smithii, A. repens* and *A. tenerum,* did *P. graminis* occur. The other perennial species were also free from *P. graminis.*

Hordeæ

Agropyron Smithii Rydb. This grass is a native of the Missouri drainage basin from southwestern Iowa, along Missouri river, extending northwestward through Carroll, Ida, Humboldt, Kossuth, Hancock and Cerro Gordo counties, especially in northwestern Iowa, where it forms a part of the native sod, westward through Nebraska northward to the Dakotas and Minnesota. It has become naturalized along the right of way of railroads in almost every county in Iowa, from Keokuk, Iowa, to La Crosse, Wisconsin, Tracy, Ortonville and Graceville, Minnesota; Walnut, Hamilton, Zearing and La Salle, Illinois. *Puccinia graminis* was common at Humboldt, Fonda, Pocahontas, Sibley, Spirit Lake, Rock Rapids, Forest City, Luverne, Algona, Corwith, Northwood and Garner, Iowa. It was also common at Graceville, Tracy, Marshall, Ortonville, Albert Lea, Minnesota; Mitchell, Watertown, Brookings, Millbank and Sioux Falls, South Dakota. In many of these places the plants were in proximity to barberry hedges.

Agropyron psuedo-repens Scribner and J. G. Smith. This species has been united with *A. tenerum* by A. S. Hitchcock. It is not common in the region. It occurs in northwestern (Lyon county) Iowa and adjacent parts of South Dakota, as at Sioux Falls and Mitchell. *P. graminis* occurs on this grass but not as abundantly as on the *A. tenerum* or *A. repens* or *A. Smithii.* It is not an important factor in rust.

Agropyron tenerum Vasey. Slender wheat grass is widely distributed and common in eastern South Dakota, as near Mitchell, Watertown, Brookings, Sioux Falls; in southern Minnesota, at Graceville, Ortonville, Granite Falls, Worthington and Albert Lea; in Iowa at Rock Rapids, Little Rock, Thompson, Sibley, Spirit Lake, Lake Park, Forest City, Lake Mills, Garner, Britt, Humboldt, Havelock, Marathon and Armstrong. It is a native in Iowa, especially west of Mason City.

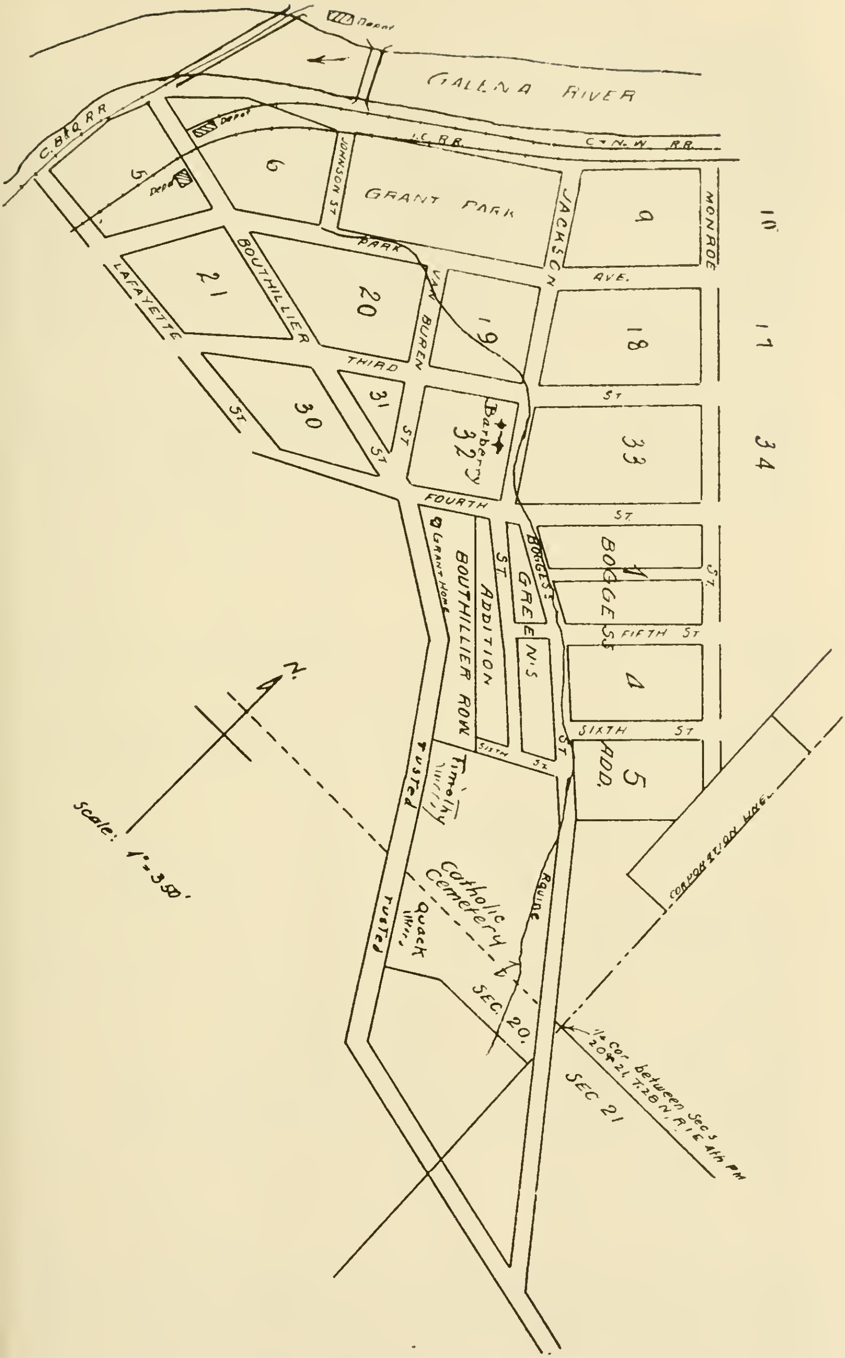

FIG. 43.—Relation of Barberry to stem rust of grass (*Puccinia graminis*) in Galena, Illinois. Barberry marked +, grasses marked ||||. (C. M. King.)

Agropyron Richardsonii Schrad. is not uncommon in native prairie sod of northern Iowa, southern Minnesota and eastern South Dakota. In Iowa it was observed in Winnebago, Dickinson, Kossuth, Lyon and Osceola counties, and in Minnesota at Graceville, Ortonville, Luverne, Worthington and Tracy; in South Dakota at Watertown, Sioux Falls, Mitchell and Brookings. There is no tendency for this grass to spread. The grass is not common and not much of a factor in rust. At Mitchell, South Dakota, and Sanborn, Minnesota, it was infected with *P. graminis;* also at Sibley, Iowa, and a few other points.

Agropyron repens Beauv. Quack grass is generally established in northern Iowa, Illinois, western and southern Wisconsin, Minnesota, eastern South Dakota and western Minnesota. The grass occurs in the greatest abundance in the area north of the main line of the

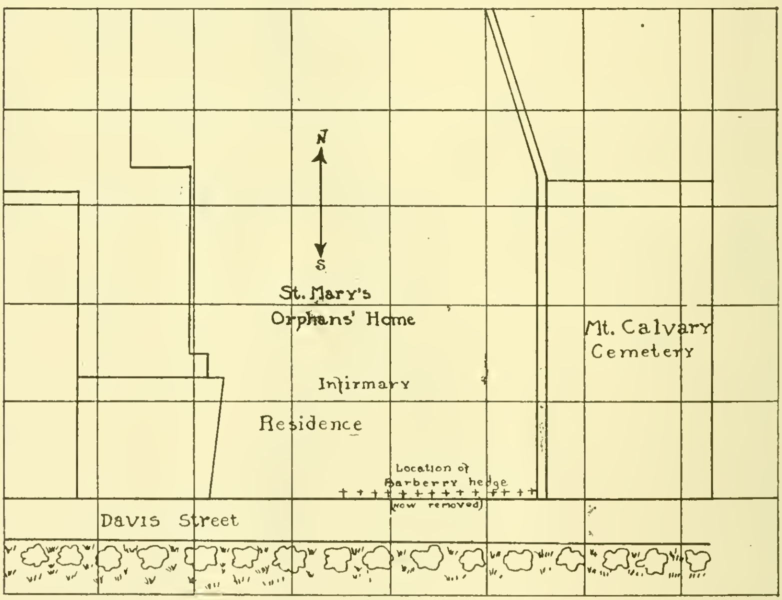

Fig. 44.—Barberry and rust, Saint Mary's Orphans' Home, Dubuque. (C. M. King.)

Chicago & North Western Railway and is most abundant in the center of the Wisconsin drift area, a region embracing the following counties: Emmet, Kossuth, Winnebago, Hancock, Cerro Gordo, Franklin, Wright, Humboldt, Hamilton, Story and Marshall counties, with the center of distribution in Kossuth, Winnebago and Hancock counties. It is also extremely common in the counties immediately north of these in Minnesota, extending east to Mississippi river. Locally the grass is well etablished in Dubuque county, Iowa, and in the vicinity of Galena, Illinois. It occurs in northern Missouri and southern Iowa, but only in isolated areas. *Puccinia graminis* was common everywhere in the region. Mention may be made of the following localities where I noted its occurrence: Garner, Britt, Corwith, Forest City, Thompson, Lake Mills, Humboldt, Northwood, Clinton, Dubuque, Keokuk, Burlington, Ottumwa, Des Moines, Ames, Sibley, Spirit Lake, Sioux City, Hamburg, Council Bluffs, Rock Rapids, Little Rock, McGregor, Postville, Clermont and Farley in Iowa; Hamilton, Zearing, Walnut, LaSalle, East Dubuque, Galena, and Scales Mound in Illinois; La Crosse, Prairie du Chien, Onalaska, Wisconsin; Albert Lea, Marshall, Luverne, Granite Falls, Sanborn, Graceville, Ortonville, Minnesota; La Bolt, Watertown, Humboldt, Mitchell, Brookings, Sioux Falls, South Dakota.

Hordeum jubatum L. Squirrel tail grass is widely distributed throughout northern Illinois, Iowa to northern Minnesota, Nebraska and South Dakota, less commonly in southern Iowa and northern Missouri. It is found throughout the region of Iowa and except southward it is one of the most common of our weeds and weedy grasses. Pastures everywhere in June are purple with the bristly tops of this grass and everywhere from July to frost one may find the *P. graminis* on it. *Puccinia graminis* was abundant at Forest City, Garner, Corwith, Algona, Rock Rapids, Humboldt and Little Rock in Iowa and at Graceville, Marshall, Ortonville, Luverne, Minnesota; Watertown, Mitchell, Brookings, Humboldt and Sioux Falls, South Dakota. It was also abundant at La Crosse, Wisconsin. Its course of development and spread during the early autmun months and late summer is rapid. It is of interest to add that all uredo spore development practically ceases with the hard killing frost, which in 1918 was the latter part of November. I may also add that *P. graminis* did not spread much after the early frosts of October. I watched the grass during much of the winter, which was a mild one. I made observations on squirrel tail grass from November 18, 1918, to April 20, 1919. The severe frosts late in November prevented any further growth of squirrel tail grass. The older stems were covered with the teleutopustules and occasionally some uredo pustules disappeared after the first of December. Even such plants removed to the greenhouse, for another purpose, when they were cut close to the surface of the ground, did not show any uredo sori. Plants observed at Ames and Des Moines beginning December 9, 16, 23, 30, in 1918, and January 4, 11, 18, 25, February 1, 8, 15, 22, March 1, 8, 15, 22 and 29, April 5, 12 and 19 showed no traces of uredo spores although the old stems in some cases were covered with teleuto sori of the fall. It is certain that by the cold previous to November 8, when much of the vegetation of delicate plants was killed, leaving volunteer plants of wild oats and wheat,

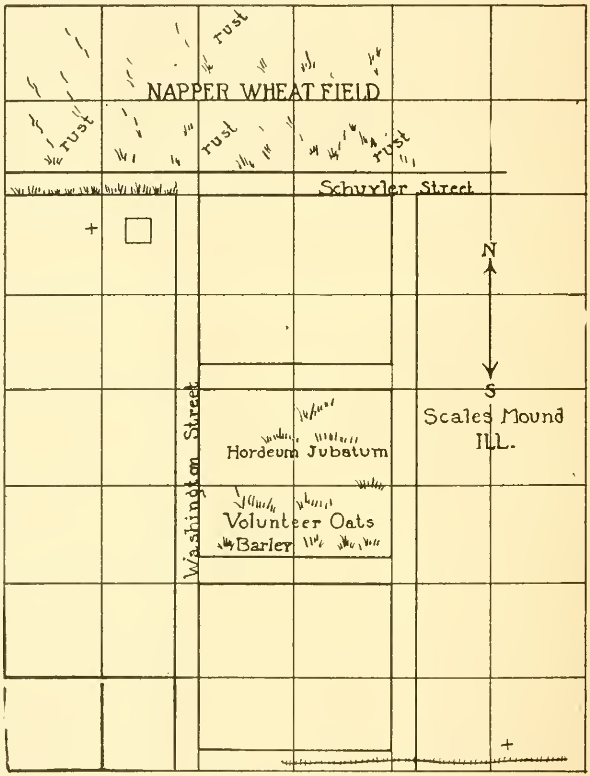

FIG. 45.—Rust and Barberry, Scales Mound, Illinois. +=Barberry. (C. M. King.)

the squirrel tail was uninjured or but slightly injured. Though wild rye, *Elymus virginicus,* had considerable leaf rust and *Puccinia montanensis* and *P. rubigo-vera* were common on the leaf of squirrel tail, no further development of *Puccinia graminis* occurred on oats, wheat, quack grass, timothy or squirrel tail.

Hordeum cæspitosum (Scribner) is a grass of western and northern Wyoming, northern Colorado and central Utah. It was found, as a waif, near Mitchell, South Dakota, and had some rust on it.

FIG. 46.—Map of Forest City showing relation of Barberry to rust. Barberry marked +, wild grasses marked |||. Chauper hedge, Hancock County, shown at margin.

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Hordeum pusillum Nutt. Little barley is a very common grass from southern Iowa and central Illinois, southward to the gulf coast and westward. In Missouri it occupies streets and waste places, excluding many vernal plants. It is common in Marshall, Johnson, Scott, Louisa, Wapello, Pottawattamie and Clinton counties, and has been reported from Lyon county in northwestern Iowa by Shimek. It is not, however, except locally, a common grass much north of Clinton county on the east, Marshall in central Iowa and Harrison county in western Iowa.

I did not find *Puccinia graminis* on this host. Stakman and Piemeisel reported it on this grass at University Farm, St. Paul, Minnesota.

Hordeum nodosum L., is common in the Rocky mountain region, extending eastward to western Iowa, Minnesota, Texas and Mississippi. *P. graminis* has not been found on it by me. There is no reason why it should not occur because of its close relationship with the squirrel tail.

Hordeum vulgare L. Generally cultivated in the region, more especially in northern and northeastern Iowa, southern Minnesota and eastern South Dakota and Nebraska. *Puccinia graminis* was found at Lake Mills, Spirit Lake, Rock Rapids in Iowa; La Crosse, Wisconsin; Graceville, Ortonville and Granite Falls, Minnesota; Watertown, Brookings and Mitchell, South Dakota, but was not serious at any of these points.

Hordeum Pammeli Scribner and Ball. This grass was first collected by the writer a great many years ago near Dakota City, Humboldt county, Iowa. It is not common in Iowa, at least the writer had not observed it in Iowa until this year, probably because it matures early and then disappears. During the past summer fragments of the grass were found at Sibley, Iowa, and near Mitchell, South Dakota. It is distributed from central Illinois, Stark county, to Humboldt and Osceola counties in Iowa, Brookings and Mitchell, South Dakota and Wyoming. This is an early maturing perennial grass. It is probably overlooked by most uredinologists for this reason; then, too, it is a rare grass. The specimens found at Sibley, Iowa, were fragmentary. The plant was growing on the right-of-way of the Chicago, Rock Island & Pacific Railway, next to some plants of *Hordeum jubatum, Agropyron Smithii* and *A. tenerum.* There were some good uredo pustules on the stem. It must therefore be given as one of the host plants of the rust. I did not make cultures, so the biological form was not determined. Some *P.*

graminis occurred on *Agropyron Smithii* and *A. tenerum* in the vicinity.

Triticum vulgare Vill, is generally cultivated in the region. Its cultivation in Iowa in 1918 was quite general and in Minnesota and South Dakota it was grown extensively. Winter wheat is grown most extensively in southern Iowa and along the Mississippi, as far north as La Crosse, Wisconsin; Winona, Minnesota, and along the Missouri to Sioux City, as well as in eastern Nebraska, Illinois and Missouri. *Puccinia graminis* is common on this host throughout the region. In the winter wheat section only a little rust occurred on the host in the southern part of the state as at Indianola, Burlington, Ottumwa and Keokuk, but the damage was not great. The government advised the planting of spring wheat in spring grain areas of Iowa. Acting on the advise of the government and the Extension Department of the college, small areas were planted to spring wheat in many sections of the state, where for many years spring wheat had not been grown. Many farmers used Marquis, which is less rusted than most other spring varieties, because of its earliness. The Velvet Chaff, for instance at Britt, Duncombe, Forest City and Lake Mills in Iowa was much more rusted than Marquis. At Sanborn and Graceville, Minnesota, Velvet Chaff in some places was badly rusted, while there was little rust on Marquis. It is also noteworthy that oats *(Avena sativa)* when grown under the same conditions at all of the above points, had less stem rust than wheat. In most cases only slight injury resulted. The early oats practically escaped rust in most instances.

Secale cereale L. This cereal is not common in Iowa, except on sandy soils in eastern Iowa from Muscatine northward, through Clinton, Dubuque, Clayton and Allamakee counties in Iowa and north to La Crosse and Trempleau counties in Wisconsin. It is common also on sandy soil in southern Minnesota, and west to Graceville and Ortonville and to South Dakota. In Iowa winter rye is not an important agricultural crop. The winter rye crop was not seriously injured by *Puccinia graminis* in Iowa. A little was noted at Clinton and in Dickinson counties. This rust was not serious in western Minnesota at Sanborn, Graceville and Ortonville. The same conditions prevailed at Watertown, LaBolt, Mitchell, Sioux Falls and Brookings, South Dakota.

Elymus Macounii Vasey. This wild rye is common from northern Iowa to Minnesota and westward, especially in prairie regions. The species occurs from Hamilton county, Iowa, northeast through western Hardin and Franklin, Cerro Gordo and Worth counties, north into Minnesota; northwest from central Hamilton county to Buena Vista and Plymouth counties and westward into South Dakota. It is abundant in Hancock, Winnebago, Kossuth, Palo Alto, Dickinson, O'Brien, Osceola, Lyon counties in Iowa; Minnehaha, Davison, Brookings, Codington, Grant and Roberts counties in South Dakota; Freeborn, Faribault, Jackson, Nobles, Martin, Lyon, Yellow Medicine, Chippeway, Bigstone and Traverse counties in Minnesota. *Puccinia graminis* is common on Macoun's Wild Rye everywhere. It is one of the most commonly infected of the grasses in the region where it occurs. All of the culms are frequently covered with the pustules of this rust from below the head to the surface of the ground, close to the roots. This grass, like quack grass and slender wheat grass, is a perennial. If there is any probability of the mycelium of this rust being perennial there is some chance that *P. graminis* is carried over the winter on this host. It is, however, I believe, an important factor in carrying the rust to some of the cereals.

Elymus canadensis is widely distributed throughout this region from Illinois, Wisconsin, Minnesota, Kansas City, Missouri, and Kansas City, Kansas, to Hamburg, Council Bluffs, Missouri Valley, Sioux City, Iowa; to Mitchell, Brookings and Watertown, South Dakota; east to Graceville and Ortonville in western Minnesota to Winona and Houston in eastern Minnesota.

Elymus robustus Scrib and Smith. This large wild rye is the most abundant of the species in the central prairie region of Iowa. It occurs from western Illinois (Hamilton) and eastern Iowa to Scales Mound, Illinois, and Dubuque, Iowa, north to La Crosse, Wisconsin, to southeastern Minnesota and westward to Ortonville, Minnesota; Brookings and Mitchell, South Dakota; south to Sioux City and Hamburg, Iowa. Cultural experiments have shown that *P. graminis* occurs on *Elymus canadensis* and *E. robustus*. The writer found uredo pustules of what appear to be *P. graminis* on the culms of *Elymus canadensis* at Sibley, Thompson and Spirit Lake, Iowa. At Luverne, Minnesota, and La Crosse, Wisconsin, it was found on *E. robustus*. The uredo sori were not numerous but these observations were made early in August. I am satisfied that the pustules may have increased in number later in the season. It may be of interest to mention that at Sioux Falls and Mitchell, South Dakota, and in northeastern Hancock county, Iowa, an abundance of rust outwardly resembling *P. graminis* occurred on the *Elymus robustus*. *Elymus robustus* was abundant but isolated at Ottumwa, Burlington and Keokuk, Iowa, and Hamilton, Zearing and Walnut, Illinois, but with no evidence of *P. graminis*. The uredo and teleuto pustules of the rust on the *E. canadensis* and *E. robustus* are somewhat scattered. Cultural experiments were not made, but I am told by Mr. Kirby that some of this rust obtained by culture is undoubtedly *P. graminis*. It has, however, none of the external appearances of the *P. graminis* as it occurs on *E. Macounii* and *Agropyron repens* and *A. Smithii*. The pustules of the rust on *E. robustus* are not often confluent although the teleuto sori occur around the stem sometimes for nearly the entire length of the culm. The plants of *Elymus canadensis* and *E. robustus* with uredo spore pustules appear to be *P. graminis*. These plants were invariably near *Agropyron tenerum, A. Smithii* and *Hordeum jubatum*. A *Puccinia* resembling *Puccinia graminis* was found in abundance on *Panicum virgatum* near Camanche. It was growing in proximity to *Elymus robustus,* but the wild rye was free from rust. The *Puccinia* on *Panicum virgatum* is usually referred to *P. Pammelii* whose aecidium stage occurs on *Euphorbia corollata*. This spurge was common in the vicinity. Another rust, the *Puccinia montanensis* Ell., first described on *Elymus condensatus* Ell., occurs on the leaf and was described as follows:[9] "Sori mostly linear, lying between the nerves of the leaf and often confluent for 1 cm. or more long, so very abundant as to blacken the leaf, hypophyllous, black, at first covered by the epidermis, but soon bare, not prominent. Teleutospores ovate or elliptical, 25-50 by 15-22 μ, sessile or nearly so, moderately constricted at the septum, apex rounded or flattened, sometimes obliquely flattened, strongly thickened, but not papillate, darker colored and mostly shorter and broader than in *P. rubigovera*. The sori are mostly surrounded by paraphyses. The habit also is different." It is a well known rust of Iowa on several species of *Elymus*. H. H. Hume[10] described it because of the marked peculiarities of the teleutospores. This rust has been found repeatedly by me during the past summer on *Elymus canadensis, E. robustus* and *E. virginicus*. H. S. Jackson in the Uredinales of Indiana reports this rust *(Dicæoma montanensis)* (Ell.) Kuntze on *Elymus canadensis*. The writer and Miss King[11] in 1912 referred a leaf rust found on *Phleum pratense* and *Elymus robustus* to *Puccinia Impatientis* (Schw) Arthur. This was based on the work done by Arthur in 1902[12]. Only a single species of grass was there recorded.

[9]Journal Myc. 7 : 274.
[10]Bot. Gazette 28 : 429, f. 4, 1899. See also Saccardo Sylloge Fungorum 11: 201.
[11]Rep. Ind. Acad. Sci. 1915 : 454.
[12]Bull. Ia. Agrl., Exp. Sta. 131 : 204.

Jackson[13] has since added some additional hosts, the *Agrostis hyemalis.*

Agrostis perennans, Elymus striatus. It is a significant fact that in my field work this rust was invariably common in places in proximity to patches of *Impatiens aurea* or *I. fulva,* as at Pocahontas, Spirit Lake, Thompson, Garner and Forest City. The timothy infested host of this rust was found in proximity to *Elymus* and also to *Impatiens aurea.* The teleuto spores have a tendency to produce one or more crowns, as figured by us and Mr. Hume. It has some resemblance to *P. coronata.* These field observations are referred to here because they show the complexity of the problem before us.

Elymus virginicus L. A widely distributed grass throughout the region embraced in this paper, usually found in low grounds from Missouri and Illinois to Wisconsin and South Dakota and Nebraska. *Puccinia graminis* has been recorded for this grass but it was not observed by me although I looked for it carefully at Burlington, Ottumwa, Clinton, McGregor, Postville, Lake Mills, Thompson, Forest City, Garner, Northwood, Dubuque, Rock Rapids, Little Rock, Spirit Lake, Sibley, Sioux City, Hamburg and Council Bluffs in Iowa; at Sioux Falls, Mitchell and Brookings, South Dakota; at Luverne, Granite Falls, Albert Lea, Minnesota; at La Crosse, Wisconsin, and at La Salle, Galena, Walnut, Hamilton and Zearing, Illinois. I am inclined to think that this grass is not a factor in stem rust of grains in this region.

Elymus brachystachys Scribner and Ball. The short spiked rye grass on which *P. graminis* has been reported occurs from Michigan to Texas, west to Nebraska and South Dakota. It is not uncommon in the region. In Iowa it has been found at Sioux City, Hawarden, Dakota City, Elmore, Rock Rapids; also from Sioux Falls, South Dakota. *Puccinia graminis* has not been found on the grass by the writer. It must be rare on this grass. Several other species of *Elymus* occur in the region. The fact that *P. graminis* has been reported on five species of *Elymus* occurring in the region would lead one to believe that the rust may occur on other species. Of the other species the most common are *E. striatus* and *E. Arkansanus,* which are more closely related to *E. Macounii* than *E. virginicus, E. canadensis* and *E. robustus,* on which *P. graminis* had been reported. The aspect and texture of leaf and stem of *E. Macounii* approach those of *Hordeum* which may make it easier of infection. Field

[13]Bot. Gazette **35**: 18.
Proc. Ind. Acad. Sci. **1915** : 452. See also Uredinales of Indiana
Proc. Ind. **1917** : 345, reported under *Puccinia Impatientis* (Schw) Arth.

studies certainly show that *E. Macounii* is more commonly infected with *P. graminis* than any other *Elymus,* and that it ranks with *Hordeum jubatum, Agrostis alba, Phleum pratense, Agropyron tenerum, A. repens* and *A. Smithii* in being an important host for *P. graminis.*

Asprella Hystrix Willd. This grass is widely distributed in Iowa from Hamburg in Fremont county to Rock Rapids in Lyon county on the west and across the state from Keokuk in Lee county to New Albin in Allamakee county; also abundant in western Illinois north to Galena, and to La Crosse, Wisconsin, west to Big Stone Lake in Minnesota and to eastern South Dakota. It is found in woods and borders of woods. Stakman and Piemeisel report the rust on the species from St. Paul and Ramsey county, Minnesota, both *P. graminis tritici* and *P. graminis secalis.* The strain found was less virulent than the typical *P. graminis secalis.* On some of the grasses they report a normal development naturally and when inoculated. It must be a rare host for it in nature. The host is quite generally free from fungus diseases, except the *Phyllachora graminis,* which is common.

THE RELATION OF WILD GRASSES TO THE BARBERRY

I shall not attempt in this connection to give an extensive account of the relation of the various biologic forms of *Puccinia graminis* to the aecidium on the barberry. I will cite a few illustrations which have come under my observation.

Lake Mills Case—The Lake Mills region is a glaciated one in the Wisconsin drift area, consisting of marshes and wooded areas interspersed originally with prairie. At Lake Mills I found a barberry hedge of 100 plants near the elevator on the premises of Mr. Opdahl. The hedge was removed about June 29, a month before my visit. The Chicago & North Western Railway is adjacent to this lot and the right-of-way of the railroad contains the usual wild grasses, *Hordeum jubatum, Agroypron Smithii, A. tenerum, A. repens, Agrostis alba, Phleum pratense* and *Elymus canadensis.* A small field of oats and barley adjacent to the railroad and 900 feet away from the barberry bushes was badly rusted. The wheat and oats were hardly worth cutting. The wild grasses mentioned also were badly rusted in the vicinity. The rust on these grasses also occurred for 300 feet from the barberry bushes, the infection gradually diminishing up to 1,500 feet. The rust on a small patch of wheat one-half mile away was not severe. It is certain that the barberry influenced rust on the wild grasses to a considerable extent.

Forest City Cases—At Forest City in the same county a hedge of the purple leaved barberry on the Thorson place was not removed. There was plenty of evidence of old æcial spots on the barberry leaves and for two blocks in each direction an abundance of uredo

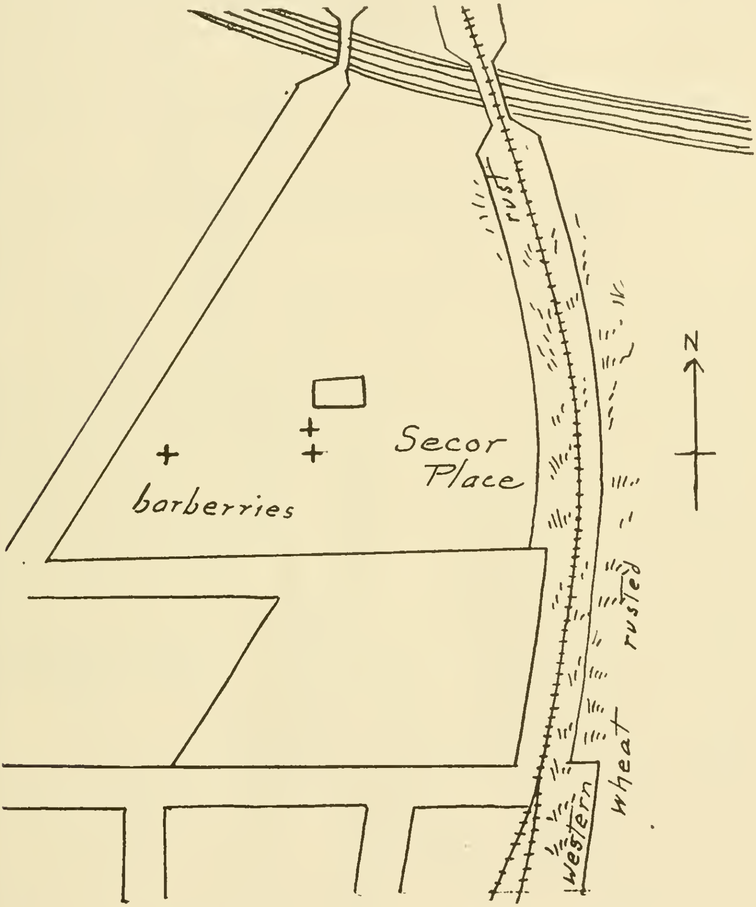

FIG. 47.—Barberries on the Secor place, Forest City.

stage on red top *(Agrostis alba)* and also on timothy *(Phleum pratense* and *Hordeum jubatum).* If the infection on the timothy was not direct from the barberry leaves, it must have been carried from the *Hordeum jubatum.* The same thing was true for wild grasses in the vicinity of the Emanuel Lutheran church. I next visited the south side of the city along the road crossing Lime Creek, about one-half mile from the Lutheran church. The roadside was abundantly grown over with *Agropyron repens* and *A. tenerum,* there was also some late oats in a few places. These plants were all badly infected with *P. graminis.* I did not know at the time that there was any barberry in the vicinity. Two months later there was located the barberry bush which accounted for the heavy rust infection in that vicinity.

The Chauper Place, Hancock county.—I found some bushes of the common barberry, one and a half miles south of Forest City in Hancock county. Immediately south of the place was a barley field. Old æcia occurred in abundance on the barberry leaves. The barley was badly rusted as was the Marquis wheat, one-fourth of a mile a way. The *Agropyron tenerum, A. repens, Hordeum jubatum* on the road near the barberry bushes were all badly rusted. The infection on these grasses could be traced along the highway for 800 feet.

At Northwood, Iowa, the rust on *Hordeum jubatum* and *Agropyron repens* was easily traceable to the hedges on the Mrs. Butler place and another hedge near the Minneapolis & St. Louis Railroad.

At Spirit Lake and Lake Park there was an abundance of rust on volunteer oats, *Agropyron Smithii, A. tenerum,* wheat, and *Elymus Macounii.* According to Mr. Sawhill all barberry plants were removed in April. I am, however, inclined to think that some bushes were overlooked. The infection of grain probably came from the wild grasses. At Lake Park, Green Russian oats and Spring wheat where they were lodged were badly rusted. I did not see any barberry. All of the barberry plants were said to have been removed early in the spring. I have my doubts about this.

Sibley, Osceola county—An active campaign to remove the barberry was carried on in the spring and I was informed that there were none in the vicinity. Wheat and oats were badly rusted, but there was an abundance of *P. graminis* on *Hordeum jubatum, Agropyron Smithii, A. repens, A. tenerum* and some on *H. Pammeli.* These rusted plants were all found in the same vicinity. It occurs to me in this case that some æcia were produced infecting the plants or some of the barberry plants which were overlooked.

Rock Rapids, Lyon county—I observed a great deal of rust on *Hordeum jubatum* and *Agrostis alba* in the vicinity of the city library at Rock Rapids. A little search revealed the presence of barberry, several clumps, in the yard of the public library. This accounted for the abundance of rust for several blocks in the vicinity. Old æcia were common on the barberry. I made a count of the infected leaves

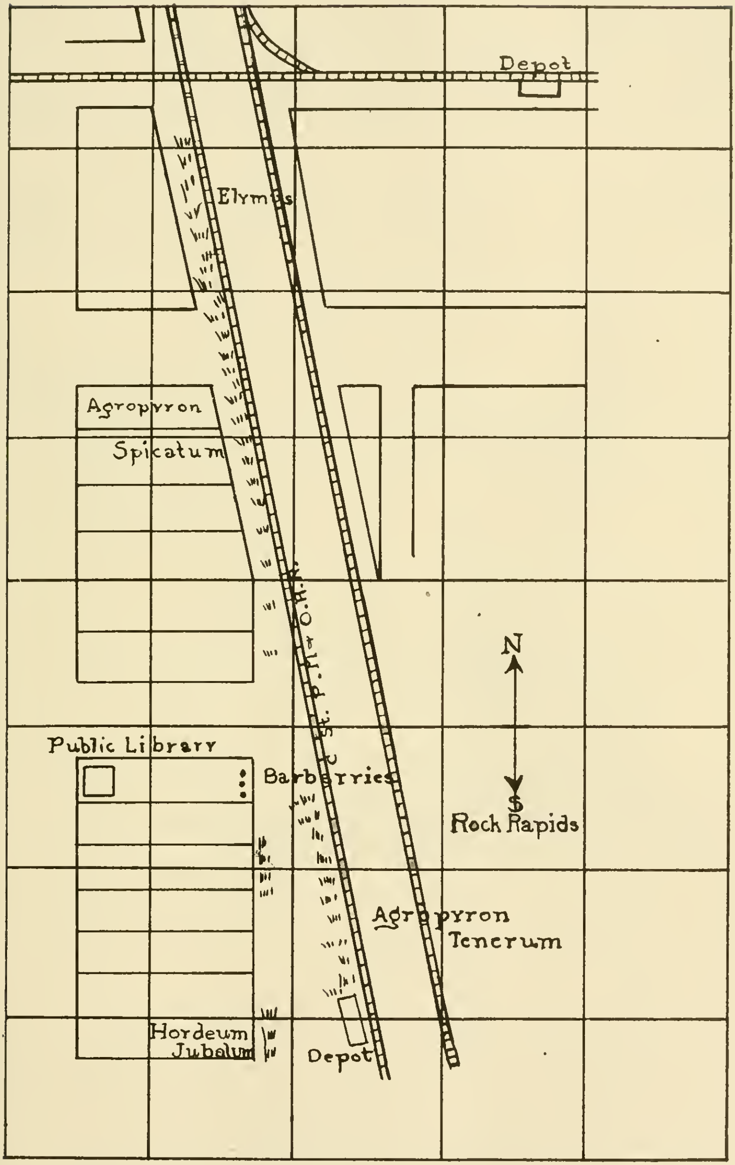

FIG. 48.—The relation of Barberries to infected grasses at Rock Rapids. (C. M. King.)

and found 25 per cent. This accounts for the heavy rust infection. For 900 feet along the right-of-way of the Illinois Central Railway *Hordeum jubatum, Agropyron Smithii, A. tenerum, A. repens* and oats were all badly infected with *Puccinia graminis*.

Sioux Falls, South Dakota—The abundance of rust near the Woodlawn cemetery was undoubtedly connected with the barberry cut off early in the spring, the low growing shoots having produced some æcia.

Garner, Hancock county—There was evidence on every hand that this rust on *Hordeum jubatum, Agropyron repens,* wheat and barley could be traced directly to the barberry in the vicinity. The same thing was true for two other points in this county.

Dallas Center—On the Charles Rhinehart place were several bushes of barberry. *Hordeum jubatum* and *Agrostis alba* were badly infected for thirty-two feet from the bushes. On the William Danner place a mile and a quarter from Dallas Center there was a hedge of barberry fifty feet long. Red top on the roadside was

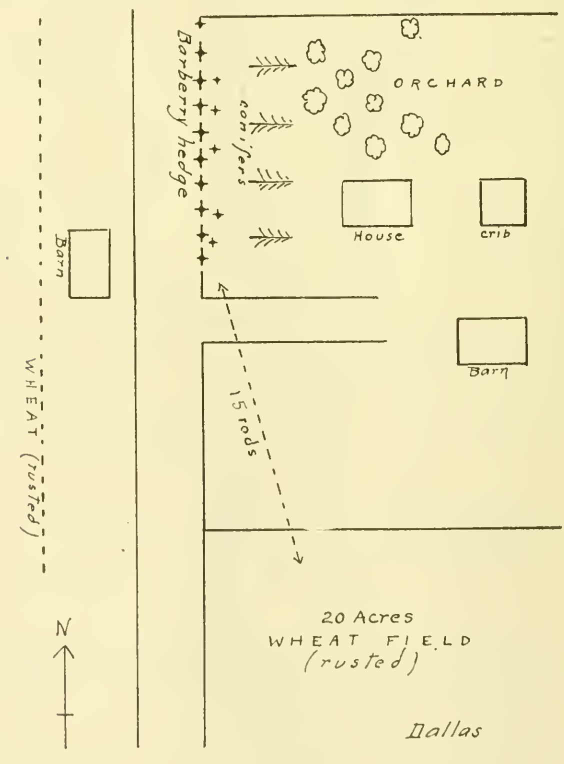

Fig. 49.—Danner wheat field and Barberry, Dallas Center.

badly infected with *P. graminis*. A field of wheat of the variety known as Gold Drop on the farm of William Nissley 460 feet to the west of the barberry hedge was badly rusted. Mr. Pickford, the county agricultural agent, said it was the most severely rusted field of wheat in the county. It may be noted here that farm buildings occurred between the barberry hedge and the field of wheat.

The Waukon, Postville, McGregor and *Clermont Cases*—These cases are all of interest because of the presence of wild barberry in all of these places, except the Waukon locality. A barberry hedge

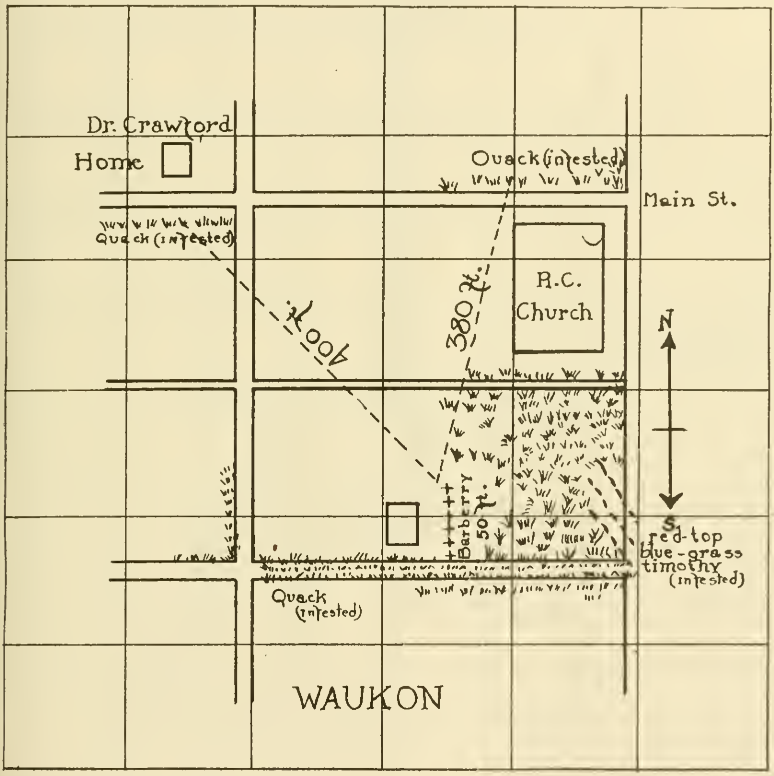

Fig. 50.—Barberry hedge and relation to Barberry of abundance of rust on streets near hedge, Waukon. (C. M. King.)

some fifty feet long in the city of Waukon was next to a vacant lot covered with timothy and red top with some quack grass in the street and on the lot adjacent to the street. *Puccinia graminis* was abundant on the culms of quack grass, in fact it was literally covered with rust. It was also found that quack grass in the streets for several blocks in every direction had rust upon it, the amount gradually becoming less. Timothy and red top in the vacant lot also

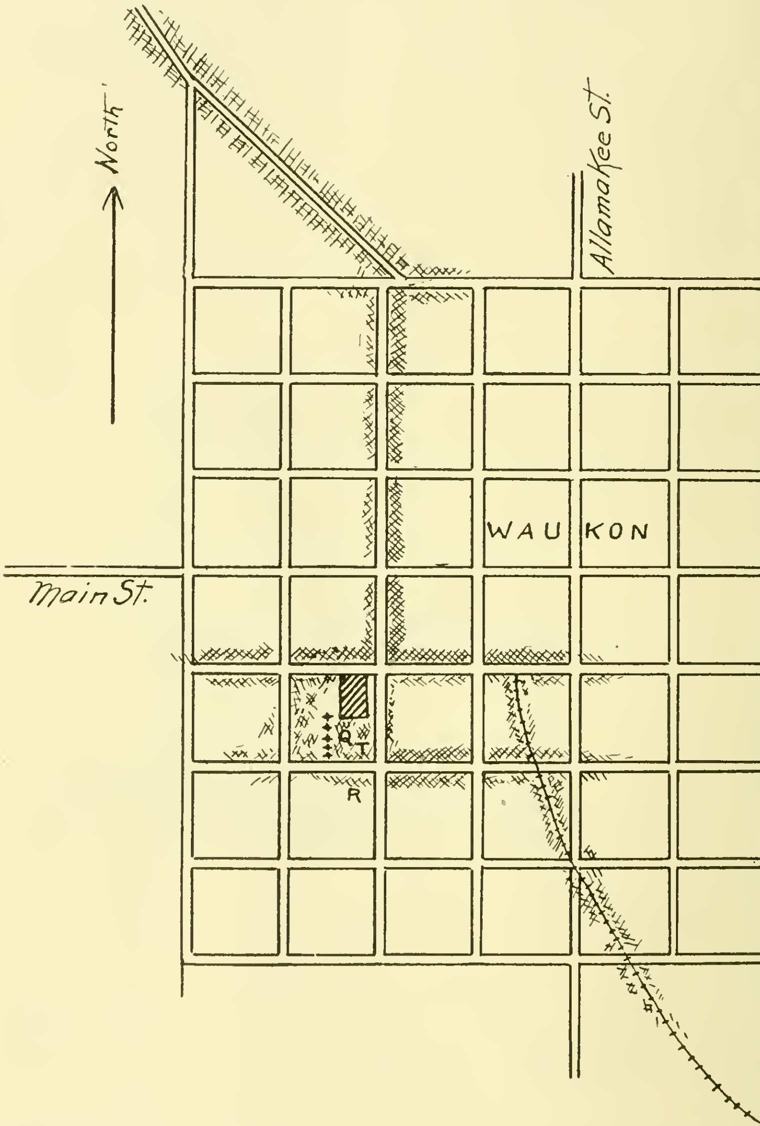

Fig. 51.—Relation of Barberry to rust on grasses at Waukon.

were badly infested, the rust on timothy occurring on leaf and stem. It seemed to me a very clear case of the influence of the æcidium of the barberry on the rust on grasses. There were plenty of old æcia on the barberry. At Postville the writer found a single large clump of wild barberry and several smaller ones on the farm of Mr. Orr, a little distance out of the city of Postville. There was an abundance of *P. graminis* on oats in the field nearby and on red top. Several hedges of barberry occurred in the city of Postville and the presence of these accounted for the large amount of *P. graminis* along the Chicago, Rock Island & Pacific Railway, on wild grasses like red top, squirrel tail, quack grass and volunteer oats, and on wheat near the elevator.

At Clermont wild barberries occurred for half a mile along the highway and in these places there was invariably considerable rust on squirrel tail, red top and timothy as well as on oats.

Early in July the writer examined the red top in the vicinity of several hedges in the city of McGregor. Red top, which was the most common grass in the vicinity, was badly rusted in every case. Later in the season I examined the wild grasses in the vicinity of the wild barberry. An abundance of rust was found on squirrel tail grass and quack grass. In some cases the culms were covered with the black pustules.

The Fonda and Pocahontas Cases—In response to a request from Mr. O. B. Dunbier of Pocahontas, Iowa, I visited the place of Mr. J. Jordan of Fonda, who had a hedge 266 feet long, facing two streets and adjacent to fields of small grain. The barberries had been planted in two rows; in all there were about 500 separate clumps with an average of 15 stalks to each clump, making all told about 7,500 stalks with about 1,125,000 leaves. As near as I could determine, 5,000 leaves carrying æcial spores or about 11,250,000 spores were produced by this hedge. Perhaps 50 per cent would reach a favorable nidus for germination. There was certainly enough material here to produce a rust epidemic. The oats in the vicinity, according to testimony, were badly rusted. It is certain that *Hordeum jubatum, Agropyron Smithii,* as well as the *Agropyron tenerum* growing on the highway were abundantly rusted.

The writer also found in the city of Pocahontas a single large clump of barberry and the orchard grass adjacent to it was infected with *Puccinia graminis*. An abundance of this rust was found on quack grass also. The same rust was found at Thorpe in the same county, but whether it was associated with a barberry I am unable to say. None of the barberry was observed.

Hamilton, Illinois, Case—Another interesting case came under my observation in Hamilton, Illinois. In going through the woods and fields looking for rust, which was not much in evidence, I found in one place an abundance of *P. graminis* on red top and timothy. Mr. Dadant informed me that there was a barberry hedge 150 feet away, which of course accounted for the rust infection at this point.

As other instances where rust could be directly connected with the barberry, mention might be made of Scott, Clinton and Dubuque counties, but these have been considered by Melhus, Kirby and Durrell in a paper on stem rust of cereals.

In conclusion, I have always believed that the barberry is an important factor in the production of rust, but not the only one. I felt that possibly, under some conditions the mycelium may be perennial, or that the uredo spores may be viable in the spring or that there is a possibility that rust may move northward as the season advances. I am of the opinion that our rust epidemics in the north can be attributed mainly to the æcial stage on the barberry, and that its removal in the grain belt will very materially increase the production of wheat, oats and barley. Wherever the barberry occurred there was much rust on grain and wild grasses, like squirrel tail grass, red top, quack grass, Macoun's wild rye, western wheat grass and in some cases timothy.

Department of Botany,
Iowa State College.

THE BARBERRY IN IOWA AND ADJACENT STATES

L. H. PAMMEL

Of the 160 species of barberry generally recognized only the following have been commonly cultivated in Iowa; the common or European barberry *(Berberis vulgaris)*, the Japanese barberry *(B. Thunbergii)*, the *B. canadensis, B. amurensis, B. Sinensis, B. ilicifolia, B. Fischeri* and *B. macrocarpa*. The *B. Fischeri* and *B. macrocarpa* are regarded as synonyms of *B. canadensis*. The common European barberry, though commonly credited to western Europe, is Asiatic according to J. Lind's "The Barberry Bush and its Law," being a translation from Berberisbusken og Berberisloven. Through the kindness of Dr. Humphrey and Dr. Melhus I was furnished with the paper by J. Lind in which he makes the following statements: "The original home of the barberry bush is the middle and western Asiatic mountains, where it still grows wild in the Himalayas; its brightly colored berries attracted the attention of man and it is spoken of as a medicinal plant by the early Babylonian and Hindu writers. On the signs which composed King Sardanapal's library in Nineveh, B. C. 650, the berries are spoken of as a detersive agent. Later the plant has had the same destiny as so many other Asiatic medicinal plants; that of being carried from one country to another by man and cultivated as a useful plant until it has been replaced by other mediums. Many of the noxious herbs we have in our land, have, in earlier times been introduced as useful plants, sometimes as a kitchen garden plant, sometimes cultivated in the medicinal gardens of the monasteries and finally lost track of. The barberry bush is not mentioned by the Greek or Roman doctors who are noted for their knowledge of the medicinal quality of herbs from the time of Hippocrates, who lived in southwestern Asia from 459 to 377 B. C., to the time of Galen, who was the life doctor for the Roman Emperor Marcus Aurelius, 200 A. D. There is therefore cause to believe that the bush was not found north of the Mediterranean at that time. It came into use in the seventh century when the Arabians had spread their power over the neighboring states and established a kingdom whose well-organized conditions and blossoming culture was unequalled at that time. Medical art was considered very important among the Arabians, and we owe many of the physical remedies which we used during the middle ages and until the present day to the Arabians, besides the origin of the pharmacies. One of the Arabian doctors who used the berries from the barberry bush as medicine was Rhazes. He was born in Persia 850 and died 923. He was the life doctor for the Kaliff in Bagdad. Nikolaos Myrepaus, doctor in Alexandria from 1270 to 1290 was another. Their books were translated into Latin and became well known in Europe during the middle ages. Constantinus Africanus was the first man to bring the knowledge of the barberry plant to Europe. He was born in Carthage during the eleventh century and traveled for many years through Babylon, India, Egypt, and northern Africa for the purpose of studying the medical art of the Arabians. He was finally made manager of the medical school in Salerno. Because of his ability this was the most noted institution in Europe for doctors, during several centuries. Constantinus Africanus died in 1087. His books were translated into many languages. The first Danish botany was written by King Erik Plovpenning's doctor, Henrik Harpestraeng, who died 1244. This is a translation from Constantinus Africanus' works.

"Because Henrik Harpestraeng speaks of the barberry bush, several people considered it a proof that the plant existed in the north before the book was published. This is surely a false conclusion. But there is reason to believe that the knowledge of the bush and the recommendation it received in the books has led man to obtain samples of it and cultivate it just as the other plants that were used at that time, since each physician's or each monk's medical power lay in the herbs he cultivated in his garden. The transplanting of the bushes into the gardens surely took place a long time after the publication of the books concerning it, but there is reason to believe that the transplanting followed the same course as the knowledge of it; namely, from southern Asia across Egypt and Barbary to southern Europe; from there northward along two lines, one from Italy by those who visited the school of Salerno, the other by the Arabs to Spain and France.

"It is worth noticing that Constantinus Africanus used the name barberry which truly did not distinguish the bush but its berries, just as we use the names gooseberries, currants and strawberries for the eatable berries, and so name the bushes accordingly; as gooseberry bushes, etc. This name is found unchanged in many languages; for example, in Italian, berbero; in English barberry; in German, berbersbeere, berberitzen, etc.; in Danish, Norse, Sweden and Latin, berberis, in Polish, berverys; only in France has it a different name

"Epine-vinete." Later it was called sour-thorn, but this name has never been as common as barberry. This great similarity of names in the various languages proves that the plant was introduced proportionately. Wettstein writes concerning the origin of the name that it is derived from " the Arabian barberrys which signify the berries of this bush; or from Barberry in Africa where the Arabians first found the plant, and brought it to Spain." Professor Buhl, whose advice I have asked on this occasion, has willingly informed me that he believes it is quite possible that the name is derived from the Barbary States.

"This presentation of the introduction of the barberry bush, is confirmed by the fact, that remains of the barberry have never been found in antediluvian or other layers of earth, and it is not mentioned in the earliest books on herbs. According to botany, it has a characteristic common to most of the prominent medicinal plants, that is, that it is very difficult for the barberries to disperse by themselves, and they grow very firmly where they once take root. E. Henning has collected some information about the dispersement of the barberry bush. He says the berries are destroyed by only a very few birds and thus just when they can find no better food. Because of its original nature as a mountain plant, it is known to take root firmly in mountainous places. For this reason it is more common in Norway and Sweden than in Denmark. It is also allowed to grow undisturbed in the mountains. This encourages its growth there. Of the many minerals found in the mountains, this plant prefers limestone. For this reason it is found in great numbers on Moen's Hill.

"During the seventeenth century it was introduced into America from Europe, the result being that laws prohibiting its growth were passed in Connecticut, 1726, and in Massachusetts, 1755."

The genus is widely distributed. Of the 160 species, a dozen are credited to the United States; thirty-three to Chili, forty-two more to other parts of South America, of which Peru has twelve. Mexico has fourteen, China and Japan thirteen, and the Himalayan region of Europe and Siberia nine. The genus is therefore most largely represented in America from Chili to the southern Rockies, including Texas.

During the seventies the discussion on hedge plants in the agricultural and horticultural press as well as in the reports of the State Horticultural and Agricultural Societies is quite voluminous. The plants most frequently mentioned are the osage orange, white willow, honey locust and buckthorn. The barberry, buffalo berry and

Caragana (Professor Budd) were less frequently mentioned. It is, however, interesting to note the opinion of some nurserymen who were adverse to the use of the barb wire. For instance in the report of 1880 Mr. Dickey[1] said: "The repairing costs much more than the time required to cultivate and trim the hedge."

Professor J. L. Budd distributed several Asiatic species rather widely, among them the *B. amurensis* and *B. Thunbergii* but he was probably not the original introducer of the Japanese barberry in Iowa, as the letter from Mr. M. J. Wragg indicates that his father purchased his stock from the Arnold Arboretum in 1868. The *B. amurensis* and *B. Thunbergii* were on the college grounds at Ames when the author came here in 1889. The plants were then about ten years old, making the date of planting about 1879. In the report of the State Horticultural Society for 1881, there is this note by Professor Budd.[2]

"We have introduced from China two distinct species of barberry said to have nearly sweet fruit of which raisins are made in that country. We have not seen the fruit, but can say the plants are interesting on account of their freedom of fungus, while our common species this season are badly afflicted. The new species are richly worth trial." This note establishes the fact that one of the barberries introduced by Professor Budd was the *B. Thunbergii,* the other probably *B. amurensis,* and also that *B. vulgaris* was growing on the grounds. The bush of the common barberry referred to was still there in 1889, in front of what is now Morrill Hall.

As to the early planting of the common barberry in Iowa there is much uncertainty. It appears that there are three phases to its introduction: (1 the pioneer planting because of the old New England associatons, (2) the "living fence" as hedge planting to turn stock, (3) the ornamental planting. The first period falls before 1868 and few plants were planted in this way. The second period falls between 1868 and 1878, the last being the year in which barb wire became quite general in use. Mr. M. W. Robinson mentions the use of the wire fence in 1871.[3] The author states in this article that it may become the fence of the prairie. The zeal in planting and taking care of hedges was flagging in 1878, according to G. H. Little.[4]

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[1]Rep. Ia. State Hort. Soc. 1880; 582.
[2]Rep. Ia. State Hort. Soc. 1881; 378.
[3]Fencing in Iowa, Rep. Iowa State Agrl. Soc. 1871; 268.
[4]Rep. Ia. State Agrl. Soc. 1878; 745.

The third period overlaps the second because men like Professor Budd spoke of its culinary use and its value from an ornamental standpoint.

Most of the older bushes in the state go back to the time when farmers began to plant it to turn stock, during the day of hedge planting, which occurred in Iowa during the late sixties and seventies. A statement by Thomas J. Brooks of Indiana, used in the Iowa Homestead and Western Farm Journal, is of interest in this connection. He said[5] "Seven years ago two barberry bushes were sent to me at my request, as I wanted my children to see them and taste the fruit. Three years ago I became interested in the plant as a hedge plant. These plants are now from six to seven feet high and each plant has sent up from its stool some thirty stalks." Mark Miller, who was then the editor of the Iowa Homestead and a horticulturist, said "We are interested in this new hedge plant and hope to make other experiments." Professor J. L. Budd mentions the use of the barberry as a hedge plant in his report on hedges.[6] A year later, before the Southeastern Horticultural Society several hedge plants are mentioned,[7] but not the barberry. Mr. D. W. Adams,[8] in the report as secretary of the Iowa State Horticultural Society in 1870, mentions the use of the barberry as a living fence. He says the results are not satisfactory. Hon. J. R. Dodge in 1868[9] recommended the purple leaved barberry to introduce variety. In the report on hedges Prof. J. L. Budd,[10] chairman of the hedge committee, makes a lengthy report on the use of the Osage orange, buckthorn, honey locust, scarlet or white thorn, Norway spruce, arbor vitæ and barberry. On the barberry he makes the following comment: "The English barberry, now found wild in New England is the plant used for hedging. The American barberry *(Berberis canadensis)* is not strong enough in species or habit of growth. For a yard fence near the house in country and town, the barberry makes a very beautiful and useful hedge, though not strong enough for an outside fence until, at least, twelve years old, without wires drawn through it. After six years growth, with two wires, it can be relied upon. When loaded in the fall with a crop of its oblong scarlet berries, it is truly the ornamental of deciduous hedges. The fruit is also useful for culinary purposes. Many think the fruit equal to cranberries."

[5]Iowa Homestead and Western Farm Journal, March 20, 1867, copied from the Northwest Farmer.

[6]Meeting of Iowa State Horticultural Society, June 12, 1870, Iowa Homestead and Western Farm Journal 16: No. 4.

[7]Rep. Ia. State Agrl. Soc. 1871; 330.

[8]Rep. Ia. State Hort. Soc. 1871; 111.

[9]Rep. U. S. Dept. of Agrl. 1868; 197.

[10]Rep. Ia. State Hort. Soc. 1870; 68-77.

Then a paragraph on starting a hedge from seed and a paragraph as follows: "The popular opinion has been that rust in grain emanated from the barberry. Late researches seem to confirm this popular notion. A peculiar fungus, called by scientists *Æcidium Berberidis* can be found on the leaves of all species and varieties of the barberry." A short description of the fungus follows. "Smut in wheat is declared only another form of this fungus. Admitting the idea to be well founded, no harm would result when used near dwellings for yard hedges." Mr. Suel Foster of Muscatine esteems the barberry for an ornamental hedge.

Professor Budd was a student of scientific horticultural literature of the time. What he wrote about the barberry may have been his experience in his nursery in Benton county, but he does not say so. I am inclined to think that some of the information was gleaned from published sources. He was familiar with the Darlington-Thurber Agricultural Botany[11] where the statement is made: "It was formerly a popular belief, and one which prevails yet to some extent, that the barberry possesses the power of blasting grain."

At the annual meeting of the Iowa State Horticultural Society held in 1869[12] various hedge plants were mentioned like the buckthorn, osage, honey locust, white willow, but no reference to the barberry was made. We infer from this that the plant was not generally used in Iowa.

In 1872 James Mathews, president of the Iowa State Horticultural Society, in his presidential address says: "I pass over the thorn, barberry, etc., because I have had no experience with them, nor has my observation enabled me to form any satisfactory conclusion on the subject." In other words these plants were not commonly used as hedge plants in Iowa. Mr. Mathews lived in Knoxville, Iowa, where he conducted a nursery and orchard. Hedges are further discussed in the report of this society for 1872, but no mention was made of the barberry by the persons who discussed the subject. It was evidently not such a common plant, otherwise some comments would have been made.

Samuel Lorton of Davenport is said to have extensively propagated the barberry in 1870. This is his recollection. Dr. I. E. Melhus, R. S. Kirby and L. W. Durrell in some unpublished manuscript make this statement, with reference to the early introduction of the common barberry. "The earliest reliable information regarding the

[11] American Weeds and Useful Plants; being a second and illustrated edition of Agricultural Botany, revised with additions, by George Thurber.
[12] Iowa Homestead and Western Farm Journal 14: 26, No. 4, 1869.

introduction of European barberry in Iowa dates back to 1851. At this time John Evans, according to his son, Oliver Evans, purchased from Ellwanger and Barry, of Rochester, New York, a shipment of European barberry. These plants were first planted at Davenport in a small garden. Six years later Mr. Evans purchased a farm at Pleasant Valley and transplanted some of his barberries into a hedge at this place. From this hedge in the early seventies, Mr. Samuel Lorton, of the Nichols and Lorton Nursery located at Davenport, secured seed for propagation. Later this hedge served as a source of seed for many people interested in securing barberries."

Mr. J. J. Wilson, in an interview in the Davenport Democrat,[13] states that "John Evans is said to have imported his first stock from Rochester, New York, in 1850." I believe it is more likely that these plants were started from seed rather than from nursery stock.

Ellwanger & Barry in a letter to the writer, state: "Replying to yours of the eleventh, we find offered in our catalogue for 1867 the following barberries: *vulgaris, purpurea, canadensis,* white fruited, violet fruited and Nepal fruited."

A few large bushes of the common barberry were observed by me on the Lowry place near Montpelier in Muscatine county. Mr. Lowry stated that the bush was there as long as he could remember. Mr. Samuel Merry in 1839 purchased this land now owned by Mr. Lowry.[14] His grandson, Samuel Hughes, who now lives at Muscatine at the age of 68 years, states that Dr. Merry moved from St. Louis to his farm at Montpelier in 1842 and gave much of his time in his old age to orcharding and to accumulating in his garden various kinds of shrubbery. On one of his visits to St. Louis, Dr. Merry brought back among his nursery stock a collection it is thought of the European barberry. The exact date of this introduction is not known, but the facts at hand suggest that it must have been in the forties. He said the barberry might have been there early in the last century. Walton,[15] in Scraps of Muscatine History, states that one Nye landed at the mouth of Pine creek in 1834 and that the first post office and store in Muscatine county were located at Montpelier in 1838. One would hardly suppose that the barberry had been planted at that point in 1838 or for some years later. F. D. Lowry was born in Muscatine in 1868. His father, W. E. Lowry, moved to Muscatine in 1849 and to Montpelier later. The exact

[13]Davenport Democrat, Dec. 11, 1918.
[14]I am told that Mr. Merry (Lowry) was a brother of Mr Lowry, Sr. He said he would not change his name for anyone.
[15]Scraps of Muscatine History, 17.

date is not given, but it must have been between 1868 and 1870, about the time the barberry began to be distributed as a hedge plant.[16]

It would appear to us that most of the older barberry bushes in the state go back to the seventies. Mrs. William Larrabee, Sr., of Clermont, a woman of unusually keen intellect, told me that the barberry bushes on their place were planted by Governor Larrabee in 1876, largely because of the reported value as a plant to "turn stock", and the governor's interest in the plant because of his boyhood recollection of Connecticut.

The barberry was occasionally planted in the prairie region for protection to stop the drifting snows in the winter, according to Mr. Ingram of Garner, who planted a hedge on his place in Hancock county many years ago. On the Hoag farm a hedge was also planted for this purpose about forty years ago (in 1878) according to Mr. Ingram.

The discussions on the barberry in the report of the Iowa State Horticultural Society are of interest to us, as giving us some of the history. Col. John Scott of Nevada wrote:[17] "I have a few plants of this shrub that grow so thickly and so bristly with thorns, that only a small bird can penetrate them. I have not yet used it for a fence, but believe it would answer a good purpose. Unlike the willow, it is a shrub, and thorny. It grows in rich soils, and with pruning and cultivating attains a height of twenty to thirty feet, but in ordinary hedge row, may readily be kept at a height of five or six feet. Owing to a very general but erroneous impression, that the bushes cause rust in wheat, it has not been largely planted. It is subject to a species of rust, but this is entirely different from that of the wheat plant."

"It is propagated by layers, cutting, seeds, suckers of offshoots, and grows with little care. Left to itself it throws up numerous suckers from its base, making it very close at the foot, and as it bears the shears well, I see no reason why it would not make a very close hedge and occupy but little room." In 1876 C. L. Watrous reported to the Iowa State Horticultural Society as follows:[18] "The Society has sometimes discussed the barberry as a hedge plant. I have to report one experiment with it. In 1874, A. Nighswander, of Dallas county, planted 100 yards or so of barberry hedge, using two year old plants. The same season, oats growing near it rusted badly, while the balance of the field escaped. In 1875 wheat near it was

[16]History of Muscatine county 672-673, 1911.
[17]Rep. Ia. State Hort. Soc. 1876; 152.
[18]Rep. Ia. Hort. Soc. 1876; 152-153.

killed dead, the injury shading off one-half to three-fourths of a mile south and west. North and east was prairie. Wheat generally suffered from rust, but that near the hedge to a far greater extent. In 1876, oats near it were utterly killed and left on the ground, the injury gradually shading off as before and disappearing at from one-half to three-fourths of a mile, and the barberry was beheaded as a criminal, not fit to live, with what justice this Society may decide. I will only add that nothing appeared in soil or location to account for the phenomenon. I know of no other trial of barberry as a hedge plant."

In regard to the relation of rust Captain Watrous said: "Of the barberry as a hedge plant, I know but little. But the very habit of its growth convinces me that it will answer the purpose. I have one plant in my yard which is a special favorite; year after year this barberry bush is the favorite meeting place of the Brown Thrush. It stands not sixty feet from my door, and I believe, without this bush, I would not have the benefit of its morning song."

Mr. Briggs, of Wyoming, Iowa, in 1879, made the following interesting comment. "The barberry has astonished us in its results in growing into a good hedge. I have 20 rods of barberry hedge near my house, which is now eight years from the seed (this would make the date of introduction 1871) and as firm and strong as any farmer could desire, and a very thing of beauty, being well trimmed. On this hedge I have never known a twig injured by winter. But there is one great drawback to it in my opinion. Since the starting of ths hedge, I have not known a square rod of wheat or oats within half a mile of it that was worth the harvesting. Invariably a black rust strikes the grain before ripening that prevents maturing of the grain. I think there is no question about this matter, as I have watched it for six or seven years at my own cost, and to some extent, my neighbors, and I have observed that in a field of grain growing near the hedge, the further I go from the hedge the less the damage from rust. On this account I do not dare recommend it for a farm fence."[19] He did, however, recommend it for ornamental purposes. J. W. Whiting,[20] reflecting perhaps the opinion of Prof. J. L. Budd, in 1878 states that the buckthorn and barberry were good hedge plants. Mr. Samuel Bowers[21] also gives testimony of the growing of the barberry on his place in 1878.

In a discussion on the subject of "Diseases of Plants"[22] Dr. C. E. Bessey in 1881 comments as follows. "In the spring the leaves of

19Rep. Ia. Hort. Soc. 1879; 348.
20Rep. Ia. State Hort. Soc. 1878; 326.
21Rep. Ia. State Hort. Soc. 1878; 153.
22Rep. Ia. State Hort. Soc. 1882; 95, 96.

the barberry are attacked by a fungus which growing inside of th leaf-tissues soon breaks out through the epidermis and form numerous very minute yellow cup-like cavities; hence this has bee called the barberry cluster-cup or barberry rust.

"When these spores fall out and are blown away, those whic alight upon leaves of wheat, oats or barley germinate and soon pene trate the leaf-tissues (the leaf rust was then considered identica with stem rust) growing there parasitically. This growth in th grain leaf is very rapid in hot damp weather, and in a short spac of time it produces myriads of orange red spores just beneath th epidermis, which they soon break, thus forming the well known re rust patches too common on our small grain nearly every season.

"The peculiarity in this case of the first stage of the parasit occurring upon another plant has made many doubt the correctne of DeBary's conclusion that the cluster-cup of the barberry wa identical with the rust of grain. How soon the study of allied form appears to indicate the truth of DeBary's conclusion. I have litt doubt that we shall find that not only the cluster-cups of the ba berry, but that one or more native plants as well produce the ru of our grains.

"Two remedies or rather preventives will suggest themselves every thinking person. The general destruction of the cluster-cu bearing plants would reduce greatly the disease. This, however, not as yet possible. The destruction of the black spores by burnir or otherwise would be an effective preventive if generally done. Tl thorough burning of the stubble soon after harvest, and the burn ing or thorough composting of all rusted straw would if do throughout wide acres of territory, prove effective."

LETTERS FROM NURSERYMEN IN REGARD TO THE EARLY INTR DUCTION OF THE BARBERRY

During the fall I sent letters concerning the early planting of th barberry in Iowa to some of the older nurserymen in the stat Mr. M. J. Wragg wrote me as follows. "My father commence growing the barberry *vulgaris* which was then called the Canadia barberry, about the year 1870.

"We grew a great many thousand of these because they we widely lauded as a plant for making a good hedge for guardin purposes. Along in later years, possibly about the early eighties, th question of rust had commenced being discussed. Consequently, we stopped the growing of the plants in large quantities and merely grew them as ornamental shrubs from then on.

"Purple barberry, we did not commence growing to any great extent until along about 1890. I remember that we got our first stock from the late Robert Douglas of Waukeegan, Ill. There were many other kinds of barberry that we had growing on our place during these years, many of them are still old plants. I speak more especially of *Berberis ilicifolia.* There was a time that we considered this hardy, but during the last ten years it has almost all gone out.

"My father was the first man, as far as known, in Iowa to grow *Berberis Thunbergii.* Ours was imported from the Sargent Botanical Gardens about fifty years ago."

The honorable Silas Wilson, formerly of Atlantic, Iowa, a large grower of grapes, apple trees and other trees and shrubs, wrote me that he had never sold barberry.

Mr. D. C. Snyder of the Linn county nursery informs me that a common barberry in their fruit yard in Center Point, must have been planted in 1878. They started to sell the common barberry in 1892, but there was not much demand for it. He says: "You might be interested to know that the writer's first recollection of shrubbery was of a large barberry bush near our house. From the size of the bush at the time and the writer's age, it must have been planted at least forty years ago, as it was a very large specimen and bore great quantities of fruit. Very likely this bush was received from Patten at Charles City, as Father secured most of his nursery stock there."

The Iowa Seed Company also began to distribute them, with other ornamental plants, along in the nineties. Captain Watrous of Des Moines probably sold the barberry in the eighties or late seventies. Mr. Markel of the Watrous Nursery Company says they were in stock in 1898 and had been sold for some years previous to that. The Earl Ferris Nursery Company of Hampton say they never sold many, except a few locally. Mr. D. S. Lake of the Shenandoah Nursery Company writes that they sold the purple leaved barberry for forty-nine years and in early years never sold large amounts.

Mr. H. A. Johns of the Sioux City Seed Company began to sell the purple leaved barberry in 1884 and the *B. Thunbergii* in 1900. Mr. E. S. Welch of the Mount Arbor Nurseries of Shenandoah says they bought their nursery in 1891 and that they sold the common and purple leaved barberry from that time up to the spring of 1918.

Mr. C. F. Gardner of Osage, Iowa, writes to me under date of December 16th as follows. "The first common barberry that I planted in Iowa was long before I issued a catalogue. I think it was in the spring of 1866. I grew a few thousand each year from the seed and sold the plants generally in small lots to parties who wanted to grow berries for the sake of mixing them with apples to make a kind of sauce which was in great favor with people from the New England states. It was generally planted in hills of single plant, or in a short hedge-row. About 1880, as near as I can figure, we raised probably about twenty thousand plants, which were sold to our customers. The greater number of plants that we sold were for hedges. Finally about the year 1895 the sales of the plants ran so low that we discontinued planting them entirely. And we, thereafter, might have bought a few plants to fill a few orders. This was also about the time we commenced growing the Japanese *(Thunbergii)*.

CAN THE AGE OF THE BARBERRY BE DETERMINED BY THE ANNUAL RINGS?

I thought it might be possible to determine the age of the barberry by making cross sections of the stem.

LOCALITY	DIAMETER OF BRANCH IN INCHES	ANNUAL RINGS
Humboldt, Warner	¾	8
Humboldt, Warner	½	3
Humboldt, Warner	1-½	15
Humboldt, Warner	½	8
Humboldt, Warner	1	14
Humboldt, Warner	1-¼	12
Garner, Hedden	2-½	15
McGregor, Chapin	2-½	17
McGregor, Chapin	3-¾	20
McGregor, Chapin	1-¾	25
McGregor, Guttheil	1-¾	16
LeClaire, Johnson	¾	6
LeClaire, Johnson	½	5
Des Moines, State House	¾	9
Des Moines, State House	1-⅛	15
Des Moines, State House	1-¼	10
Des Moines, State House	1-⅝	13
Des Moines, State House	1-¼	13

WIDTH OF RINGS DIFFERENT YEARS, WILD BARBERRY FROM CHAPIN PLACE, McGREGOR, IOWA.

1901	wide	1910	medium
1902	narrow	1911	medium
1903	narrow	1912	medium
1904	narrow	1913	medium
1905	narrow	1914	wide
1906	narrow	1915	medium
1907	wide	1916	medium
1908	wide to medium	1917	wide
1909	widest	1918	medium

FIG. 52.—Old stem and root of common Barberry showing the older portion in center and two lateral stalks. (C. M. King.)

The annual rings are somewhat unequal, but the largest annual ring of the Chapin barberry occurred in 1901.

Mr. L. E. Foglesong, the associate landscape architect of Des Moines, sent to me a large barberry bush from the state house grounds, Des Moines, set out by Mr. Jackson in 1896. As near as I can determine these branches had rings as follows:

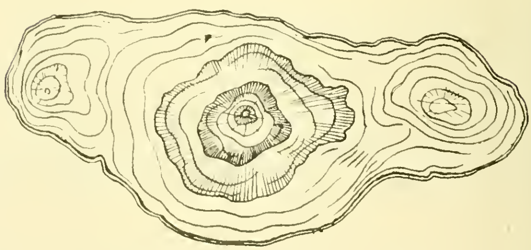

FIG. 53.—Another portion of the same stem showing eight stalks. The central part has five stalks, the right hand lateral has one stalk and the left hand lateral has two. The section of this stem is shown in the upper part of the figure. (Drawn by C. M. King.)

WIDTH OF ANNUAL RINGS IN DIFFERENT YEARS FOR PLANTS, STATE HOUSE GROUNDS, DES MOINES.

YEAR	WIDTH RING. (WIDE RING EARLY STAGE)	YEAR	WIDTH RING. (WIDE RING EARLY STAGE)
Thirteen Years.			
1905	wide	1911	narrow
1906	wide	1912	narrow
1907	medium	1913	medium
1908	medium	1914	narrow
1909	medium	1915	medium
1909	medium	1916	medium
1909	wide	1917	medium
1910	narrow	1918	medium

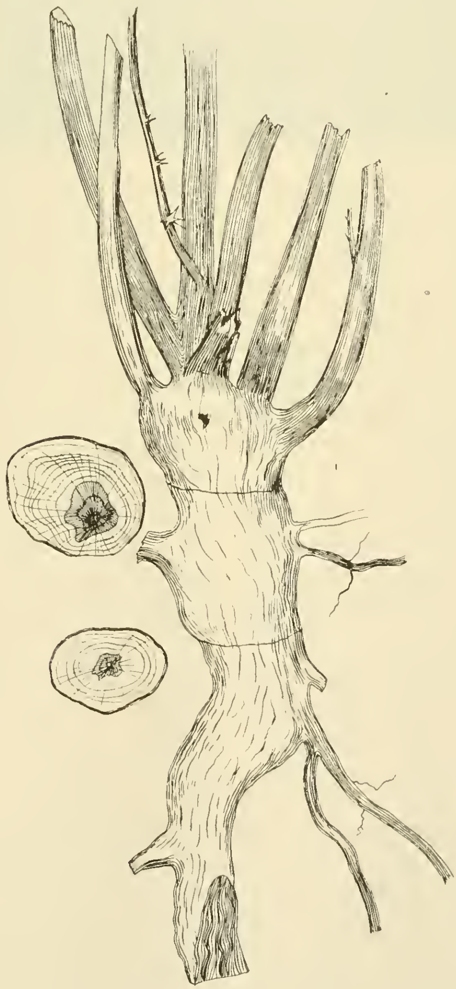

FIG. 54.—Another root and stem on an old Barberry. (Drawn by C. M. King.)

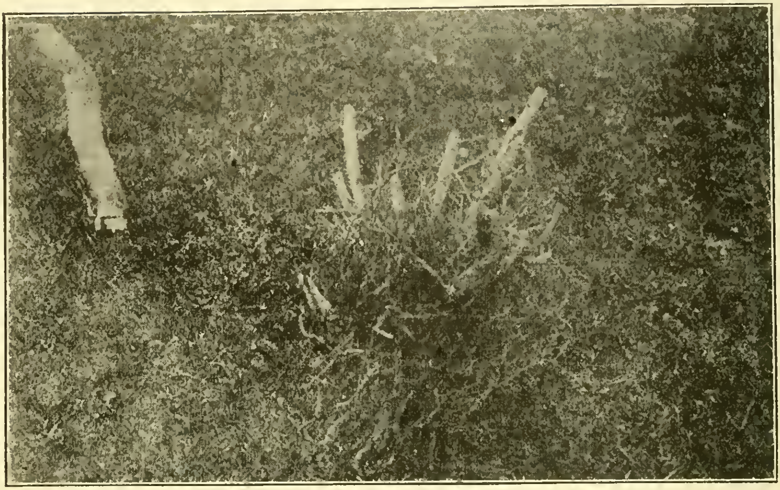

Fig. 55.—Roots of Barberry planted on the State House grounds in 1894. Photographed by J. J. Wilson, 1919.

YEAR	WIDTH RING. (WIDE RING EARLY STAGE)	YEAR	WIDTH RING. (WIDE RING EARLY STAGE)
Nine Years.			
1909	medium	1914	narrow
1910	medium	1915	narrow
1911	medium	1916	narrow
1912	wide	1917	narrow
1913	narrow		
Fifteen Years.			
1903	wide	1917	medium
1904	medium	1918	medium
1905	medium		
1906	medium	1908	medium
1907	medium	1909	medium
1908	narrow	1910	medium
1909	wide	1911	medium
1910	medium	1912	medium
1911	medium	1913	medium
1912	wide	1914	medium
1913	medium	1915	medium
1914	medium	1916	medium
1915	medium	1917	medium
1916	medium	1918	medium

These tables show clearly that widths of rings from the same clump vary greatly, and that no conclusion can be drawn as to a wet or dry year, from the data at hand.

Owing to the varied life of different stems it is impossible for one to determine the age of the common barberry from the annual rings. As the bush becomes older stalks are constantly dying, sometimes the center of the clump contains numerous decayed remants of old stalks and new shoots are formed every year from the old roots. The diameter of a bush therefore increases every year so that the old bushes found near Montpelier on the Lowry place which measured twelve feet across must be of long standing.

THE WILD BARBERRY.

It is not surprising that the barberry should have escaped from cultivation since many other shrubs and some trees have escaped from cultivation like *Lonicera tatarica, Juniperus virginiana.* As the studies of barberry have continued the number of places where the barberry has escaped from cultivation is increasing. Wild plants were noted at the following points by me: Garner, Postville, Clermont, Montpelier, McGregor, LeClaire, Kelley, Carroll county, Monmouth, Clear Lake, Iowa Lake, Iowa; Galena and Port Byron, Illinois.

The Wild Barberries at Garner—During the month of September, 1918, Miss Winifred Gilbert called my attention to some escaped barberries near Concord in Hancock county. The place was visited and the following facts learned about the escaped plants. The present owner of the wood lot is Mr. Hedden. The editor of the Garner Signal, Mr. Clark, informed the writer that a Mr. Bailey ran a nursery on this farm about 1878, and later the nursery was operated by a Mr. Doolittle for a few years. The place was then purchased, according to Mrs. Hedden, by Mr. C. Cramer in 1881, Mr. Hedden operating the place since 1891. The Heddens and Cramers never sold any nursery stock. The place was allowed to take care of itself, either as a pasture or as a hog lot. The plants had escaped on both sides of the road, but the barberry was originally on the south side. Some of the old plants are still standing in the nursery row. These plants have scattered in every direction where there were groves. Most of the wild plants are found within a quarter of a mile from the original nursery stock, but few were found one-half mile from the original plants. The plants to the west in a white willow grove, were mostly small, two to four years old, although there were a few somewhat older and a few seedlings. Most of the wild barberry plants to the west of the original nursery next to the fence were small. The larger wild plants occurred to the north along the highway fence and in a hog lot. Some were found in a willow hedge east and north from the hog pasture and a few isolated plants along the line fence to the east, separated

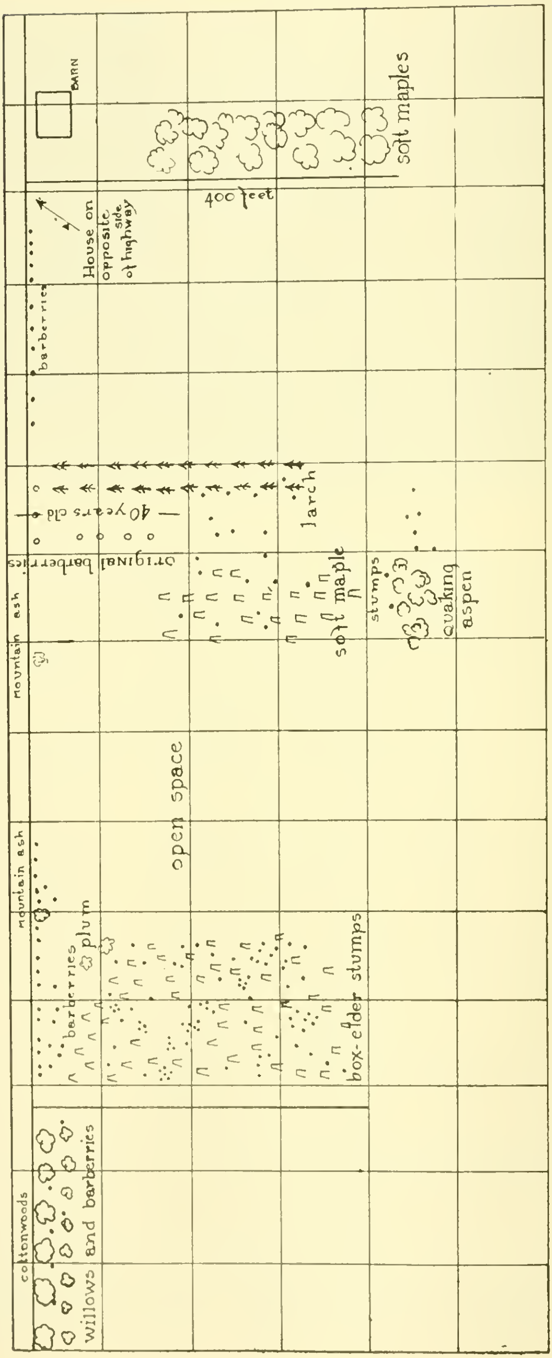

FIG. 56.—Wild (escaped) common Barberry (*Berberis vulgaris*) south of highway, Hedden farm, Garner, Barberry marked (.).

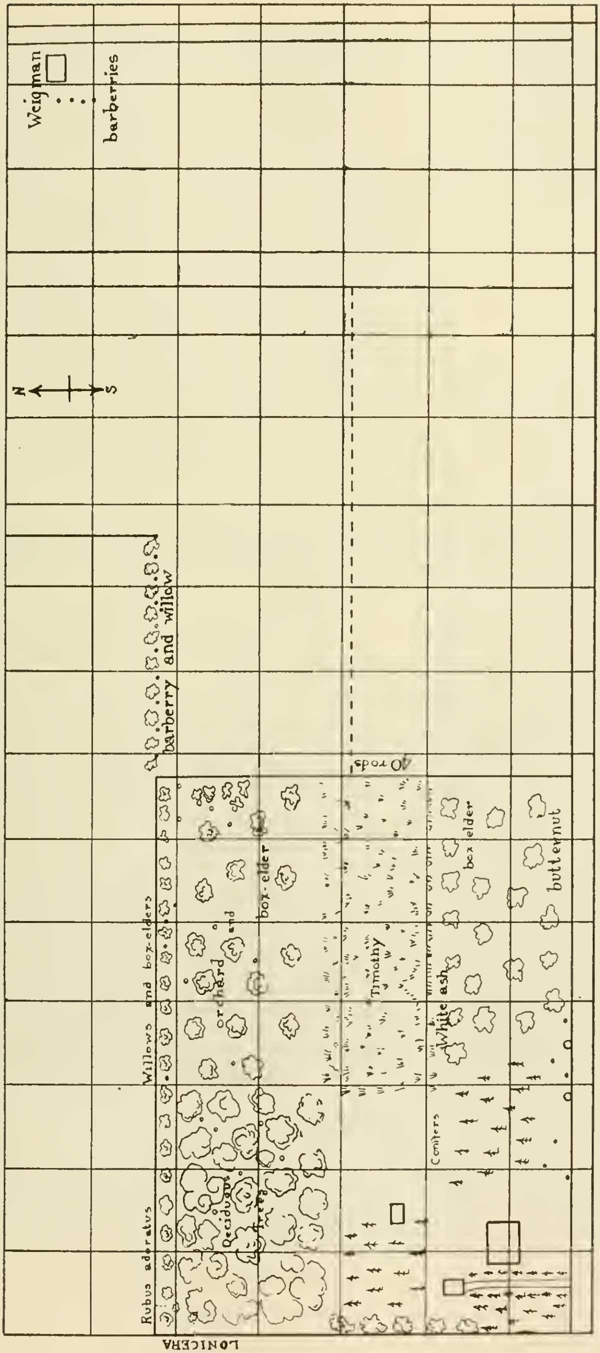

FIG. 57.—Wild (escaped) common Barberry (*Berberis vulgaris*) north of highway. Hedden farm, Garner. Barberry marked (.), original plants marked (o).

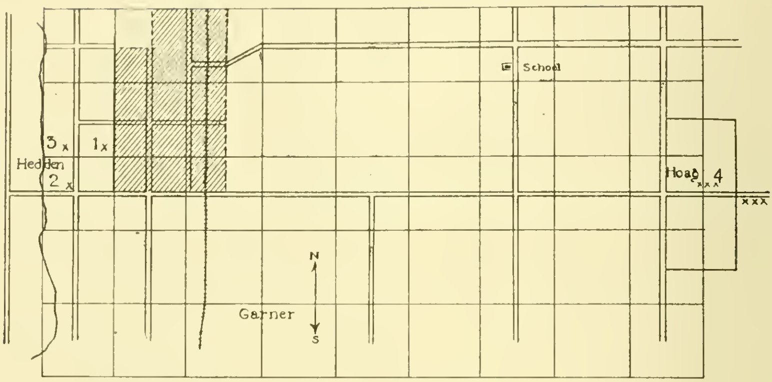

Fig. 58.—Wild Barberry (escaped) near Garner. 1, 2, 3, location of Barberry marked X. 4, Barberry hedge, next to grain field on the Hoag farm. (C. M. King.)

Fig. 59.—Young wild (escaped) Barberry (*Berberis vulgaris*) in front of grove, Hedden farm, Garner. Photographed by F. Fritsch, 1918.

entirely from trees and bushes of all kinds, showing that trees are not always necessary to scatter the seeds. I should judge that most of these older wild plants have not been in these groves for more than twenty-five years. Many of the plants were loaded with fruit this year.

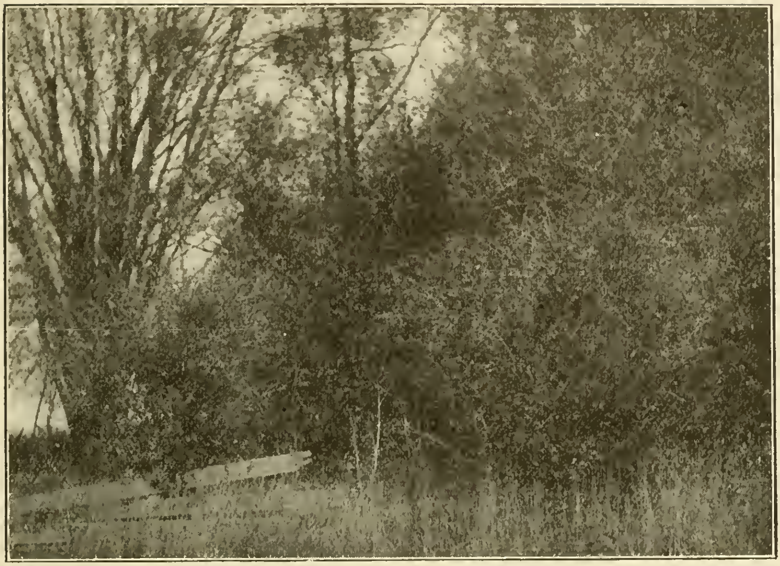

FIG. 60.—Old original common Barberry from which the seed came, near larch grove, Hedden farm, Garner. Photographed by F. Fritsch, 1918.

FIG. 61.—Wild (escaped) Barberry *(Berberis vulgaris)* distributed in larch grove, Garner. Photographed by F. Fritsch.

The cedar waxwing probably was responsible for scattering the barberry. The grove of Mr. Hedden was used by Miss Elder to study the bird population of the region because of the interesting species found there. It was not the only grove in that vicinity, since Mr. Elder, who ran a nursery in Concord, had planted a fine lot of trees around his home. The soil of the region is a black prairie soil and fifty years ago was a virgin prairie. It may be of interest to note here the establishment of other shrubs and trees in the Hedden grove. I note first of all the *Rubus odoratus* which is

Fig. 62.—A single young Barberry (escaped) root, Garner. Photographed by F. E. Colburn, 1918.

scattered over a rod in the south grove, the elderberry *(Sambucus canadensis)* in both groves, the snowberry *(Symphoricarpos occidentalis)*, the chokecherry *(Prunus virginiana)*, the black cherry *(P. serotina)* and the poison ivy *(Rhus Toxicodendron)*. The following trees were found in the grove: *Acer saccharinum, Populus deltoides, Acer negundo, Salix alba, Fraxinus viridis lanceolata, Pyrus aucuparia, Juglans nigra, J. cinerea, Larix decidua, Pinus strobus, Picea alba, P. excelsa,* and *P. austriaca.*

The Wild Barberries at McGregor, Postville and Clermont.—I will only consider these found on the Chapin and Guttheil places in McGregor. In the former place the plants occurred in the rocky limestone area, 150 feet from an old cellar where once stood a house. There was no evidence here of any barberry ever having been cultivated. It is certain, therefore, that the wild plants must have been brought from some wild plants up further in the hills. The plants were seventeen to twenty-five years old. There were a number of young plants around the old bush which was loaded with fruit.

The Guttheil barberry in McGregor is also of interest. A family by the name of Reynolds lived on the place and when the Guttheils

FIG. 63.—Old roots of Barberry, Garner. Photographed by F. E. Colburn, 1918.

took possession in 1897 there were two hedges about 160 feet long. Mr. Guttheil started to remove the hedge. At this time it probably had escaped to the nearby woods. Mr. C. Bickel furnished me the following information. "I was disappointed in finding the original hedge had been cut down twelve years ago. What stands now has come up from the old roots. I thought that the one large bush which stood in the field by itself was a part of the original planting, but it also had grown from a root of the original bush which had been cut down about 15 years ago. I grubbed up several of these bushes

FIG. 64.—Wild (escaped) Barberry (*Berberis vulgaris*), McGregor, branches loaded with fruit, goldenrod and asters growing with it. Photographed by Fryklund, McGregor, 1918.

which had sprung up from the original hedge in the hopes of finding an old root which might aid us some in determining the age of the hedge, but all the original is decayed. I find that this hedge was planted between 1869 and 1872, and that the plants came from New

Fig. 65.—Two branches of wild (escaped) Barberry *(Berberis vulgaris)*, McGregor, showing the fruit in racemes. Photographed by Fryklund, 1918.

York or New England. I do not think the hedge was raised from seed, as the party I learned the above from said he thought the hedge had been set out from plants."

It appears that much of the wild barberry in the region came from the original plants on the Reynolds (now Guttheil) property and

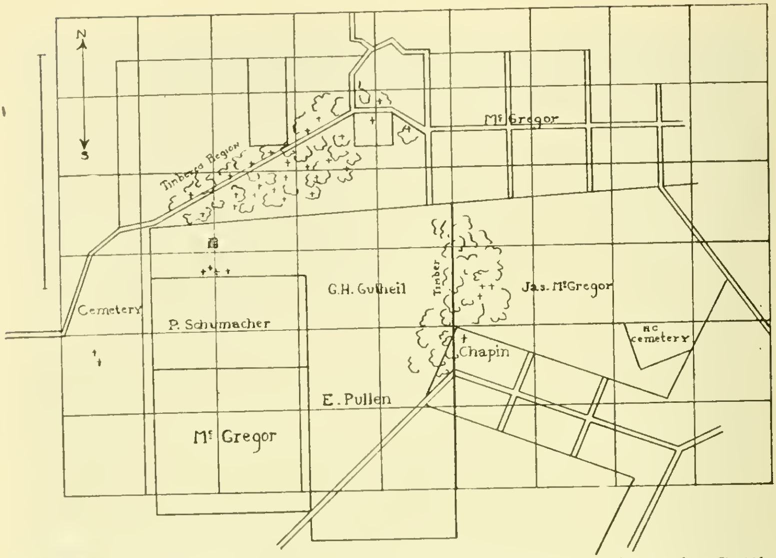

Fig. 66—Wild Barberry, McGregor. This probably started from the Guttheil place. (C. M. King.)

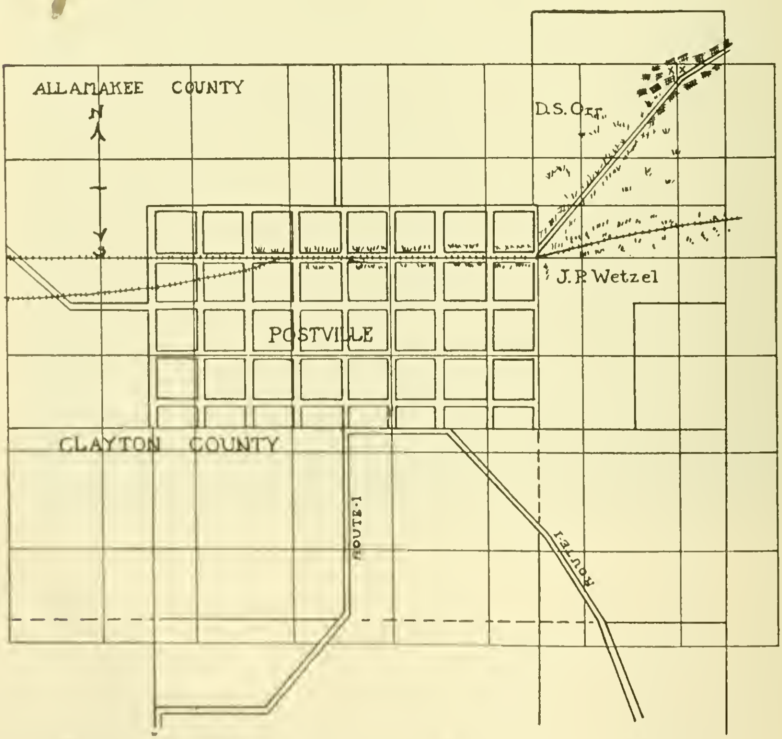

Fig. 67.—Wild Barberry and rust near Postville. (C. M. King.)

the cemetery. A Mr. Kenyon was in the nursery business in McGregor for many years. His daughter, Mrs. Jesse K. Nagel of Seattle, Washington, writes me as follows: "I cannot tell you what variety of barberry my father grew, but remember that it was about

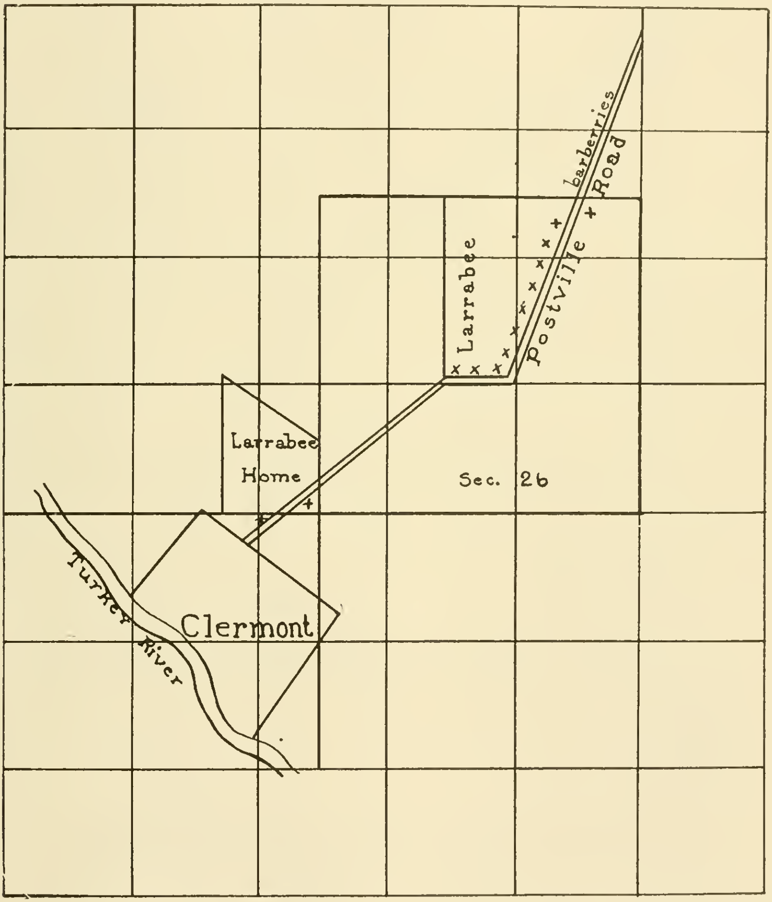

FIG. 68.—Barberry hedge, Clermont, showing wild plants along the highway. (C. M. King.)

as tall as the fence in front of the yard, that it had a leaf with a rough edge; that the berries hung in clusters similar to currants; that they were a very bright red, with a flat seed, and that they hung on the bushes after the leaves had dropped. We had a hedge of these bushes about thirty-five years ago. I do not know of his having distributed them."

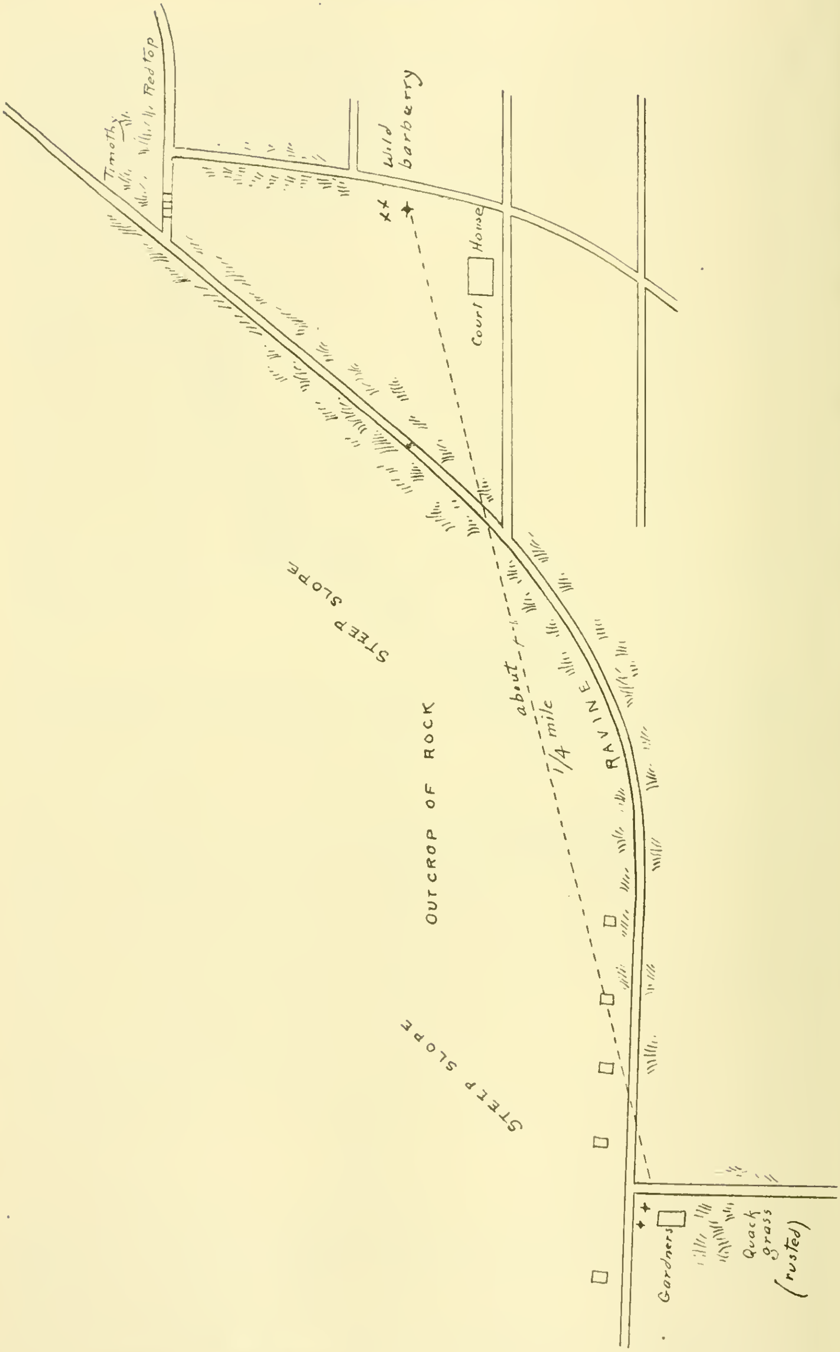

FIG. 69.—Map of West Galena, Illinois, showing relation of wild Barberry to the cultivated Barberry patch.

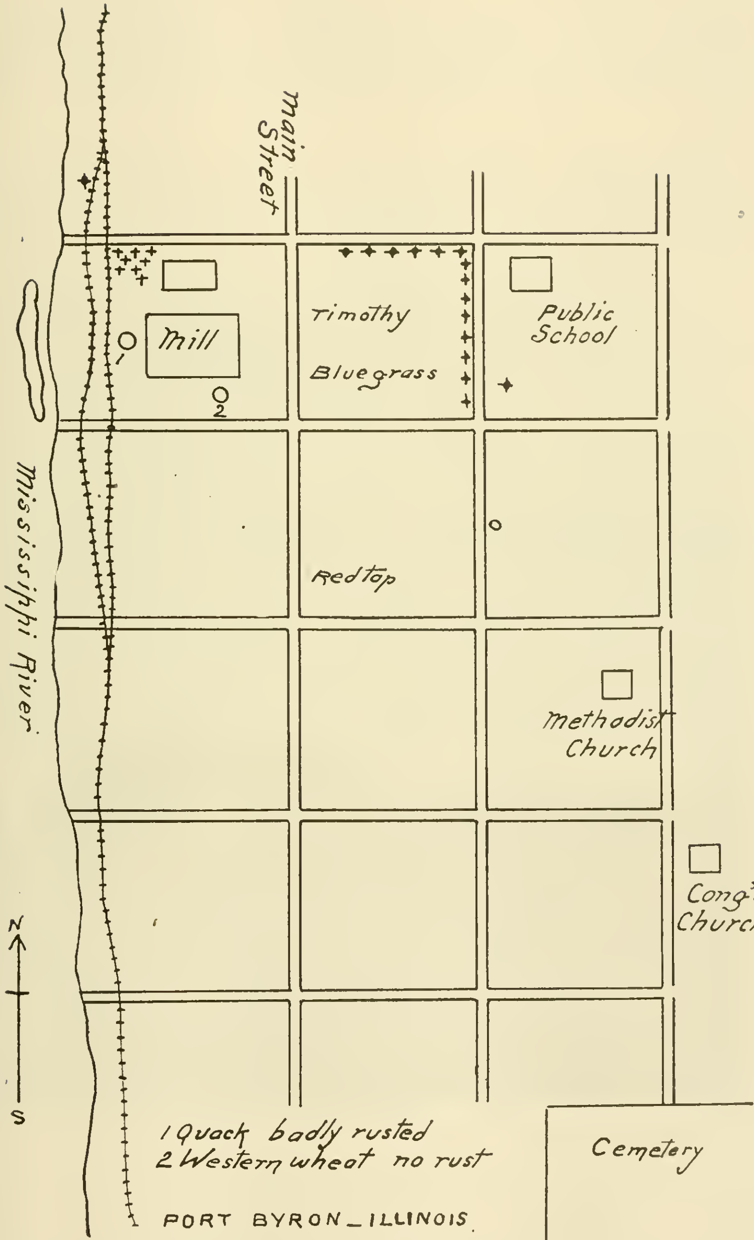

FIG. 70.—Wild Barberry on Chicago, Milwaukee and Saint Paul Railway and a hedge near public school. Port Byron, Illinois. (C. M. King.)

The wild barberry on the Jeremiah Orr place, Postville, was undoubtedly carried to the place by birds. Mr. Orr never planted it and he has lived on the place for sixty years. There was a wild apple approaching the Hyslop crab near it. The wild plants carried

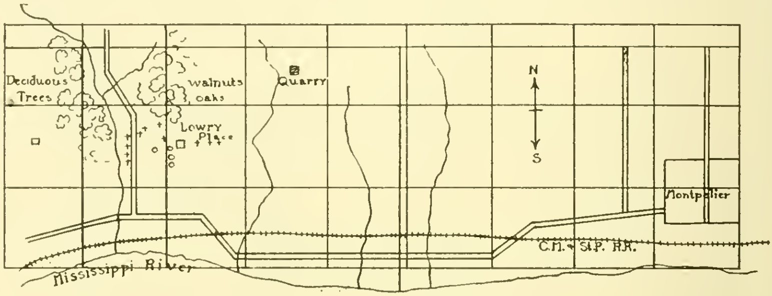

Fig. 71—Lowry place, Montpelier, wild Barberry. The Barberry near the house is the original hedge, the Barberry next to the highway and woods is escaped. Individual oaks and walnuts near the house marked by circle.

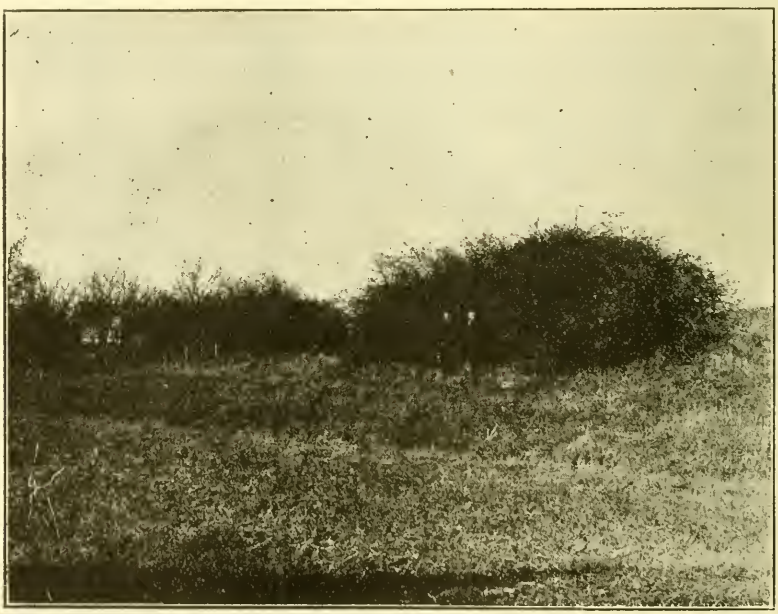

Fig. 72.—The original hedge planting of Barberry (*Berberis vulgaris*) on the Lowry place near Montpelier. The height may be judged by the men standing alongside of the hedge. Photographed by A. L. Parrman, 1918.

by birds at McGregor and Postville were *Rubus villosus, Rhus glabra, Prunus virginiana, P. serotina* and *Rhus Toxicodendron.* The soil at Postville was yellow clay, at McGregor clay and limestone rock.

The wild barberry at Clermont is of interest. Elsewhere we have given the date of the introduction of the bush by Governor William Larrabee. The wild plants occurred on both sides of the highway and in the woods on a sloping hill, before reaching the valley of the Turkey river. In some cases the older plants appeared to be about

FIG. 73.—A single large Barberry on the Lowry place, Montpelier. Photographed by A. L. Parrman, 1918.

twenty years old. Many of the plants were, however, only four or five years old.

The Wild Barberries at Galena, Freeport and Port Byron, Illinois. —The limestone rock of the Galena region is highly favorable for the development of wild barberry. Some very large cultivated bushes with thousands of shoots occurred at several points in Galena and Port Byron. How long the barberry has been cultivated in Galena is not known, probably twenty or thirty years. The courthouse was built in 1839. It is probable that the barberries were introduced much later. The large plants may have been thirty-five years old, or perhaps forty. Up in the limestone bluffs about one-quarter of a mile distant from the cultivated barberry plants were barberry plants which had been carried there by birds. Wild barberries also occur at Freeport, according to the statement of Mr.

Luther of Dubuque and Mr. Reintz of Freeport. Both men were quite familiar with the plant. The town of Port Byron, Illinois, is opposite LeClaire, Iowa. There were many hedges of the common barberry at this point. Wild plants were found along the right of way of the Chicago, Milwaukee & St. Paul Railway, on both sides of the track, on the bank of Mississippi river. The plants undoubtedly came from larger bushes about 800 feet away.

Wild Barberry Plants at Montpelier and Le Claire.—The city of Montpelier is one of the oldest places in Muscatine county. An old

FIG. 74.—A clump of escaped Barberry (*Berberis vulgaris*) near Montpelier. The original clump was to the right of the house and back of the evergreens. Photographed by A. L. Parrman, 1918.

hedge was observed on the F. D. Lowry place, one and a half miles from Montpelier. The old hedge might have been between forty and fifty years old. Mr. Lowry stated that the plants had been there for fifty years, as long as he can remember, and he thought they might have been eighty years old. We doubt this, since that would carry it back to the time of the earliest settlement in the county. The plants were large and many of the old stalks died many years ago. Some had spread across the road some 1500 feet away from the older clumps. The trees in the Lowry pasture consisted of a row of black walnut *(Juglans nigra)* on the edge of the pasture and near it were red cedars *(Juniperus virginiana).* The black walnuts had evidently been planted there many years ago. Other trees noted in the pasture were bur oak *(Quercus macrocarpa),* American elm *(Ulmus Americana),* slippery elm *(U. fulva),* red haw, white ash, black cherry, and across the road were basswood *(Tilia Americana),* swamp white oak *(Quercus platanoides),* and

FIG. 75.—Old (escaped) Barberry roots, Montpelier. Photographed by F. E. Colburn, 1918.

honey locust *(Gleditsia triacanthos).* Of the shrubs I observed the Missouri gooseberry *(Ribes gracile),* wild grape *(Vitis vulpina),* sumach *(Rhus glabra),* dogwood *(Cornus asperifolia),* blackberry *(Rhubus nigrobaccus)* and black currant *(Ribes floridum).* The herbaceous plants observed were sweet William *(Phlox divaricata),* blue grass *(Poa pratensis), P. compressa,* timothy, *Phleum pratense.*

The timothy was common near the barberry bushes. On every one of the clumps of wild barberry æcial infection was observed on May 19, 1919, but there were no cups. It would appear that the infection might have come from timothy. The writer observed in Muscatine and Louisa counties *Hordeum pusillum, Bromus tectorum, Secale cereale* heading out. Winter wheat and squirrel tail grass also were observed, but in no case did the writer observe uredo stage on these grasses. In this connection attention may be called to stations established in Manchester in the fall of 1918 containing an abundant infection of *Puccinia graminis* on *Hordeum jubatum, Agrostis alba, Agropyron repens, Phleum pratense* and *Dactylis glomerata* and rye. In no case did the writer find any indication of *P. graminis* on the grasses on May 12, 1919. In this connection it may be said that *P. coronata* was common on orchard grass in Manchester in October, 1918, and yet there was no indication of uredo spores of this rust on orchard grass on May 12, 1919. The writer also made observations on *Hordeum jubatum*, *Agrostis alba*, *Agropyron repens* and winter rye at LaMont in Butler county, but there were no indications of uredo spores of *P. graminis* on these grasses. *Hordeum jubatum*, squirrel tail grass, was observed at Ames with a heavy infection of *P. graminis* last fall, but up to the writing of this paragraph on May 22d has shown no indication of uredo spores. On May 18th there was no indication of *P. graminis* on winter rye.

The large wild barberry plants here were perhaps twenty-five years old. Several clumps were scattered through the woods and along the roadside.

The barberry had escaped near Montpelier before 1900 according to Mr. W. D. Barnes, Ferd Reppert and A. A. Miller. On page 202 of the Flora of Scott and Muscatine counties[23] published in 1900 they state: "In woods west of Montpelier." This is the only locality given by these authors. If other had been known they would have been mentioned by Mr. Reppert who was a keen observer.

Warren Upham in his Catalogue of the Flora of Minnesota[24] published in 1884 reports that Leiberg found barberry spontaneous in old fields at Mankato, Minnesota. It is likely that Leiberg found the plant several years previously, making barberry spontaneous .in the late seventies or early eighties.

At Le Claire we visited the J. B. Johnson hedge two and one-half miles from Le Claire. According to Mr. Johnson the hedge is forty-six years old, and is seventy rods long. Formerly it was trimmed back, but now little is done. It was not dug out or removed because his mother said the father planted it, and there was much sentiment connected with it. The house stands on a hill, a private road leads from the highway west and then curves slightly to the north, leaving a bank to the south. On the bank I found some black oak *(Q. velutina)* and some red cedar, a single red cedar on the top of the hill south side and several red cedars on the north side of the road on the slope; between the hill and the highway on the north side are several wild bushes and on the bank below the oaks I found between fifty and sixty wild plants, one to five years old. The man who originally planted this hedge must have had considerable horticultural interest. He set out some *Rhamnus cathartica, Syringa vulgaris, Spiræa Thunbergii* and back of it is an orchard overrun with *Rhus occidentalis, R. villosus* and weeds. I did not, however, find any

23Proc. Davenport Acad. Sci. 1900: 202.

24Geol. and Natural History Survey of Minn., Pt. VI. Annual Report of Progress.

wild barberry. The wild plants are some 400 feet from the original hedge. A few are only twenty feet away. There is no question that the plants on the hill were scattered by birds. Professor Paar-

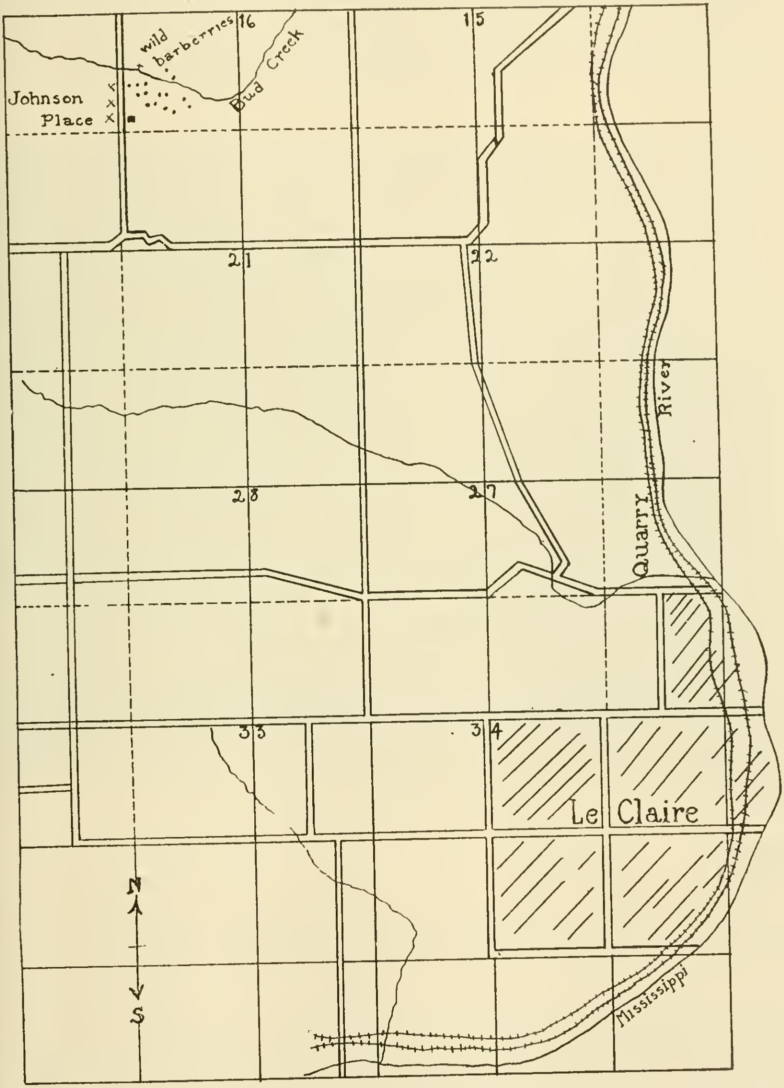

FIG. 76.—General map of LeClaire and the Johnson place. (C. M. King.)

man says that the Cedar wax wing is the important scatterer of the seeds, and in Iowa this occurs from February to April. We next visited the timber where the wild plants are scattered over an area of some eighty acres. In all cases the wild plants were observed on the slope of the hills from seventy-five to ninety rods from the hedge. In some cases these wild plants were loaded with fruit. Mr. Johnson states that there was one large plant on the river

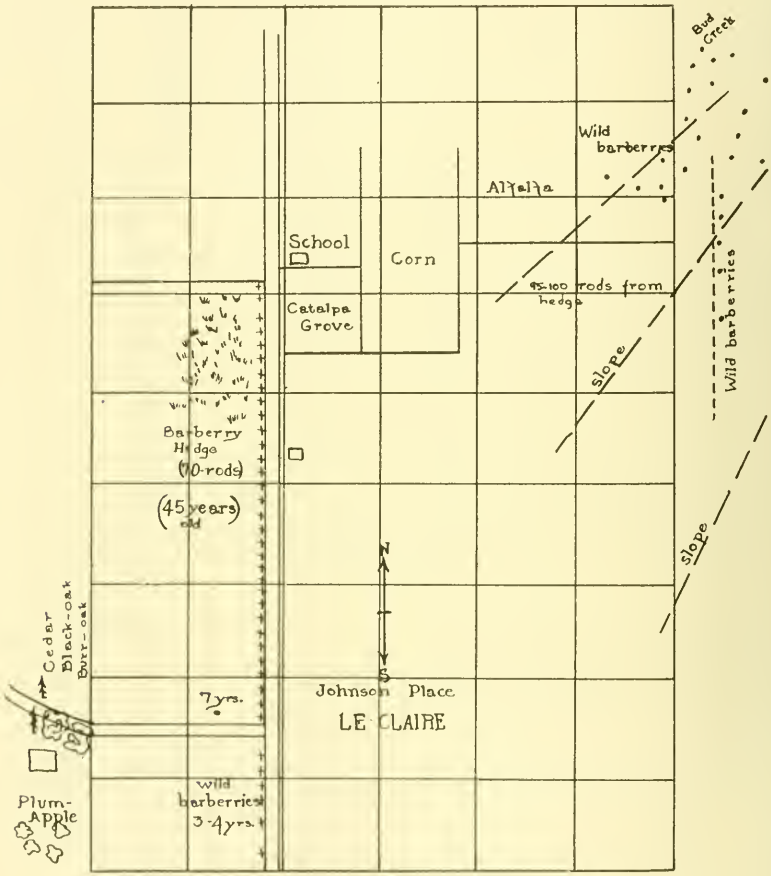

Fig. 77.—Wild Barberry on Johnson place near LeClaire. Original hedge on highway. Oats not fit to harvest.

bottom, a little over a quarter of a mile away. The wild plants in the pasture are perhaps thirty years old. On a single large clump in the hedge, I estimated 30,000 seeds. In some cases there are even as high as 40,000. Red top and timothy in the vicinity were badly rusted. According to Professor Bliss, wheat in the vicinity was also badly rusted. However, Mr. Johnson does not think the barberry is responsible for the rust on grain.

Wild Barberry in Manchester.—The history of the wild barberry on the Cook farm, four miles west of Manchester and one-fourth of a mile from the Hawkeye trail in Delaware county, is as follows: Mr. Edward Cook bought the place twenty years ago. He found on it several bushes of the common barberry. These were cut off a few years later. From the cut-off bushes new clumps began to come

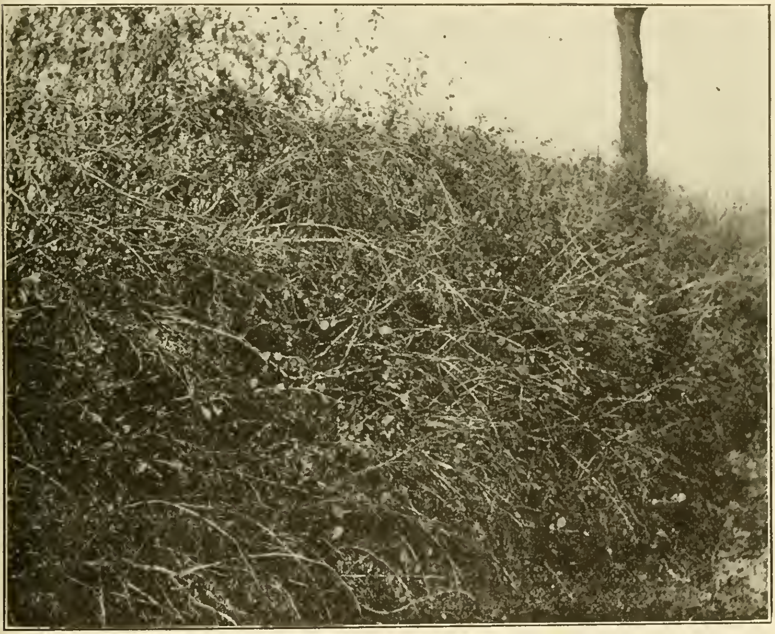

FIG. 78.—The Johnson Barberry hedge near LeClaire, from which the wild Barberry in that vicinity originated. Photographed by A. L. Parrman, 1918.

up. The Cooks found that birds carried the seed to the orchard and to the native timber beyond. The timber has since been removed, leaving numerous old stumps of trees remaining. The timber consisted of bur oak, black oak, black cherry and haw *(Crataegus mollis)*. There were also clumps of choke cherry *(Prunus virginiana)*, *Ribes gracile* and in low places *Spiræa salicifolia*. The old grove is now pretty closely grazed so that few shrubs remain. However, the large clumps of barberry are conspicuous in the wood lot. It would appear that the larger clump may have been there for twenty or thirty-five years. Only a few planted hedges were reported to Doctor Melhus in the county, and one of these was in Manchester.

Wild Barberry at Clinton, Iowa.—Mr. R. S. Kirby reported a considerable number of wild barberries in Clinton early in the season of 1918. The plants occurred on the E. E. Pearce place, Mount Pleasant Park and Turner Hall woods. The Pearce place is situated on Bluff Boulevard and Second Avenue. The Mount Pleasant Park is on Second Avenue and Turner Hall woods are beyond. Mrs. Pearce told me the barberry hedge was planted on

Fig. 79.—Clump of Barberry on Johnson place near LeClaire. Photographed by C. R. Quade, 1918.

the property about forty years ago. Mount Pleasant is situated on a hill, and on Second Avenue there is a trimmed osage orange hedge. To the west of this enclosure there is an old barberry hedge and some osage. This hedge originally separated the wooded pasture from the other ground to the east. There are some fairly good sized white pine adjacent, running north, and with the hedge are willow and Scotch pine. Adjacent to this hedge is the pasture, which consists of various hardwood, bur oak, red oak, *Carya ovata, Ulmus Americana, U. fulva* and some *Catalpa kæmpferi.* There were also some *Sambucus canadensis, Quercus velutina, Tilia Americana, Celtis occidentalis* and *Rubus occidentalis.*

Among the other plants observed in this pasture, mention may be made of *Eupatorium urticæfolium, Hedeoma pulegioides, Monarda fistulosa, Verbena stricta, Arctium major, Verbena urticæfolia, Solidago canadensis* and *S. serotina, Brunella vulgaris, Muhlenbergia Schreberi, Bromus inermis* (abundant along the fence and hedge rows) thoroughly naturalized, *Poa pratensis, Dactylis glomerata,* *Agrostis alba, Phleum pratense.* There was also some naturalized *Symphoricarpus orbiculatus* along the hedge and *Smilax* (Green Brier).

There are some rather large clumps of escaped barberry in this wooded pasture (north side of Second Avenue and west of the build-

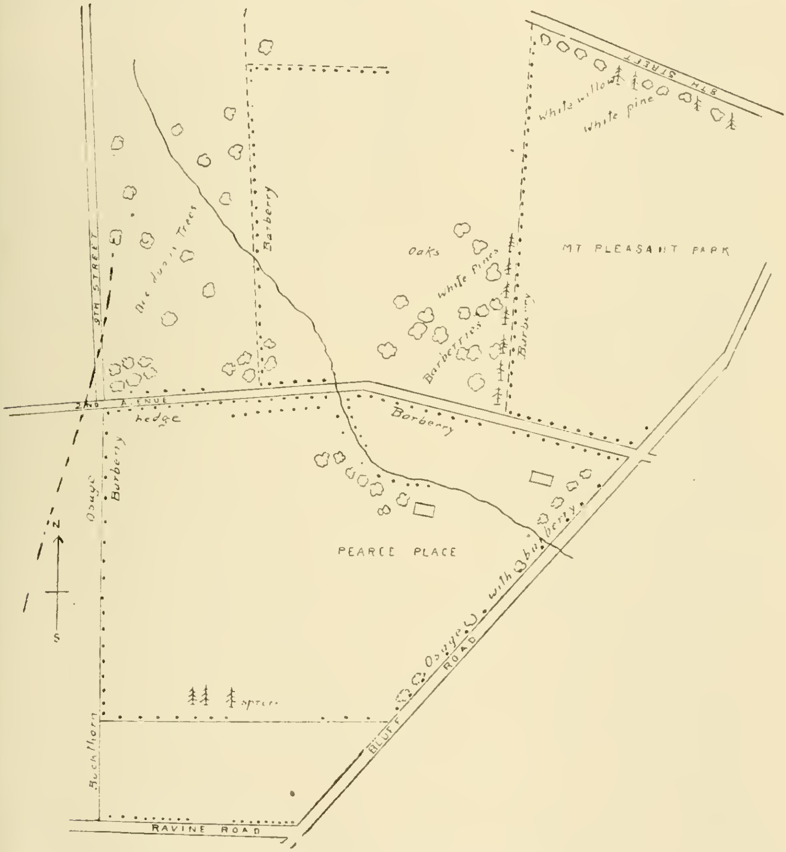

Fig. 80.—Wild Barberry, Clinton. Barberry marked by dots. R. S. Kirby, L. H. Pammel and C. M. King.

ings belonging to the Spiritualists). One clump I found may have been twenty to twenty-five years old. On one of the larger of the stalks, one and one-half inches in diameter, I counted fourteen annual rings. Two of the others were between ten and fifteen years old. The larger clump had a large number of young seedlings from one to three years old under the tree. The large wild barberry had an abundance of fruit, about 5,000 seeds. This plant was about 450 feet from Second Avenue and about 200 feet from the nearest barberry bush. The bushes in northwest corner of the pasture were some 300 feet from the nearest barberry bush. All of the plants occur on the hillside. The larger ones are on the north slope. Several ravines run through this pasture. The plants in the Pearce hedge had few seeds. Many of the plants had been cut back. Where the plants had been cut back a large number of young shoots have appeared from suckers.

As to the rust an abundance was found on the old stems of *Hordeum jubatum*, *Agrostis alba*, and some on timothy, nothing on orchard grass. No recent pustules of *P. graminis* were seen on volunteer oats or on green stems of *Hordeum jubatum*. The rust pustules were found on *Phleum pratense* but no *P. graminis* was seen on volunteer oats and very little of *P. coronata*. Nothing (*P. graminis* or *P. coronata*), was present on *Bromus inermis*. There was an abundance of uredo spores on blue grass, but nothing, however, on orchard grass. There was a buckthorn hedge west of the Pearce place. There was some *P. simplex* near the Chicago & North Western Railway depot in Clinton, but no *P. graminis* on barley.

This trip was made late in November, which accounts for the scarcity of uredo pustules on the wild grasses and oats. The volunteer oats had been killed nearly to the ground.

Wild Barberry at Kelley.—During the winter in a conversation with Mr. P. L. Petersen, I learned that a considerable number of escaped barberries occurred on his place two miles east of Kelley on Walnut creek. The original hedge was planted by Mr. Giddings who sold the farm to Mr. W. P. George. Mr. Raymond Fogelman, who a little later investigated the area for the federal government, found and placarded the area where the escaped barberries occurred. I visited the place with Dr. E. D. Ball and Mr. Ness on May 22, 1919. The wild and cultivated barberries have been in the region for at least twenty years, according to Mr. Weeks. I counted 300 clumps, varying from a few years standing to clumps at least fifteen or eighteen years old. One large clump, six feet across, had eighty stalks and there were others as large. Many of the plants were full of bloom. There seems to be at least some barberry not referable to the true *B. vulgaris*. In leaf character it fits the *B. canadensis*, but the flowers are like *B. vulgaris*. The leaves resemble the leaves of one of the varieties of *B. vulgaris* in our herbarium. The plants, as a whole, were healthy looking, except on some of the steep banks where they suffered somewhat from the drought of last year. The escaped barberry occurred on the east and west sides of the creek, on the farm owned by Messrs. Petersen and Finch, altogether for about one-half mile along the wooded creek, in the valley, as well as on the hillside. In some places it was much more abundant than in others. They were found on the banks, as well as on the slightly sandy alluvial bottom. The soil on the banks is a bluish, sticky clay, or of a yellowish color in a few places slightly springy.

It may be of interest to make a note of the plants found in the region; the Missouri gooseberry (*Ribes gracile*) is common and is generally distributed in the area. There was also some *Ribes Cynosbati* and *Cornus asperifolia*. The only other shrubs found here are *Vitis vulpina, Psedera vitacea, Rhus Toxicodendron, Celastrus scandens, Xanthoxylum americanum, Rosa arkansana, Rubus occidentalis*. The following trees were rather common, hackberry *(Celtis occidentalis)* hickory *(Carya ovata)* bur oak *(Quercus macrocarpa)*, a few red oaks *(Q. rubra)* and white oak *(Q. alba)*, red haw *(Crataegus mollis, C. punctata)*, elm *(Ulmus americana, U. fulva)*, ironwood *(Ostyra virginiana)*, basswood *(Tilia americana)*, wild crab *(Pyrus ioensis)*, choke cherry *(Prunus virginiana)*, black cherry *(P. serotina)*, hard maple *(Acer nigrum)*, red mulberry *(Morus rubra)*, the Russian mulberry *(Morus alba* var. *Tatarica)* (naturalized in several places, came from the Giddings place), black walnut *(Juglans nigra)*. The herbaceous plants noted were the blue violet *(Viola cucullata)*, Sweet William *(Phlox divaricata)*, columbine *(Aquilegia canadensis)*, *Solidago ulmifolia, Poa pratensis, Phleum pratense, Sanicula marilandica, Smilacina stellata, S. racemosa, Fragaria virginiana* var. *illinœnsis, Vicia americana, Aster sagittifolius*, wild cranesbill, *Geranium maculatum*. The question has sometimes been raised as to whether the soil where the plants establish themselves belongs to the calcareous type. The area near Kelley belongs to the Wisconsin drift soil and while limestone is not in evidence on the surface the soil is not acid but must be classed as one having an abundance of lime. It may be of interest to remark that every clump of barberry examined by the writer contained yellow spots, showing infection, and in quite a few cases spermogonia were evident and in others full developed æcia discharging their spores freely. I found some timothy in the vicinity of the bushes, but the æcial infection, I think, came from the oats some 300 feet away and in all probability also from the squirrel tail which was much nearer, some 150 feet away. There were certainly enough æcia on these barberries to cause a local rust epidemic.

In a previous paper I gave the approximate number of æcial spores produced at Pocahontas, Iowa. The figures I gave there are perhaps too small. On one plant I counted twelve æcial infected leaves. Miss C. M. King estimated approximately 4,000 spores in one of the æcia. This infected leaf had 48,000 spores. Another badly infected leaf had 120 æcia. On the same basis there were

480,000 spores on this single leaf. I did not try to find all of the infected leaves on any single barberry, but on some I counted as many as ten infected leaves, which would make 4,800,000 spores per plant. If we now multiply this by 100 it would give us 480,000,000 æcial spores for this little area, enough to cause a rust epidemic in the region.

Wild Barberries in Other Localities.—During the summer of 1919 the writer observed wild barberries at the following points in Iowa:

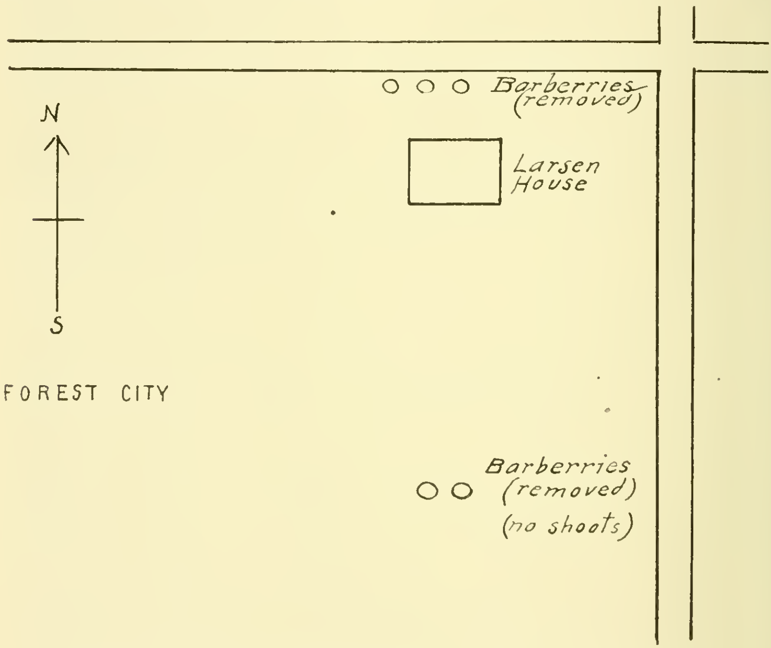

Fig. 81.—Barberry removed, but an abundance of young shoots.

McIntosh woods shore of Clear Lake, Doughty woods shore of Iowa Lake, a mile southwest of Monmouth in Jackson county, Van Wert where it was collected by Mrs. E. E. Castor and a mile from Mt. Carmel on the farm of Albert Wiederin, section 30, Sheridan township, in northern Carroll county where it was found by the writer and Mr. J. F. Coupe. The circumstances under which these wild barberries occur are so different that it may not be amiss to say a few words about it.

The Carroll county specimens were found on the banks of the highway and growing with such plants as *Solidago Missouriensis, S. rigida, Aster lævis* and *Kuhnia eupatorioides.* It is on the divide between the Missouri and the Mississippi basin and the soil is Missouri loess.

The specimens at Monmouth were growing in Maquoketa limestone rock, associated with bur oak *(Quercus macrocarpa) Solidago nemoralis, S. rigida* and *Aster azureus.*

The specimens at Clear Lake occurred on drift soils associated with *Quercus macrocarpa, Ostrya virginiana, Prunus serotina, P. virginiana, Tilia americana, Ulmus fulva* and *Celtis occidentalis.*

The specimens on the shores of Iowa Lake also are in drift soil. Some of the plants noted by me as being found in the woods were as follows: *Quercus macrocarpa, Ulmus fulva, U. americana, Tilia americana, Celtis occidentalis, Prunus virginiana, P. serotina, Rhus typhina.*

FIG. 82.—Young Barberry shoots coming from roots of old plant removed two feet from the center of the area B. Drawn by C. M. King.

It is difficult to say from what I have observed that calcareous rocky soil is particularly favorable to the establishment of the barberry. The habit of the plant has been changed because of its long period of migration from Asia. It has established itself wherever birds have scattered its seed.

Mr. J. J. Wilson tells me that there are also some escaped barberries near Colo. These escaped from an old nursery.

The localities of wild escaped barberries in Iowa and adjacent states known to the writer may be summarized as follows:

Locality	Collector
Calamus, Clinton county, Iowa	J. J. Wilson
Near Calamus, Scott county	J. J. Wilson
Kelley, Story county, Iowa	L. H. Pammel
Clinton, Clinton county	R. S. Kirby
Clinton, Clinton county	L. H. Pammel
Manchester, Delaware county, Iowa	L. H. Pammel
Le Claire, Scott county, Iowa	L. H. Pammel
Montpelier, Muscatine county, Iowa	L. H. Pammel
Montpelier, Muscatine county, Iowa	First reported 1900
Mankato, Minnesota	J. B. Leiberg, 1884
Galena, Illinois	L. H. Pammel
Postville, Allamakee county, Iowa	L. H. Pammel
Clermont, Fayette county, Iowa	L. H. Pammel
McGregor, Clayton county, Iowa	L. H. Pammel
McGregor, Clayton county, Iowa	Carl Bickel
Monmouth, Jackson county	L. H. Pammel
Mt. Carmel, Carroll county	L. H. Pammel and F. J. Coupe
Shores of Clear Lake, Cerro Gordo county	L. H. Pammel
Shores of Iowa Lake, Emmet county	L. H. Pammel
Van Wert, Decatur county, Iowa	Mrs. E. E. Castor
Garner, Hancock county, Iowa	L. H. Pammel
Garner, Hancock county, Iowa	Winifred Gilbert

In conclusion, I wish to express my thanks to C. R. Ball and to Dr. H. B. Humphrey of the Cereal Investigations Bureau of Plant Industry, U. S. Department of Agriculture, for their kindness in the prosecution of this work; to Dr. I. E. Melhus, R. S. Kirby and L. W. Durrell for the use of some unpublished manuscript, to Prof. A. Paarman for notes on birds in connection with the distribution of the barberry and some photographs, and to Miss Charlotte M. King for sketching of maps showing distribution of the barberry.

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DEPARTMENT OF BOTANY,
THE STATE COLLEGE.

THE GENUS LACTUCA IN IOWA.

R. I. CRATTY.

The present paper on the genus *Lactuca* and its distribution in Iowa is the result of a study of this group of plants carried on at the Iowa State College during the past two years, supplemented by field work, and a visit to some of the other large herbaria in the state. The extensive collection of this genus in the State College herbarium, very largely the result of Doctor Pammel's work, has been freely used. To Dr. B. Shimek the author is indebted for the privilege of examining the *Lactucæ* in the herbarium of the State University, and to Prof. T. J. Fitzpatrick, of the State University of Nebraska, for access to his fine herbarium near Iowa City, which contains an especially rich and valuable collection of Iowa plants. The Hon. O. M. Oleson, of Fort Dodge, kindly loaned some specimens for examination. Mr. C. Neuberth, of the Field Columbian Museum, Chicago, also granted access to the *Lactucæ* in that institution. To all these gentlemen grateful thanks are extended. For the drawings of the akenes in the plate accompanying this paper the writer is indebted to Miss Charlotte M. King, of the Iowa State College, whose skillful hand has done so much to illustrate the numerous publications issued by this institution.

Some of the species of *Lactuca* are very puzzling, especially when only leaves and flowers are present, on account of the great variation in the color of the flowers, and the greater diversity of leaf forms in several species. The mature fruit should be secured if possible, as it is a great help in determination.

The genus *Lactuca* is represented in our state flora by eight species, six of which are native. It belongs to the subfamily *Cichoriaceæ* of the great family *Compositæ*. The genus *Mulgedium* is considered distinct by Engler and Prantl in *Die Naturlischen Pflanzenfamilien,* and by DeCandolle in the *Prodromus,* but by Bentham and Hooker it is reduced to a section of *Lactuca* and in this they are followed by most American botanists.

There is a great diversity of opinion among our systematists regarding the disposition of the Linnaean species *L. virosa* and *L. scariola*. The oldest described species of this group is *L. virosa* and the majority of authors now accept it as the true name for what by many American bontanists has been called var. *integrata* of *L. scariola,* and the author of this paper considers this the best diposition to

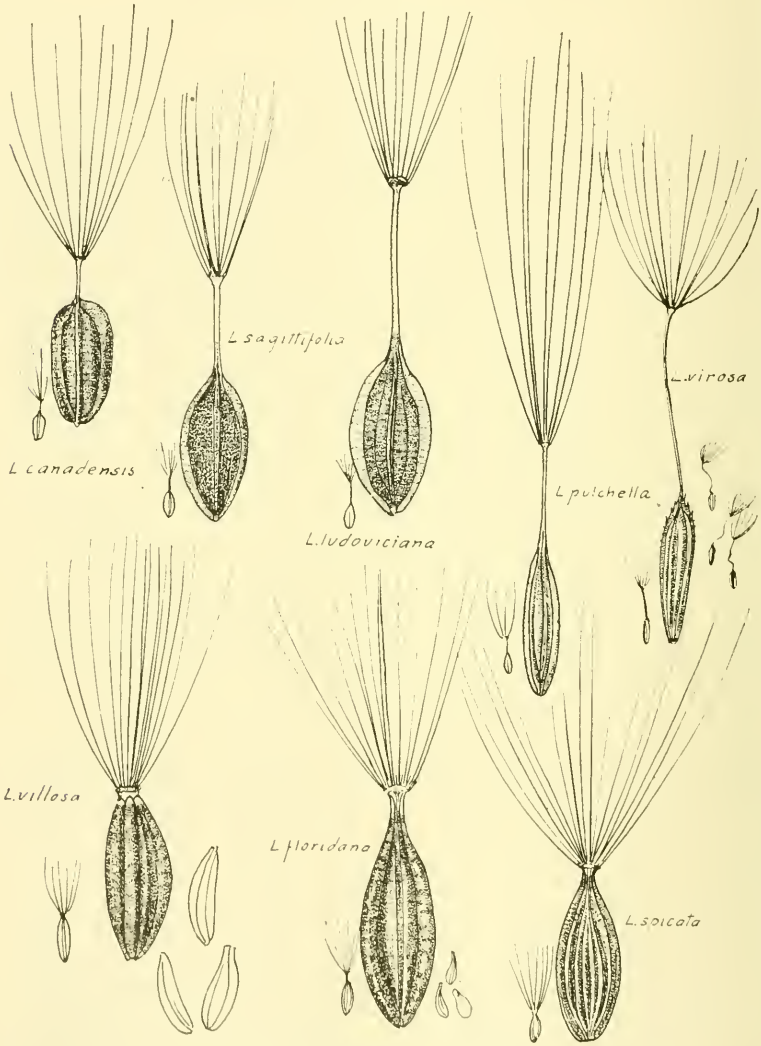

Fig. 83.—Akenes of Lactuca.

make of the plant. In the second edition of the *Illustrated Flora, L. scariola* is reduced to a synonym of the older Linnaean species. However, in this paper *L. scariola* is retained as a distinct species, although it might well be considered as only a variety of ***virosa.***

The leaf-forms of the two plants are strikingly different and appear very uniform throughout our range. *L. virosa* appeared in Iowa some ten years previous to *L. scariola,* but the latter is rapidly supplanting it, especially in the central and southern portions of the state, and threatens to become one of our most persistent weeds. *L. virosa* seems to prefer drier conditions, and is the prevailing form in the arid regions of the west.

The common garden lettuce *L. sativa* L. which, at least in our region, does not possess sufficient vitality to exist without cultivation, is not included in this list. It is very closely related to *L. virosa* and by some is thought to be derived from that species.

All the species contain an acrid juice which probably accounts for their seldom being eaten by stock. The dried milky juice of several old world species, especially *L. virosa,* is a mild anodyne or narcotic, and has frequently been used in medicine, under the name Lactucarium.

The genus *Lactuca* may be characterized as follows: Leafy herbs, two to ten feet tall, with rather open, panicled heads of yellow, white, blue or violet flowers, and variously formed alternate leaves; bracts disposed in two or more rows, the successive inner ones longer. Akenes flat or somewhat thickened, contracted at the summit into a long slender beak, or in the third section decidedly contracted at the summit, or beakless in *L. villosa;* the dilated summit of the beak or neck bearing a copious pappus of soft capillary bristles, which are white, except in one of our species; heads six to thirty flowered; receptacle flat and naked.

The name *Lactuca* is from the Latin *Lac,* milk, in allusion to the milky juice.

The species, which number about one hundred, are most numerous in the old world. Besides those here listed five others occur in the Atlantic coast states, one of which, *L. saligna*, is a recent introduction from Europe, and two other species have been described from the Rocky Mountain region.

Key to the Species.

1 Section, *Scariola* D. C. Akenes flat, orbicular to linear-oblong, with filiform beak, cauline leaves sagittate-clasping, annual or biennial.

 Heads 6 to 12 flowered, akenes linear-oblong, several nerved, flowers yellow.

  Leaves mostly entire, midrib usually prickly-setose ....*L. virosa*

Leaves pinnatifid, spinulose-denticulate............... *L. scariosa*
Heads 12 to 20 flowered, akenes oval to oval-oblong, blackish, 1 nerved on each face with narrow margins.
Tall, 4 to 10 feet high, leaves 4 to 15 inches long, sinuate, pinnatifid, flowers pale yellow......... *L. canadensis*
Leaves thickish, strictly entire......................... *L. sagittifolia*
Stem more uniformly leafy, basal bracts somewhat foliacious, lobes of leaves spinulose-toothed, flowers in our plant light purple.......................... *L. ludoviciana*
2 Section, *Lactucastrum,* A. Gray, Akenes flat, marginless, beak slender, pappus white, perennial............................ *L. pulchella*
3 Section, *Mulgedium* (Cass) A. Gray. Akenes thickish, oblong; beak or neck almost wanting, annual or biennial; flowers mostly blue.
Pappus white, akenes beakless, curved.................. *L. villosa*
Pappus tawny, neck short.. *L. spicata*

1. *Lactuca virosa* L. Sp. Plant, 795. (1753.)

L. scariola integrata Auct. Am. *L. integrata* Aven Nelson. Prickly Lettuce.

Green and glaucous, stems paniculate branched, two to six feet high, scabrous or hirsute at base; leaves mostly entire with spinulose denticulate margins, the midrib usually spiny; margins of the leaves more frequently retaining a horizontal position than the following. Bases sessile or auriculate-clasping, the lower frequently six to ten inches long and two to three inches wide. Heads four to six lines high and two to four lines broad, six to twelve flowered, very numerous, the outer bracts shorter, rays yellow; akenes linear-oblong, or ovate-oblong, somewhat shorter than the wavy, filiform beak; pappus copious, white. This plant is reported to be poisonous to young geese, and Mr. Fred Fitzpatrick of Iowa City says that young goslings pasture on it in preference to any other plant and that he once deliberately experimented by allowing a number of goslings to feed on it, all of which died as a result. This, like the following, being an annual, may be easily controlled by not allowing it to ripen seed, but the laws regarding the mowing of weeds must be more rigidly enforced if these pests are to be kept in subjection. The seeds have mostly been introduced as impurities in clover, millet and heavier grass seeds. Doctor Pammel in his Weed Flora, pp. 396-399, gives illustrations and interesting notes regarding this and the following species, and in Rhodora for October, 1918, p. 180, is an article from his pen giving additional information regarding their distribution and frequency. He also states that hybrids between this and the common garden lettuce have been reported.

This species was introduced into Iowa about ten years earlier than *L. scariola*, but throughout the central and southern parts of the state the latter seems to be getting the stronger foothold. *L. virosa* is the prevailing form in the arid regions of the west, its foliage being better calculated to resist the arid conditions.

Specimens examined:

Iowa: Ames, *Pammel,* 1897, 1904, 1911, 1912, 1913; *Campbell,* 1909, 3 sheets; *Ellis,* 1914; *McKinney,* 1916; *Harlan;* Okoboji, *Cratty,* 1901; Burlington, *Pammel,* 1918; Council Bluffs, *Pammel,* 1918; Des Moines, *Bakke,* 1912; *Pammel,* 1894, 2 sheets; Eddyville, *Pammel,* 1912; Decatur County, *Anderson,* 1914; Eagle Grove, *Pammel,* 1894; Marshalltown, *Pammel,* 1902; Winneshiek County, *Goddard,* 1895; Herbarium, *T. J. Fitzpatrick,* Henry County, 1895, Van Buren County, 1896, Dubuque County, 1895, Fremont County, 1898, Taylor County, 1898, Johnson County, 1896; Herb. Iowa State University, Coll. *B. Shimek,* Hamburg, 1898, Jackson County, 1894, Keokuk, 1895, Forest City, 1895, Dallas County, 1897, Rock Rapids, 1896, Davenport, 1895, Spirit Lake, 1896, Clear Lake, 1896; Jasper County, *Miss Cavenaugh,* 1898; Muscatine, *Ferd. Reppert,* 1896; Kossuth, *Cratty,* 1896; Goldfield, *Cratty,* 1896; West Bend, *Cratty,* 1919; Madison County, *Pammel,* 1919.

North America: *Michigan*—Dearborn, *Stewart,* 1898. *Illinois*—LaSalle, *Pammel,* 1918; Champaign, *Fink,* 1892; Urbana, *Trelease,* 1916. *Wisconsin*—Madison, *Allen,* 1914, 4 sheets; *Churchill,* 1893: "Wisconsin" *Herb. Parry.* *Ohio*—Mansfield, *Wilkenson,* 1896. *Missouri*—Kansas City, *Pammel,* 1918. *Montana*—Billings, *Pammel,* 1904, 2 sheets. *Colorado*—Greeley, *Pammel,* 1901; La Porte *Pammel & Johnson,* 1901; College Farm, 1898. *Utah*—Logan, *Isabel Mulford,* 1896. *Washington*—Seattle, *Pammel,* 1906.

2. *Lactuca scariola* L. sp. Pl. Ed. 2, 1119 (1763), Prickly Lettuce.

Similar to the preceding species in flowers and fruit, but leaves pinnatifid, with spinulose-denticulate margins, one edge of the leaf usually inclined upwards. Although given specific rank here it might possibly be better considered as a variety of the former. Although appearing in the state some years later than *L. virosa* it is spreading very rapidly and promises to be the most troublesome of the two.

Specimens examined:

Iowa: Harlan, *Pammel*, 1916; Frazer, *Hayden* and *Henderson*, 1916; Ames, *Pammel*, 1916; Sioux City, *Mrs. Taylor*, 1916; Fairmont, *Mrs. Tuttle*, 1918; Burlington, *Pammel*, 1918; Goldfield, *Cratty*, 1919; West Bend, *Cratty*, 1919; Avoca, *Pammel*, 1919.

North America: *Ohio*—Gambier, *Pammel*, 1918. *Illinois*—Urbana, *Trelease*, 1916, 2 sheets; Chicago, *Pammel*, 1887. *Minnesota*—Black Duck, *Mrs. Westley*, 1918. *Nebraska*—Hastings, *Pammel*, 1895. *Colorado*—Golden, *Pammel*, 1895, altitude 8,000 feet. *Dist. of Col.*—Washington, *Dewey*, 1895.

3. *Lactuca canadensis* L. Sp. Plant, 796 (1753). Wild or Tall Lettuce; Wild Opium.

Glabrous and somewhat glaucous throughout, three to ten feet high, leafy up to the narrow branched panicle. Leaves mostly sinuate-pinnatifid, the upper lanceolate and entire; stem leaves clasping, the lower sometimes ten to twelve inches long and narrowed into a petiole. Flowers yellow, numerous, the heads four to seven lines high. Akenes oval, flat, about as long as the beak, and having a distinct margin and strongly one-nerved on each face. A most variable species, especially in its leaf forms.

Open places in moist soil from Nova Scotia to the Northwest Territory and south to Georgia, Louisiana and Colorado. Common throughout Iowa, but not especially troublesome.

Specimens examined:

Iowa: Ames, *Pammel*, 1911, 2 sheets; *E. D. McKune*, 1916, 2 sheets; Burlington, *Pammel*, 1917; Fairmont, *Mrs. Tuttle*, 1918; Clear Lake, *Cratty*, 1918; McGregor, *Pammel*, 1918; Decorah, *Goddard*, 1895, 2 sheets; Des Moines, *Carver*, 1895; *Pammel*, 1902; *Bakke*, 1912; *McKune*, 1916, 2 sheets; Keokuk, *Rolfs*, 1891; Ogden, *Pammel*, 1898; Boone, *Ellis*, 1914; Armstrong, *Cratty*, 1897; Mason City, *Pammel*, 1902; Fayette, *Fink*, 1896; Adel, *C. F. Clark*, 1907; Decatur, *Anderson*, 1914; Postville, *Pammel*, 1918; Frazer, *Pammel*, 1916; Salem, *Jaques;* Kelly, *Miss Clayton*, 1911; Johnson County, *Fitzpatrick*, 1904 and 1905; Jefferson County, *Fitzpatrick*, 1900; Winneshiek County, *Goddard*, 1895; Decatur County, *Fitzpatrick*, 1898; Jackson County, *Shimek*, 1894; Lee County, *Paul Bartsch*, 1895; Greene, *Pammel*, 1919; Madison County, *Pammel*, 1919.

North America: *Illinois*—Walnut, *Pammel*, 1918. *Minnesota*—Black Duck, *Mrs. Westley*, 1918; Anoka, *Cratty*, 1918; Cass Lake, *Pammel*, 1914. *Missouri*—Kansas City, *Pammel*, 1918; St. Louis, *Greeneman*, 1916. *Wisconsin*—Prescott, *Miss Edgar*, 1915; "Wisconsin" *Herb. Parry;* Madison, *Allen,* 7 sheets; Onalaska, *Pammel,* 1917. *Utah*—Logan Canon, *Pammel,* 1908. *Colorado*—Soldier Canon, elevation 6,500 feet, 1898.

4. *Lactuca sagittifolia* Ell. Bot. S. C. & Ga. 2 : 253 (1821-24) Arrow-leaved Lettuce.

Very leafy up to the branched inflorescence; two to six feet high, glabrous throughout; leaves entire, thickish, lanceolate to broadly oblong, the broad amplexicaul auricles of the sagittate base slightly toothed, the basal leaves sometimes petioled. Heads five to seven lines high, rays yellow or reddish; akenes oval, flat, longer than the filiform beak.

The plant ranges from New Brunswick and Ontario to Georgia, Missouri and Idaho. All Iowa specimens seen are from the southern portion of the state. Frequent locally in rich soil.

Specimens examined:

Iowa: Ogden, *Pammel,* 1898; Decatur County, *Anderson,* 1904; Des Moines, *McKune,* 1916; Mt. Pleasant, *Jaques,* 1917; Hopkinton, *Macbride;* Appanoose, *Fitzpatrick,* 1902; Taylor County, *Fitzpatrick,* 1898; Ringgold County, *Fitzpatrick,* 1898; Decatur County, *Fitzpatrick,* 1896.

North America: *Illinois*—Morris, *Pammel,* 1918; Urbana, *Trelease,* 1916. *Missouri*—St. Louis, *Greeneman,* 1916, 2 sheets. *Wisconsin*—Madison, *C. A. Davis,* 1916. *Minnesota*—Duluth, *Pammel.*

5. *Lactuca ludoviciana* (Nutt) D. C. Prod. 7 : 141 (1838). Western Lettuce.

Lactuca campestris Greene is probably only a color form of this species. Biennial, glabrous throughout up to the branched, paniculate inflorescence; two to five feet high, with stem stout, leaves sinuate-pinnatifid, the lobes spinulose toothed. Heads large, eight to ten lines high, the flowers not so numerous as in the two preceding species. Bracts glabrous, the lower ones ovate. Akenes oval to obovate, flat, about equaling the beak; rays pink or light purple so far as observed in Iowa; the flowers seldom opening except early in the morning or on cloudy days; a very variable species. This plant is a good example of color variation in the flowers. The color given in the manuals is yellow, but forms with blue flowers occur in Colorado according to Dr. N. L. Britton. The range is from Minnesota and Illinois to Montana, Colorado and Texas.

Specimens examined:

Iowa: Ames, *Miss Marie Rees,* 1918; *Pammel* and *Maxwell,* 1911: *W. S. Dudgeon,* 1904, 2 sheets; *S. W. Beyer,* 1888; *Rolfs,* 1897. 2 sheets; *D. C. McKune,* 1916; *Cratty,* 1918; Kelly, *Pearl Clayton,* 1911, 3 sheets; *Pammel* and *Maxwell,* 1911; Frazer, *Pammel;* Ogden, *Pammel,* 1898; Slater, *Rembrandt* and *Fawcett,* 1902; High Lake, Emmet County, *Shimek,* 1895; Winnebago County, *Shimek,* 1895; Emmet County, *Wolden,* 1916; Des Moines, *McKune,* 1916; Salem, *Pammel,* 1917, 2 sheets; Arnold's Park, *Pammel,* 1913; West Bend, *Cratty,* 1919.

North America: *Illinois*—Pullman, *Pammel,* probably introduced. *Wisconsin*—Madison, *Pammel,* 1913; LaCrosse, *Pammel,* 1889. *Kansas*—Wichita, *Dr. Andrews,* 2 sheets. *South Dakota*—Watertown, *Pammel,* 1918.

6. *Lactuca pulchella* (Pursh) D. C. Prod. 7 : 134 (1838) Large Flowered Blue Lettuce.

Perennial, glabrous throughout, and somewhat pale and glaucous, two to four feet high; leaves sessile, oblong or linear-lanceolate, entire or the lower runcinate-pinnatifid. Heads few and large, eight to ten lines high, the outer successively shorter, and ovate-lanceolate. Akenes oblong-lanceolate and nearly twice as long as their beaks.

Frequent in moist soil, having the widest range of any native American species; Ontario to British Columbia and south to Michigan, Kansas, New Mexico and California. It is quite rare as a native of Iowa, but is becoming quite commonly introduced throughout the state as an impurity in timothy seed. Being a perennial it is less easily eradicated than most of the other species, and is reported to be a pernicious weed in some sections. Its handsome blue flowers make it our most beautiful species of the genus.

Specimens examined:

Iowa: Fremont County, *Fitzpatrick,* 1898; Boone, *Geo. Carver,* 1890; Sioux City, *Pammel,* 1895, 2 sheets; Armstrong, *Cratty,* 1901. 2 sheets; Turin, *Pammel,* 1904; Wallingford, *Wolden,* 1916; Mount Pleasant, *Mills;* Osceola County, *Fitzpatrick,* 1904; Montgomery County, *Fitzpatrick,* 1898; Fremont County, *Fitzpatrick,* 1898; O'Brien County, *Jordan,* 1919; Arcadia, *Pammel,* 1919; Paullina, *Yockey,* 1919; Primghar, *Bernsten,* 1919.

North America: *Minnesota*—Star Island, Cass County, *Pammel,* 1914; International Falls, *Kellogg,* 1914. *South Dakota*—Brookings, *Pammel,* 1918; Spear Fish Canon, *Miss King.* *North Dakota*—*Sheldon,* 1889. *Nebraska*—McCook, *Pammel,* 1895; Callaway, *Bates,* 1901. *Montana*—Miles City, *Pammel,* 1904. *Wyoming*—Halleck Canon, *Aven Nelson,* 1900; Sheridan, *Reppert* and *Estella Paddock. Colorado*—Fort Collins, *Pammel,* 2 sheets; Colorado Springs, *Pammel,* 1895; Greeley, *Pammel,* 1896; Clear Creek, *Herb. Parry. Utah*—Peterson, *Pammel* and *Blackwood,* 1902. *Arizona*—Walnut Canon, *McDougal,* 1898.

7. *Lactuca villosa* Jacq., Hort. Schoen. 3 : 62, plate 367 (1798).

L. acuminata A. Gray., Proc. Am. Acad. 19 : 73 (1883). *Mulgedium acuminatum* D. C., Prod. 7 : 249 (1838). Hairy-veined Blue Lettuce.

A glabrous stemmed annual or biennial which is leafy up to the paniculate inflorescence; four to seven feet high, heads numerous on diverging peduncles. Leaves oblong to lanceolate, sharply and sometimes doubly serrate. The lower often deeply lobed or runcinate, glabrous above, pubescent with short stiff hairs on the veins beneath, slightly clasping at the base, four to six inches long and one-third as wide. Rays blue, involucre about five lines high, the outer bracts much shorter and mostly obtuse. Akenes narrowly oblong, slightly curved and flattened, narrowed at the summit and almost beakless; pappus white. Borders of woods, New York to Iowa, and south to Florida and Kentucky. Abundant, especially in the eastern and southern parts of the state.

This species has been confounded with the southeastern *L. floridana* (L) Gaertn, with which it is almost identical in foliage. The latter species probably does not occur in this region, although credited to it in our manuals, and in all the herbaria examined. In every case where so labelled the fruit has proved to be typical of *L. villosa.* In the first edition of the *Illustrated Flora,* vol. III, p. 275, the figure of the akene given on the cut of *L. floridana* is identical with that of *L. villosa* on the same page, but in the second edition the error is somewhat remedied by removing the figure of the akene from the cut of the former. A good figure of the akene of *L. floridana* is given in Gray's Manual, 7th edition, p. 688, and for the benefit of those interested in this species a figure of the akene from an authentic specimen (Curtis's No. 5763, collected at Jacksonville, Florida, in 1896) is given on the plate which accompanies this paper. A specimen listed below, labelled *L. floridana,* and collected by Webber in Nebraska in 1886 is in the herbarium of the Field Columbian Museum, Chicago, but it proves to be *L. pulchella,* and is presumably the same plant on which Webber admitted *L. floridana* into his flora of Nebraska. The heads of the latter species are a third larger than those of *L. villosa,* the bracts with tapering points; the most striking difference, however, is in the shape of the akenes.

Specimens examined:

Iowa: Ames, *Ball,* 1897; *Pammel,* 1910; Keosauqua, *McDonald,* 1907; Des Moines, *Carver,* 1895; Decatur County, *Anderson,* 1904; Lee County, *Bartsch,* 1895; Des Moines County, *Fitzpatrick,* 1896; Decatur County, *Fitzpatrick,* 1897 and 1898; Johnson County, *Fitzpatrick,* 1894, 1896, 1900; Van Buren County, *Fitzpatrick,* 1896; Council Bluffs, *Miss Cavenaugh,* 1898; Mount Pleasant, *Mills;* Des Moines County, *Bartsch,* 1895; Jackson County, *Shimek,* 1894; Iowa City, *Somes,* 2 sheets; Madison County, *Pammel,* 1919.

North America: *Missouri*—Allenton, *Letterman,* 2 sheets; St. Louis, *Greeneman. Illinois*—Urbana, *Trelease,* 2 sheets. *Wisconsin*—Prescott, *Miss Edgar. Nebraska*—Cass County.

8. *Lactuca spicata* (Lam.) Hitch., St. Louis Acad. Sci. 5:506 (1891), *L. leucophæa* A. Gray., Prod. Am. Acad, 19:73 non Sibthorp (1840). *Mulgedium leucophoeum* D. C., Prod. 7:250 (1838). Tall Blue Lettuce.

A stout stemmed annual or biennial, leafy up to the rather dense panicle. Leaves irregularly pinnatifid or runcinate, coarsely toothed, the upper stem leaves sessile or auriculate clasping. Flowers bluish or cream color. Akenes short beaked, the copious pappus tawny.

Common, Maine to Minnesota and Alaska, south to North Carolina and Tennessee. Infrequent in Iowa in moist soil.

Specimens examined:

Iowa: Fayette, *C. C. Parker;* Winneshiek County, *Goddard,* 2 sheets; Des Moines, *Paul Bartsch.*

North America: *Illinois*—Urbana, *Trelease,* 1916. *Wisconsin, Allen,* 2 sheets. *Minnesota*—Hennepin County, *Burglehaus,* 1891; Coleraine, *Cratty,* 1919. *Kentucky*—Bell County, *T. H. Kearney, Jr.,* 1893. *Michigan*—Mackinac Island, very common and the only species observed, *Cratty,* 1919. *Alaska*—Haines, *J. P. Anderson,* Plants of Alaska, No. 890, Aug. 21, 1918.

Herbarium Iowa State College.

MAMMOTH CLOVER RUST[1]

W. H. DAVIS

Before the work of Liro, there was thought to be but one clover rust. He proved the rust on white clover to be autœcious and it was classified as *Uromyces trifolii-repentis* (Cast) Liro. It has been shown that the rust on red clover is also autœcious, having all four stages on red clover, and it is generally classified as *Uromyces trifolii* (Hedw. f.) Liro. The rust on alsike clover is autœcious, having all the stages, and was classified as *Uromyces hybridi,* Davis, in Vol. XXIV, Iowa Academy of Science, 1917.

The disposition of the rust on mammoth clover is not clear. Morphological examinations of the spores have caused taxonomists to assign this rust to the species on red clover or *U. trifolii* (Hedw. f.) Liro, but no inoculations have been made to prove this supposition. The teliospores and urediniospores of the rusts on the red and mammoth clovers are similar in size and in number of germ pores together with other structures. An æcial stage has not been reported on mammoth clover; it is taken for granted that only the uredinial and telial stages of red clover rust are found on the mammoth by using the mammoth as another host. Thus three important questions arise:

1. Is the rust on mammoth clover the same as that found on red clover?
2. Is an æcial stage found on mammoth clover?
3. Is this an autœcious or heterœcious rust?

With these questions in mind, the solution of this problem was started in the fall of 1918. Herbarium specimens of rusted clover plants of different species were collected. The winter being very open, plants could be dug from out of doors and repotted at various times. The plants were placed in the greenhouse and the rust harbored all winter.

The æcial stage, æciospores and pycnia.—Plants of mammoth clover were repotted from out of doors on December 9, 1918.

[1]The usage of the common and species names are as follows: White clover, *Trifolium repentis* L.; Red Clover, *Trifolium pratense* L.; Alsike, *Trifolium hybridum* L.; Mammoth—a species of red clover, generally classified as *Trifolium medium* L. Leaflets hairy, entire, spotless, notched at tip. Stipules mostly smooth. Stems larger and taller than red clover.

Several blades and petioles bearing æcia and pycnia, on two different plants, were discovered on January 13, 1919. A red clover plant brought in on the same date (December 9, 1918) bore æcia on January 15, 1919. These materials were used for inoculations,

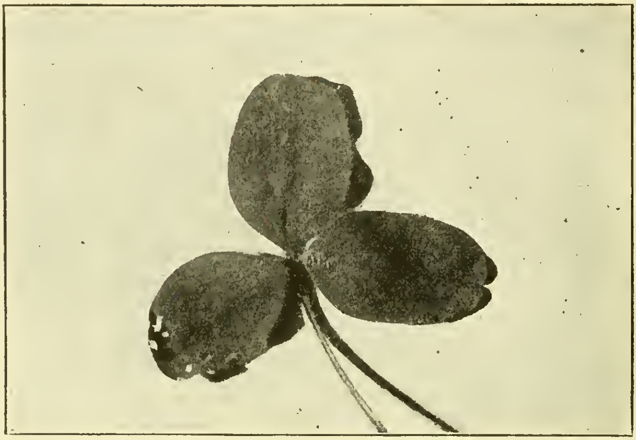

Fig. 84.—Aecia on a leaflet of a transplanted plant. *(T. medium L.)*

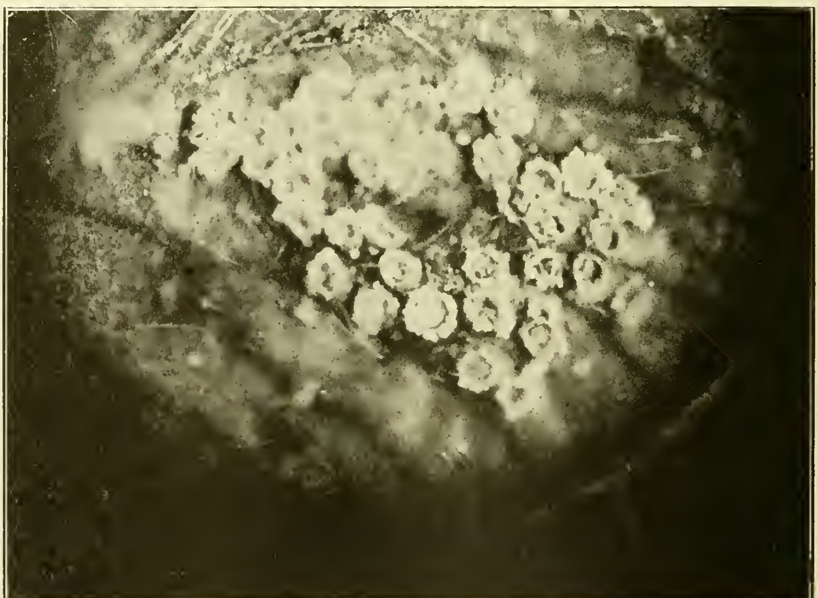

Fig. 85.—Aecia, magnified about one hundred and seventy-five times, showing the nature of the peridial cells (recurving). *(T. medium L.)*

spore examinations and germinations, for imbedding and other work. Aeciospores allowed to fall in a drop of tap water on a glass slide, germinated 98 per cent in 24 hours. Some germ tubes were 0.7 mm. long. Measurements of æciospores mounted in water were as follows: 16-26x16-28 microns. Standard 20x24 (thirty

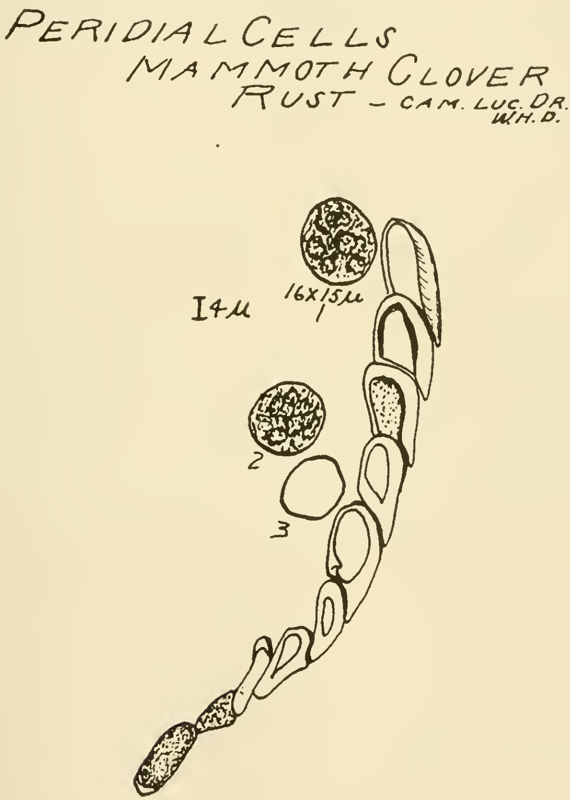

Fig. 86.—Peridial cells drawn from a prepared slide. Outer walls averaged 4 microns, inner walls, 2 microns. The upper cell was the only one on which striations were observed on the outer wall.

measured). This would tend to show the æciospores of red clover rust are larger than those on mammoth clover. These spores are shown in figures 84 and 85, also in figures 86 and 87.

Urediniospores.—Urediniospores collected October 10, 1918, germinated by February 13, 1919, about 75 per cent. Those on the stems seemed to retain their vitality longer than those on the leaves. On February 20, 1919, but two of the spores on the leaves germinated. One specimen showed the life of urediniospores on leaves in a dry, warm living room to be 55 days. A rusted mammoth clover plant retained the uredinial stage in the greenhouse all winter until April 2 when it was entirely dead, probably due to the rust as others not rusted were in a healthy condition.

Urediniospores mounted in lacto-phenol and examined after standing one week showed plainly 5 and 6 germ pores scattered.

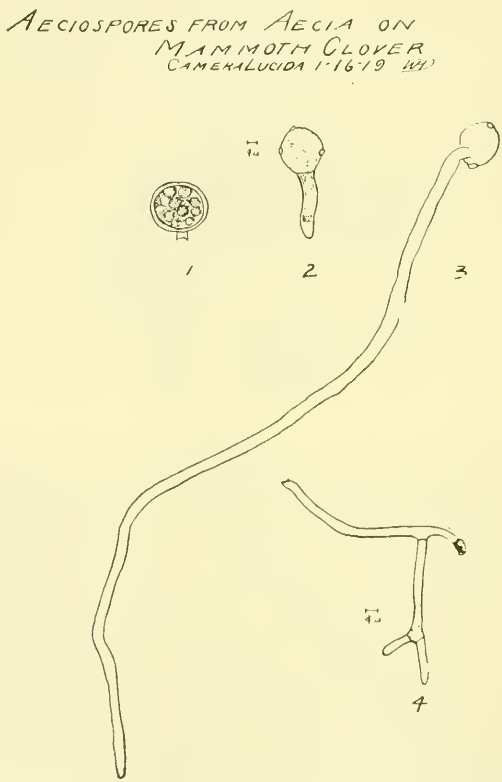

Fig. 87.—These germ tubes averaged 4 microns in diameter. Taken from a transplanted plant, December 12, 1918. Drawn after standing twenty-four hours in water. Number 4 shows a germ tube branching.

The number of germ pores varied from 5 to 7, thus following the rust on red clover in this respect. The spores are ecinulated and fifty projections were counted on one side of one spore. The spores are shown in figure 88.

The measurements of the spores varied slightly from the urediniospores on red clover but the variation is no more than could be expected between the measurements of any two spore samples.

Taxonomists, in general, regard the measurements as about the same.

Teliospores.—Teliospores from a collection of November 14, 1918, were set to germinate on January 2, 1919, and had germinated

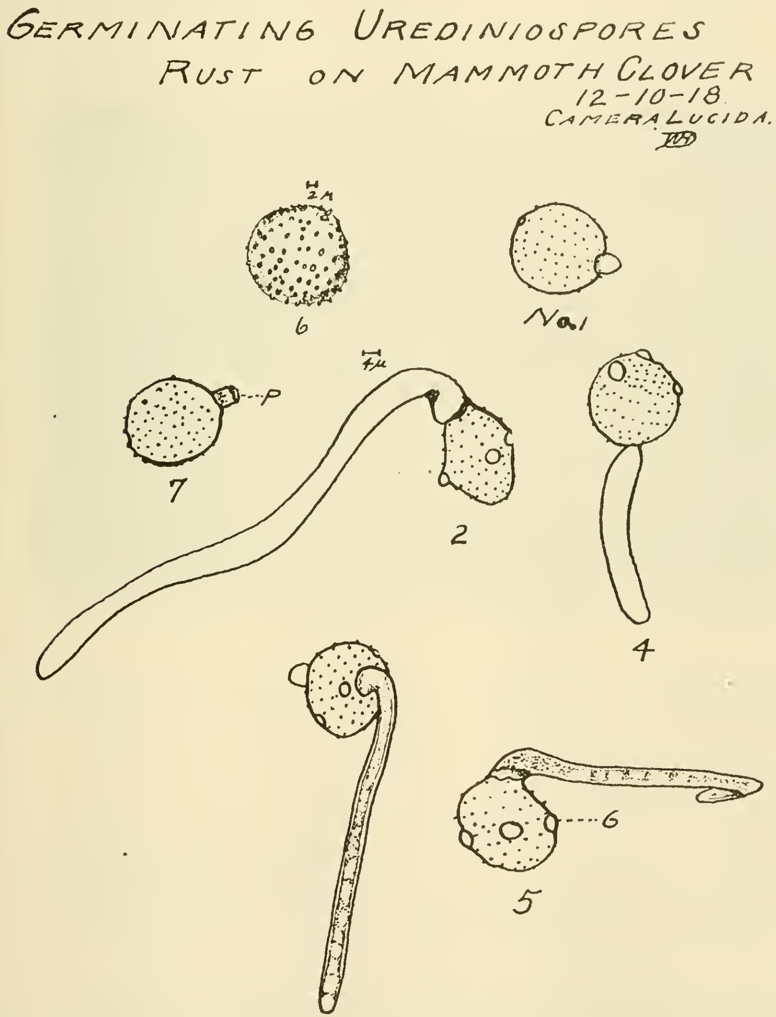

FIG. 88.—These spores averaged 22 by 24 microns. Drawn after being twenty-four hours in tap water. P=Pedicle. Number 5 shows uredinia at the time of opening (magnified).

40 per cent on January 12. Germinating teliospores are shown in figure 90, numbers 4 and 5.

Teliospores mounted in water and measured gave the following: 16-20x22-32 microns. Standard 18x24 (thirty-five measured). The teliospores on red clover measured 12-18x18-25 microns, on white clover 17-19x22-26 (thirty measured in each case). Thus it would appear that the teliospores on mammoth clover are larger but this fact is not of much importance since taxonomists differ so much in reporting spore measurements for these rusts. The following

Fig. 89.—Uredinia opening.

table will show the measurements given to teliospores on different hosts by different authors. Germinating teliospores are shown in figure 90, numbers 4 and 5. D=A germinating sporidium.

Host	Arthur	Saccardo	Sydow	Howell	Davis
T. repens..........	13–19x20–29	15–22x20–35	16–25x18–30	15–20x20–28	17–19x22–26
T. pratense......	16–20x20–27		16–25x18–30	16–20x27–35	12–18x18–25
T. (medium)....	Do.		Do.	Do.	16–20x22–32

All measurements in Microns.

As the rust on *T. repens L.* is treated by most of these authors as that on *T. medium*, this would complicate matters still more. The teliospores conform to the shape, structure and color of the rusts on white and red clovers. There seems to be no safe basis on which to separate the species on examination of teliospores.

Peridial Cells.—Five different sections of leaves from two different plants of mammoth clover bearing æcia, were killed in Flemming's and in Gilson's solution, imbedded, cut, stained and the peridial cells examined for morphological differences. The inner walls are minutely verrucose like the other clover rusts, striæ could be found on the outer walls. The inner walls of the peridial cells were so thin that difficulty was experienced in sectioning them.

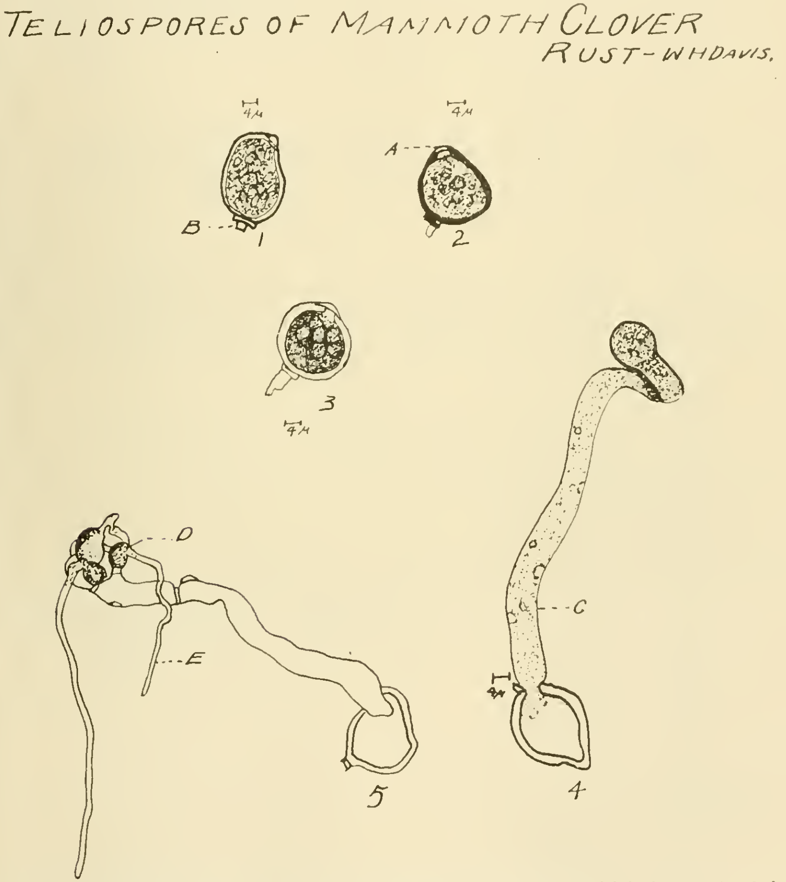

FIG. 90.—Numbers 4 and 5 are germinating teliospores which have stood in tap water for two weeks. In number 5 D=sporidium germinating.

Measurements of sections of the peridium showed the inner walls to average 2 microns thick and the outer walls, 4 microns thick. The inner walls of the peridial cells of red clover rust are 3 microns; outer, 6 microns. Of alsike, inner, 1 micron, outer, 3 microns. Thus it would seem that the peridial cell thicknesses conform closer to those of alsike clover than to red clover rust. The peridial cells are shown in figure 86.

Inoculations.—The following table will show some of th e principal inoculations and spore s owings made together with the results.

TABLE OF INOCULATIONS ON CLOVERS.

Number	Spores Used	Date of Sowing	Host	Number Leaves	Date	Results Number Infected	Remarks
1	II from White	10–28–15	Mammoth	10	11–14–15	0	
			Red	10		0	
			White	10		7	
2	II from Red	10–28–15	Mammoth	10	11–14–15	10	
			Red	10		10	
			White	10		0	
4	I from White	11–15–15	Red	5	11–28–15	0	
			White	5		4	
			Mammoth	5		0	
5							Same as Number 2
41	II from Mammoth	12–16–18	Mammoth	5	1–3–19	4	I Dead. Not rusted
			Med. Red	5		4	3 highly; 1 clear
			White	5		0	One dead
			Alsike	5		0	One dead
42	I from Mammoth	1–13–19	Mammoth	5	2–3–19	1	4 leaves dead
			Med. Red	3		3	
43	I from Red	1–13–19	Mammoth	3	4 wks.	3	
			Red	2		2	
	I from Mammoth		Mammoth	4		4	
			Red	4		1	3 dead

The rust on mammoth clover was transferred to red clover only and the rust on red clover transferred to mammoth through the æciospores and urediniospores of each.

SYNONOMY.

(Referring to the rust on *T. pratense L.*).

1. *Uromyces trifolii* (Hedw. f.) Lev. Monographia Uredinarium 2:133.

2. *U. trifolii* (Hedw. f.) Lev. The British Rust Fungi. Grove, p. 92.

3. *U. fallens* (Desm.) Kern. Danish Fungi. Lind, p. 338.

4. *Nigredo fallens* (Desm.) Arth. N. Am. Flora 73:255 Arthur.

Note—Synonomy prepared by Dr. J. J. Davis, Wisconsin University.

Causal Organism.—The causal organism is probably *Uromyces trifolii* (Hedw. f.) Lev. and all stages are found on mammoth clover. There is not enough definite proof to establish a new species.

CONCLUSIONS.

1. This rust on mammoth clover may be transferred to red clover.
2. The rust on red clover may be transferred to mammoth clover.
3. All stages of the clover rust may occur on mammoth clover.
4. The rust can not be transferred to alsike and to white clover.
5. There seem to be morphological differences between this rust and the rust on red clover.
   (a) Sizes of the different spores.
   (b) Thickness of peridial cells.

IOWA STATE TEACHERS COLLEGE.

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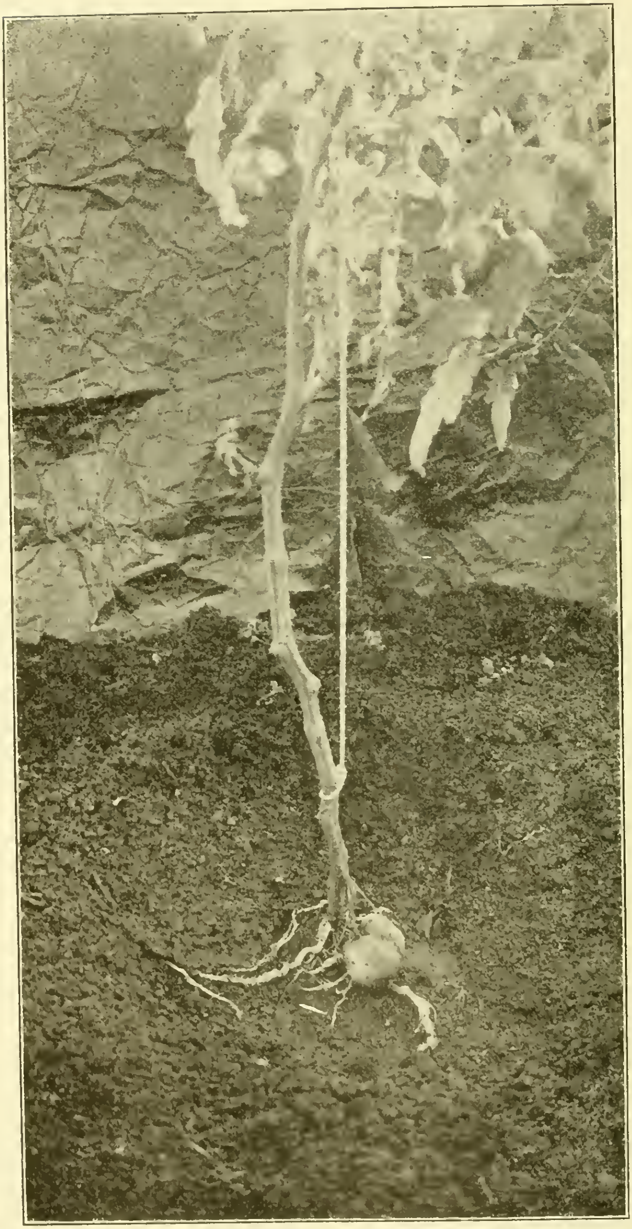

Fig. 91.—A subterranean tomato. This tomato was a Field's Red Head, grown in the greenhouse, started in the fall of 1918. On February 12, 1919, while Mr. Robert Billings was working the soil around the roots he called my attention to the formation of the under-ground tomato. The photograph was taken three weeks later.

THE MOSS AND LICHEN FLORA OF WESTERN EMMET COUNTY.

(AN ANNOTATED LIST OF THE BRYOPHYTES AND LICHENS OF THE HIGH LAKE AND DES MOINES RIVER REGION.)

B. O. WOLDEN

The prairie region does not, as a rule, offer a very rich field for the student of mosses and lichens. However, the territory which this paper attempts to cover does present several features of interest not only to such students but to the general botanist as well. For here we have not only the level prairie, but also lakes and deep woods, dry wooded ridges and shady ravines and hillsides.

There are chiefly three localities represented in the collections on which this list is based. These are the wooded region around High lake and Mud lake; the bowlder-strewn knolls and hillsides east of Des Moines river near the southern part of the county; and the wooded hills and ravines west of Estherville. Of particular interest to the student of local plant life are the High lake and Estherville woods. Here are found a number of plants otherwise rare to this part of the state, many of which have not been reported by botanists. The Estherville woods are interesting ground for the collector because of the diversity of the topography, which is quite rough when compared with the surrounding country.

It has been the hope of the writer to prepare a more extended paper covering the entire flora of this region, but time has been lacking for completing the collections on which such a paper would have to be based. And as the war conditions make it unlikely that such a hope will be realized this paper is presented with its present limitations.

By most people these little forms of plant life are overlooked and yet it can not be said that they are at all inconspicuous. In the woods and groves the lichen growths meet our eyes wherever we look, almost, as the tree trunks are, so to speak, clothed with lichens in more open situations. The old stumps are often covered with different species of *Cladonia* and the prairie bowlders, when left undisturbed, are strangely mottled by the variously colored, mostly crustose lichens. Some of these are very beautiful objects when seen under a lens.

Mosses are among Nature's most beautiful handiwork. We will find this to be true whether we look at the luxuriant green carpet that lines the cool shady lake bank or hillside, or at an individual plant through a lens or a microscope. Though some kinds are very common in more open grassy woodlands, the largest number of species and the most luxuriant growth are found along shaded lake banks and hillsides facing an exposure away from the sun. To the nature lover such situations are often most enchanting, especially in early spring and during rainy days of autumn.

The author realizes that this list is far from complete. It is the result of odd hours spent in collecting on infrequent occasions and with long intervals. Another season of more systematic work would no doubt have added many species, and if this had been possible the publication of the paper would have been delayed until it could have been made more complete. However, it is believed that the list is fairly representative of the region and it is, therefore, presented with the hope that it may be of interest and assistance to some one who may, in the future, undertake the study of the lichen and moss flora of this or adjacent counties or localities. The writer knows of no other moss list for this section of the state. The lichen flora is fairly well represented in Professor Shimek's "The Plant Geography of the Lake Okoboji Region."

The writer has not depended on his own determination in making up this list. In order to add to the value of the paper duplicates of all the specimens collected, even of the common and well-known forms, have been submitted to the different curators of the herbariums of the Sullivant Moss Society.

The author is indebted to Miss Mary F. Miller, of Washington, D. C., formerly curator of the Lichen Herbarium, for the determination of the specimens of his earlier collections, and to the present curator, Mr. C. C. Plitt, of Baltimore, for the later collections. The mosses have been determined by Mr. George B. Kaiser, of Germantown, Pennsylvania, curator of the Society Moss Herbarium.

LICHENS

The greater number of lichens listed below were collected in the High lake vicinity. This will include most of the species growing on trees. On the other hand nearly all the rock-loving species were collected on the bowlders which are so abundant along the hillsides and knolls bordering on the Des Moines river plain, on the east, near the south side of the county. Only a small number of species were found on earth, and most of these were from the Estherville woods.

The species growing on trees are found mostly in open situations and are especially abundant in rather dry upland woods. The heaviest growth is generally on the north side of the trunks, except when the trees face an opening, when the lichen growth is most abundant on the side exposed to the light. In low dense woods where little light penetrates, the trunks are almost without lichen growth. Apparently plenty of light without direct exposure to the sun is the most favorable situation for the species growing on tree trunks.

MOSSES AND LIVERWORTS

Contrary to what might be expected, the region offers many things of interest to the moss student. The banks around the lakes and the many smaller ponds and marshes offer many favorable situations for mosses and search reveals a fairly large number of species for a prairie country. Most of the species listed were collected around the lakes.

The species from Estherville were collected, mostly, on high ground near the top of the hillsides and slopes. At the time the collections were made there was a light covering of snow in the ravines which made it difficult to obtain material from such places. Many of these places being ideal for mosses it is likely that continued work during a more favorable time of the year would add several species to this list from the Estherville woods.

Hepaticæ are not common in this region. Only four species have been collected by the writer. Very likely a careful search might bring to light a few more from the Estherville locality.

NOMENCLATURE.

For lichens the nomenclature is, in the main, that of Zahlbruckner in Engler and Prantl, but in the arrangement of families and genera Fink's "Lichens of Minnesota" has been followed.

For mosses both the nomenclature and arrangement are mainly those of Engler and Prantl.

CLASS LICHENS.

Sub-Order Coniocaspineæ.

Family Caliciaceæ.

Cyphelium tigillare (Pers.) Th. Fr. On old board fence near High lake.

Sub-Order Graphidineæ.

Family Graphidaceæ.

Phægraphis dendritica (Ach) Muell. Eng. Collected on dead *Prunus virginiana*. Common at High lake.

Arthonia radiata (Pus.) Ach. On bitternut, "Cedar Island," Mud lake. Other specimens of *Arthonia* collected on bitternut near High lake, on wild plum near Mud lake, on willow in Estherville woods, have not been satisfactorily determined.

Sub-Order Discocarpineæ.

Family Lecidiaceæ.

Lecidea melancheima Tuck. On bitternut, High lake; also on cedar post; prairie south of High lake.

Buellia myriocarpa (D. C.) Mudd. On old wood, High lake.

Family Cladoniaceæ.

Cladonia sylvatica (L.) Hoffm. On old stump in High lake woods; very rare.

Cladonia bacillaris (Del.) Nyl. On decayed stump, High lake.

Cladonia cristatella Tuck. On old stumps at High lake and Estherville. One specimen marked by Miss Miller as "approaching var *paludicola* Tuck, but without soredia on primary squamules."

Cladonia mitrula Tuck. On soil; woods west of Estherville.

Cladonia verticillata Hoffm. On old stump; High lake.

Cladonia verticillata cervicornus (Ach.) Flat. On old stump; High lake.

Cladonia pyxidata neglecta (Floerte) Mass. On earth; abundant in Estherville woods.

Cladonia fimbriata (L.) Hoffm., var. *subulata* (L.) Wainio. On old stump near High lake and on earth on high ridge, west of Estherville.

Family Pannariaceæ.

Pannaria microphylla (Sw.) Moss. On prairie bowlder near Des Moines river.

Pannaria lanuginosa (Ach.) Koerb. On dead wood near Mud lake.

Family Peltigeraceæ.

Peltigera malacca (Ach.) E. F. On earth, along shaded hillside, north of Oak Hill cemetery, Estherville.

Peltigera canina (L.) Hoffm. On the earth; shaded hillsides, Estherville.

Peltigera canina spongiosa Tuck. Along southwest bank of Mud lake.

Family Leconoraceæ.

Acarospora belle (Nyl.) Hsse. On prairie bowlder near Des Moines river.

Lecanora subfusca (L.) Ach. On bitternut, High lake.

Lecanora hageni Ach. On dead wood in Crane grove.

Lecanora varia (Hoffm.) Ach. Frequent on dead wood, board fences, etc., High lake. Also on *Prunus americana* near Mud lake. Specimen collected on red cedar stump near High lake seems to be a variety of the above.

Family Pertusariaceæ.

Pertusaria pustulata (Ach.) Nyl. On *Prunus virginiana,* High lake.

Family Parmeliaceæ.

Parmelia cetrata Ach. On base of trees; east bank of Mud lake.

Parmelia borreri Turn. Very common throughout, on trees.

Parmelia saxatilis (L.) Ach. On bowlder in woods southwest of Estherville.

Parmelia caperata (L.) Ach. Common throughout and very conspicuous on account of the large size and bright straw-green color of the thalus. On tree stumps and stones.

Parmalina calicaris (L.) Fr. var. *fraxinea* (L.) Fr. Variable, but specimens collected have been referred to this subspecies. Mostly on dead trees.

Family Teloschistaceæ.

Caloplaca annabarina (Ach.) Zahlb. On prairie bowlders near Des Moines river.

Caloplaca cerina (Ehrh.) Zahlb. On prairie bowlders near the Des Moines and on dead wood, Crane grove.

Caloplaca cerina sideritis Tuck. On bowlder, shore of Mud lake.

Caloplaca gilva (Hoffm.) Zahlb. On the base of *Quercus macrocarpa,* bank of High lake.

Candelariella vitellina (Ehrh.) Muell. On prairie bowlder near the Des Moines.

Placodium microphyllinum Tuck. On red cedar stump, banks of High lake.

Placodium aurantiacum (Lightf.) Hepp. Very common on green ash.

Teloschistes chrysopthalmus (L.) Th. Fr. Quite abundant on trees and on old wood.

Teloschistes polycarpus (Hoffm.) Tuck. Common on trees.

Teloschistes lychnens (Ach.) Tuck. Common and appears to be variable.

Teloschistes concolor (Dicks.) Tuck. Abundant on trees, old wood and on rocks. One form appears to the writer to be var. *effusus* Tuck. But this has not been verified.

Teloschistes parietinus (L.) Th. Fr. Common on trees, High lake.

Family Physciaceæ.

Rinodina oreina (Ach.) Mass. On prairie bowlder, near Des Moines river.

Rinodina sophodes (Ach.) Koerb. On bitternut, High lake.

Physcia speciosa (Wulf.) Nyl. On earth, Estherville woods. A specimen collected on *Salix* on bank of High lake was referred to this species but is missing from the author's collection.

Physcia pulverulenta (Schreb.) Nyl. var *leucoleiptis* Tuck. Several specimens were referred to this subspecies by Mr. Plitt.

Physcia stellaris (L.) Nyl. Our most common lichen, found everywhere on trees.

Physcia tribacia (Ach.) Nyl. Abundant on oaks *(Quercus macrocarpa)* in pastured woods near High lake.

Physcia obscura (Schaer.) Nyl. Common on trees, High lake.

Physcia adglutinata (Floerke) Nyl. Very common on trees everywhere.

SUB-ORDER PYRENOCARPINEÆ.

Family Dermatocarpaceæ.

Dermatocarpon sp. uncertain. On prairie bowlder near Des Moines river.

CLASS BRYOPHYTES.

SUB-CLASS HEPATICEÆ.

Ricciella fluitans (L.) Br. The Slender Riccia. Both the terrestrial and the aquatic forms collected in small sloughs near Mud lake.

Ricciocarpus natans (L.) Corda. Purple-fringed Riccia. Abundant in a small slough near Mud lake. Floating on water or growing on mud. These determinations verified by Dr. G. H. Conklin, Superior, Wisconsin.

Marchantia polymorpha L. Liverwort. On soil; mostly in low woods. Not very common.

Porella platyphylla (L.) Lindb. Common Porella. Collected on base of tree near Mud lake. The sterile specimen was determined by Miss Caroline C. Haynes, of New York.

SUB-CLASS MUSCI.

ORDER III. BRYALES.

Family Dinanaceæ.

Ceratodon purpureus (L.) Brid. Common on dry soil, decayed stumps and other situations.

Dicranella heteromalla (L.) Schimp. On soil on dry ridge, Estherville woods.

Family Fissidentaceæ.

Fissidens subbasilaris Hedw. On dry gravelly soil in Estherville woods.

Family Fumariaceæ.

Physcomitrium Hookeri Hempe. Urn Moss. Rare; collected once on shore of High lake.

Fumaria hygrometrica (L.) Sibth. Cord Moss. Common on ground in woods.

Family Bryaceæ.

Bryum cæspiticium L. Most common among thin grass in open ground, pastures, etc., where it is a conspicuous object in early May on account of its shining red seta. Also along sandy lake banks.

Bryum argenteum L. Silvery Bryum. On soil, High lake.

Bryum inclinatum (Sw.) B. and S. On soil especially along sandy lake banks. High lake and Mud lake.

Rhodobryum roseum (Wees.) Limpr. The Giant or Rose Bryum. Around the lakes; most common along the well-shaded banks on the south and southwest side of Mud lake. It is sometimes found forming tufts but more often the plants are scattered among other mosses. Whether seen individually or in tufts this moss is a most beautiful object.

Family Mniaceæ.

Mnium cuspidatum (L.) Legr. Pointed Mnium. Our most common species. Forming beautiful mats along shady banks and in woods.

Mnium affine Bland. var. *negicum* Schimp. This appears to be common in the Estherville woods. Specimens of a somewhat different appearing form, found in wet woods near Mud lake also were placed here by Mr. Kaiser.

Family Polytrichaceæ.

Catharinea undulata (L.) W. and M. Wavy Catharinea. Along shady hillsides in the Estherville woods.

Catharinea angustata Brid. Narrow-leaved Catharinea. Common in dry woods west of Estherville.

Polytrichium juniperinum Willd. Juniper Hairycap Moss. Common in dry woods west of Estherville. This and the tree moss are our largest mosses and are quite conspicuous objects where they occur.

Family Climaceaceæ.

Climacium americanum Brid. American Tree Moss. On soil in woods west of Estherville. Abundant along steep slope northwest of Oak Hill cemetery where it forms beautiful carpets of dark green.

Family Entodonaceæ.

Entodon sedutrix (Hedw.) C. M. Round-stemmed Entodon, Common; mostly on decayed woods.

Entodon cladorrhizons (Hedw.) C. M. Flat-stemmed Entodon. Common; especially on decayed wood.

Platygynum repens (Brid.) B. and S. Quite common in woods on decayed stumps and logs.

Family Leskeaceæ

Anomodon rostratus (Hedw.) Schimp. On soil, and in damp places in woods. High lake.

Anomodon minor (P. B.) Fuern. Blunt-leaved Anomodon. A very beautiful moss commonly growing on the north side of the trunks of trees in low ground, forming a conspicuous "apron".

Anomodon attenuatus (Schrib) Hueb. Slender Anomodon. Along banks of Mud lake; forming a dense mat on ground.

Leskea gracilescens Hedw. Very common; growing on the trunks and bases of trees.

Family Hypnaceæ

Amblystegium serpens (L.) B. and S. Creeping Hypnum. Common on soil or on decayed wood in damp shady places; also on sand or clay along lake shores.

Amblystegium riparium (L.) B. and S. On decayed wood, in low woods near High lake.

Amblystegium Kochii B. and S. On soil in wet shady ground near Mud lake.

Amblystegium varium (Hedw.) Lindb. On soil; banks of High lake.

Eurynchium scrulatum (Hedw.) Lindb. On soil, in High lake woods.

Campylium chrysophyllum (Bria.) Bryhn. Some material of *Funaria hygrometrica* collected on banks of High lake was found to contain this species.

Dreponocladus aduncus (Hedw.) Wamst. var. *gracilescens* Schimp. Abundant in marshes and low meadows near High lake and Mud lake.

Family Brachytheceaceæ

Brachythecium oxycladon (Brid.) J. and S. Common on soil along shady lake banks and hill sides.

Brachythecium plumosum (Sw.) B. and S. Usual habitat on damp rocks. Collected in High lake woods on soil. A very pretty moss.

Brachythecium acuminatum (Hedw.) Lindb. Common in damp woods, on soil, or on decayed logs.

Brachythecium acutum (Mitte) Sulliv. Abundant on mud and among grass in small slough in High lake woods.

WALLINGFORD.

FLORA OF MITCHELL COUNTY

FLORA MAY TUTTLE

From the time that I opened my eyes on the beauties of our glorious prairies, down in that little log cabin in Delaware county, I have been deeply interested in the flora of our state. Years ago the unbroken prairies were one gorgeous flower garden. The wild lily, the painted cup, fireweed, ironweed and blazing star vied with the golden glory of the sunflower and the golden rod. Some of these have so nearly become extinct that every bit of unbroken prairie is sacred ground.

My interest in Mitchell county dates back to March, 1878, and I have never ceased to search for treasures on my tramps over the county.

A large part of the data gathered has been in the vicinity of Osage, but I have always made it a point to study every locality, and with this conclusion, that Osage township is typical of the rest of the county. Here we have river, creek, pasture, waste ground, bluffs, a very little low ground, sandy soil and bayous, each clothed with its own typical verdure.

Some of the localities given after the names of the specimens found are purely local and therefore need a word of explanation.

The "Old Farm" is known to geologists as the Gable farm in Calvin's Geology of Mitchell County. Two years of my childhood were spent here and I shall never forget the delicate, fragrant beauty of the banks of Sugar creek in the springtime, when they were covered with the blue, pink and purple-tinted Hepaticas, our Mayflower. Here, too, grew Adam and Eve in conjugal bliss, the bloodroot, spring beauty, blue phlox and wild geranium, each in its time and place. The road to school for a quarter of a mile lay through dense woods, now long since cut down, and sister and I dreamed dreams and lived wonderful stories as our weary feet plodded home from school. The dark green of the oaks, the trailing virgin's bower and wild grape, or the crimson shades of the maples in autumn, made an artist of one little girl and a naturalist of the other.

Pierce's bridge is one of my favorite haunts and has revealed many secrets hid in Mother Nature's story book. There I found the rare grey birch—fifty of them; the fragile cliff brake growing from a crack in the limestone bluff; and here, too, I put three blind baby woodchucks to sleep one Memorial Day—but that is another story.

Cedar river, or Wa-shood Ne-shun-a-ga-tah, Big Timber River, as the Winnebagoes once called it, makes a big curve in Osage township, circling about Osage with a radius of two miles from west to south. Pierce's bridge is south of Osage, the Middle bridge is

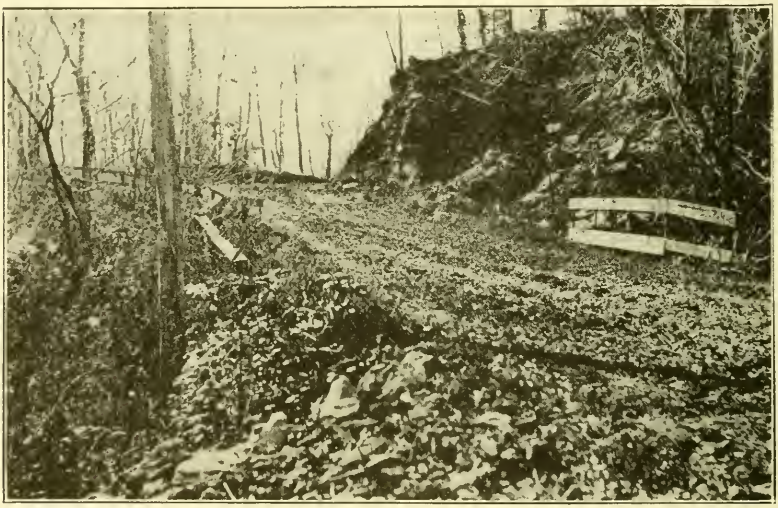

Fig. 92.—The old Lime Kiln Road, Osage.

southwest, and two miles west of Osage on Main street is another bridge. The most bewildering experience that ever came to me was the day I found the colony of deep blue-purple *Chelone glabra* or Turtle Head near the Middle bridge. They stood all of five feet tall in the brink of the river, close to a bubbling spring. Every year they come true as to color. This same mutant has been found near Pierce's bridge by Mrs. Walter Wheeler, of Osage.

The old Lime Kiln road leads out of Osage southwest to the Middle bridge and is bordered on one side by vertical bluffs, and on the other side for some distance by Sugar creek.

Spring Park is a tract of about forty acres of land owned by an association for a picnic and camping site. Here is found a wonderful spring flowing the year round. From it flows a little brook filled with water cress, blue iris, yellow marsh marigolds, and bordered by a large colony of the sensitive fern.

A forest expert on strolling through these grounds one day counted eighty-one varieties of trees. Millions of the supposedly

FIG. 93.—Rock outcrops along the Old Lime Kiln Road, Osage.

rare Muscatel grow here and on a bank overlooking the spring are found the showy orchis, while down in a moist spot have been found the Indian Pipe or corpse plant.

The River road follows the bank of Cedar river for about six miles from the bridge west of Osage up the river to Mitchell. It is one of the prettiest bits of scenery in Iowa. The peacefully flowing river, with its wonderful reflections of tree and cloud lies on one side while to the right rise sheer bluffs of limestone, draped with the graceful bladder fern and its twin sister, *Cystopteris fragilis,* wild grape, moonseed and clematis vines, with a touch of coral-colored columbine, or pink and yellow honeysuckle in their season. If you search carefully in a shaded portion on top of the bluff you may find the lady slipper, *Cypripedium pubescens,* while clinging close to the water are the so-called lady slippers, more properly known as jewel weed, both *I. pallida* and *I. biflora.*

The Winona Track, leading out of Osage to the southwest, once a proposed railroad, is now only a trail, where hundreds of feet hurry away in the spring time, when we hear that the pussy willows are out or the mayflowers are in blossom.

The old mill, too, is a misnomer now, for all that is left of it are the old mill stones and the weed-grown race. This lies about half way between Pierce's bridge and the Middle bridge. It is so dense and damp down in there that one is sure to find some new treasure of bird, bug or botany.

The Ryan farm lies on the prairie road that runs between Osage and Mitchell and just off from the River road. It is one of my

Fig. 94.—The spring at Spring Park, Osage.

favorite haunts, not only because of the natural beauties I find there, but because of the hospitality of its owners.

The Indian Head bluff is on the east bank of Cedar river about a quarter of a mile down from the bridge west on Main street. Here we find again the combination of bluff, river bank and field or pasture that brings such a varied flora. The base of the cliff is an example of one of the most puzzling nonconformities in Iowa, while the upper layers of rock strongly resemble the features of an Indian, with a juniper or red cedar tree for a scalp lock.

Pelton's woods is a wood tract a quarter of a mile south of the fair grounds, in Osage. They are never disturbed save as the writer and her friends search for birds and plants. The shield ferns

FIG. 95.—Indian Head Bluff, Osage, showing unconformity of the strata.

here grow to enormous size, and here also is a large colony of the sensitive fern, while occasionally in the heart of these woods we have found the showy orchis.

This paper would be incomplete were I not to lay a tribute at the feet of one of the most noted botanists in this country, who for several years has given me unstintedly of his time and with the most gracious generosity has verified hundreds of analyses and has analyzed as many more that were too difficult for me to determine. This paper would not be possible were it not for Dr. L. H. Pammel, of Ames.

Polypodiaceæ.

ADIANTUM.

A. pedatum: common in rich woods.

PTERIS.

P. aquilina: Ryan farm; river road.

Pelleæ.

P. atropurpurea: three and one-half miles northwest of St. Ansgar.

CRYPTOGRAMMA.

C. Stelleri: Pierce's bridge.

ASPLENIUM.

A. Filix-femina: once common on the streets of Osage, before the old board walks were replaced by cement; now found in rich woods.

ASPIDIUM.

A. noveboracense: Indian Head bluff.

A. Filix-mas: abundant in Pelton's woods, where the fronds are often 3 to 4 feet long.

CYSTOPERIS.

C. bulbifera: common along the banks of Cedar river.

C. fragilis: common along the banks of Cedar river.

ONOCLEA.

O. sensibilis: Pelton's woods; Lincoln township; river road.

O. Strutheropteris: rare near Osage. The writer has a large bed from a root found in Pelton's woods several years ago. But one other specimen seen and that was in Spring Park.

Osmundaceæ.

OSMUNDA.

O. Claytoniana: Lincoln township; Osage township.

Ophioglossaceæ.

BOTRYCHIUM.

B. virginianum: common in rich woods.

Equisetaceæ.

EQUISETUM.

E. arvense: Nelson's pasture; common along roadside and railroad tracks.

E. hyemale: Nelson's pasture.

Taxaceæ.

TAXUS.

T. Canadensis: common on the banks of Cedar river.

Pinaceæ.

JUNIPERUS.

J. virginiana: common on banks of Cedar river.

J. sabina (*J. horizontalis*): found near Rockford, Iowa, by Mahlon Palmer of Charles City, Iowa.

Typhaceæ.

TYPHA.

T. latifolia: South 7th street, Osage.

Alismaceæ.

SAGITTARIA.

S. latifolia: common around the borders of ponds or bayous.

Hydrocharitaceæ.

ELODIA.

E. canadensis: Spring Park.

Gramineæ.

ANDROPOGON.

A. Scoparius: banks of Cedar river.

DIGITARIA.

D. sanguinalis: common weed.

PANICUM.

P. capillare: common weed.

P. Scribnerianum: river road.

CENCHRUS.

C. tribuloides: sandy banks: railroad track.

PHLEUM.

P. pratense: common.

ALOPECURUS.

A. geniculatus: Gardner Nursery Company, Osage.

AGROSTIS.

A. alba: Pelton's woods.

KŒLERIA.

K. Cristata: river road.

AVENA.

A. sativa: roadsides.

SPARTINA.

S. Michauxiana: Burr Oak township; South 7th street, Osage.

ERAGROSTIS.

E. Megastachya: Cedar river bank, railroad track.

POA.

P. triflora: Pelton's woods.

GLYCERIA.

G. grandis: South 7th street, Osage.

BROMUS.

B. commutatus: river road.
B. ciliatum: bank of Cedar river.
B. inermis: Indian Head bluff.

AGROPYRON.

A. repens: railroad track.
A. spicatum: 1233 State street, Osage.
A. Smithii: railroad track; roadsides.

HORDEUM.

H. jubatum: roadside.

ELYMUS.

E. Canadensis: South 7th street, Osage.
E. striatus: river road.

HYSTRIX.

H. patula: river road.

Cyperaceæ.

SCIRPUS.

S. validus: South 7th street, Osage.
S. atrovirens: Pierce's bridge.

ERIOPHORUM.

E. angustifolium: Riceville.

Araceæ.

ARISÆMA.

A. triphyllum: common in rich woods.

SYMPLOCARPUS.

S. fœtidus: Riceville, collected by Mahlon Palmer, of Charles City, Iowa.

Commelinaceæ.

TRADESCANTIA.

T. bracteata: river banks.

Juncaceæ.

JUNCUS.

J. tenuis: Spring Park.

Liliaceæ.

ZYGADENUS.

Z. Chloranthus: Riceville.

UVULARIA.

U. perfoliata: common in rich woods.

ALLIUM.

A. cernuum: Old mill.
A. Canadense: Spring Park.

NATHOSCORDUM.

N. bivalve: woods near Osage.

LILIUM.

L. philadelphicum var. *andinum*: railroad track.
L. superbum: railroad track: also a bed in the writer's garden.
L. canadense: railroad track.

ERYTHRONIUM.

E. albidum: common in woods and roadside.

SMILACINA.

S. racemosa: common in rich woods.

S. stellata: common in rich woods.

POLYGONATUM.

P. biflorum: common in rich woods.

P. commutatum: common in rich woods.

TRILLIUM.

T. grandiflorum: rich woods, rare.

T. cernuum: rich woods, common.

T. nivale: rich woods, common.

T. undulatum: Rockford, Iowa, collected by Mahlon Palmer of Charles City, Iowa.

SMILAX.

S. herbacea: common.

S. scirrhata: Simpson farm in Lincoln township.

S. rotundifolia: Iron spring on the river road.

Dioscoriaceæ.

DISCOREA.

D. villosa: river road; Mitchell.

Amaryllidaceæ.

HYPOXIS.

H. hirsuta: river banks.

Iridaceæ.

IRIS.

I. versicolor: edge of Cedar river or bayous.

SISYRINCHIUM.

S. angustifolium: Pierce's bridge.

Orchidaceæ.

CYPRIPEDIUM.

C. parviflorum var. *pubescens*: river road; Riceville.

C. candidum: reported by old settlers.

C. acaule: reported by old settlers.

ORCHIS.

O. spectabilis: Moore's woods that formerly stood on South 7th street, Osage; Pelton's woods; Spring Park.

CALOPOGON.

C. pulchellus: Riceville, collected by Mrs. Walter Wheeler, Osage.

APLECTRUM.

A. hyemale: rich woods.

Salicaceæ.

SALIX.

S. amygdaloides: Ryan farm.
S. longifolia: river road.
S. cordata: Nelson's pasture.
S. discolor: Winona track.
S. humilis: prairie near Osage.
S. rostrata: Simpson farm in Lincoln township.

POPULUS.

P. alba: Osage; Winona track.
P. tremuloides: common everywhere.
P. grandidentata: Orchard; Winona track; North 7th street.
P. candicans: Mitchell; Pierce's bridge.
P. deltoides: Osage; Winona track; Old farm.
(*P. nigra*: escaped from cultivation.)

Juglandaceæ.

JUGLANS.

J. cinerea: Winona track; in moist woodlands.
J. nigra: river bank; old mill.

CARYA.

C. ovata: Nelson's pasture the only locality found, so far, in Mitchell county. This was a sapling.
C. glabra: Nelson's pasture.
C. cordiformis: Winona track; common.

Betulaceæ.

CORYLUS.

C. americana: Lincoln township; common along roadside.

OSTRYA.

O. virginiana: South 7th street; common.

CARPINUS.

C. caroliniana: Pierce's bridge; Old Lime Kiln road.

BETULA.

B. lutea: fifty trees counted at Pierce's bridge; Middle bridge; Spring Park.

B. alba var. *papyrifera*: common at Pierce's bridge.

Fagaceæ.

QUERCUS.

Q. alba: Old mill; South 7th street, Osage; Winona track.

Q. macrocarpa: common.

Q. rubra: Ryan farm; common.

Q. ellipsoidalis: Winona track; common.

Q. velutina?: Ryan farm, two young trees that answer the description very well.

Urticaceæ.

ULMUS.

U. fulva: common everywhere.

U. americana: common everywhere.

U. racemosa: South 12th street, Osage; Spring Park.

CELTIS.

C. occidentalis: river banks; Spring Park; river road.

CANNABIS.

C. sativa: Middle bridge; roadsides.

HUMULUS.

H. Lupulus: North 10th street.

URTICA.

U. gracilis: Pelton's wood; common.

PILEA.

P. pumila: a common weed.

Aristolochiaceæ.

ASARUM.

A. canadense: common on banks of streams.

Polygonaceæ.

RUMEX.

R. patientia: Simpson farm in Lincoln township.

R. crispus: East Mechanic street, Osage; common along roadside.

R. altissimus: two miles east of Osage.

R. acetosella: common weed.

POLYGONUM.

P. aviculare: common weed.
P. lapathifolium: Osage.
P. Muhlenbergii: South 7th street, Osage; river banks.
P. orientale: Spring Park.
P. Persicaria: common weed.
P. virginianum: river bank, Pierce's bridge to Middle bridge.
P. convolvulus: East State street, Osage.

FAGOPYRUM.

F. esculentum: waste places.

Chenopodiaceæ.

CHENOPODIUM.

C. album: common everywhere.

ATRIPLEX.

A. patula var. *hastata*: Osage.

Amaranthaceæ.

AMARANTHUS.

A. retroflexus: common weed.
A. paniculatus: Old mill.
A. spinosus: Osage.
A. blitoides: Osage.

Nyctaginaceæ.

OXYBAPHUS.

O. nyctagineus: roadsides; railroad track.

Caryophyllaceæ.

ARENARIA.

A. lateriflora: Middle bridge.

STELLARIA.

S. longifolia: Middle bridge.
S. media: common.

CERASTIUM.

C. arvense: fields.
C. nutans: Pierce's bridge; Spring Park.
C. vulgatum: common.

AGROSTEMMA.

A. Githago: 1114 State street, Osage; wheat field near Nelson's pasture.

LYCHNIS.

L. chalcedonica: 1114 State street.
L. alba: Spring Park.

SILENE.

S. antirrhina: Riceville, collected by Mrs. Walter Wheeler.
S. noctiflora: 1114 State street, Osage.
S. stellata: river road; common.
S. latifolia: Simpson farm in Lincoln township.
S. virginica: Simpson farm in Lincoln township.

SAPONARIA.

S. officinalis: common.
S. vaccaria: 1114 State street, Osage.

Portulacaceæ.

CLAYTONIA.

C. virginica: common in rich woods.

PORTULACA.

P. oleracea: common weed.

Ceratophyllaceæ.

CERATOPHYLLUM.

C. demursum: Spring Park.

Nymphæaceæ.

NYMPHÆA.

N. advena: common in still water.

CASTALIA.

C. odorata: In still water.

Ranunculaceæ.

RANUNCULUS.

R. abortivus: common weed.
R. septentrionalis: moist places.
R. pennsylvanicus: bank of Cedar river.

THALICTRUM.

T. revolutum: Pelton's woods.
T. polygonum: roadsides, especially bordering woods.

HEPATICA.

H. acutiloba: common in shady woods.

ANEMONE.

A. cylindrica: Spring Park; common.
A. virginiana: Spring Park; common.
A. canadensis: Spring Park; common.
A. quinquefolia: shady woods.

CLEMATIS.

C. virginiana: river banks; common.

ISOPYRUM.

I. biternatum: shady woods everywhere.

CALTHA.

C. palustris: Spring Park.

AQUILEGIA.

A. canadensis: shady woods; river banks.

DELPHINIUM.

D. Penardi: railroad track.

ACTÆA.

A. rubra: river road; Nelson's pasture.
A. alba: river road; Pelton's woods.

Menispermaceæ.

MENISPERMUM.

M. canadense: river banks; Old farm; roads bordered by woods.

CALYCOCARPUM.

C. Lyoni: river road.

Berberidaceæ.

PODOPHYLLUM.

P. peltatum: rich woods.

Papaveraceæ.

SANGUINARIA.

S. canadensis: common in woods or cut over land.

Fumariaceæ.

DICENTRA.

D. cucullaria: river banks; rich woods.

CORYDALUS..

C. aurea: river bank.

Cruciferæ.

(*Draba caroliniana*: just over the line in Floyd county.)

LEPIDIUM.

P. apetalum: common weed.

CAPSELLA.

C. Bursa pastoris: common weed.

BRASSICA.

B. arvensis: common weed.
B. Juncea: common weed.
B. nigra: common weed.

CONRINGIA.

C. orientalis: corner of 11th and Pleasant streets; 1114 State street. Doubtless introduced in chick feed.

SISYMBRIUM.

S. officinale.

ERYSIMUM.

E. cheiranthoides: Pierce's bridge.
E. asperum: Simpson farm in Lincoln township.

RADICULA.

R. Nasturtium aquaticum: Spring Park.
R. palustris var. *hispida*: Pelton's woods.

IODANTHUS.

I. pinnatifidus: Middle bridge.

DENTARIA.

D. laciniata: common in moist woods.

CARDAMINE.

C. bulbosa: Spring Park.
C. Douglassii: Orchard, Iowa.

ARABIS.

A. virginica: Pierce's bridge.

Crassulaceæ.

PENTHORUM.

P. sedoides: Pierce's bridge.

Saxifragaceæ.

SAXIFRAGA.

S. pennsylvanica: Riceville (just over the county line).

HEUCHERA.

H. villosa: river bank.

MITELLA.

M. diphylla: rich woods, stream banks.

RIBES.

R. cynosbati: woods and pastures.
R. oxyacanthoides: woods and pastures.
R. floridum: Pierce's bridge.

Rosaceæ.

PHYSOCARPUS.

P. opulifolius: Pierce's bridge; river banks.

SPIRÆA.

S. salicifolia: railroad track.

PYRUS.

P. coronaria: common in open woods.
P. ioensis: South 7th street, Osage.
P. sitchensis: Indian Head bluff.
P. Aucuparia: Pelton's woods.

AMELANCHIER.

A. canadensis: Iron spring on the river road.

CRATÆGUS.

C. punctata: Pierce's bridge; Spring Park; corner 8th and Mechanic streets, Osage.
C. coccinea: Spring Park.
C. mollis: river road.

FRAGARIA.

F. virginiana: common everywhere.

POTENTILLA.

P. monspeliensis: East State street, Osage.
P. tridentata: East State street, Osage.
P. canadensis: Simpson Farm, Lincoln township.

GEUM.

G. canadense: East State street, Osage.
G. macrophyllum: Old farm.
G. triflorum: St. Ansgar.

RUBUS.

R. aculeatissimus: borders of woods.
R. occidentalis: borders of woods.
R. villosus (?): borders of woods.

AGRIMONIA.

A. gryposepala: Pierce's bridge.

ROSA.

R. pratincola: Old farm.
R. Woodsii: roadsides.
R. carolina: roadsides.

PRUNUS.

P. serotina: Fair grounds, Osage.
P. virginiana: Fair grounds, Osage.
P. pennsylvanica: Pierce's bridge.
P. Americana: Railroad track; along streams.

Leguminosæ.

GYMNOCLADUS.

G. dioica: South of Orchard; Burr Oak township.

GLEDITSIA.

G. triacanthos: South 4th street, Osage.

CASSIA.

C. marilandica: railroad track.
C. chamæcrista: railroad track.

BAPTISIA.

B. leucantha: railroad track; Riceville, collected by Mrs. Walter Wheeler.

TRIFOLIUM.

T. pratense: roadside.
T. repens: roadside.
T. hybridum: roadside.
T. procumbens: roadside.
T. agrarium: roadside.

MELILOTUS.

M. officinalis: roadside, not common.
M. alba: roadside, common.

MEDICAGO.

M. sativa: roadside.

PSORALEA.

P. agrophylla: railroad track.

AMORPHA.

A. canescens: prairie.
A. fruiticosa: Burr Oak.

PETALOSTEMUM.

P. purpureum: railroad track.
P. candidum: Mitchell.

ROBINIA.

R. Pseudo-Acacia: East Chase street, Osage

ASTRAGALUS.

A. canadensis: six miles south of Osage.

DESMODIUM.

D. grandiflorum: Pelton's woods.
D. canadense: river bank.

VICIA.

V. americana: Middle bridge; river road.

LATHYRUS.

L. venosus: Ryan farm.
L. ochroleucus: river road.

APIOS.

A. tuberosa: river road.

AMPHICARPA.

A. monoica: East Chase street, Osage.

Oxalidaceæ.

OXALIS.

O. violaceæ: cemetery, Osage; river bank.
O. stricta: common weed.
O. corniculata: common weed.

Geraniaceæ.

GERANIUM.

G. maculatum: common in open woods.
G. carolinianum: Osage.

Rutaceæ.

ZANTHOXYLUM.

Z. americanum: common in woods and on the river bank.

Polygalaceæ.

POLYGALA.

P. Senega: river road; Pierce's bridge.
P. sanguinca: railroad track between Osage and St. Ansgar.

Euphorbiaceæ.

ACALYPHA.

A. virginica: common weed, Osage.

EUPHORBIA.

E. maculata: East State street, Osage.
E. corollata: Fair grounds, Osage.
E. cyparissias: cemetery.

Anacardiaceæ.

RHUS.

R. glabra: common along the roadside.
R. toxicodendron: roadsides, woods, fields.

Celastraceæ.

EVONYMUS.

E. atropurpurcus: ravine on the Old farm; river banks.

CELASTRUS.

C. scandens: woods and roadsides.

STAPHYLEA.

S. trifolia: Pierce's bridge.

Aceraceæ.

ACER.

A. saccharum: common in all woods.
A. saccharum var. *nigrum*: 1114 State street, Osage.
A. saccharinum: woods; streets of Osage.
A. rubrum: Spring Park; old mill.
A. Negundo: common in woods.

Balsaminaceæ.

IMPATIENS.

I. pallida: common in moist places.
I. biflora: common in moist places.

Rhamnaceæ.

CEANOTHUS.

C. americanus: railroad track near St. Ansgar.

Vitaceæ.

PSEDERA.

P. quinquefolia: common in woods and along the roadside.

VITIS.

V. vulpina: common in woods; river banks and along roadside.

Tiliaceæ.

TILIA.

T. americana: rich woods.

Malvaceæ.

ABUTILON.

A. Theophrasti: waste places.

MALVA.

M. rotundifolia: common weed.

Hypericaceæ.

HYPERICUM.

H. Ascyron: Nelson's pasture.
H. perforatum: Spring Park.

Cistaceæ.

HELIANTHEMUM.

H. canadense: Riceville, collected by Mrs. Walter Wheeler.

LECHEA.

L. minor: Riceville, collected by Mrs. Walter Wheeler.

Violaceæ.

VIOLA.

V. cucullata: woods, common.
V. pedatifida: Pierce's bridge; prairie land; cemetery, Osage.
V. blanda: rich woods, rare.
V. pubescens: common.

Onagraceæ.

EPILOBIUM.

E. angustifolium: railroad track between Osage and St. Ansgar.

ŒNOTHERA.

O. biennis: Middle bridge; common along roadside.
O. rhombipetala: Nelson's pasture near Cedar river.
O. serrulata: St. Ansgar.

CIRCÆA.

C. lutetiana: Pelton's woods.

Araliaceæ.

ARALIA.

A. racemosa: Pelton's woods; Simpson farm in Lincoln township.
A. nudicaulis: Iron spring on the river road.

PANAX.

P. triflorum: river road.

Umbelliferæ.

ERYNGIUM.

E. Yuccifolium: railroad track.
E. aquaticum: seven miles south of Osage.

SANICULA.

S. marylandica: Pelton's woods.
S. gregaria: Pelton's woods.

OSMORHIZA.

O. Claytoni: Pelton's woods.

CICUTA.

C. maculata: Pelton's woods; New Haven.

CRYPTOTÆNIA.

C. canadensis: South 7th street, Osage; Pelton's woods.

ZIZIA.

Z. aurea: Osage.
Z. cordata: Simpson farm, Lincoln township.

TÆNIDIA.

T. integerrima: Iron spring, river road.

THASPIUM.

T. barbinode: river road.

PASTINACA.

P. sativa: river bank.

HERACLEUM.

H. lanatum: railroad track.

Cornaceæ.

CORNUS.

C. circinata: six miles south of Osage.
C. asperifolia: Fair grounds; river road.
C. stolonifera: six miles south of Osage.
C. paniculata: Fair grounds; river road.
C. alternifolius: Ryan farm.

Ericaceæ.

PYROLA.

P. elliptica: Iron spring on the river road; Sawyer farm near Mona.
P. americana: Pierce's bridge.

MONOTROPA.

M. uniflora: Spring Park.

Primulaceæ.

STIERONEMA.

S. ciliatum: Fair grounds; border of Pelton's woods.
S. lanceolatum: Nelson's pasture.

DODECATHEON.

D. meadia: Riceville, collected by Mrs. Walter Wheeler.

Oliaceæ.

FRAXINUS.

F. americana: Simpson farm in Lincoln township.

F. pennsylvanica: river road; banks of Cedar river.

F. pennsylvanica var. *lanceolata*: corner 9th and Main streets, Osage.

F. nigra: Spring park.

Gentianaceæ.

GENTIANA.

G. quinquefolia: Pierce's bridge.

G. flavida: Old lime kiln.

G. linearis: river bank between Pierce's bridge and the Middle bridge.

Apocynaceæ.

APOCYNUM.

A. androsæmifolium: roadside.

A. cannabinum: roadside; near river.

Asclepiadaceæ.

ASCLEPIAS.

A. tuberosa: fields and banks of river.

A. incarnata: South 7th street; wet places.

A. syriaca: roadside.

A. verticillata: railroad track.

A. phytolaccoides: St. Ansgar.

Convolvulaceæ.

CONVOLVULUS.

C. sepium: South 7th street, Osage.

C. arvensis: six miles south of Osage.

CUSCUTA.

C. arvensis: South 4th street, Osage.

Polemoniaceæ.

PHLOX.

P. maculata: Riceville, collected by Mrs. Walter Wheeler.

P. pilosa: cemetery, Osage; prairies.

P. divaricata: common in all woods.

POLEMONIUM.

P. reptans: rich woods.

Hydrophyllaceae.

HYDROPHYLLUM.

H. virginianum: woods; roadside.
H. canadense: Spring Park.
H. appendiculatum: Spring Park.

ELLISIA.

E. Nyctelia: common weed.

PHACELIA.

P. bipinatifida: Spring Park.

Boraginaceæ.

CYNNOGLOSSUM.

C. virginianum: North 7th street, Osage.

LAPPULA.

L. virginiana: common weed in woods.
L. echinata: Nelson's pasture near the river.

MERTENSEA.

M. virginica: rich woods near streams.

LITHOSPERMUM.

L. canescens: six miles south of Osage.
L. augustifolium: six miles south of Osage.

ONOSMODIUM.

O. hispidissimum: river banks.

Verbenaceæ.

VERBENA.

V. urticæfolia: roadsides; waste ground.
V. hastata: common in fields.
V. stricta: fields. The writer has found it in red, white and pink as well as purple.
V. bracteosa: waste ground.

Labiatæ.

TEUCRIUM.

T. canadense: Pierce's bridge.
T. occidentale: Simpson farm, Lincoln township.

SCUTELLARIA.

S. lateriflora: river banks.

AGASTACHE.

A. scrophulariæfolia: Simpson farm, Lincoln township.

DRACOCEPHALUM.

D. parviflorum: Pelton's woods.

PRUNELLA.

P. vulgaris: woods and fields.

PHYSOSTEGIA.

P. virginiana: river banks.

GALEOPSIS.

G. tetrahit: river bank.

LEONURUS.

L. cardiaca: Pierce's bridge.

STACHYS.

S. tenuifolia: Indian Head bluff.
S. aspera: Pelton's woods.
S. palustris: Middle bridge.

MONARDA.

M. fistulosa: roadsides.

HEDEOMA.

H. hispida: Middle bridge.

ORIGANUM.

O. vulgare: South of Osage.

PYCNANTHEMUM.

P. virginianum: Burr Oak.

LYCOPUS.

L. virginicus: Pierce's bridge.
L. americanus: Pierce's bridge.

MENTHA.

M. arvensis var. *canadensis*: Middle bridge.

Solanaceæ.

SOLANUM.

S. Dulcamara: North 7th street, Osage.
S. nigrum: common weed.
S. rostratum: Osage.

PHYSALIS.

P. virginiana: roadside; railroad track.
P. subglabrata: roadside; railroad track.

Scrophulariaceæ.

VERBASCUM.

V. thapsus: common weed.

LINARIA.

L. vulgaris: roadsides.

SCROPHULARIA.

S. marilandica: open woods.

CHELONE.

C. glabra: Pierce's bridge; Middle bridge. Both colonies were a deep blue-purple fading to white, with no suggestion of pink.

MIMULUS.

M. ringens: Little Cedar.

ILYSANTHES.

I. dubia: river banks.

VERONICA.

V. virginica: Indian Head bluff; common in rich woods.
V. Tournefortii: 1114 State street, Osage.
V. anagallis-aquatica: Spring Park.

GERARDIA.

G. aspera: prairie.
G. tenuifolia: low ground near the river.

PEDICULARIS.

P. canadensis:

Phrymaceæ.

PHRYMA.

P. Leptostachya: Spring Park; Pierce's bridge.

Plantaginaceæ.

PLANTAGO.

P. major: common weed.

Rubiaceæ.

GALIUM.

G. boreale: roadsides.
G. trifidum: rich woods.
G. concinnum: railroad track.
G. triflorum: Simpson farm, Lincoln township.

HOUSTONIA.

H. purpurea: Spring Park.

Caprifoliaceæ.

LONICERA.

L. tatarica: Osage.
L. canadensis: Mitchell.

SYMPHORICARPOS.

S. occidentalis: river road; Nelson's pasture.

TRIOSTEUM.

T. perfoliatum: Winona track.

VIBURNUM.

V. opulus var. *americanum*: Pierce's bridge.
V. pubescens: Iron spring on the river road.
V. lentago: river road.
V. prunifolium: Fair grounds.

SAMBUCUS.

S. canadensis: borders of woods.

ADOXA.

A. Moschatellina: Indian Head bluff; Spring Park; Pelton's woods.

Valerianaceæ.

VALERIANA.

V. edulis: Riceville, collected by Mrs. Walter Wheeler.

Cucurbitaceæ.

ECHINOCYSTIS.

E. lobata: river banks.

Campanulaceæ.

CAMPANULA.

C. rapunculoides: 1233 State street, Osage.
C. americana: river banks.
C. aparinoides: river banks.

Lobeliaceæ.

LOBELIA.

L. siphilitica: river banks.
L. spicata: river banks.

Compositæ.

VERNONIA.

V. fasciculata: prairie.

EUPATORIUM.

E. purpureum: woods.
E. altissimum: six miles south of Osage.
E. perfoliatum: rich woods.
E. urticæfolium: common everywhere.

LIATRIS.

L. scariosa: roadsides; prairies.
L. pycnostachya: roadsides.

SOLIDAGO.

S. latifolia: Middle bridge.
S. speciosa: roadsides.
S. nemoralis: prairie.
S. canadensis: prairie.
S. serotina: roadsides.
S. rigida: roadsides.

ASTER.

A. oblongifolius: river banks.
A. undulatus: roadsides.
A. sagittifolius: roadsides.
A. Drummondi: river bank.
A. laevis: river bank; Simpson farm, Lincoln township.
A. multiflorus: Riceville, collected by Mrs. Walter Wheeler.
A. lateriflorus: river bank; West Main street, Osage.
A. salicifolius: Pierce's bridge.
A. umbellatus: South 7th street, Osage.
A. divaricatus: Pierce's bridge.

ERIGERON.

E. philadelphicus: Middle bridge.
E. annuus: South 4th street, Osage.
E. canadensis: common weed.

ANTENNARIA.

A. plantaginifolia: Middle bridge; Indian Head bluff.

SILPHIUM.

S. laciniatum: roadside; prairie.
S. perfoliatum: roadsides.

PARTHENIUM.

P. integrifolium: six miles south of Osage.

AMBROSIA.

A. trifida: roadsides, Osage.
A. artemisiifolia: roadsides, Osage.
A. psilostachya: roadsides, Osage.

HELIOPSIS.

H. scabra: Simpson farm, Lincoln township.

RUDBECKIA.

R. laciniata: Simpson farm, Lincoln township; roadsides.
R. hirta: common along the roadsides.

BRAUNERIA.

B. purpurea: roadsides on the prairie.

HELIANTHUS.

H. annuus: river bank, Pierce's bridge to Middle bridge.
H. lætiflorus: roadsides.
H. grosseserratus: Simpson farm, Lincoln township.
H. strumosus: river bank, Pierce's bridge to Middle bridge.

COREOPSIS.

C. palmata: Simpson farm, Lincoln township; St. Ansgar.

BIDENS.

B. connata: river bank near the Old Mill.
B. trichosperma: river bank near the Old Mill.
B. vulgata: Osage.
B. cernua: Pierce's bridge.

GALINSOGA.

G. parviflora: common weed.

HELENIUM.

H. autumnale: river banks.

ACHILLEA.

A. Millefolium: common weed.

ANTHEMIS.

A. Cotula: common weed.

TANACETUM.

T. vulgare: common roadside weed.

ARTEMISIA.

A. caudata: river bank.
A. ludoviciana: East Pleasant street, Osage.
A. biennis: 1114 State street, Osage.

CACALIA.

C. suaveolens: river bank, Pierce's bridge to Middle bridge.

SENECIO.

S. aureus: Spring Park.

ARCTIUM.

A. Lappa: common weed.

CIRSIUM.

C. lanceolatum: pastures and roadsides.
C. Hillii: railroad track.
C. arvense: railroad track.
C. altissimum: East State street, Osage.

CICHORIUM.

C. Intybus: East State street, Osage.

TARAXACUM.

T. officinale: common weed.

SONCHUS.

S. oleraceus: common weed.
S. asper: common weed.

LACTUCA.

L. scariola: common weed.
L. canadensis: common weed.

PRENANTHES.

P. alba: Simpson farm, Lincoln township.

HIERACIUM.

H. aurantiacum: 1114 State street, Osage.

A NATURALIST'S GLIMPSE OF THE LIMBERLOST

FLORA MAY TUTTLE

An errand combining business and pleasure carried me into the eastcentral part of Indiana, and so on my return I resolved to see the home of the gifted creator of Freckles, Laddie and the Girl of the Limberlost.

I had passed Crown Point on the "Pennsy" and was nearing Logansport, when my attention was called to clumps of majestic trees, standing in swampy grounds—trees that I knew from their form had one day stood in a dense forest. But when I passed rail fences, it dawned upon me that this was once the region of the Limberlost, or more correctly speaking, the Timberlost. It is the biggest crime that can be laid at the door of the state of Indiana. Not even her wonderfully paved roads will ever redeem her from the short sightedness of allowing so much of that wonderful forest to be sacrificed.

Tramps along White River at Anderson, Madison county, Indiana, resulted in many delightful experiences. I found two varieties of snails that were new to me, and at Rome City in the northern part of the state, a tiny worm shell shaped like a powder horn. In the gravel at Anderson were fossils of worm borers, and Favosites that I recognized as coming from the Niagara formation; as well as specimens of Acervularia from the Hamilton group of the Devonian and which may have come from southern Michigan. The gravel, while in the main unlike that with which I am most familiar—the Iowan—in that I found that the red Jasper and Agates were an unknown quantity, had one characteristic of the Iowan and that was the amount of greenstone found in it. This may be due to the fact that the gravel came from the Labradorean instead of the Keewatin glacier. The prevailing rock outcrops were a blue-gray limestone—Niagara formation.

I had the joy of seeing my first robin down along the river, February 26th, of learning that the spring song of the song sparrow does not end in a trill, and of studying at close range the cardinal, which is a much lighter red than the ones that have taken up their abode in Osage.

The most common tree along the river bank is the sycamore, and at Mounds Park I saw my first beech tree, and found the tiny burs and queer, three-cornered nuts that Grandmother always brought back with her after a trip to Boston.

In Mounds Park is the largest mound in Indiana. It is in the form of a fortification, 384 feet in diameter, with a ditch inside that is 10½ feet deep. On the crest of the mound are grand old trees, red, white, bur and chesnut oaks, and elms, and close by, beeches, all characteristic of the Limberlost.

On my return I came northeast from Anderson to Rome City, crossing at Bluffton a branch of the Wabash that has been immortalized by the Indiana Bird Woman.

After a night's rest at Lakeside Inn, I started out the morning of March 14, 1919, in a sleety storm for a two mile hike around the end of Sylvan Lake, in order to stand in the forest beside the home of Gene Stratton Porter, and breathe into my soul the spirit of the forest that she has so idealized.

At the Sower's farmhouse I left the main road, and took a short cut down the lane that leads from their barn to Mrs. Porter's back door. On one side of the lane was a rail fence, and in fancy I could see the robins that would soon be nesting there, the cardinals and bluebirds that would pour forth their glorious notes of gladness for the babies nestled close under the little mother's breast.

At the end of the lane stands a grand old oak, and when I returned I was fortunate in securing a good picture of it. It is a typical Limberlost tree, tall, straight as an arrow, and no branches lower than fifteen feet at least.

Passing through two gates that each bore the sign, "Private Grounds—No admittance" I at last stood in the land of my dreams. At the right stood the story and a half log cabin of Mrs. Porter, with the other buildings. In front of me lay beautiful Sylvan Lake, with the gentle lapping of its wind-whipt waves on the beach, while all around me were the grand old forest trees. Nothing broke the Sabbath quiet but the creaking of the wind-tossed treetops—until out of the stillness there came the song of a cardinal, "Pretty-pretty-pretty-pretty-bird-bird-quip-quip," and there only fifty feet away he sat and sang a greeting to the Iowa Bird Woman. All about me flitted bluebirds, nuthatches and chickadees, while over the tree top came the familiar call of a crow.

Osage.

ROSA PRATINCOLA GREENE

EVELYN ENSIGN

There is more or less confusion as to the name and description of the wild rose of the prairies. A study of this problem was undertaken more particularly with reference to our Iowa forms.

R. PRATINCOLA GREENE

R. pratincola Greene.

R. Arkansana Auct.

Stems low, usually very prickly; leaflets seven to eleven, rhachises usually pubescent; inflorescence commonly corymbose; sepals frequently connivent; hypanthiums and pedicels usually naked.

The name for our commonest wild rose, the one found on the prairies everywhere, has not been unanimously agreed upon. Small and Britton call it *R. Arkansana*. In the latest editions of the Britton and Brown and the Gray manuals *R. pratincola* has replaced the *R. Arkansana* of former editions.

The original description of *R. Arkansana* was made by Porter in 1874. He thought that it might be an extreme form of *R. blanda*, but it differed in so many points that he ventured to describe it as new. His description is as follows: "Stem stout, erect, leafy, one foot high, glabrous and glaucous, armed with weak, deciduous prickles; *leaflets* 9-11, ovate and oblong-ovate 1 in. long or more, acute or obtuse, glabrous or sharply serrate, midrib and long stipules somewhat prickly and minutely glandular; the *flowers* numerous, terminal corymbed on peduncles about 1 in. long; fruit globose, smooth, glaucous; calyx segmented, ovate, reflexed in fruit, with terminal and sometimes lateral appendages, more or less glandular and tomentose, pubescent on the margins; petals broadly obcordate or emarginate, longer than the calyx segments, rose-color; flower 2 in. in diameter. Canon City, Colo."

This description does apply to our prairie roses better than that of *R. blanda* and as a result the wild roses found on the prairies extending from Minnesota to Missouri and from West Texas to Colorado were named *R. Arkansana*.

But in 1899 Greene described *R. pratincola* and since then there has been more or less confusion. Greene's description and comments are as follows: "*R. pratincola*. Almost herbaceous and never more than suffrutescent, 1-2 ft. high, usually flowering terminally and corymbosely from upright shoots of the season; bark of the stem glaucescent, the prickles dark purplish, all slender and weak, but some larger and less slender than others, all straight, spreading or slightly deflexed; leaves very ample for the plant, leaflets 7-11, obovate and oblong-obovate, sharply serrate, somewhat cuspidately acute, pubescent on both surfaces when young, the upper surface glabrate in age; stipules very narrow and entire, soft-pubescent, but neither glandular nor prickly, the rhachis often setose-prickly; receptacle smooth and glabrous, the sepals very wooly within and also marginally, the tips villous on both sides, the back of the basal part glandular-hispid; achenes nearly smooth, but more or less hirsute on certain of the angles and about the base or summit.

"I thus designate unhesitatingly as a new species one of the commonest of North American roses, and one of the most abundantly habitating a very extensive range in U. S. and Canada; a denizen of the prairie regions of the west and northwest, from Illinois and Missouri to the Dakotas and Manitoba. It has passed for *R. Arkansana* and to that extent that probably almost all the so-called *R. Arkansana* of the herbaria of the country is of this species. It is found in eastern Kansas and Nebraska, but does not occur in Colorado or anywhere very near its borders in so far as we can ascertain. It is the peculiar rose of the rich grassy prairies of the upper Mississippi valley; and though passing for *R. Arkansana* has been distributed by Sandberg from Minnesota as R. humilis. It is of course, a part of *R. blanda* of the earlier American authors and of local botanists residing in prairie regions.

"Probably no botanist, knowing as I know both the Illinois and Wisconsin prairies and the valley of the Arkansas in Colorado, could be brought to entertain the notion that any species of rose could be common to the two. The latter is an arid and subsaline half-desert country, a region of cactaceous and salicorniaceous plants, probably about as different from the region of *R. pratincola* as Arabia is from England; a consideration which does not seem to have entered the minds of our American rhodologists—if we have any—much less those of the European students of the genus.

"*R. Arkansana* has not been, I think, collected a second time; and as I spent many a week in arduous collecting about Canon City, in different years between 1873 and 1896, without having seen the original *R. Arkansana,* I entertain a suspicion that it may have been founded on some corymbosely-flowering precocious shoot of the so-called *R. blanda* of that region, or perhaps of *R. Fendleri.* But apart from the antecedent probability of this our eastern prairie species being also an inhabitant of a cactus desert, the western and xerophilous rose, the real *R. Arkansana* is glabrous, while ours is pubescent; it has stipules both glandular and prickly, while ours has them softly pubescent only; it has sepals reflexed in fruit, while in ours these are erect."

It will be noted that the above descriptions differ principally in the number and surface of the leaflets, the position of the sepals, and the surface of the stipules. After a study of the roses of Iowa it was found that both descriptions were needed; for, there are prickly and deciduously-prickly stems; plants with seven to eleven and nine to eleven leaflets; leaf surfaces as Greene describes them but some glabrous above and below; there are connivent and spreading sepals; and stipules with entire, glandular-toothed and glandular-hispid margins. However, on account of the promiscuous variation, which will be discussed later, one cannot recognize two species.

The description of *R. pratincola* in the seventh edition of Gray's manual differs from that of Greene's as follows:

Greene	Gray
1. Stipules; entire	More or less toothed
2. Sepals; glandular-hispid	Rarely hispid
3. Rhachis; often setose-prickly	Softly and finely villous or tomentulose, glandular hairs occasional or none.

The *R. pratincola* of Britton and Brown has spreading, sparingly glandular hispid calyx-lobes, stipules that are in some cases toothed, and leaflets glabrous on both sides.

These inconsistencies in the descriptions of the various authors suggested variability in the plants themselves. Accordingly an investigation of the extent of variation was made.

A part of the material used for this work was collected during the summer of 1918 from Dickinson and Buena Vista counties. Professor Shimek's extensive collection and the material of the herbarium of the State University of Iowa also were used.

The writer wishes to here acknowledge her indebtedness and gratitude to Professor Shimek for his helpful suggestions and kind criticism in the preparation of this paper.

VARIATIONS IN *ROSA PRATINCOLA*

Sepals

Position.—In the schemes of classification made for roses much stress is laid upon the position of the sepals on the mature fruit, whether connivent and persistent, or spreading and deciduous. No uniformity was found in the specimens of *R. pratincola.* In one group of these roses that grew along a roadside in Dickinson county, a part had spreading sepals and a few combined the two types. In regard to the other characters, viz., leaves, pedicels, stem, etc., there was sufficient uniformity to satisfy one that there were not two species and a hybrid. In this same general locality there was another group in which all the plants save one had connivent sepals. It can be said, however, that the greater proportion of the plants have connivent sepals.

Surface of the basal part.—Out of the 250 specimens examined the majority have glandular-hispid and pubescent surfaces. A small per cent of the surfaces are glandular-pubescent, a few are pubescent and occasionally naked ones are found.

Foliaceous Tips.—The outer extremities of the sepals are more or less dilated. These are quite variable in length, ranging from two to fifteen mm. Only a very small per cent are lobed though in Gray's manual one of the taxonomic characters is "outer sepals lobed."

Stem

Height.—The smallest plant found in bloom was thirteen cm. in height while the tallest plants average about seventy-five cm.

Surface.—The greater percentage of the stems can be classed as prickly or very prickly. Most of the prickles are small with larger spines intermingled. The prickles may be weak or stiff and harsh. It is a common occurrence to find one stem with deciduous prickles among a group of prickly forms.

The upper portion of the stem may be unarmed. Specimens were collected the upper part of whose stems are free from spines of any kind, while the basal portions are covered with a flaky epidermis and there are a few spines about one mm. long. The prickles may be few but scattered along the whole length of the stem. In addition to prickles there may be stipitate glands. The climax of variability seemed to be reached when stems free from prickles of any description were found.

Branches.—The young stem very seldom branches but the older stems are usually much-branched. No difference was found in the prickliness of the sterile and fertile branches. Naked and prickly flowering branches may be found on the same plant.

Leaves

Number of leaflets.—The maximum number of leaflets is commonly 11 though it may be 7 or 9. On individual plants the variation may be 5 to 7; 5 to 9; 7 to 9; 7 to 11 and 9 to 11.

Length of leaflets.—The average length is about 2.5 cm. They vary from 1.5 to 4.5 cm.

Surface.—The upper and lower surfaces usually have a grayish cast due to the presence of soft hairs. However, both may be glabrous. On an individual plant there may be naked and scant pubescent surfaces, both upper and lower.

Rhachis

Surface.—The rhachises are frequently covered with short hairs but occasionally, scattered among these hairs, there are stipitate glands or prickles.

On one plant the rhachises may be naked and glandular-hispid; pubescent and glandular-hispid; pubescent, occasionally prickly, and glandular-hispid; or pubescent and occasionally prickly.

Stipules

Form.—The several types of stipules are shown on the plate, narrow, medium, and rather dilate. The narrow stipule is the prevailing form. Narrow and dilate stipules are occasionally found on the same plant.

Margin.—The margins of the stipules may be ciliate, ciliate and glandular-hispid, or ciliate and glandular-toothed.

Inflorescence

Form.—Seldom does *R. pratincola* bear a solitary flower; it is usually a corymb, sometimes of twenty to thirty buds and flowers. The pedicels are short and commonly glabrous, only a small per cent being glandular-hispid and a few pubescent. A few glandular-hispid hypanthiums were found, the remainder being glabrous.

Color of buds and flowers.—The varied hues and markings defy accurate representation with paper and pencil. A mere outline of the extent of variation is all that will be attempted.

The range is typified for large areas by the colors of the buds and flowers found along a half mile of prairie roadside in Dickinson county. There was the deep red to the pure white and between these extremes various shades and combinations of colors that seemed to show a gradual transition from one extreme to the other.

Number of petals.—Very rarely does the number of petals exceed five. In Dickinson county there were two groups of roses in which the petals numbered six, seven, eight, nine, and even ten.

The petals are commonly obcordate but a few cuspidate forms were found.

Fruit

The dark red fruits are commonly globose though some are pyriform.

One would be inclined to think that in a species exhibiting so much variation at least varietal subdivision could be made but the variation is not concomitant. One feature changes without apparent connection with any other. It exhibits what Dr. Gray called promiscuous variation.

This type of variation is well illustrated in the following examples. The features underscored are the exceptions to the general rule.

Example 1. *Stem with only an occasional prickle, pedicel pubescent, stipules dilate,* leaflets eleven, inflorescence corymbose, hypanthium glabrous, rhachis pubescent, sepals glandular-hispid.

Example 2. Stem very prickly, pedicel glabrous, *stipules dilate, leaflets seven to nine, inflorescence* 2-corymbose, hypanthium glabrous, rhachis pubescent, sepals glandular-hispid.

Dilate stipules is an exception common to both the above examples but note the difference in the accompanying variations. In example 1 they are almost naked stem and a pubescent pedicel and in example 2 they are seven to nine leaflets and a few-flowered inflorescence. In another specimen dilate stipules were accompanied by a deciduous-prickly stem.

In the above examples variations are cited which accompany dilate stipules, but narrow stipules is the prevailing form. The following examples will show that variations also accompany narrow stipules.

Example 1. Stipules narrow, *sepals spreading and pubescent, pedicel* pubescent, hypanthium glabrous, stem very prickly, leaflets nine to eleven, rhachis pubescent, inflorescence corymbose.

Example 2. Stipules narrow, *deciduous-prickly stem, leaflets seven to nine,* rhachis pubescent, hypanthiums and pedicels glabrous, sepals glandular-hispid, inflorescence corymbose.

Example 3. Stipules narrow, *sepals spreading* and glandular-hispid, *leaflets seven,* stem very prickly, hypanthiums and pedicels glabrous, inflorescence corymbose.

Example 4. Stipules narrow, *leaflets five to seven,* sepals connivent and glandular-hispid, hypanthiums and pedicels glabrous, stem very prickly, flowers corymbose.

It will be noted that in example 1 there are three exceptions, viz., spreading and pubescent sepals and pubescent pedicels; in example 2 deciduous-prickly stem and seven to nine leaflets; in example 3 spreading sepals and seven leaflets, and in example 4, five to seven leaflets.

These examples show that one cannot predict concomitant variations. There is no uniformity. One is justified in asking if a *R. pratincola* does exist which conforms to the general rule in every respect. The following example is a typical *R. pratincola.* Sepals connivent and glandular-hispid, hypanthiums and pedicels glabrous, flowers corymbose, stem prickly, leaflets seven to eleven, rhachis pubescent, stipules narrow.

DISTRIBUTION

General.—Prairies of the United States and Canada, Manitoba to New Mexico and Texas and Iowa to Colorado.

Specific locality references outside of Iowa:—Colorado, Indiana, Southwest Minnesota, North Dakota.

Iowa counties:—Dickinson, Buena Vista, Iowa, Delaware, Johnson, Emmet, Cerro Gordo, Winnebago, Pottawattamie, Woodbury, Harrison, Winneshiek, Shelby, Lyon, Hardin, Calhoun, Webster, Fremont, Monona, Lee, Des Moines, Wapello.

Reported Iowa counties:—Boone (Diehl), Dickinson (Shimek, Pammel), Emmet (Shimek), Fremont (Fitzpatrick), Harrison (Shimek, Pammel), Johnson (Shimek, Somes), Ida (Macbride), Lyon (Shimek, Boot), Muscatine (Shimek, Pammel), Monona (Shimek, Pammel, Boot), Sioux (Shimek), Sac (Macbride), Story (Shimek, Pammel), Woodbury, Winneshiek, Polk, Palo Alto, Clay, Kossuth, Winnebago, Allamakee, Clinton, Scott, Decatur (Pammel).

ECOLOGY

The four species which were studied in the field, viz., *R. pratincola, R. virginiana, R. Woodsii,* and *R. blanda,* grow in xerophytic or semi-xerophytic habitats. The division of the leaf surface into small leaflets, thick cutin, water-storage cells, compact palisade tissue, hairs and glands are all good adaptations for preventing too rapid transpiration and hence they may be expected to hold their own in such habitats.

The most xerophytic species is *R. pratincola* and it further protects itself by not reaching a greater average height than three decimeters. It thereby receives protection from the surrounding vegetation and is less exposed to the greater evaporation due to increased height.

No list of prairie plants would be complete without *R. pratincola*. It is not limited by any type of soil or topography, being absent only from bogs. It grows on every type of prairie; flat, rolling, alluvial, exposed ridges, sandy areas, and even sand dunes. The habitat of maximum exposure expresses itself in stunted plants, shorter and finer-leaved than usual.

R. pratincola is a troublesome weed in the prairie grainfields. It is difficult to eradicate due to its rather deep-growing, perennial rhizome.

Department of Botany,
The State University.

THE FERN FLORA OF NEBRASKA*

T. J. FITZPATRICK

Nebraska lies near the center of the region known as the great plains of North America and near the eastern side of the semiarid district. The boundaries are natural or nearly so. Missouri river forms the eastern boundary, the northern boundary lies in the valley of the Niobrara, the southern in the valley of the Republican, while the western boundary is in the foothills. The range is from the 40th to the 43d parallel and the western border is the 104th meridian. The greatest width is 208 miles, the greatest length is 455 miles, the area is 77,530 square miles, of which 712 square miles are water. As to comparative size Nebraska is much larger than all of New England and considerably larger than England and Wales together. The elevation varies from 785 feet to about 5390 feet. As a whole the state has the aspect of a rolling prairie, there being plateaux and foothills only in the western portion. The annual rainfall varies from 35 inches along Missouri river in southeastern Nebraska to 14 inches in the semiarid districts in the western portion. The mean annual temperature varies from 52°F. in the southeastern corner to 45° in the northwest corner. The recorded evaporation data give the average annual total amount from April to September inclusive, for Lincoln, during an eleven year period, as 34.8 inches, and for a three year period at North Platte as 41.3 inches.

The physiographic regions of the state are: (1) river valleys, (2) wooded bluffs, (3) prairies, (4) sandhills, (5) plateau or foothill region, (6) pine ridge, and (7) bad lands.

RIVER VALLEY REGION

On the eastern side of the state is the narrow valley of Missouri river. It is bordered by steep and wooded bluffs, broken by numerous ravines. The width varies from half a mile to as much as eight miles. Missouri river meanders between the bordering bluffs, thus leaving a variable width of valley to the Nebraska side. Horseshoe lakes or lagoons are abundant. The soil is of alluvial origin, being of fine silt and sand. Old woods are common.

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Platte river, with its main tributary the North Platte, flows across the state through the central portion from west to east. The width of the North Platte where it enters the state is about five hundred feet, while the width of the Platte at its mouth is more than a mile. The valley of the North Platte is deep and narrow, usually less than half a mile in width, but the valley of the Platte varies in width from one to eight miles. The river banks are low and for the most part are treeless. The water is shallow and in many places divides into several streams which are separated by long sandbars or low wooded islands.

Niobrara river flows in a narrow gorge for more than two-thirds of its course in Nebraska. The last fifty miles of its course is through a valley varying in width from half a mile to a mile. Here the banks are low and wooded, the bluffs are steep and densely covered with thickets and young trees, and in places the valleys are heavily wooded.

Republican river enters the state near the southwestern corner, flows eastward through eight counties of the southern tier, then turns southward into Kansas. The valleys are rather broad and treeless, the bluffs low and bare of trees, in the ravines are willow, cottonwood and ash trees, the river banks usually have a fringe of willows. The river is broad and shallow with abundant sandbars.

Big Blue river with its tributaries drains much of the southeastern portion of the state. The current is slow, the bed and banks are muddy, the valleys are broad, level and rich, and along much of their extent are heavily wooded.

The fern species that may be found in the river valleys are *Osmunda regalis* (rarely), *Dryopteris thelypteris,* and *Onoclea sensibilis.* The fern allies are *Equisetum robustum* and *Equisetum fluviatile.*

WOODED BLUFFS REGION

This region consists of narrow strips of country bordering on the river valleys on one side and the uplands on the other. The line of demarcation with the river valley is rather sharp although the woods are in many cases continuous. The separation of the wooded bluffs from the uplands is often not sharply drawn, there being varying degrees of divergence, yet within limits it is distinctive. The wooded bluffs extend in narrow dichotomous strips over much of the state, paralleling the valleys of the main water courses. They reach their greatest development near Missouri river which is the center of their extension westward. Upland woods are an extension from the wooded bluffs into favorable situations. The trees are of the broad leaf species except in the northwest where there is a development of the yellow pine.

In Nebraska the fern flora reaches its greatest development in this region. The principal fern species of this region are *Botrychium virginianum, Adiantum pedatum,* and *Filix fragilis.* In the crevices of the rock cliffs, often more or less exposed, are found: *Cryptogramme acrostichoides* (rarely), *Notholaena dealbata* (rarely and locally), *Pellaea atropurpurea, Woodsia obtusa,* and on dry rocky soil *Selaginella rupestris* (rarely).

THE PRAIRIE REGION

The prairies lie immediately west of the Missouri river bluffs and in general cover the eastern half of the state, extending farther westward in the southern portion and being much restricted in the northcentral portion. These prairies with their gently undulating surfaces are the western representatives of those characteristic of Iowa and Illinois and are made up of indiscriminately arranged series of low rounded swells or hills interpersed with broad shallow depressions or limited valleys. The soil is of glacial drift which is quite deep in many places and is more or less veneered with loess. Drainage systems are well established and ponds or lakes are uncommon or rare.

This region is not conducive to fern growth. Where a belt of upland woods occurs *Botrychium virginianum* and *Adiantum pedatum* may be found. *Onoclea sensibilis* and *Dryopteris thelypteris* occur in wet prairie bottoms. Of the fern allies there are *Equisetune arvense,* preferring dry soil, and *Equisetum laevigatum,* preferring moist soil. Both species are abundant to common and widely distributed in this region. *Equisetum variegatum* is rarely found. In ponds *Marsilea vestita* occurs in small numbers or locally abundant. *Isoetes melanopoda* occurs rarely and locally.

THE SANDHILL REGION

The sandhills lie west of the prairies and cover much of the western half of the state, being confined largely to the central and westcentral portions. The eastern boundary of this region is not well marked, the prairies passing gradually into the sandhills, but in general the boundary line is irregular, receding westward in the river valleys and extending eastward along the watersheds. The greatest eastern extension is in the northcentral portion. The western boundary is quite distinct, although there are outlying sandhills in the foothill region. The area is about 18,000 square miles, a little less than two-fifths of the area of the state. The soil is porous and sandy. The hills are broken, abrupt or rounded, many of them are pitted with blow-outs or crater-like depressions, and the valleys are deep and narrow. The variable contours of the hills and blow-outs are the direct result of the prevailing winds. Drainage systems are poorly established. Large ponds and small lakes occur throughout the region and lakes of considerable size occur near the heads of the water courses, particularly in Cherry, Grant, and Hooker counties. Lost creeks are numerous. These are streams which rise in ponds or springs and flow on the surface for a distance and then sink in the soil to pursue a subterranean course, in some instances coming to the surface for a short distance only to be lost again. The valleys are broad and marshy and their limits are marked by high sandhills. A few buttes occur in the western part. This is the bunch-grass region of the state. Woodland vegetation is scanty.

In favorable situations, usually in moist soil, there occur: *Dryopteris cristata* (rarely), *Dryopteris spinulosa* (rarely), *Dryopteris thelypteris* (locally abundant), *Onoclea sensibilis, Woodsia oregana* (rarely), *Marsilea vestita, Azolla caroliniana* (rarely), *Equisetum arvense* (in dry soil), *Equisetum laevigatum, Equisetum variegatum* (rarely), and *Selaginella rupestris* (locally) which forms mats on sandhills.

THE PLATEAU OR FOOTHILL REGION.

The plateau region, in the western part of the state, comes rather abruptly from the sandhill region. It is an elevated district well marked by numerous isolated buttes and by deep and precipitous ravines. It is the short-grass region of Nebraska.

The fern flora of this region is scanty. The following species have been collected: *Cheilanthes feei,* in canons; *Woodsia oregana.* on buttes; *Marsilea vestita* in ponds; and *Selaginella rupestris,* on exposed dry situations, often forming dense mats on high hills and buttes.

PINE RIDGE REGION

Pine Ridge is a northerly facing escarpment extending from Wyoming into Nebraska near the northwest corner and in the middle western part of Sioux county and extending eastward across Sioux, Dawes, Sheridan, and Cherry counties, approximately parallel with the northern boundary of the state. The ridge varies from a mile to several miles in width and has its greatest development in Nebraska in Sioux and Dawes counties. Eastward it becomes lower and narrower. The ridge is much broken by deeply cut canons crossing transversely to the general trend. Along this ridge upon the canon sides is a development of the western yellow pine (*Pinus ponderosa scopulorum*). The vegetation peculiar to Pine Ridge extends farther eastward across Brown, Rock, and Keya Paha counties. Pine Ridge is essentially a variation of the wooded bluffs region.

In favorable, usually moist situations are found: *Botrychium virginianum, Athyrium filix-foemina* (rarely), *Cystopteris fragilis, Dryopteris spinulosa, Dryopteris thelypteris, Woodsia oregana,* and *Equisetum laevigatum.*

BAD LANDS REGION

The bad lands in Nebraska are confined largely to Sioux and Dawes counties, in the northwestern part of the state, with occasional outliers in the foothill region south of the North Platte river in Scottsbluff county. The region is a rugged, submontane one, marked with deep canons, mostly drained by Hat creek and White river and their tributaries. The larger part of the region is known as the Hat creek basin. The soil is largely clays and marls, absorbs little water, and readily erodes. This unstable soil receives little rain and much summer heat, hence there is little or no vegetation.

In favorable situations in the canons are found: *Botrychium virginianum, Filix fragilis, Woodsia oregana, Equisetum arvense, Equisetum laevigatum,* and *Equisetum robustum.*

GENERAL DISTRIBUTION

The fern flora in Nebraska is represented by seventeen genera and twenty-six species. Of these *Botrychium neglectum, Osmunda regalis, Osmunda claytoniana, Cryptogramma acrostichoides, Dryopteris cristata, Notholæna dealbata,* and *Isoetes melanopoda* are quite rare, each being known from but one locality in the state. *Cheilanthes feei, Dryopteris spinulosa,* and *Azolla caroliniana* are each known from two localities. *Pellaea atropurpurea* and *Athyrium filix-foemina* have been collected in three or four localities. *Adiantum pedatum,* a common eastern fern but which ranges across the continent, occurs in Nebraska only in the southeastern quarter. *Botrychium virginianum, Filix fragilis, Dryopteris thelypteris, Onoclea sensibilis, Marsilia vestita, Equisetum arvense, Equisetum laevigatum,* and *Equisetum robustum* are the only species that are frequent to common and widely distributed over the state. *Pteris aquilina*, the nearly cosmopolitan species, does not occur, neither does *Polypodium vulgare* nor *Camptosorus rhizophyllus*. There are no Lycopodiums. The nearly cosmopolitan species, *Athyrium filix-foemina*, is found in Nebraska only in two or three favorable locations.

SUMMARY AND CONCLUSIONS

From this it is readily seen that the fern flora of Nebraska is conspicuous for its poor development. The reasons for this paucity may be due to the effects or mutual reactions of the effects of several causes. Some of these are:

(1) The greater portion of the state is too arid for a rich development of fern growth; much of the surface is unsuitable for any ferns, the suitable areas being few and restricted, thus limiting the possible number of species.

(2) Entire absence of endemic forms; there are no species peculiar to Nebraska.

(3) Lack of development of features favorable to distributional adaptation; ferns are rather rigid in their requirements and do not readily overcome new environmental difficulties.

(4) Ferns are comparatively old from the standpoint of evolution, being far beyond their period of culmination, while the soil of Nebraska is comparatively new.

(5) The centers of migration for the ferns into this area are the Appalachian and the Rocky Mountains. The broad prairies of northern Missouri, of Iowa, and of southern Minnesota prevent migration from the east. A number of species of ferns that are absent from similar localities in eastern Nebraska, are found along the eastern border of Iowa. The aridity of the western portion of the state prevents migration from the Rocky Mountains.

(6) The line of easiest migration into Nebraska is by way of the Missouri river valley, a route suitable to only a limited number of ferns.

(7) Lack of development of a mountain range within the state or near by with a humid climate, the submontane region of western Nebraska being too arid.

(8) The area of fern distribution tends to lessen, many species are now quite limited in range, and ferns as a whole have little migrating tendency.

ACKNOWLEDGMENT

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ANNOTATED LIST OF SPECIES

Ophioglossaceae

Botrychium virginianum (L.) Swartz. Grape fern. In rich woods, preferring bluffs and canons, rather common in favorable locations.

Douglas county: woods near Florence, July 9, 1897, *Wm. Cleburne.*

Sarpy county: Bellevue, open woods, June 3, 1887, *Wm. Cleburne*; Bellevue, May 2, 1893, No. 3232, *Roscoe Pound and DeAlton Saunders.*

Cass county: Weeping Water, June, 1889, *Tom A. Williams.*

Lancaster county: Lincoln, June 30, 1886, No. 6102, woods west of Saltillo, *H. J. Webber.*

Thomas county: in woods near Plummer ford, Dismal river, July 3, 1893, No. 1467, *P. A. Rydberg;* Halsey, June 18, 1912, *Raymond J. Pool and Donald Folsom.*

Dawes county: Belmont, wooded bluffs, July 18, 1889, No. 6103, *H. J. Webber.*

Sioux county: Squaw canon, August, 1892, No. 444, *Albert F. Woods;* Monroe canon, north of Harrison, June 21, 1911, *Raymond J. Pool and C. V. Williams.*

Botrychium neglectum Wood. (*Botrychium ramosum* (Roth) Aschers.) Franklin county; one specimen in the herbarium, collected by E. M. Hussong, in August, 1895, copses and meadows on Mr. Ewing's farm, one mile northeast of Franklin, not abundant, No. 4689. It is labeled *Botrychium ternatum australe.*

Osmundaceae

Osmunda regalis L. Royal fern. Flowering fern. Franklin county: in original prairie in Republican river valley, near Franklin, May 5, 1896, No. 6776; also one and one-half miles southwest of Franklin, near Ashby's mill and on low ground near the river, June, 1896, No. 4693, both specimens collected by E. M. Hussong.

Osmunda claytoniana L. One specimen, No. 7516, without definite locality, and doubtfully referred to Nebraska.

Polypodiaceae

Adiantum pedatum L. Maidenhair. This species is frequent to common in rich woods, especially in the southeastern quarter of Nebraska, the region of the state having the greatest rainfall.

Douglas county: June 29, 1875, *Samuel Aughey;* woods, south of Omaha, June 25, 1873, *William Cleburne;* Florence, October 3, 1908, *N. F. Petersen.*

Sarpy county: Bellevue, September 2, 1893, No. 3146, *Roscoe Pound and D. A. Saunders;* south of Albright, September 1, 1908, *F. G. Ernst.*

Cass county: Plattsmouth, woods of the Missouri river bluffs, May 15, 1886, No. 6127, *H. J. Webber.*

Nemaha county: Nemaha, July 5, 1910, No. 5145, *Rev. J. M. Bates;* also reported from the vicinity of Peru by Bessey and Webber.

Richardson county: wooded bluffs of Missouri river, common, August 26, 1889, No. 6129, *H. J. Webber.*

Pawnee county: Table Rock, May, 1896, *J. E. Shue.*

Lancaster county: Lincoln, June 3, 1890, No. 6128, *H. J. Webber,* from Lucena Hardin; Lincoln, May, 1895, rich, moist woods, *E. B. Robinson;* another specimen by Fred C. Cooley without further data.

Athyrium filix-foemina (L.) Roth. (*Asplenium filix-foemina* (L.) Bernh.) Lady fern. Woods and thickets, frequent only in favorable places, but not found in most portions of the state. A widely variable species and widely distributed, ranging generally throughout North America, also found in Europe and Asia.

Brown county: Long Pine, Seven Springs, July, 1892, No. 441, *Albert F. Woods;* Long Pine, September, 1893, No. 2938, *Fred Clements.*

Douglas county: Omaha, from garden, from a plant got from 2569 Pierce St., July 27, 1901; also September 16, 1901, and September 2, 1902, *William Cleburne.*

Lancaster county: Lincoln, July, 1886, No. 6122, *H. J. Webber,* a poor and fragmentary specimen but clearly this species. It is labeled *Asplenium thelypteroides* Michx.

Cheilanthes feei Moore. (*Cheilanthes lanuginosa* Nutt.) Lip fern. Known only from the extreme western and southwestern parts of the state, occurs on exposed rocks.

Banner county: Exposed rocks of a canon, one mile southwest from Hackberry Springs, August, 1890, *P. A. Rydberg;* August 8, 1891, No. 479, *P. A. Rydberg.*

Redwillow county: reported by C. E. Bessey.

Cryptogramma acrostichoides R. Br. Rock-brake. Rocky places, rare, known only from one locality.

Franklin county: Franklin, 1893, *E. M. Hussong.* A single fruiting blade sent to Dr. C. E. Bessey for determination. The locality is somewhat outside of the known range of the species but the specimen seems properly referred.

Cystopteris fragilis (L.) Bernh. (*Filix fragilis* (L.) Underw.) Brittle fern. This species is found in rich woods, along wooded banks of streams and in canons, and is rather common in most portions of the state. It is the most abundant fern of Nebraska.

Dixon county: Ponca, bluffs of Missouri river, June 15, 1893, No. 2556, *Fred Clements.*

Douglas county: Omaha, April, 1889, No. 6118, *H. J. Webber.*

Cass county: Plattsmouth, shaded ravines, Missouri river bluffs, May 15, 1886, No. 6117, *H. J. Webber;* also reported from the vicinity of Weeping Water by Bessey and Webber. There is an immature specimen from Weeping Water, collected in moist rocky places, May 14, 1892, by *Emma Stover.*

Otoe county: Nebraska City, June 1, 1889, No. 6115, *H. J. Webber.*

Saunders county: Ashland, June 24, 1890, *Tom A. Williams.*

Nemaha county: Nemaha, July 5, 1910, No. 5140, *Rev. J. M. Bates;* also reported from the vicinity of Peru by Bessey and Webber.

Johnson county: Tecumseh, *Anna Pinnel.*

Jefferson county: Endicott, Republican valley, August 23, 1893, No. 2002, *A. F. Woods and DeAlton Saunders.*

Lancaster county: Lincoln, damp wooded banks, June 3, 1890, No. 6120, *H. J. Webber* from Lucena Hardin; old sandstone quarry, June, 1886, *J. G. Smith;* on banks of Antelope creek, opposite H. street, May 20, 1886, *T. Walton;* Lincoln, shaded cliffs, May, 1895, *C. B. Robinson.*

Seward county: Milford, May, 1886, No. 6116, *H. J. Webber.*

Custer county: Anselmo, wooded bluffs, July 8, 1889, No. 6121, *H. J. Webber.*

Thomas county: near Plummer ford, shaded banks of Dismal river, July 3, 1893, No. 1452, *P. A. Rydberg;* Halsey, June 24, 1912, *Raymond J. Pool and Donald Folsom.*

Antelope county: on Verdigris creek, near Royal, 1908, *N. F. Petersen.*

Brown county: Long Pine, canons, July 23, 1887, *C. E. Bessey;* Long Pine, Seven Springs, July, 1892, No. 439, *Albert F. Woods;* Long Pine, July 29, 1892, No. 270, *J. G. Smith and Roscoe Pound.*

Dawes county: Belmont, wooded bluffs, July 18, 1889, No. 6119, *H. J. Webber.*

Sioux county: Squaw canon, August, 1892, No. 439, *Albert F. Woods;* Monroe canon, north of Harrison, June 22, 1911, *Raymond J. Pool and C. V. Williams.*

Dryopteris cristata (L.) A. Gray. *(Aspidium cristatum* (L.) Swartz.) Crested shield-fern. This species is known only from one locality in the state.

Thomas county: central Nebraska, on south fork of Dismal river, on wet meadows, August 14, 1893, No. 1530, *P. A. Rydberg.*

Dryopteris spinulosa (Muell.) Kuntze. *(Aspidium spinulosum* (Muell.) Swartz.) Spinulose shield-fern. Rarely found in Nebraska and known from only two localities.

Thomas county: damp shaded banks, near water's edge, Dismal river, July 12, 1889, Nos. 6125, 6126, 6127, *H. J. Webber;* near Plummer ford, Dismal river, in damp woods, July 4, 1893, No. 1484, *P. A. Rydberg.*

Brown county: Long Pine, June 25, 1892, *Rev. J. M. Bates;* September 4, 1893, No. 2939, *Fred Clements.*

Dryopteris thelypteris (L.) A. Gray. *(Aspidium thelypteris* (L.) Swartz.) Marsh shield-fern. This species is common in most portions of the state. It occurs in moist shaded places and grassy wet bottoms, often associated with *Onoclea sensibilis,* and forming with it a fern meadow.

Jefferson county: Endicott, Republican valley, August 23, 1893, No. 2004, *A. F. Woods and DeAlton Saunders.*

Franklin county: in prairie hay, cut in the Republican valley, near Franklin, May 5, 1896, No. 6777, *E. M. Hussong.*

Kearney county: marsh near Platte river, June 15, 1891, No. 478, *P. A. Rydberg;* Newark, July, 1892, *Dr. H. Hapeman.*

Buffalo county: Kearney, 1887, *G. A. Beecher;* August, 1893, *Misses Smith and Lee.*

Thomas county: wet bottoms, Loup river, July 11, 1889, No. 6123, *H. J. Webber;* wet bottoms, Dismal river, July 12, 1889, No. 6124, *H. J. Webber;* on south fork of Dismal river, in wet meadow, August 14, 1893, No. 1684, *P. A. Rydberg;* Halsey, July, 1911, *R. J. Pool;* also reported from the vicinity of Thedford by Bessey and Webber.

Dodge county: Fremont, August 9, 1872, *C. E. Bessey.*

Brown county: Long Pine, July 23, 1887, *C. E. Bessey;* Long Pine, Seven Springs, July, 1892, No. 443, *Albert F. Woods;* Long Pine, September 2, 1893, No. 2936, *Fred Clements.*

Cherry county: July 19, 1892, No. 278, *J. G. Smith and Roscoe Pound.*

Dawes county: reported from the vicinity of Crawford by Bessey and Webber.

Notholæna dealbata (Pursh) Kunze. *(Notholæna nivea dealbata* (Pursh) Davenport.) This species reaches its northern limit in Nebraska, ranging from Nebraska and Missouri to Texas and Arizona. Known in Nebraska only from a single locality.

Cass county: Weeping Water, growing from crevices in rocks, August 22, 1888, No. 6112, *H. J. Webber;* dry rocks, August 22, 1888, *Tom A. Williams;* November 11, 1895, No. 6773, *T. A. Williams.*

Onoclea sensibilis L. Sensitive fern. Frequent to common in low wet soil, often in grassy places, in some localities becoming a weed, ranges generally throughout the state.

Otoe county: Nebraska City, March, 1904, *Cooper Dunn,* a weather beaten fragment of the preceding year's growth.

Jefferson county: Fairbury, southern Nebraska, September 1, 1892, No. 7270, *Ruth A. Price;* Endicott, Republican valley, August 23, 1893, No. 2003, *A. F. Woods and DeAlton Saunders.*

Buffalo county: Kearney, August, 1893, No. 7703; along Platte river, 1894, both by *Misses Smith and Lee;* Kearney, No. 6111, *H. J. Webber.*

Franklin county: in prairie hay cut in the Republican valley near Franklin, May 5, 1896, No. 6775, *E. M. Hussong.*

Thomas county: in woods near Plummer ford, Dismal river, August 23, 1893, No. 1377, *P. A. Rydberg;* low prairies, very common, Dismal river, July 12, 1889, No. 6110, *H. J. Webber;* Halsey, July, 1911, *R. J. Pool.*

Antelope county: reported by Bessey and Webber.

Holt county: Paddock, July 29, 1893, No. 2802, *Fred Clements.*

Brown county: Long Pine, June 25, 1892, *Rev. J. M. Bates,* an unusual specimen with tips of the lobes coarsely crenately toothed or incised and fluted; Long Pine, July, 1892, No. 442, *Albert F. Woods;* Long Pine, August 25, 1908, *Rev. J. M. Bates.*

Cherry county: July 19, 1892, No. 277, *J. G. Smith and Roscoe Pound;* also a specimen collected twenty miles southwest of Valentine, no further data.

Pellæa atropurpurea (L.) Cliff brake. In localities where it is found this species is frequent in crevices of rocks; in Nebraska found only in the southeastern portion.

Cass county: Weeping Water, dry calcareous rocks, May 23, 1887, No. 6108, *H. J. Webber;* April 19, 1919, *R. J. Pool.*

Nemaha county: Brownville, January 2, 1889, No. 6109, *H. J. Webber;* reported from the vicinity of Peru by Bessy and Webber.

Jefferson county: Endicott, July 17, 1892, *Miss Case;* August 23, 1893, No. 2001, *A. F. Woods and DeAlton Saunders.*

Woodsia obtusa (Spreng.) Torrey. This species seems to be limited mostly to the southeastern portion of the state, rarely found in the central and western portions. Found in crevices of rock cliffs.

Pawnee county: Pawnee City, 1892, *C. H. Barnard.*

Lancaster county: Emerald, December 7, 1895, No. 6774, *A. S. Hunter.*

Custer county: Callaway, July 3, 1902, No. 2370, *Rev. J. M. Bates.*

Brown county: Long Pine, reported by Bessey and Webber.

Woodsia oregana D. C. Eaton. This species apparently is confined to the western half of the state; it is frequent on dry open bluffs.

Thomas county: Dry banks, Dismal river, July 12, 1889, No. 6106, *H. J. Webber;* on hillside near Plummer ford, Dismal river, July 3, 1893, No. 1479, *P. A. Rydberg.*

Brown county: Long Pine, collected by *J. Conklin,* No. 8 ex-herbarium G. D. Swezey; Long Pine, canons, July 23, 1887, *C. E. Bessey.*

Dawes county: Belmont, dry banks, July 18, 1889, No. 6105, *H. J. Webber.*

Sioux county: on buttes, August, 1892, No. 440, *Albert F. Woods;* Hat creek, June 24, 1890, *Tom A. Williams.*

Marsiliaceae.

Marsilea vestita Hook. and Grev. Hairy pepperwort. In ponds, frequent in many places in the state. During periods of drought terrestrial specimens may be found having hairy and narrow leaflets and these have been named the variety *tenuifolia* Und. and Cook.

Jefferson county: Meridian township, section 22, 1891, *E. F. Lange;* Fairbury, September 3, 1892, *E. F. Lange.*

Fillmore county: Fairmont, August, 1890, and August 4, 1891, *J. H. Haughawout;* August, 1890, No. 6113, labeled var. *tenuifolia*

Und. and Cook, *H. J. Webber;* ponds, August 1, 1890, *J. H. Haughawout,* labeled var. *tenuifolia* Und. and Cook.

Webster county: Red Cloud, *Rev. J. M. Bates.*

Kearney county: Minden, August 13, 1891, *Dr. H. Hapeman,* labeled var. *tenuifolia,* prairies and sandhills of central Nebraska, July 13, 1900, altitude 500 meters, No. 6604, *P. A. Rydberg.*

Deuel county: July 3, 1893, *E. M. Gilliard.*

Box Butte county: July 7, 1892, No. 275, *J. G. Smith and Roscoe Pound.*

Pierce county: Plainview, July 2, 1907, in shallow ponds, *N. F. Petersen.*

Antelope county: Clearwater, June 16, 1899, reported as a weed, No. 12036, *D. M. Decamp;* Brunswick, June, 1909, *N. F. Petersen.*

Salviniaceae.

Azolla caroliniana Willd. Apparently known from only one or two localities, rare.

Thomas county: on ground at edge of water, Dismal river, July 12, 1889, No. 6101, *H. J. Webber;* in a spring near Plummer ford, Dismal river, August 24, 1893, *P. A. Rydberg.*

Garden county: Doctor R. J. Pool reports finding this species in great abundance along Blue creek in May, 1912.

Equisetaceae.

Equisetum arvense L. Common in sandy soil, fields, pastures, waste places, roadsides. The simple fertile stems appear in March and April and soon wither after fruiting, the branched sterile stems come later and persist throughout the summer. This species seems to appear mostly as a weed and will be found in low wet grounds to rather high and dry situations.

Sarpy county: Bellevue, May 13, 1893, No. 4097, *Roscoe Pound and DeAlton Saunders.*

Saunders county; Ashland, June 24, 1890, *Tom A. Williams.*

Cass county: Weeping Water, reported by Bessey and Webber.

Otoe county: Nebraska City, May 28, 1893, No. 4067, *Roscoe Pound and F. E. Clements.*

Nemaha county: Brownville, reported by Bessey and Webber.

Gage county: Wymore, reported by Bessey and Webber.

Lancaster county: Lincoln, May, 1890; May 2, 1893, No. 3230, *Pound, Clements and Saunders;* also a specimen without definite data by *A. F. Woods,* and a similar one by *Fred C. Cooley.*

Seward county: Milford, low wet ground, May 23, 1886, No. 6138, *H. J. Webber.*

Custer county: Anselmo, reported by Bessey and Webber.

Thomas county: near Thedford, in meadow on Middle Loup river, September 9, 1893, No. 1378, *P. A. Rydberg;* on wet meadow near Nattick, June 20, 1893, No. 1378, *P. A. Rydberg.*

Brown county; Long Pine, reported by Bessey and Webber.

Dawes county: near Pine Ridge, July 24, 1889, *H. J. Webber.*

Sioux county: Squaw canon, August, 1892, No. 447, *Albert F. Woods;* Hat Creek basin, August 1, 1889, No. 6133, *H. J. Webber.*

Equisetum fluviatile L. (*E. limosum L.*) This species apparently is infrequent in Nebraska. It occurs in swampy places and along borders of streams and ponds.

Kearney county: Platte river, June 15, 1891, No. 475, *P. A. Rydberg.*

Garfield county: Burwell, July 22, 1909, No. 4917, *Rev. J. M. Bates.*

Holt county: southwest part, along Holt creek, August 2, 1892, *Rev. J. M. Bates.*

Brown county: Long Pine, August 3, 1909, No. 4933, *Rev. J. M. Bates.*

Equisetum lævigatum A. Braun. Common in moist soil in low fields, pastures and waste places.

Dixon county: Ponca, June 14, 1893, No. 2542, *Fred Clements.*

Cass county: Weeping Water, reported by Bessey and Webber.

Lancaster county: Lincoln, prairie bank of Antelope, northeast of town, May 8, 1885, No. 6139, *H. J. Webber;* marshy prairie, Lincoln, April, 1886, *J. G. Smith;* marshy grounds, Lincoln, May, 1886, *J. G. Smith.*

Saline county: Crete, reported by Bessey and Webber.

Jefferson county: Fairbury, low land near water, May 31, 1886, No. 32.

Webster county: Red Cloud, June 2, 1908, No. 4509, *Rev. J. M. Bates.*

Kearney county: wet prairie, June 15, 1891, No. 476, *P. A. Rydberg.*

Dundy county: Benkelman, August 5, 1893, No. 2000, *A. F. Woods and DeAlton Saunders.*

Custer county: Callaway, May 28, 1902, No. 2225, *Rev. J. M. Bates.*

Thomas county: in wet meadow on Middle Loup river near Thedford, June 14, 1893, Nos. 1260 and 1283, *P. A. Rydberg;* Thedford, July 11 and 14, 1889, Nos. 6136 and 6131, *H. J. Webber;* Halsey, July, 1911, *R. J. Pool.*

Garden county: Oshkosh, June 6, 1912, *Raymond J. Pool.*

Brown county: Long Pine, reported by Bessey and Webber.

Sheridan county: July 9, 1892, No. 276, *J. G. Smith and Roscoe Pound.*

Dawes county: Pine Ridge, July 24, 1889, No. 6130, *H. J. Webber.*

Sioux county: Squaw canon, August, 1892, No. 445, *Albert F. Woods;* Hat creek basin, August 2, 1889, *H. J. Webber.*

There are also two sheets collected by Samuel Aughey, about 1875, without definite data.

Equisetum robustum A. Braun. This species is quite common along river banks throughout the state.

Dixon county: Ponca, June 14, 1893, No. 2543, *Fred Clements.*

Sarpy county: Bellevue, September 3, 1893, No. 3189, *Roscoe Pound and D. A. Saunders.*

Cass county: South Bend, *Mr. Kemble,* no further data.

Nemaha county: Missouri bottoms, Brownville, January 2, 1889, Nos. 6132 and 6140, *H. J. Webber,* specimens with branches.

Kearney county: along Platte river, June 15, 1891, No. 475, *P. A. Rydberg.*

Buffalo county: Kearney, banks of Platte river, July 20, 1901, No. 54, *J. J. Thornber.*

Thomas county: on hillside near Plummer ford, Dismal river, August 24, 1893, No. 1722, *P. A. Rydberg;* Thedford, July 10, 1889, No. 6135, *H. J. Webber.*

Cherry county: Fort Niobrara, August, 1890, No. 38, *Rev. J. M. Bates.* This fragmentary specimen is labeled *Equisetum hyemale* L. and it was published as such by Dr. C. E. Bessey.

Dawes county: Pine Ridge, July 14, 1889, No. 6134, and July 24, 1889, No. 6137, *H. J. Webber.*

Sioux county: Squaw canon, August, 1892, No. 446, *Albert F. Woods;* Monroe canon, north of Harrison, June 18, 1911, *Raymond J. Pool and C. V. Williams.*

Equisetum variegatum Schleich. This species seems to be infrequent or rare; it occurs usually in wet soil.

Lancaster county: Lincoln, Antelope creek, May, 1887, *J. R. Schofield.*

Kearney county: wet prairies, June 13, 1891, No. 477, *P. A. Rydberg.*

Hooker county: on wet meadow near Middle Loup river, July 17, 1893, No. 1801, *P. A. Rydberg.*

Brown county: Long Pine, reported by Bessey and Webber.

Cherry county: Valentine, July, 1891, No. 39, *Rev. J. M. Bates.*

Selaginaceae.

Selaginella rupestris (L.) Spring. Dry rocky soil or cliffs, infrequent or rare, apparently confined to certain localities, sometimes locally frequent.

Brown county: sandhills, Long Pine, July 23, 1887, also 1890, C. E. Bessey; July 28, 1892, No. 271, *J. G. Smith and Roscoe Pound.*

Antelope county: near Royal, August 7, 1907, *N. F. Petersen.*

Lincoln county: reported by Bessey and Webber.

Cheyenne county: reported by Bessey and Webber.

Isoetaceae.

Isoetes melanopoda J. Gay. Known in Nebraska from one locality in the southeastern portion, rarely collected.

Fillmore county: northeastern part of the county, roadside ditches on road north from Exeter, about one-half mile from the depot, September 8, 1888, *Dr. J. Herman Wibbe.*

Department of Botany,
The University of Nebraska.

SUPPLEMENTAL LIST OF PLANTS FROM SOUTHEASTERN ALASKA

J. P. ANDERSON

The following list comprises plants that have been collected or determined during the past year. The larger portion of the species here enumerated is the result of a trip to Haines and Skagway at the head of Lynn canal on August 19 to 21, 1918. Elevations are only approximate. The writer was told by well-informed residents of Skagway that the elevation of upper Lake Dewey was about 4,000 feet. All species for which this elevation is given were collected in the vicinity of the lake.

Most of the determinations were made by Dr. P. A. Rydberg, of the New York Botanical Garden.

In addition to the list here given there is a small amount of undetermined material and what appears to be undescribed species of the following genera: Alsine, Epilobium, Solidago, Aster, Arnica.

Polypodiaceæ.

Thelypteris oreopteris hesperia Slosson. At Mendenhall and Skagway.

Woodsia scopulina D. C. Eaton. Collected at Haines.

Lycopodiaceæ.

Lycopodium selago L. Occurs at Sitka and Skagway.

Equisetaceæ.

Equisetum pratense Ehrh. *Equisetum hyemale* L. Scouring Rush. These two species were collected on Stickine river, a short distance beyond the international boundary in British Columbia.

Pinaceæ.

Abies lasiocarpa (Hook.) Nutt. Alpine Fir. Common at Skagway.

Thuja plicata D. Don. Western Red Cedar. Occurs from Wrangell southward.

Scheuchzeriaceæ.

Triglochin palustris L. Frequent in bogs.

Poaceæ.

Deschampsia bottnica (Wahl.) Trin. At Mendenhall.

Poa triflora Gilib. At Petersburg.

Arctagrostis arundinacea Trin. At Mendenhall.

Arctagrostis macrophylla Nash. *Panicularia borealis* Nash. At Petersburg and Mendenhall.

Panicularia grandis (Wats.) Nash. At Mendenhall.

Agropyron tenerum Vasey. At Mendenhall.

Polypogon monspeliensis (L.) Desf. At Sitka.

Cyperaceæ.

Rynchospora alba (L.) Vahl. At Sitka.

Scirpus cæspitosus L. At Petersburg.

Scirpus pauciflorus Lightf. Skagway at 3,000 feet.

Eriophorum gracile Koch. At Petersburg near sea level, Skagway at 4,000 feet.

Eriophorum angustifolium Roth. At Mendenhall.

Juncaceæ.

Juncus richardsonianus Schult. At Mendenhall and Skagway.

Juncus stygeus L. At Wrangell.

Juncus tenuis L. At Juneau.

Juncoides piperi Coville. At Skagway.

Iridaceæ.

Iris setosa Pall. At Juneau and Haines. This is the species previously reported as I. arctica Easlw. It is especially abundant in marshy places at Haines.

Orchidaceæ.

Corallorrhiza corallorrhiza (L.) Karst. Occasional at Mendenhall.

Limnorchis viridiflora (Cham.) Rydb. Skagway at 4,000 feet.

Betulaceæ.

Alnus tenuifolia Nutt. At Mendenhall and Haines.

Betula alaskana Sarg. Occurs at Skagway.

Polygonaceæ.

Bistorta ochreosa Small. Collected at Mendenhall.

Polygonum neglectum Besser.

Polygonum aviculare L. These two species of Polygonum are common at Skagway.

Chenopodiaceæ.

Blitum capitatum L. Frequent at Haines.

Amaranthaceæ.

Amaranthus græcizans L. Introduced at Juneau.

Alsinaceæ.

Alsine humifusa (Rottb.) Britt. Occurs at Sitka.
Alsine crassifolia (Ehrh.) Britt. At Skagway.
Mœhringia lateriflora (L.) Fenzl. At Sitka.
Sagina saginoides (L.) Britt. At Sitka.

Ranunculaceæ.

Batrachium sp. In shallow water at Skagway.

Aquilegia formosa Fisch. Seems to be distinct from *A. columbiana* Rydb. Sitka specimens belong here. Collected at Skagway at 4,000 feet.

Aquilegia brevistyla Hook. A few specimens collected at Skagway.

Actea eburnea Rydb. On mountain side at Skagway.
Caltha leptosepala DC. Skagway at 4,000 feet.
Caltha natans Pall. In swamps at Mendenhall.
Ranunculus turneri Greene. Collected at Juneau.
Coptidium lapponicum (L.) Gand. Skagway at 3,000 feet.
Halerpestis cymbalaria (Pursh) Greene. Collected at Skagway.
Anemone richardsoni Hook. Skagway at 4,000 feet.

Brassicaceæ.

Campe americana (Rydb.) Cockerell (*Barbarea americana* Rydb.). Collected at Haines.

Campe stricta (Andrz.) W. F. Wight (*B. stricta* Andrz.). Collected at Mendenhall.

Radicula hispida (DC.) Heller. Collected at Mendenhall.
Sophia sophia (L.) Britt. Common at Skagway.
Cheirinia cheiranthoides (L.) Link. Found at Haines.
Arabis drummondii Gray. Collected at Haines.
Thlaspi arvense L. At Juneau and Haines.
Lepidium densiflorum Schrad. Frequent at Skagway.
Draba lutea Gilib. Skagway at 4,000 feet.

Droseraceæ.

Drosera longifolia L. This interesting species was collected at Petersburg.

Elæagnaceæ.

Lepargyræa canadensis (L.) Greene. Found at Skagway and Haines.

Violaceæ.

Viola adunca Smith. Collected at Haines.

Onagraceæ.

Chamænerion latifolium kamtschaticum. On the mountain side at Skagway.

Epilobium palustre L. Collected at Juneau.

Cornaceæ.

Chamæpericlimenum (Cornus) unalaschkense (Ledeb.) Rydb. Collected in a swampy place near Juneau.

Pyrolaceæ.

Pyrola uliginosa Torr. Collected along Stickine river in British Columbia near the international boundary.

Pyrola elliptica Nutt. Skagway at 2,000 feet.

Vacciniaceæ.

Vaccinium alaskense Howell. This includes one of the forms reported under Vaccinium sp. in former list.

Scrophulariaceæ.

Verbascum thapsus L. Introduced at Juneau but not able to maintain itself.

Veronica xalapensis H. B. K. Collected at Skagway.

Orthocarpus sp. (*hispidus* form?). Common at Skagway.

Plantaginaceæ.

Plantago lanceolata L. Sparingly introduced at Juneau.

Rubiaceæ.

Galium columbianum Rydb. Collected at Mendenhall.

Galium trifidum L. Collected at Juneau.

Caprifoliaceæ.

Linnæa longiflora (Torr.) Rydb. Common at Petersburg.

Carduaceæ.

Solidago canadensis L. Collected at Skagway.

Aster major (Hook.) Porter. Collected at Mendenhall.

Erigeron yellowstonensis A. Nels. At Skagway and Haines.

Artemisia elatior (T. & G.) Rydb. Common around Skagway.

Cichoriaceæ.

Lactuca spicata (L.) Hitchc. Collected at Haines.

Agoseris gracilens (Gray) Kuntze. Skagway at 4,000 feet.

Lampsana communis L. Collected at Juneau.

Hypochaeris radicata L. Collected at Juneau.

Taraxacum alaskanum Rydb. Collected at Skagway.

JUNEAU, ALASKA.

MEASUREMENTS OF WOOD FIBER

H. S. CONARD AND W. A. THOMAS.

Many of the properties of wood depend upon the character and arrangement of the fiber cells which enter into its composition. This is especially true of those properties which determine its strength, hardness and adaptability for the manufacture of paper pulp. With a view to throwing light on these properties, we have made measurements of the length and diameter of the fibers in forty-one species of trees. No attempt was made to segregate the various types of fiber that occur in different species. We have taken any of the slender, fusiform, non-septate, thick walled members of the xylem. The maximum and minimum figures indicate that this lack of discrimination has not introduced any serious error. Were very critical discrimination attempted, the comparison of species would prove unduly complex, if not impossible.

Our material was obtained partly from local lumber dealers, partly from the Grinnell College collection of wood specimens, and partly from fresh material cut from the College botanic garden and campus, and from neighboring groves. It was mostly heart wood, though not in every case. This should not affect the measurements.

Shreds of the wood about two millimeters in diameter were split off and placed in test tubes of strong commercial nitric acid. To each tube is added about 0.5 gm. of potassium chlorate. The maceration is carried on for about thirty hours at 35 to 40 degrees centigrade. The acid is then poured off. The wood is washed in several changes of water extending over four to six hours. The resulting fragments are usually nearly colorless, and the constituent cells are readily separated by teasing or by more or less violent shaking in water. A drop of a suspension of the separated cells is then placed on a slide, covered, and the fibers are measured with an eye-piece micrometer. Some specimens were stained in safranin, dehydrated, and mounted in balsam as permanent preparations. A few species of wood were softened in hydrofluoric acid and sectioned in the three usual planes. These served as checks on the macerated material, but were much less satisfactory for purposes of measurement, especially measurement of length. Only one genus, viz. Prunus, showed marked swelling of the fibers as a result of maceration. *Prunus Davidiana* was the most swollen species. This affected the diameter, but apparently did not affect the length.

A survey of the measurements shows first of all a striking difference between the lengths of fiber in Gymnosperms and Angiosperms. The greater length of fiber in the former group doubtless stands in relation to the demands of water conduction in these ductless plants. But when *Pinus ponderosa, Abies balsamea, Thuja occidentalis* and *Juniperus virginiana* all show lengths of fiber comparable with those of Angiosperms, one is at a loss for an explanation. It must be noted that *Pinus ponderosa* and *Juniperus virginiana* are inhabitants of dry soils, and *Abies balsamea* and *Thuja occidentalis* prosper in bog soils. All may be considered xerophytic. The remaining Gymnosperms in our list must be considered as mesophytes. But Taxodium is a bog plant, and has very long fiber. Comparing the species of Thuja, the one from the moist region of the northwest coast, *T. plicata,* shows much the longer fiber.

Among Angiosperms there is a striking uniformity in length of fiber in the apetalous series, where the measurements nearly all average above one millimeter. In the higher orders, the lengths are nearly all below one millimeter. Liriodendron, which in some respects is a relatively primitive species, and is certainly very ancient, has a fiber a little less than 1 mm. in length, i. e. intermediate between the principal groups. Platanus and Fraxinus, both very unique among their near relatives from the standpoint of floral structure, are also decidedly aberrant in fiber length. *Prunus Davidiana* is similarly aberrant. On the whole, it would seem that fiber length varies very widely within narrow taxonomic limits.

From the standpoint of the uses of wood, the length of fiber alone is not a guide to weight, strength or elasticity. Western spruce, so valuable for aeroplanes, has the longest fiber on our list. But Taxodium is a close second. Oak, ash, elm, birch and cottonwood are remarkably similar in fiber length.

Probably the length of fiber in wood has more relation to its value for paper plup than for any other practical use. It is well known that coniferous woods make the best pulp, and of these spruce pulp brings the highest price. This is due to the length of the fibers. Spruce and Sequoia, however, proved to be the most difficult woods to break down by the maceration process used by us. In view of the excellent fiber produced by *Picea sitchensis,* attention should be called to the tremendous waste of the wood of this species in stumps and tops by the lumbering methods current in the northwest. Stumps six to ten feet in diameter and eight to twelve feet high cover the deforested areas. And tops less than two feet in diameter are usually left in the slashes. There remains on the ground after an ordinary lumbering operation in western Washington more cubic feet of wood than would be found in the total stand of many a profitable eastern woodland. Some way must be found to utilize this vast wastage, and convert it into paper pulp and other valuable by-products.

GRINNELL COLLEGE.

FIBER LENGTHS AND WIDTHS IN WOODS.

	MINIMUM		AVERAGE		MAXIMUM	
	Length	Width	Length	Width	Length	Width
Pinus strobus	3.85mm	0.0510mm	4.04mm	0.0592mm	4.20mm	0.0731mm
P. ponderosa	1.11	.0217	1.43	.0262	1.81	.0292
P. palustris	4.40	.0425	5.28	.0462	6.50	.0510
P. sylvestris	1.40	.0212	2.00	.0277	2.20	.0340
Picea sitchensis	5.60	.0585	6.70	.0744	8.00	.0877
Tsuga heterophylla	4.00	.0425	5.64	.0526	5.40	.0595
Abies balsamea	.97	.0170	1.17	.0229	1.32	.0255
Sequoia sempervirens	4.10	.0340	5.98	.0552	7.10	.0723
Taxodium distichum	5.50	.0360	6.10	.0530	7.40	.0650
Thuja occidentalis	1.26	.0183	1.57	.0215	2.14	.0255
T. plicata	4.20	.0297	4.81	.0387	5.50	.0430
Juniperus virginiana	.84	.0170	1.00	.0198	1.15	.0212
Juglans cinerea	.63	.0170	.92	.0216	1.05	.0297
J. nigra	1.26	.0170	1.41	.0228	1.76	.0297
Hicoria ovata	1.38	.0127	1.69	.0219	1.95	.0255
Populus tremuloides	.38	.0170	.55	.0216	.65	.0233
P. deltoides	1.11	.0212	1.73	.0307	2.40	.0405
Salix nigra	.88	.0255	1.05	.0289	1.26	.0340
Betula lutea	1.13	.0212	1.67	.0262	2.00	.0297
Fagus americana	1.07	.0127	1.36	.0186	1.55	.0212
Quercus rubra	1.32	.0170	1.59	.0199	1.85	.0230
Q. alba	1.15	.0148	1.51	.0213	1.77	.0290
Ulmus americana	1.17	.0175	1.47	.0247	1.68	.0297
U. campestris	.84	.0127	1.03	.0159	1.26	.0200
Celtis occidentalis	.90	.0149	1.03	.0185	1.26	.0225
Liriodendron tulipifera	.80	.0195	.98	.0251	1.26	.0297
Platanus occidentalis	1.13	.0174	1.43	.0222	1.66	.0250
Prunus americana	.63	.0094	.71	.0124	.99	.0161
P. serotina	.59	.0128	.73	.0161	.86	.0212
P. davidiana	.86	.0098	1.02	.0134	1.57	.0157
P. persica	.48	.0127	.72	.0144	1.13	.0162
Robinia pseudacacia	.53	.0149	.67	.0174	.78	.0233
Acer saccharum	.67	.0195	.86	.0253	1.05	.0280
A. platanoides	.46	.0127	.59	.0145	.79	.0170
A. saccharinum	.63	.0170	.77	.0201	.84	.0255
A. rubrum	.59	.0132	.73	.0192	.90	.0242
A. negundo	.40	.0157	.46	.0173	.59	.0212
Tilia americana	.48	.0195	.77	.0240	1.16	.0297
Fraxinus americana	1.36	.0130	1.62	.0163	1.90	.0190
Catalpa speciosa	.52	.0195	.62	.0240	.71	.0297
C. bignonioides	.48	.0170	.59	.0198	.69	.0255

STUDY OF A SECTION OF THE OREGON COAST FLORA

MORTON E. PECK

The following paper is the result of a somewhat detailed study of the flora of a small section of the Oregon coast in Lincoln county, namely, that lying between Yaquina Head and the mouth of Yachats river. These two points are distant from each other in a straight line about twenty-five miles; by the beach, striking across the mouths of the bays, the distant is perhaps twenty-eight miles. The flora in the neighborhood of Seal Rocks, about midway between the two points, received the most attention, though the whole ground was gone over rather carefully. This section is fairly representative of the entire coast of the state, except the extreme southern part.

Yaquina Head is a high, narrow headland, at the extremity of which is a lighthouse. From its landward end southward to the town of Newport there is a nearly straight coast line of about four miles, with a narrow beach. A mile above Newport, over a high bluff, is Nye Beach, a popular resort. Newport touches the north side of the mouth of Yaquina bay, a narrow, winding indentation some twelve miles in length. From the southern shore of the bay mouth to Alsea bay there is again a nearly straight coast line of thirteen miles, with an almost uninterrupted beach, which in places is quite wide. Much the same conditions hold from the mouth of Alsea bay to the mouth of Yachats river.

On the shoreward side of the beach we find a variety of conditions. Yaquina Head has no beach, but high, perpendicular sea-cliffs, rising to the eastward into bold, rounded bluffs. Southward to Nye Beach the shore face has a steep ascent, sometimes almost perpendicular above the narrow beach, to a height of perhaps twenty to forty feet. At Nye Beach the shore face is cut away and sand dunes have developed. On the southward side of Yaquina bay there is quite an extensive beach with a gradual rise to the landward, but a little farther to the south the steep shore bluffs begin again and continue with slight interruptions some distance below Seal Rocks. The latter are a group of picturesque rocks, mostly islanded by erosion of the shore. A mile below Seal

Rocks the steep bluffs stop, and from here to Alsea bay there is a continuous succession of sand drifts and dunes. Midway between Seal Rocks and Alsea bay behind the line of dunes is a small lake, called Sand lake, with an area of several acres. From Alsea bay to the mouth of the Yachats there is mostly a rather wide beach, and the country behind this is low with no shore bluffs.

Before taking up the flora a word should be said as to climatic conditions. The difference between the average summer and winter temperatures is of course relatively small. There is little freezing weather in winter and the summers are uniformly cool. The annual precipitation, nearly all rain, is about 72 inches. During at least half of the year clear days are the exception, and for the remainder cloudy weather and rain are to be expected at any time. Even during June, July, and August it frequently happens that the cloudy days greatly outnumber the clear. Very strong westerly winds prevail during the winter, and even in summer they are frequent, but less violent.

Let us now consider the several ecological groups of plants occurring in our territory, noting some of the more strongly marked effects of the environmental conditions upon some the species.

We may begin with the plants of the beach, including those that are occasionally reached by waves directly, and also those of the shore cliffs and damp seaward faces of those shore bluffs which are frequently wet by clouds of fine spray from the sea, so that the foliage is more or less encrusted with salt. The special factors here concerned are evidently high winds, copious moisture, sandy soil, and strong salinity. This group includes the following:

Abronia latifolia
*Achillea millefolium
*Agrostis alba
*A. exarata
*Aira praecox
Ammodenia peploides
*Amsinckia lycopsoides
Angelica hendersoni
*Aster douglasii
*Calamagrostis aleutica
Cakile edentula
Carex macrocephala
*C. obnupta
*Chenopodium album
C. humile
*Cirsium edule
*C. lanceolatum
Coneoselinum gmelini
Convolvulus soldanella
Cotula coronopifolia
Crambe maritima
Distichlis spicata
*Eleocharis palustris
Elymus arenarius
*Epilobium franciscanum
Erigeron glaucus
*Festuca rubra
*Fragaria chilœnsis
Franseria bipinnatifida
F. chamissonis
*Grindelia oregana
*Holcus lanatus
*Hypochaeris radicata
*Juncus bufonius
*J. ensifolius
J. falcatus
Lathyrus littoralis
Lobularia maritima
*Lolium multiflorum
L. perenne
Lupinus littoralis
*Lycopus americanus
*Maianthemum dilatatum
*Mimulus langsdorfii

Pentacæna ramosissima
*Picea sitchensis
*Plantago lanceolata
P. bigelovii
*P. major
P. maritima
*Poa annua
P. macrantha
Polygonum paronychea
*Potentilla anserina
Rumex acetosella
R. maritimus var. fueginus
*R. mexicanus
*Sagina occidentalis
Salicornia pacifica
*Salix hookeriana
Scripus americanus
S. riparius
*Sisyrinchium californicum
Spergularia macrotheca var. scariose
S. sparsiflora
Statice armeria
Stellaria humifusa var. oblongifolia
Tanacetum huronense
*T. repens
Triglochin maritima

The species of this list marked with an asterisk are only incidentally seashore or salt marsh plants and are found more or less widely distributed in other situations; the rest are ordinary halophytes. On some species of the former group the effect of the exceptional environment is very marked, on others it is scarcely perceptible. It is noticeably more pronounced on those that occur most abundantly and appear to have made themselves at home among the true halophytes. These with their most prominent characteristics are the following:

Achillea millefolium.—Very low and stout, often only twelve to fifteen centimeters in height; foliage ample, glabrous and succulent. This is the variety *nigricans*. As we pass inland out of the influence of salt water and high winds it is found to intergrade perfectly with the usual Coast mountain form of the species.

Aira praecox.—Stout, the culms radiately spreading and nearly prostrate.

Agrostis alba.—Culms and rootstocks poorly differentiated from each other, long, abundantly branched, largely aerial but prostrate and rooting, mostly sparingly leafy throughout, the leaves very short; panicles mostly very small and contracted. This is the variety *maritima*, and all intergrades with the typical form are found as we recede from the maritime influence.

Agrostis exarata.—Remarkable for the very short, stout, spreading culms, often no more than fifteen cm. long; panicles large and dense; whole plant succulent. Intergrades perfectly with the typical form. This is *A. glomerata*.

Aster douglasii.—Extremely unlike the ordinary form of the species. Stems very short and depressed, often no more than ten to fifteen centimeters in length; leaves crowded, thick and glabrous;

rootstock system greatly developed. All intergrades with the typical form occur.

Eleocharis palustris.—Very short and relatively stout.

Epilobium franciscanum.—This is at best a poorly defined species. It is a rather low, stout, sparingly branched form with ample foliage and leaves somewhat fleshy. It is one of the *E. glandulosum* assemblage, which has been variously broken up into species and varieties without very satisfactory results. The present form is supposed to be confined to the seashore, but nearly or quite identical material has been found in the Willamette valley. Back from the beach it intergrades with other forms of *E. glandulosum.*

Festuca rubra.—In situations of maximum exposure to maritime influences this species is remarkably modified. The leaves are very rigid, folded, and strongly curved, surpassing the very short culms, while the panicles are extremely dense and contracted. All intergrades with the typical form occur.

Fragaria chilœnsis.—Very low with excessively developed runner system; leaves glabrous and shining above, the leaflets broad and thick. Intergrades with the ordinary inland form, which has thin glaucous leaves and narrower leaflets, are easily found in places where the maritime influences are less marked. The species here has flowers and fruit all summer. The fruit is decidedly saline.

Juncus ensifolius.—Stout, with large black heads and large perianth; leaves very narrow and thick. This is a strongly marked form intergrading, however, with the typical plant occurring farther inland.

Plantago major.—Leaves thick, usually wrinkled, and perfectly glabrous; spikes short and dense with large capsules. All intergrades with the typical form occur.

Rumex mexicanus.—Stems stout, often elongated and freely branched, completely prostrate; leaves oblong, fleshy, and very glabrous; panicle dense and akenes very large. A strongly marked phase. No intergrades with the typical form were found.

Sagina occidentalis (*crassicaulis*).—This species presents a phase closely paralleling that of *Epilobium franciscanum.* The branches are stout, fleshy, and prostrate, and the flowers and fruit large. *S. occidentalis* in typical form flourishes a little way back from the beach, and the two appear to completely intergrade.

Of the remaining facultative halophytes, nearly all show the effect of their exceptional environment in some degree. They are mostly dwarfed, but in a few cases they are exceptionally large; pubescence is relatively scant and the leaves are slightly thickened.

Several of the true halophytes, for one reason or another, are of particular interest. Such are the following:

Abronia latifolia.—This species grows in abundance on the beach in various places, especially at the mouth of Alsea bay, where over quite a large area the fine clean sand is piled into rounded, billowy drifts, each drift crowned with one of these plants. The prostrate stems are completely buried and only the fleshy leaves and umbels of fragrant, orange-colored flowers are visible. The species is doubtless of considerable importance in catching and holding the drifting sand.

Angelica Hendersoni is a remarkable species, differing widely from others of the genus in its thick, leathery leaves and very dense umbels. It grows most abundantly along the extreme seaward margins of the shore bluffs, where it is often wet with driving clouds of spray. Here it is very low and stout. Farther back, in more protected situations, it is much taller.

Convolvulus soldanella.—This species is plentiful on the seaward faces of sandy bluffs just above the beach where the latter is narrow. It does not form a sufficiently close growth to greatly retard the movement of the sand.

Elymus arenarius.—This large, coarse grass is common along the seaward slopes of shore bluffs and dunes, and is more or less effective in checking the movements of the latter.

Erigeron glaucus is a low, stout, succulent plant, rarely to be found where it is not often wet with salt water. It is most abundant on exposed cliffs and projecting headlands.

Franseria bipinnatifida and *F. chamissonis.*—These species grow in precisely the same situations as *Abronia latifolia*. *F. chamissonis* is by far the more abundant of the two, occupying a large portion of the sand-drift area at the mouth of Alsea bay. The copious, silvery gray foliage with a satiny luster gives the plant a very striking and attractive appearance.

Juncus lescurii.—An abundant and characteristic species of the deep drifting sand and young dunes of the higher beach. The long decumbent and tangled wiry stems spring from a deep and strongly developed rootstock system. It is of importance in checking the movement of the wind-blown sand.

Juncus falcatus.—Very plentiful in wet sand on the low beach, where it sometimes forms almost a turf.

Lupinus littoralis.—This species often occurs with *Juncus lescurii*. It is remarkable among Lupines for its prostrate habit. Nowhere very abundant.

Plantago maritimus.—This form is more tolerant of salt water than any other land plant occurring in this section. Its favorite habitat is in clefts of the exposed faces of shore cliffs and rocky islets where it often grows so low down that it must frequently be submerged by the waves in winter.

Poa macrantha.—Plentiful in a few places. One of the most effectual retainers of the beach sand where it occurs in sufficient abundance.

The association of plants we have been considering passes more or less gradually into one much less subject to the influence of salt water, though doubtless more or less affected by the fine salt mist blown shoreward in windy weather. The area occupied by this group is for the most part fully exposed to the wind, which is consequently a most important factor in determining the character of the vegetation. This is of course particularly true of the shrubs and such dwarfed trees as are here capable of maintaining an existence. The territory occupied by this association is a narrow strip of land beginning just back of the edge of the shore bluff, or of the beach, as the case may be,.and extending inland in some cases for several hundred yards, usually much less, according to the contour of the land. The area includes many seaward slopes, some moderately level land, occasional sand dunes that have become more or less fixed by vegetation, and a few small sphagnum bogs. The following species occur here:

Achillea millefolium
Aira caryophyllea
Agoseris apargioides
Agrostis alba
A. exarata
A. hyemalis
A. hyemalis var. geminata
Alchemilla occidentalis
Anaphalis margaritacea var. occidentalis
Anemone oregana
Arctostaphylos tomentosa
A. uva-ursi
Aster douglasii
Bellis perennis
Berberis aquifolium
Brassica campestris
Bromus hordaceus
B. marginatus
Calamagrostis aleutica
Carex pansa
Castilleja dixonii
Centaurium umbellatum
Cerastium vulgatum
Chrysanthemum leucanthemum var. pinnatifidum
Cirsium edule
C. lanceolatum
Cornus canadensis
Crepis capillaris
Deschampsia cæspitosa
Dipsacus sylvestris
Disporum smithii
Epilobium angustifolium
E. glandulosum var. adenocaulon
Erigeron canadensis
Festuca rubra
Fragaria chilœnsis
Gaultheria shallon
Gentiana sceptrum
Geraniun molle
Gnaphalium chilense

G. purpureum
Habenaria michaeli
Holcus lanatus
Holodiscus discolor
Hypericum anagalloides
Hypochæris radicata
Iris tenax
Juncus bufonius
J. effusus var. hesperius
J. ensifolius
Ledum columbianum
Lolium perenne
Maianthemum dilatatum
Medicago lupulina
Montia parviflora
Myrica californica
Oenantha sarmentosa
Panicum occidentale
Picea sitchensis
Pinus contorta
Plantago lanceolata
P. major
Poa annua
P. pratensis
Polygonum aviculare
P. persicaria
Prunella vulgaris var. lanceolata
Pyrola bracteata
Ranunculus bongardi
R. occidentalis
Rhododendron californicum
Rosa nutkana
Rubus macropetalus
R. spectabilis
Rumex acetosella
Sagina occidentalis
Salix hookeriana
Sanguisorba microcephala
Sisymbrium officinale var. leiocarpum
Sisyrinchium californicum
Solidago elongata
S. glutinosa
Spergularia rubra
Spiræa douglasii
Spiranthes romanzoffiana
Stellaria media
Streptopus amplexifolius
Synthyris rotundifolia
Taraxacum officinale
Trifolium dubium
T. fimbriatum
T. repens
Urtica lyallii
Vaccinium ovatum
V. parvifolium
V. uliginosum var. mucronatum
Viola sarmentosa

A number of species, such as certain aquatic and subaquatic forms, and others that barely come within this area are omitted from the list, as they contribute nothing toward an understanding of the characteristics of the assemblage as a whole, and will be mentioned elsewhere.

The most interesting of this group of species are the trees and shrubs, since they show to a more marked degree than the herbaceous plants the effect of their exposure to the winds from the sea.

Picea sitchensis is excessively distorted, and many of the trunks are inclined landward at a very low angle. The small branches and twigs on the seaward side are very short and densely matted, appearing as if closely clipped, so that viewed from this side the tree presents a smooth, sloping surface. The trees usually grow in close order but seldom in large groups, though in some instances they form a continuous border along the seaward side of a forest of more normal development. Often the closely interwoven and matted branches cut off the light to such an extent that all the lower limbs die out, and for the same reason no smaller vegetation springs up beneath them and among the close-ranked trunks there is a comparatively open space where a deep twilight always prevails. The trees are not commonly more than three or four meters in height, and so firm and rigid is this natural roof that with care one can walk over it without danger of falling through.

Pinus contorta is much less common than *Picea sitchensis*. Where it is most exposed it has a very short trunk with long, depressed branches. The whole tree is greatly distorted and usually not more than two or three meters in height.

Vaccinium ovatum is the most abundant and characteristic shrub of this area. It forms low, cushion-like clumps of remarkably uniform shape. These cushions have a low pitch on the seaward side, but a more abrupt slope on the landward, so that when one is looking across them from the west he sees a series of smooth, low, and gently sloping mounds, but from the east they present the appearance of large green hummocks. The branches are so closely matted and interwoven that one can often sit on the top of a bush without bending it over.

Myrica californica forms clumps somewhat similar to those of *Vaccinium ovatum*. *Gaultheria shallon* is dwarfed and matted, making a continuous turf-like growth where it is fully exposed. *Ledum columbianum, Rhododendron californicum, Rosa nutkana* and *Rubus spectabilis* are much dwarfed. The same is true of *Arctostaphylos tomentosa,* which, however, grows very sparingly in the most exposed places. *Vaccinium uliginosum* var. *mucronatum* is abundant in some localities, but it is too low to be affected by the winds.

Of the herbaceous plants it may be said in general that they show the effects of the peculiar environment just in proportion to the height which they reach under normal conditions; that is, they show more or less tendency to become low and stout.

The association we have just been considering passes more or less gradually into the forest on the landward side. The low vegetation that is fully exposed to the winds from the sea protects that on its leeward side, thus enabling the latter to grow a little taller, and this in turn protects that which succeeds. In this manner the powerful air currents that could not be withstood by the taller trees if they were exposed from the ground upward, are shot over their tops by the inclined plane up which they have been directed.

In some places the forest is extremely dense, in others it is more open. The area studied includes only the narrow strip of comparatively low coastal forest, which is approximately co-extensive with the distribution of *Pinus contorta* in this section. The land occupied by this forest association is in places comparatively level, and here we find the closest stand of trees. In other places it is hilly or cut by ravines and small swampy tracts. The species making up this assemblage are in the majority of cases the same as those occurring in the area last considered, but they are here in very different proportions as to numbers, and in many cases they have a strikingly different habit. The following are the most important:

Acer circinatum
Achillea millefolium
Aira caryophyllea
Agrostis alba
Agrostis exarata
Alnus oregona
Anaphalis margaritacea var. occidentalis
Anthemis cotula
Arctostaphylos tomentosa
A. uva-ursi
Aster douglasii
Boschniakia hookeri
Boykinia elata
Campanula scouleri
Deschampsia elongata
D. cæspitosa
Disporum smithii
Epilobium angustifolium
E. glandulosum var. adenocaulon
Epipactis decipiens
Fragaria chilœnsis
Galium triflorum
Gaultheria shallon
Gnaphalium palustre
Holcus lanatus
Holodiscus discolor
Hypericum anagalloides
Hypochæris radicata
Juncus bufonius
J. effusus var. hesperius
J. ensifolius
Ledum columbianum
Lonicera involucrata
Lotus crassifolius
Luzula campestris var. multiflora
L. parviflora
Lysichiton camtschatcense
Maianthemum dilatatum
Mimulus dentatus
M. langsdorfii
M. moschatus
Montia parviflora
M. parvifolia
M. sibirica
Myrica californica
Phleum pratense
Picea sitchensis
Pinus contorta
Prunella vulgaris var. lanceolata
Pseudotsuga mucronata
Pyrus diversifolia
Ranunculus bongardi
Rhododendron californicum
Ribes divaricatum
Ribes sanguineum
Rosa gymnocarpa
Rubus laciniatus
R. macropetalus
R. parviflorus
R. spectabilis
Sambucus callicarpa
Spiræa douglasii
Stachys ciliata
Stellaria media
Streptopus amplexifolius
Thuja plicata
Tolmiea menziesii
Trientalis latifolia
Trisetum cernuum
Vaccinium ovatum
V. parvifolium
Viola sarmentosa

As in the case of the preceding area various aquatics and species not of regular occurrence here, especially a number of introduced forms, are omitted.

The following merit special mention:

Achillea millefolium.—In some cases reaches one meter in height, with lax and diffuse foliage, in strong contrast to the drawf form with thick foliage found close to the sea.

Aster douglasii.—Wholly different in appearance from the beach form, developing into tall, widely branched plants, some of them 130 centimeters in height.

Gaultheria shallon.—The most abundant shrub, often forming a nearly impenetrable growth. Attains a height of three meters.

Myrica californica.—Very abundant, making up a large part of the tall undergrowth. Reaches a height of five meters.

Picea sitchensis.—Plentiful, though less so than the next species. The trees are well formed but small; however, they increase in size as well as in abundance as we go eastward.

Pinus contorta.—This is the most abundant tree. In many places it forms by far the dominant species, and there are considerable tracts where it occurs in almost pure stands. Places were noted where the plant association just previously described passed quite abruptly into one of these pine areas, and here appeared in strong contrast the two extreme forms of development of this tree. Along the exposed forest edge the trees were low and distorted with relatively stout trunks and long, horizontal or depressed branches. This is typical of *P. contorta*. A little farther back, where the growth was dense and the effect of the wind scarcely noticeable, the trees attained the tall slender *P. murryana* (Lodgepole Pine) form, practically indistinguishable from that of the Canadian zone tree of the Cascade mountains, except in the mode of weathering or splitting and cleaving of the bark, the difference here being doubtless due to differences in moisture, temperature, etc. The largest specimens noted were perhaps thirty centimeters in diameter and fifteen to seventeen meters in height.

Rhododendron californicum.—An abundant and conspicuous shrub, here reaching the dimensions of a small tree. Specimens seven meters in height were seen.

Rubus spectabilis.—A highly characteristic species of this section. The straggling bushes, partly supported by surrounding vegetation, attain a height of three to four meters.

Spiræa douglasii.—Plentiful in the more open places. Sometimes over three meters in height.

Tsuga heterophylla.—Moderately plentiful. The trees are small, but increase in size and numbers eastward.

Vaccinium microphyllum.—Rather infrequent among the tall undergrowth, but attaining nearly the maximum size of the species.

Vaccinium ovatum.—Abundant, forming a considerable part of the tall undergrowth. The bushes are erect, strict and sparingly branched, often five meters in height. The contrast between this species as it appears here and on the wind-swept areas above the beach is most remarkable.

Where the forest is most dense low herbaceous vegetation is nearly wanting. The most abundant and generally distributed species is perhaps *Pteridium aquilinum* var. *pubescens*, which is often two meters or more in height. In the more open places small plants are abundant. Among the commonest are *Aira caryophyllea, agrostis alba, Campanula scouleri, Deschampsia elongata, Disporum smithii, Fragaria chilænsis, Holcus lanatus, Hypericum anagalloides, Hypochæris radicata, Juncus effusus* var. *hesperius, Maianthemum dilatatum,* and *Viola sarmentosa.*

In several places there are groups of small hillocks sparingly wooded. Their contour indicates that they are old sand dunes that have become fixed by the development of a mantle of vegetation over their surface. Here *Pinus contorta* is rather low and widely branched but not distorted. *Arctostaphylos tomentosa* and *A. uva-ursi* are particularly plentiful, and there is an abundance of herbaceous vegetation.

Within the area under consideration there are several fresh water ponds and swamps. Sand lake, about two miles below Seal Rocks, with the marshy tract adjoining it, illustrates well this formation. In the shallow water at the northern end of the lake there is a colony of *Nymphæa polysepala* and one of *Potamogeton natans.* Along the margin of the water there is an abundance of *Lilæopsis occidentalis* and *Sparganium augustifolium.* A dense border of *Carex obnupta* extends much of the way around the lake. The swamp tract runs northward for some distance, terminating in a sphagnum bog of moderate size. Here were found several species not elsewhere noted: *Carex leptalea, C. sitchensis, Comarum palustre, Drosera rotundifolia, Eriophorum chamisonis,* and *Trientalis arctica.*

To the eastward the low forest area under consideration rises gradually into the great Coast mountain forest. The former is wholly wanting about the bays, where some protection is afforded from the westerly winds. Except where fires have swept over them or extensive lumbering operations have been carried on, the western slopes of the Coast mountains are covered with a magnificent growth of *Picea sitchensis, Pseudotsuga mucronata,* and *Tsuga heterophylla,* with other trees in much smaller numbers. With this forest we are not particularly concerned and no detail account of it will be given.

In studying the coast flora from the taxonomic standpoint one is impressed with the inconsistencies of the systematists in their treatment of those forms that have assumed special characteristics as the result of maritime influences. Thus if the beach forms of *Achillea millefolium, Agrostis alba* and *Sagina occidentalis* should receive varietal or even specific recognition, there is no legitimate reason why the same treatment should not be given the equally well marked maritime phases of *Aster douglasii, Festuca rubra, Rumex mexicanus,* and others.

Many species of plants that play a more or less important part in the total make-up of the vegetation of our territory have received no special mention in the foregoing discussion. It seems desirable therefore, to add the following distributional list, in which are included the names of all the seed plants ascertained to occur within our limits. Doubtless the list is far from complete for this section, especially as regards the flora about the bays.

For the records of a number of the species as well as for assistance on some points of nomenclature, I am indebted to Principal J. C. Nelson, of the Salem High School, who collected about Newport and Toledo in the summer of 1916.

Taxaceæ.

Taxus brevifolia Nutt.—Found sparingly about the bays.

Pinaceæ.

Thuja plicata Donn.—Only a few small trees were noted.

Pinus contorta Dougl.—Abundant everywhere, the distribution almost exactly coinciding with the area here under consideration.

Pseudotsuga mucronata (Raf.) Sudw.—Moderately plentiful, but always small.

Picea sitchensis Carr.—The most abundant tree excepting *Pinus contorta,* with which it is usually mingled. In protected situations the great forest of Spruce and Douglas Fir comes down to the edge of salt water, as is the case about the bays; elsewhere the trees are much smaller.

Tsuga heterophylla (Raf.) Sarg.—Moderately plentiful in the zone of low forest.

Sparganiaceæ.

Sparganium angustifolium Michx.—Plentiful in Sand lake, two miles south of Seal Rocks.

Najadaceæ.

Potamogeton natans L.—Plentiful in Sand lake.

P. pusillus L.—In pools near Newport.

Zostera marina L.—Abundant at the mouth of Yaquina bay and in drift along the beach. Good flowering and fruiting specimens were secured, which apparently is unusual.

Phyllospadix torreyi Wats.—Abundant everywhere on submerged rocks.

Juncaginaceæ.

Triglochin maritima L.—Plentiful in marshes about the bays.

Gramineæ.

Panicum occidentale Scribn.—Abundant in sandy open ground.

Anthoxanthum odoratum L.—Plentiful about Newport and Nye Beach.

Phleum pratense L.—Frequently found in more or less protected situations; often reaches a remarkable size.

Polypogon monspeliensis (L.) Desv.—Found sparingly on the beach at Newport.

Calamagrostis aleutica Trin.—Plentiful in the open area just above the beach.

C. canadensis (Michx.) Beauv.—Observed only on steep banks at the mouth of Alsea bay.

Agrostis alba L.—Common in suitable localities.

A. alba L. var. maritima G. W. F. Mey.—Plentiful in wet places on the beach where the water is more or less brackish.

A. exarata Trin.—Common in wet places above the beach. The *A. glomerata* form is not rare close to salt water, while the intermediate forms occur in intermediate situations.

A. hyemalis (Walt.) B. S. P.—Common in somewhat protected places.

A. hyemalis (Walt.) B. S. P. var. geminata (Trin.) Hitch.—Frequent, with the type.

Holcus lanatus L.—The most abundant grass. Where closely pastured it forms a very dense turf; in other places it attains an unusual size.

Aira caryophyllea L.—Abundant nearly everywhere in open ground except on the beach.

Deschampsia cæspitosa (L.) Beauv.—Plentiful in wet ground.

D. holciformis (Presl) Steud.—Only at Yaquina Head. This species seems to be known at only one or two other localities in the state.

D. elongata (Hook.) Munro.—Common in the forest area.

Trisetum cernuum Trin.—Frequent in the forest.

Bromus marginatus Nees.—Frequent in more or less open, protected places.

B. hordaceus L.—Common, with the preceding.

B. vulgaris L. var. eximius Shear.—Frequent in the forest area.

Dactylis glomerata L.—Frequent in open protected places.

Poa annua L.—Common nearly everywhere, including the beach.

P. compressa L.—Frequent in open, especially cultivated ground.

P. macrantha Vasey.—Abundant on the beach and low dunes at Newport; elsewhere scarce.

Poa pratensis L.—Common in open ground, but not forming turf.

Distichlis spicata (L.) Greene.—Found rather sparingly along the beach, but very abundant in swampy ground about the bays.

Festuca megalura Nutt.—Common, especially about houses and in cultivated land.

F. myuros L.—Found sparingly in openings in the forest at Seal Rocks.

F. rubra L.—Typical form common well back from the beach, especially in open ground. Maritime form abundant in many places on steep seaward faces of shore bluffs.

F. etatior L.—Common in open protected places.

Panicularia leptostachya Buckl.—Plentiful in small streams at Seal Rocks.

P. americana Torr.—Found sparingly along streams at Seal Rocks.

Puccinellia paupercula (Holm) Fern and Weath. var. alaskana (Scrib. & Merrill) Fern. & Mer.—Occurs sparingly about Yaquina bay.

Lolium multiflorum Lam.—On high beach at Newport.

L. perenne L.—Common in open ground, especially about houses at Newport and Seal Rocks.

Agropyron cæsium Presl.—Found only about the lighthouse on Yaquina Head. Apparently the only record of its occurence in the state (Nelson).

Elymus arenarius L.—Common along the beach and on low dunes.

Hordeum jubatum L.—Occurs sparingly about the bays.

Cyperaceæ.

Carex leptalea Wahl.—In sphagnum bog two miles below Seal Rocks.

C. macrocephala Willd.—A few specimens found at Newport, Seal Rocks, and three miles south of Alsea bay on the beach and low seaward slopes of shore bluffs.

C. pansa Bail.—Found in abundance a short distance above the beach on the south side of Yaquina bay and at Waldport near the mouth of Alsea bay.

C. sitchensis Presc.—Abundant in a sphagnum bog two miles south of Seal Rocks.

C. cryptocarpa C. A. Mey.—Plentiful in marshes about Yaquina bay.

C. obnupta Bail.—Abundant in swampy ground above the beach, and occasional on the beach.

Eleocharis palustris (L.) R. and S.—Abundant in swampy places; occasionally found on the beach.

Scirpus riparius (R. Br.) Spreng.—Common on low beaches.

S. occidentalis (Wats.) Chase.—Found sparingly about Yaquina bay.

S. americanus Pers.—Abundant in places along the beach and in brackish swamps.

S. robustus Pursh.—In swamps about Yaquina bay.

Eriophorum chamissonis C. A. Mey.—Occurs sparingly in a sphagnum bog two miles south of Seal Rocks.

Araceæ.

Lysichiton camtschatcense (L.) Schott.—Found only well back from the beach. Mainly a plant of the deep forest.

Juncaceæ.

Juncus effusus L. var. hesperius Piper.—Plentiful in wet non-saline places.

J. balticus Willd.—In marshes about Yaquina bay.

J. lescurii Boland.—Especially abundant on the sandy seaward faces of shore bluffs, also on low dunes and beaches.

J. falcatus Mey.—Abundant on beaches and in saline swampy ground.

J. ensifolius Wiks.—Common on beaches and along streams.

J. bolanderi Eng.—Abundant in various places along streams.

J. oreganus Wats.—Found plentifully in a swampy tract a mile south of Seal Rocks. This appears to be the only locality in the state from which it has been reported.

Luzula campestris (L.) DC. var. multiflora (Ehr.) Celak.—Common in open woods and thickets.

L. parviflorum Desv.—Common in the forest area.

Liliaceæ.

Lilium columbianum Hans.—On old dunes near Newport.

Streptopus amplexifolius (L.) DC.—Plentiful in the open area above the beach and in the forest.

Disporum smithii (Hook.) Piper.—Common in openings in the forest.

Maianthemum dilatatum (Wood) Nels. and Macbr.—Abundant nearly everywhere.

Iridaceæ.

Iris tenax Wats.—Plentiful in open places above the beach.

Sisyrinchium californicum Ait.—Abundant nearly everywhere in wet ground.

Orchidaceæ.

Habenaria leucostachys Wats.—In wet protected places at Newport.

H. michaeli Greene.—Rather rare on exposed bluffs at Seal Rocks.

Spiranthes romanzoffiana Cham.—Common in nearly all open places except on the beach.

Epipactis decipiens (Hook.) Ames.—Numerous in the forest.

Salicaceæ.

Salix hookeriana Barratt.—Common everywhere at the mouths of streams, also about slightly saline, or quite fresh swamps some distance back.

Myricaceæ.

Myrica californica Cham.—Abundant everywhere as tall undergrowth in the forest and as dwarfed shrubs on the exposed bluffs.

Betulaceæ.

Alnus oregana Nutt.—Abundant in many places well back from the beach; comes nearly to the beach along streams.

Urticaceæ.

Urtica lyallii Wats.—Rare in protected open places.

Polygonaceæ.

Rumex acetosella L.—Common in open places down to the beach.

R. occidentalis Wats.—Not common, in open protected places.

R. maritimus L. var. fueginus (Phil.) Dusen.—Relatively rare on the beach.

R. obtusifolius L.—Common in open places above the beach.

R. mexicanus Meisn.—Beach form plentiful; typical form not found.

R. crispus L.—In open ground above the beach.

R. conglomeratus Murr.—Rare in open ground.

Polygonum paronychea Cham. and Schl.—Abundant on the extensive dune area at the mouth of Alsea bay; also found near Yachats and Seal Rocks.

P. aviculare L.—Common in open pastured places; also on beaches.

P. persicaria L.—Frequent at Seal Rocks along streams.

Chenopodiaceæ.

Salicornia pacifica Steudl.—Abundant in salt marshes about the bays. Rare on the beach.

Atriplex patula L. var. littoralis Gray.—Scarce, along Yaquina bay near Newport.

Chenopodium humile Hook.—Scarce, on high beaches.

C. album L.—Scarce, on high beaches.

C. hybridum L.—Scarce, in open places about Newport.

Nyctaginaceæ.

Abronia latifolia Esch.—Plentiful everywhere on sandy beaches, extending down to a little below the upper limits of high winter tides; especially plentiful about the mouth of Alsea bay.

Portulacaceæ.

Montia sibirica L.—Scarce in low forest area; abundant in larger forest.

M. parviflora (Doug.) Howell.—Abundant above the beach.

M. parvifolia (Moc.) Greene.—Common on rocks in protected places.

Caryophyllaceæ.

Pentacæna ramosissima (Wein.) Hook & Arn.—Plentiful just above the beach at the mouth of Yaquina Bay.

Spergularia rubra (L.) J. and C. Presl.—Common in open places, in some places well down on the beach.

S. sparsiflora (Greene) Nels.—Scarce along the beach; more plentiful in salt marshes about the bays.

S. macrotheca (Hornem.) Heynh. var. scariosa (Britt.) Robins. —Scarce on seaward faces of shore bluffs where sometimes wet by spray; Seal Rocks.

Spergula arvensis L.—Plentiful in open, especially cultivated ground.

Cerastium arvense L.—Common in open sandy places above the beach.

C. vulgatum L.—Common on steep bluffs above the beach, also in open places in the forest.

Stellaria media L.—Common above the beach.

S. borealis Bigel. var. bongardiana Fern.—Abundant in swampy ground above the beach at Seal Rocks.

Sagina occidentalis Wats.—Typical form abundant on exposed bluffs above the beach. *S. crassicaulis* form plentiful on wet rocks close to salt water.

Ammodenia peploides (L.) Rupr.—Scarce on beach at Seal Rocks and mouth of Yaquina bay.

Nympheaceæ.

Nympheæa polysepala (Eng.) Greene.—A few plants found in Sand lake, two miles below Seal Rocks.

Ranunculaceæ.

Anemone oregana Gray.—Abundant on high, exposed bluffs on Yaquina Head.

Ranunculus flammula (L.) var. unalaschensis (Bess.) Ledeb.—Common in swampy places, in some places on the beach within reach of the spray.

R. occidentalis Nutt.—Common in open ground above the beach.

R. bongardi Greene var. douglasii (Howell) Davis.—Plentiful in forest area.

Berberidaceæ.

Berberis aquifolium Pursh.—Abundant in many places on exposed bluffs, and at some localities on sand dunes.

Cruciferæ.

Lobularia maritima Desb.—On the beach at Newport.

Capsella bursa-pastoris (L.) Medic.—Common in open protected places.

Cakile edentula (Bigel.) Hook.—Plentiful on the beach and on seaward slopes of dunes about Newport; scarce farther south.

Dentaria tenella Pursh.—Plentiful in forest.

Cardamine breweri Wats.—In wet places in the forest at Newport.

C. oligosperma Nutt.—Common in forest.

Brassica campestris L.—Plentiful in open protected places.

B. oleracea L.—On bluffs above the beach at Seal Rocks.

Crambe maritima L.—At the foot of the cliffs near the lighthouse on Yaquina Head, where apparently well established. This is the only locality on the Pacific coast from which it has been reported (Nelson).

Sisymbrium officinale (L.) var. leiocarpum DC.—Scarce in protected places at Seal Rocks.

Droseraceæ.

Drosera rotundifolia L.—Plentiful in a sphagnum bog two miles below Seal Rocks.

Saxifragaceæ.

Ribes lacustre (Pers.) Poir.—Scarce, near the mouth of Yaquina bay.

R. divaricatum Dougl.—Frequent in open protected places at Seal Rocks.

R. sanguineum Pursh.—Common in the forest at Seal Rocks and Newport.

Boykinia elata Nutt.—Abundant in the forest.

Chrysosplenium scouleri (Hook.) Rose.—In the forest at Newport.

Tiarella trifoliata L.—Plentiful in the forest at Newport.

Tolmiea menziesii Torr. & Gray.—Common in the forest.

Rosaceæ.

Pyrus diversifolia Bong.—Common in the forest area.

Holodiscus discolor (Pursh) Maxim.—Infrequent in low woods.

Spiræa Douglasii Hook.—Abundant along streams and about swampy tracts in the forest area.

Rubus macropetalus Dougl.—Abundant nearly everywhere above the beach in open ground.

R. parviflorus Nutt.—Common nearly everywhere above the beach.

R. laciniatus Willd.—Generally established throughout our area in partly open ground.

R. spectabilis Pursh.—Abundant nearly everywhere above the beach.

Rosa gymnocarpa Nutt.—Common in the forest area.

R. nutkana Presl.—Common in low thickets and open places.

Alchemilla occidentalis Nutt.—Common in open ground at Newport.

Sanguisorba microcephala Presl.—Plentiful in open boggy ground at Yachats.

Potentilla anserina L.—Abundant everywhere in wet ground.

Fragaria chilœnsis (L.) Duch.—Abundant on rocks and seaward faces of shore bluffs nearly down to tide line, here showing the maritime characteristics. Equally abundant back to the forest area, passing gradually into the usual form.

Comarum palustre L.—Plentiful in sphagnum bogs below Seal Rocks.

Leguminosæ.

Lupinus littoralis Dougl.—Common on high beaches and seaward slopes of shore bluffs nearly everywhere.

Ulex europæus L.—Established on stream banks at Newport and Yachats.

Trifolium microcephalum Pursh.—Common in moist open places along the foot of shore bluffs at Seal Rocks and Newport.

T. fimbriatum Lindl.—Abundant everywhere from beach to forest.

T. repens L.—Very abundant in open and exposed places, especially where pastured.

T. hybridum L.—Common in open ground at Seal Rocks.

T. pratense L.—Scarce, in open places.

T. dubium Smith—Common in open places above the beach.

Medicago lupulina L.—Common in open ground.

Vicia gigantea Hook.—Along the beach, scarce.

Lathyrus littoralis (Nutt.) Endl.—Abundant on the beach and on sandy bluffs facing the sea.

L. maritimus (L.) Bigel.—Scarce along the beach.

Lotus crassifolius (Benth.) Greene.—Common in the forest area.

L. formosissimus Greene.—Frequent in seepage along the foot of the shore bluffs.

Geraniaceæ.

Geranium molle L.—Plentiful about Seal Rocks and Newport.

Aceraceæ.

Acer circinatum Pursh.—Plentiful along streams well back from the beach.

Hypericaceæ.

Hypericum anagalloides C. and S.—Abundant everywhere in wet ground above the beach.

Violaceæ.

Viola macloskeyi Lloyd.—In sphagnum bogs at Seal Rocks and Newport.

V. sarmentosa Dougl.—Abundant in the forest area.

V. adunca Smith.—Abundant in open exposed situations.

Onagraceæ.

Epilobium angustifolium L.—Common in thickets on bluffs above the beach and in the forest area.

E. franciscanum Barb.—Common along the seaward faces of shore bluffs in seepage.

E. glandulosum Lehm. var. adenocaulon (Haussk.) Fern.—Abundant from just above the beach, where it intergrades with the preceding, to the forest, where it assumes the usual form.

Umbelliferæ.

Daucus pusillus Michx.—Near the lighthouse on Yaquina Head.

Angelica hendersoni Coult. and Rose.—Abundant along the margin of ocean bluffs and on the seaward slope.

Coneoselinum gmelini (C. and S.) Coutl. and Rose—Common, mostly on steep seaward faces of shore bluffs.

Oenanthe sarmentosa Presl.—Abundant in streams and non-saline swamps.

Lilæopsis occidentalis Coult. and Rose.—Abundant on the margin of Sand lake.

Ligusticum apiodorum (Gray) Coult. and Rose.—On sand drifts at Newport.

Ghlenia littoralis (Gray) Schmidt.—In drifting sand at Newport.

Cornaceæ.

Cornus canadensis L.—Scarce in thickets at Newport, Seal Rocks, and Yachats.

Pyrolaceæ.

Newberrya congesta (Torr.) Gray.—One specimen in forest at Seal Rocks.

Pyrola bracteata Hook.—Scarce in thickets and in the forest area.

Ericaceæ.

Vaccinium ovatum Pursh.—The most abundant shrub on the exposed area above the beach; also very plentiful in the forest.

V. uliginosum L. var. mucronatum Herder.—Abundant in many places from Newport to Alsea bay, mostly about the borders of sphagnum bogs.

V. parvifolium Smith.—Common in thickets and forest.

Gaultheria shallon Pursh.—Very abundant everywhere above the beach.

Arctostaphylos tomentosa (Pursh.) Dougl.—Common in thickets along the shore bluffs.

A. uva-ursi (L.) Spreng.—Abundant in open ground above the beach.

Ledum columbianum Piper.—Abundant from edge of sea bluffs to forest.

Rhododendron californicum Hook.—Abundant from margin of sea bluffs to forest.

Primulaceæ.

Trientalis latifolia Hooker.—Frequent in forest.

T. arctica Fisch.—Plentiful in sphagnum bog, two miles below Seal Rocks.

Plumbaginaceæ.

Statice armeria L.—Found sparingly on seaward faces of bluffs at Seal Rocks.

Gentianaceæ.

Centaurium umbellatum Gilib.—In open ground at Seal Rocks, scarce.

Gentiana sceptrum Griseb.—Plentiful about sphagnum bogs at Seal Rocks and Yachats.

Convolvulaceæ.

Convolvulus soldanella L.—Frequent on the beach and on low sand dunes.

Cuscutaceæ.

Cuscuta squamigera (Eng.) Piper.—On *Salicornia* in tide marshes along Yaquina bay.

Polemoniaceæ.

Gilia capitata Hook.—Scarce, on drifting sand near the mouth of Yaquina bay.

Hydrophyllaceæ.

Romanzoffia sitchensis Bong.—In forest near Newport.

R. unalaschensis Cham.—In clefts of rock some distance from the sea on Yaquina Head. Apparently the only locality for the state.

Boraginaceæ.

Amsinckia lycopsoides Lehrm.—Scarce along seaward faces of shore bluffs at Seal Rocks; more plentiful in similar places at Yachats.

Labiatæ.

Lycopus americanus Muhl.—Abundant in swampy ground at Seal Rocks and Yachats; less plentiful along the beach.

Mentha canadensis L. var. borealis (Michx.) Piper.—Common along streams and in seepage at foot of shore bluffs.

M. piperita L.—Common along streams at Seal Rocks.

M. spicata L.—In one locality at Seal Rocks.

Glechoma hederacea L.—Plentiful in wet ground about Newport.

Prunella vulgaris L. var. lanceolata (Bart.) Fern.—Abundant nearly everywhere above the beach.

Stachys ciliata Dougl.—Common along streams at Seal Rocks.

Scrophulariaceæ.

Scrophularia californica Cham.—Scarce in open protected places.

Synthyris rotundifolia Gray.—Common on exposed bluffs at Yaquina Head.

Veronica scutellata L.—Common in swampy ground at Seal Rocks and Yachats.

V. americana Schwein.—Common in swampy ground and in seepage at foot of bluffs along the beach.

V. humifusa Dicks.—Common in low ground at Seal Rocks.

Mimulus dentatus Nutt.—Common in wet places along streams and on slopes of shore bluffs.

M. moschatus Dougl.—Common in wet places above the beach.

M. langsdorfii Donn.—Common in swampy ground and on wet seaward faces of shore bluffs.

Castelleja miniata Dougl.—Frequent in protected places well back from the beach.

C. dixonii Fern.—Rare near the margin of shore bluffs at Seal Rocks.

Orthocarpus castilleoides Benth. — Abundant in somewhat swampy saline places at Yachats.

Orobanchaceæ.

Boschniakia hookeri Walp.—Scarce, on *Arctostaphylos tomentosa* at Newport.

Plantaginaceæ.

Plantago major L.—Abundant on the beach and elsewhere in open places.

P. major L. var. asiatica (L.) Dcne.—Just above the beach at the mouth of Yaquina bay.

P. lanceolata L.—Abundant nearly everywhere in open exposed places.

P. bigelovii Gray.—At Yachats, barely above tide-line.

P. maritima L.—Abundant on rocks and shore bluffs close to salt water.

P. subnuda Pilg.—In swamps along Yaquina bay. Most northerly known station on the coast (Nelson).

Rubiaceæ.

Galium triflorum Michx.—Common in forest.

G. claytoni Michx. var. subbiflorum Wieg.—Plentiful in wet sand and swamps.

Caprifoliaceæ.

Sambucus callicarpa Greene.—Common in high thickets.

Lonicera involucrata Banks.—Common in thickets and along streams.

Dipsacaceæ.

Dipsacus sylvestris Huds.—Scarce in open protected places at Seal Rocks.

Campanulaceæ.

Campanula scouleri Hook.—Common in forest.

Compositæ.

Hypochæris radicata L.—Extremely abundant in all open places, often forming almost a pure growth over large areas.

Taraxacum officinale L.—Common in open ground above the beach.

Agoseris apargioides (Gess.) Greene.—Found only on dunes at Sand lake.

Crepis capillaris (L.) Wallr.—Plentiful in open exposed ground.

Sonchus asper (L.) Hill.—Abundant in open ground.

S. oleraceus L.—Common along seaward faces of shore bluffs.

Franseria bipinnatifida Nutt.—Common on the beach.

F. chamissonis Less.—Abundant on sand drifts at the mouth of Alsea bay, scarce on the beach elsewhere.

Grindelia oregana Gray.—Found only on the beach three miles south of Alsea bay.

Solidago glutinosa Nutt.—Scarce in low thickets at Seal Rocks.

S. elongata Nutt.—Frequent in open protected places near Newport.

Bellis perennis L.—Abundant nearly everywhere from upper limit of beach to forest.

Erigeron canadensis L.—Frequent in open places.

E. glaucus Ker.—Plentiful on exposed faces of shore bluffs and cliffs.

Aster douglasii Lindl.—Abundant from the beach to the forest.

Baccharis pilularis DC.—Plentiful on slopes above Yaquina bay near Newport.

Achillea millefolium L.—Common in protected, more or less open ground.

A. millefolium (L.) var. nigricans E. Mey.—Plentiful on margins of shore bluffs above the sea and on exposed dunes.

Anthemis cotula L.—Common in open ground.

Chrysanthemum leucanthemum L. var. pinnatifidum Lec. and Lim.—Scarce at Seal Rocks in open ground; also at Yaquina Head.

Cotula coronopifolia L.—On the beach, four miles above Yachats; also near the mouth of Yaquina bay.

Tanacetum huronense Nutt.—Common along the beach and on low dunes.

Petasites speciosa (Nutt.) Piper.—Along a small stream at Nye Beach.

Senecio vulgaris L.—Plentiful in open ground above the beach.

S. sylvaticus L.—Near the mouth of Yaquina bay on both sides, in protected places.

S. bolanderi Gray.—Common on sand drifts near Newport.

Anaphalis margaritacea (L.) Benth. and Hook. var. occidentalis Greene.—Abundant from seaward slope of shore bluffs to the forest.

Gnaphalium purpureum L.—Abundant in all open places above the beach.

G. palustre. Nutt.—Plentiful in open places.

G. chilense Spring.—One specimen on sand drifts on south side of Yaquina bay.

Centaurea cyaneus L.—Common in open places.

Cirsium lanceolatum (L.) Scop.—Common from exposed margin of shore bluffs to forest. Very dwarfed where most exposed.

C. edule Nutt.—In exposed places down to the beach; common.

WILLAMETTE UNIVERSITY,
SALEM, OREGON.

HYBRIDIZATION IN IRIS

M. LOUISE SAWYER.

In the progress of some cytological studies of pollen tube formation, fertilization and related events,[1] I became interested in the cytology of hybrids, and determined to make some crosses for the sake of material for a cytological examination of fertilization between parents of different species. Some experience with hand pollination of Iris suggested the choice of that genus for my experiment. A survey revealed the fact that of species at my command, there was no pair that have been reported to produce hybrids. *Iris pseudocorus* and *Iris versicolor* were available. Their near relationship made it seem likely that crossing might be effected, although, so far as I can learn, no hybrids having these parents are known. W. R. Dykes in his magnificent book on "The Genus Iris," which was published in 1912, makes the positive statement that he found no record of that cross having been productive.

The gross results of an attempt, made in the spring of 1918, to hybridize *Iris pseudocorus* and *Iris versicolor,* growing in the botanical garden at Grinnell, seem sufficiently interesting to bring to the Academy as a preliminary report. The cytology has not yet been worked out.

In the experiment, crossing was attempted in both ways: that is, both *pseudocorus* and *versicolor* were used as seed parent. There is nothing especially distinctive in the method employed. Inflorescence stalks were covered with cheese cloth bags before the flowers to be used had opened. The bags were taken off and the stamens removed as soon as the flowers were opened sufficiently to make it possible to reach the stamens with a pair of forceps. This was done early in the morning, say between six and seven o'clock, and the bags were replaced. During the middle of the forenoon pollen was applied to the stigmas. A small scalpel is a satisfactory pollinating instrument. It is much more satisfactory than a camel's hair brush because more manageable, and less wasteful of pollen. The grains can be scraped from a stamen and applied directly to the stigmatic surface. Even if the pollen sacs are still closed, the stiff

[1]Pollen Tube and Spermatogenesis in Iris, M. Louise Sawyer, Bot. Gaz. August, 1917.

instrument can be inserted into the line of dehiscence and the pollen removed. Such stamens give a more generous supply of pollen than those whose sacs have fully opened.

A mature or "receptive" stigma has an appearance that is characteristic, but not easily described. It becomes somewhat moist looking but the amount of excretion which indicates the receptive stigma is by no means so lavish as in the Lilium species which I have pollinated. However, my experience in dissecting pollen tubes from hand-pollinated Iris stigmas, has convinced me that pollen may germinate when applied to a stigma before it is receptive, although the germination occurs in a shorter time if the stigma is mature when pollinated. I can see no reason why these tubes once started may not effect fertilization. Believing this, I pollinated the stigmas of all the flowers under a given bag while I had it off for the second time, even those I judged to be a little under maturity. I could detect no difference in the subsequent behavior of the individual flowers of the lot. Twenty-four hours after pollination all of the flowers were withered. In withering the blades of the "standards" and the "falls" become soft and limp. Each "fall" in curling, enfolded its stigma, the latter being at that time still turgid and fresh appearing, as can be seen if the withered "fall" is removed.

Some of the covered flowers were left unpollinated, as checks. A day or two before I left Grinnell for the summer the ovaries of these unpollinated flowers, especially those on *pseudocorus,* were no larger than when ready for pollination, were slightly yellowed and clearly withering, while those of the hand-pollinated flowers had noticeably grown and appeared vigorous. It looked as though the experiment was prospering, but on my return to Grinnell in September I found that the *pseudocorus* and *versicolor* had behaved in a markedly different manner. While there were a number of *versicolor* seed pods with ripe seeds, the promising ovaries of *pseudocorus* had nearly all dried and fallen off before maturing and those remaining yielded but one seed that appeared fully developed.

The cross seems to have succeeded with *I. versicolor* as the ovule parent but to have failed with *I. pseudocorus* in that role. It is fruitless to speculate as to the cause or causes of this difference, and the report of the accompanying cytological behavior will have to come at a future date.

Grinnell College.

STUDIES UPON THE ABSORPTION AND GERMINATION OF WHEAT TREATED WITH FORMALDEHYDE.

A. L. BAKKE AND H. H. PLAGGE.

Treating wheat with formaldehyde to prevent the covered or stinking smut of wheat is a general practice wherever wheat is grown. Henderson,[1] Burmester[2], Johnson[3] and Brittlebank[4] have submitted results of germination tests where wheat has been soaked for varying periods, with the purpose of obtaining safe limits where the fungus is killed, while the seed is left intact. Naturally this is the important conception from the practical standpoint. But admitting this to be the case there are still many fundamental propositions which are still open for solution and of equal import to the practical phases of grain treating to prevent smut and problems of imbibition and of germination.

While the authors were connected with the office of Cereal Investigations* of the U. S. Department of Agriculture they assisted in carrying on a campaign to prevent smut. This campaign consisted largely in giving demonstrations and discussions on smut and the means of prevention. Two outstanding propositions encountered were (1) the time for maximum absorption to take place, (2) the time in which seed can be kept in contact with formaldehyde and still give the highest per cent germination. In practically all cases wheat growers are advised to operate within the limits of safety but they are nevertheless desirous of knowing where the limits are. These facts then in themselves led the writers to submit the problems as suggested to a series of experiments, the results of which are given in this paper.

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[1]Henderson, F. L., Experiments with wheat and oats for smut. Idaho Agrl. Exp. Sta. Bul. **53**, 1906.

[2]Burmester, H., Vergleichende Utersuchungen ueber den Einfluss der verschiednen Samenheizmethoden auf die pilztotende Wirkung. Zitschr Pflanzenkrank. **18**: 154-187, 1908.

[3]Johnson, J. C., Influence of "pickling" on the germination of cereals. Jour. Bd. Agr. (London) **20**: 120-124, 1913.

[4]Brittlebank, C. C., The effect of formalin and copper sulphate on the germination of wheat. Jour. Dept. Agr. Victoria **11**: 473-76, 2 figs. 1913.

*This work was under the immediate charge of Dr. G. M. Reed, then of the University of Missouri, but now with the U. S. Dept. of Agriculture, Office of Cereal Investigations.

In this study the purpose was to use a solution of formalin* such as is given to farmers and to use methods comparable so that comparisons could be more easily made. The method used through-

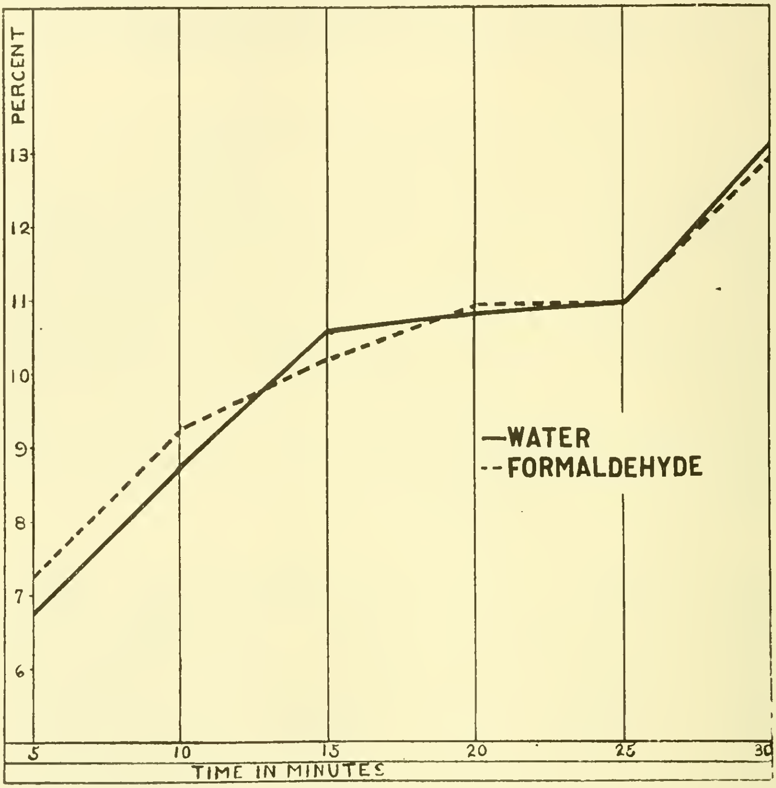


Fig. 96. Comparative difference in the absorption for wheat placed in a formalin solution and in distilled water for periods varying from five to thirty minutes.

out consisted in counting out 100 seeds of a uniform size, placing these in weighed, glass stoppered weighing bottles after which the weight of the seed was determined and finally the seed was again weighed after it had been subjected to the formaldehyde for a cer-

*The directions for treating wheat to prevent smut as given by Dr. G. M. Reed are as follows:
The solution used for treating stinking smut of wheat is made by using one pint or one pound of commercial formalin (guaranteed 40 per cent solution of formaldehyde) to forty gallons of water. One gallon of solution is sufficient to treat one bushel of grain. 1 Dipping—take two half barrels or tubs with holes and plugs near bottom. Place one tub on two saw horses and fill two-thirds full with the solution of formaldehyde. Pour slowly into this solution one-half to one bushel of wheat seed, stirring thoroughly for five to ten minutes so that the smut balls, trash, etc., will reach the surface. Skim this material off and drain this solution into the second tub. Pour the seed into a pile on the floor, exchange positions of tubs and repeat the operation. Cover the treated seed with sacks for four to ten hours.. Sow at once or spread the seed out to dry.

tain prescribed time. The seed was submerged into the formalin solution (1-320) for nine minutes; one minute was taken to pour off the solution. The grains were dried immediately by means of slips of filter paper, after the seeds had been placed in a 50 cc. porcelain crucible. When the seeds were sufficiently dry, so as not to adhere to sides of the crucible, they were returned to the weighing bottle and weighed. In all cases the bottle was rotated so as to be sure that none of the seeds would adhere. If they did they were dried further before being weighed. The germination was tested by the usual plate method, petri dishes being employed.

COMPARATIVE ABSORPTION

In the tests for comparative absorption 100 seeds were counted out, weighed, dried and again weighed as given above. In all cases the absorption for seeds placed in the formalin solution was compared directly with the absorption taking place in water; one set was handled by each of the writers. Five determinations of each were made. The data obtained are given in table I.

TABLE I

DATA GIVING THE PERCENTAGE OF ABSORPTION AND GERMINATION OF WHEAT WHICH HAS BEEN LEFT IN A FORMALIN SOLUTION AND IN WATER FOR PERIODS FROM 5 TO 30 MINUTES.

WATER					FORMALDEHYDE				
No. of bottle	Weight of 100 seeds (grams)	Increase in weight (grams)	Increase in weight (per cent)	Germination in per cent	No. of bottle	Weight of 100 seeds (grams)	Increase in weight (grams)	Increase in weight (per cent)	Germination in per cent
FIVE MINUTES									
12	2.6150	.1784	6.82	98	14	2.4899	.1817	7.29	93
6	2.5729	.1737	6.75	100	9	2.5634	.1926	7.51	95
1	2.5550	.1735	6.79	98	29	2.5680	.1584	6.16	95
27	2.5056	.1742	6.95	95	21	2.5179	.1971	7.82	95
10	2.5254	.1688	6.68	95	5	2.3666	.1764	7.45	95
Average	2.5567	.1737	6.79	97.20	Average	2.5011	.1812	7.24	94.60
TEN MINUTES									
27	2.5369	.2241	8.83	94	14	2.5125	.2430	9.67	94
24	2.4919	.2243	9.00	96	12	2.3351	.2213	9.47	90
6	2.4746	.2286	9.23	93	26	2.6115	.2364	9.05	95
5	2.4107	.1968	8.16	92	29	2.4179	.2260	9.34	93
30	2.5134	.2195	8.73	96	5	2.6396	.2457	9.30	94
Average	2.4855	.2186	8.79	94.20	Average	2.5033	.2344	9.36	93.40
FIFTEEN MINUTES									
1	2.3977	.2514	10.48	93	14	2.4533	.2634	10.73	95
9	2.4387	.2872	11.77	97	15	2.6094	.2785	10.67	94
30	2.6668	.2870	10.76	97	29	2.6399	.2725	10.32	96
21	2.5119	.2675	10.64	97	47	2.5748	.2620	10.17	95
6	2.6498	.2530	9.54	99	26	2.6498	.2455	9.26	96
Average	2.5529	.2692	10.63	96.60	Average	2.5854	.2643	10.23	95.20

TWENTY MINUTES

WATER					FORMALDEHYDE				
No. of bottle	Weight of 100 seeds (grams)	Increase in weight (grams)	Increase in weight (per cent)	Germination in per cent	No. of bottle	Weight of 100 seeds (grams)	Increase in weight (grams)	Increase in weight (per cent)	Germination in per cent
12	2.5807	.2626	10.17	96	29	2.5743	.2793	10.84	97
5	2.4511	.2652	10.81	96	24	2.5975	.2897	11.15	99
26	2.5870	.2864	11.07	98	29	2.4348	.2607	10.71	97
5	2.3981	.2722	11.35	97	47	2.5335	.2749	10.85	96
30	2.4469	.2642	10.79	97	14	2.4865	.2793	11.23	98
Average	2.4927	.2701	10.83	96.80	Average	2.5253	.2767	10.95	97.40

TWENTY-FIVE MINUTES

24	2.5950	.2778	10.70	98	9	2.5237	.2661	10.54	97
12	2.6828	.2999	11.17	97	6	2.6731	.3071	11.48	98
30	2.7730	.3150	11.35	98	47	2.5538	.2812	11.01	95
29	2.5271	.2766	10.94	99	26	2.6021	.2882	11.07	98
5	2.7284	.2844	10.81	98	27	2.6300	.2865	10.89	97
Average	2.6612	.2907	10.99	98	Average	2.5965	.2841	10.99	97

THIRTY MINUTES

26	2.3422	.3193	13.63	97	29	2.4561	.3299	13.43	96
6	2.3918	.3014	12.60	99	24	2.3970	.3141	13.10	99
21	2.5012	.3258	13.02	98	1	2.4650	.3262	13.23	98
27	2.4432	.3041	12.44	96	9	2.3548	.3046	12.93	98
47	2.3473	.3336	13.78	98	12	2.5510	.3148	12.34	98
Average	2.4051	.3168	13.09	97.60	Average	2.4447	.3179	13.00	97.80

From an examination of the data and of the graph, figure 96, it is apparent that the absorption by wheat placed in a formalin solution and in water does not vary materially during a period of thirty minutes. At the end of ten minutes greater absorption is present in the seed placed in the formaldehyde but a revisal is present at the end of fifteen minutes as seed in distilled water increases in weight to a greater extent. However, after fifteen minutes imbibition is approximately the same.

The second part of this series of investigations was confined to a study of the time of exposure to formaldehyde necessary to cause a fall in the percentage of germination. The general plan then is the same as has been previously set forth. The seeds were retained in the glass stoppered containers after the formalin solution had been poured off for varying periods from one to thirty-six hours, when they were weighed. The data are given in table II.

TABLE II.

DATA GIVING PERCENTAGE OF ABSORPTION AND GERMINATION FOR WHEAT SUBJECTED TO FORMALDEHYDE FOR VARYING PERIODS FROM ONE TO THIRTY-SIX HOURS.

Period of covering No. hours	No. of bottle	Weight of 100 seeds (grams)	Increase in weight (grams)	Increase in weight (per cent)	Germination in per cent
1	115	2.3473	.4585	19.53	97
1	110	2.5556	.4631	18.12	98
1	Average	2.4514	.4608	18.83	97.50
2	113	2.4432	.5680	23.24	97
2	111	2.4100	.5708	23.68	95
2	Average	2.4266	.5694	23.46	96
3	114	2.4329	.6143	25.24	95
3	109	2.5014	.6588	26.33	97
3	Average	2.4671	.6365	25.79	96
4	108	2.5394	.7478	29.44	97
4	102	2.6215	.4835	18.44	91
4	Average	2.5805	.6157	23.94	94
5	107	2.5935	.7940	30.61	94
5	106	2.6563	.8331	31.36	95
5	Average	2.6249	.8136	30.99	94.50

TABLE No. II—Continued

Period of covering No. hours	No. of bottle	Weight of 100 seeds (grams)	Increase in weight (grams)	Increase in weight (per cent)	Germination in per cent
6	103	2.3835	.7981	33.48	92
6	105	2.5668	.8261	32.18	93
6	Average	2.4752	.8121	32.83	92.50
7	112	2.3682	.6207	26.20	95
7	104	2.5474	.9954	39.07	95
7	Average	2.4578	.8081	32.64	95
8	101	2.5009	.8798	35.17	93
8	117	2.5234	.8360	33.12	95
8	Average	2.5122	.8579	34.15	94
9	118	2.5234	.8360	36.75	95
9	116	2.5692	.7204	28.03	96
9	Average	2.5463	.7782	32.39	95.5
10	5	2.2341	.6121	26.22	95
10	6	2.5270	.8483	33.56	94
10	Average	2.3806	.7302	29.89	94.5
11	16	2.4843	.9369	37.71	95
11	2	2.6077	1.0726	41.13	93
11	Average	2.5460	1.0048	39.42	94
12	8	2.4400	.8681	35.57	95
12	94	2.3856	.9971	41.79	90
12	Average	2.4128	.9326	38.68	92.5
13	5	2.5289	.7913	31.29	95
13	13	2.5600	.8456	33.03	95
13	Average	2.5446	.8185	32.16	95
14	4	2.6222	.9838	39.80	94
14	19	2.4553	1.0592	43.13	88
14	Average	2.5388	1.0215	41.47	91
15	17	2.3625	.8029	33.98	95
15	20	2.4310	.8635	35.52	94
15	Average	2.3968	.8332	34.75	94.50
16	92	2.4404	.7557	30.96	95
16	93	2.5197	.7170	28.45	93
16	Average	2.4801	.7364	29.72	94

TABLE No. II—Continued

Period of covering No. hours	No. of bottle	Weight of 100 seeds (grams)	Increase in weight (grams)	Increase in weight (per cent)	Germination in per cent
17 17	18 93	2.5388 2.5026	1.0640 .8842	41.95 35.33	90 94
17	Average	2.5207	.9741	38.64	92
18 18	27 17	2.5468 2.4357	.6807 1.0331	26.72 42.41	95 91
18	Average	2.4913	.8569	34.57	93
19 19	31 16	2.4698 2.5107	.7985 .7364	32.33 29.33	93 95
19	Average	2.4903	.7675	30.83	94
20 20	36 33	2.5078 2.4919	1.0095 .6941	40.25 27.76	93 93
20	Average	2.4999	.8518	34.01	93
21 21	3 7	2.5474 2.5186	.9075 .8248	35.62 32.74	95 96
21	Average	2.5330	.8662	34.18	95.50
22 22	91 1	2.5615 2.4949	.7420 1.0031	28.96 40.20	96 93
22	Average	2.5282	.8726	34.58	94.5
23 23	35 7	2.5740 2.5182	.9115 .5304	35.41 21.06	94 91
23	Average	2.5461	.7210	28.24	92.5
24 24	5 10	2.5441 2.5438	.8386 .7312	32.96 28.74	92 92
24	Average	2.5440	.7849	30.85	92
25 25	10 21	2.4175 2.3756	.7962 .7352	32.93 30.94	93 92
25	Average	2.3966	.7657	31.94	92.50
26 26	47 12	2.6136 2.5559	.8485 .6696	32.46 26.19	95 96
26	Average	2.5848	.7591	29.33	95.50
27 27	21 37	2.5104 2.5610	.7857 .8202	31.29 32.02	90 87
27	Average	2.5357	.8030	31.66	88.50

TABLE No. II—Continued

Period of covering No. hours	No. of bottle	Weight of 100 seeds (grams)	Increase in weight (grams)	Increase in weight (per cent)	Germination in per cent
28 28	39 27	2.4354 2.5680	.7926 .9725	32.54 37.86	93 94
28	Average	2.5017	.8826	35.20	93.50
29 29	20 14	2.5008 2.4822	.8275 .8027	33.08 32.33	91 89
29	Average	2.4915	.8151	32.71	90
30 30	28 29	2.3997 2.5760	1.0605 .9780	44.18 37.96	83 87
30	Average	2.4879	1.0193	41.07	85
31 31	14 30	2.5831 2.5459	.6001 .8884	23.23 34.89	93 94
31	Average	2.5645	.7443	29.06	93.5
32 32	6 14	2.5014 2.5130	.9063 .8588	36.23 34.17	88 86
32	Average	2.5072	.8826	35.20	87
33 33	41 6	2.3707 2.3482	.6947 .6406	29.30 27.27	88 87
33	Average	2.3595	.6677	28.29	87.50
34 34	24 19	2.5043 2.4343	1.1810 .7861	47.15 32.29	75 86
34	Average	2.4693	.9836	39.72	80.5
35 35	21 9	2.5324 2.3512	.7485 .8287	29.55 35.24	88 77
35	Average	2.4418	.7886	32.40	83
36 36	26 5	2.5362 2.4577	1.0178 .8541	40.13 34.75	83 84
36	Average	2.4970	.9360	37.44	83.50

By examining the data and the graph, figure 97, it is plainly discernible that absorption is the most rapid at the beginning, being 18.83 per cent at the end of the first hour; from that point there is a gradual increase until the maximum, 41.47 per cent at the fourteenth hour is attained. At no subsequent period is there as high a percentage registered.

As far as the percentage germination is concerned there is no recognized drop until after the seeds have been exposed to formal-

Fig. 97.—Diagram showing absorption and germination of wheat.

dehyde for a period of twenty-six hours. Although at the thirty-first hour the percentage germination rises again and is higher than for some of the earlier periods, yet it does not attain a percentage as high as has been delineated. However, there is a decided drop from the thirty-first hour. At the end of thirty-six hours the percentage of germination is only 83.5. It is regrettable that the series was not carried on further. Even though this feature of the experiment was not planned for at the time the experiment was started, the results show that an extension of time would give a graph similar to the temperature curve of Lehenbauer[5] for corn and the life phase curve of Buchanan[6] for a bacterial culture. But as this is beyond the scope and province of the present studies it is advisable to postpone the submission of possible reactions until definite data have been obtained.

From the results presented in this paper it is evident:

1. That the absorption in the case of wheat seed placed in contact with foraldehyde in the usual concentration for treating seed to prevent smut is not materially different from wheat seed placed in water for the same period of time.

2. Wheat seed soaked in a formalin solution for ten minutes and kept enclosed for varying periods from one to thirty-six hours does not show any impaired germination until after twenty-six hours.

[5]Lehenbauer, P. A., Growth of maize seedlings in relation to temperature: Physiol. Researches **1**: 247-288, 1914.

[6]Buchanan, R. E., Life phases in a bacterial culture: Jour. Infect. Dis **23**: 3-19, 1918.

IOWA STATE COLLEGE,
AMES, IOWA.

SOME AMERICAN DOLOMITES

BURLEIGH B. REED AND NICHOLAS KNIGHT

These rocks are among the important building materials of the country and have a wide distribution. We secured a few typical specimens from different sections, in order to make a comparison of their chemical composition. The specimens analyzed are all used as building stones in their respective localities.

1. This is a specimen from Mount Vernon, Iowa, and represents the Niagara formation, the oldest member of the Silurian age. It is of a yellowish gray color, due to the presence of iron. The substances which compose the rock are as follows:

	Per Cent
SiO_2	1.29
Fe_2O_3 and Al_2O_3	0.57
$CaCO_3$	55.17
$MgCO_3$	43.04
Total	100.07

2. This is a specimen of dolomite from West Chester county, New York, not far from New York City. It is a white crystalline rock, resembling marble. The formation is a part of the Cambro-Silurian and is believed to be equivalent to the Stockbridge limestones of the Housatonic Valley in Massachusetts. It is quite a typical dolomite in composition, not materially different from the Iowa rock. The analysis is as follows:

	Per Cent
SiO_2	2.71
Fe_2O_3 and Al_2O_3	1.05
$CaCO_3$	53.43
$MgCO_3$	42.93
Total	100.12

3. A specimen was obtained from Lockport, New York, also belonging to the Niagara Limestone. There was upon the dark-gray limestone an incrustation of milk-white crystals, and the composition of these also was determined. The analysis of the gray body of the rock resulted as follows:

	Per Cent
SiO_2	2.76
Fe_2O_3 and Al_2O_3	1.42
$CaCO_3$	51.85
$MgCO_3$	43.94
Total	99.97

This contains a sufficiently high percentage of magnesium carbonate to class the rock as a fairly typical dolomite.

4. The white crystals encrusting the foregoing specimen:

	Per Cent
SiO_2	0.18
Fe_2O_3 and Al_2O_3	1.21
$CaCO_3$	81.62
$MgCO_3$	17.15
Total	100.16

This varies quite widely from a true dolomite, as the calcium has quite largely replaced the magnesium. The amount of silica is unusually small which might possibly be expected from the crystalline structure of the material.

5. A specimen from Bertram, Iowa. The formation lies between Mount Vernon and Cedar Rapids. The rock is gray in color, with numerous light-colored crystals disseminated through the massive rock. Some analytical data had been found which seemed to indicate that the magnesian content of the rock was in excess of the calcium. Our analysis was made with a view to determine whether this were really the case. Two concordant results obtained are as follows:

	Per Cent
SiO_2	0.90
Fe_2O_3 and Al_2O_3	0.90
$CaCO_3$	55.61
$MgCO_3$	42.58
Total	99.99

The figures indicate a rather typical dolomite, as one would naturally expect from similar formations in the neighborhood.

Cornell College,
Mount Vernon.

METEOR MOUNTAIN

DAVID H. BOOT

One of the greatest natural curiosities in the world, though very little known, is Meteor Mountain, which is located about forty miles southeast of the town of Flagstaff, Arizona, and about ten miles south of the town of Sunshine, Arizona, that is, it is located in the

FIG. 98.—Upper part of rim "splash" at the northwest corner of the crater. The only place where one can climb down to the bottom.

north central part of the state. It is said by the men of the United States Geological Survey to be probably the most mysterious geological feature of the United States, lacking, as it does, all parallel anywhere in the world, and its exact cause being held in doubt by many geologists. But after visiting and investigating the site and examining the records of the mining operators who have worked there, and viewing the many large and small fragments of meteoric iron found in and about the crater the author is quite sure that the general opinion that it is the work of a giant meteor is correct. This monstor meteor must have fallen ages ago, for the wind-blown sands of the great American desert have drifted in over the high walls of the rim "splash" and have filled the pit above the meteor to a depth of at least eight hundred feet, that being the least depth, as shown by the miner's daily "log", to the solid material at the south edge of the pit. Borings very much deeper

FIG. 99.—Looking south across the crater from the top of the north side of the rim "splash."

than this at the center of the pit failed to reach the buried meteor, probably because it entered the earth at an angle. There still remains six hunded feet of unfilled pit, and the time elapsed since the meteor fell may be dimly guessed at by the very slight effect of the wind-blown sands alongside the miners' buildings in the eleven years that have elapsed since the last work was done there. The pit is about four thousand feet in diameter and nearly

FIG. 100.—Looking west at the 600 foot wall of the pit from the middle of the bottom of the crater.

circular in shape. The rim of splashed-up rock is a very conspicuous object on the desert, rising, as it does, upwards of a hundred feet above the plain. The great number of fragments of meteorite found scattered about led to extensive mining operations, the miners hoping to reach the great bulk of iron ore believed to be in the pit bottom. Several things have operated to prevent

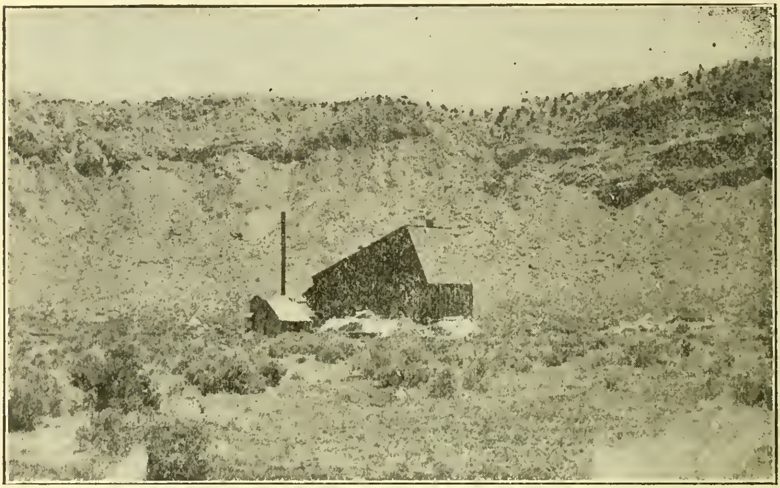


Fig. 101.—View of the south wall of the crater from a point a little northeast of the center of the bottom of the pit.

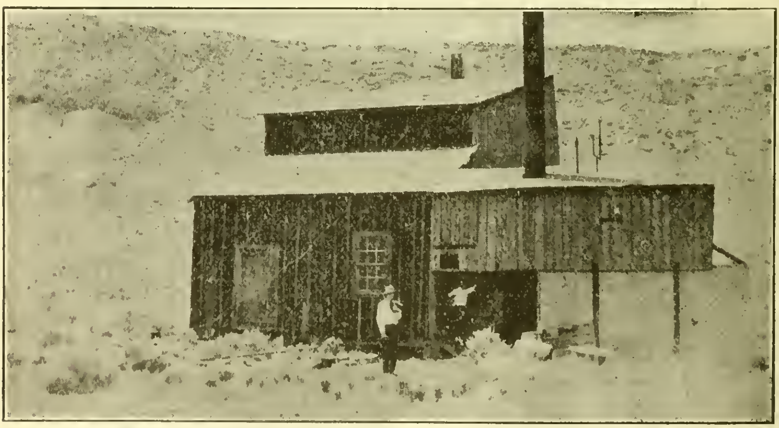


Fig. 102.—An abandoned miners' building in the bottom of the crater near the middle of the pit.

success, one of the worst being the fine, wind-blown sand, at least eight hundred feet deep in the crater, and which is very difficult to keep out of the mining shafts, because being very dry and very fine, it runs very freely. Another difficulty is lack of all timber in the neighborhood. A worse trouble is total absence of water for many miles, while a fourth difficulty is the terrible heat in the bottom of the pit, as the writer can testify from experience; the vertical walls, six hundred feet high, shutting off all air currents, and the clear sky of the Arizona desert working terrific effects with the brilliant sun of

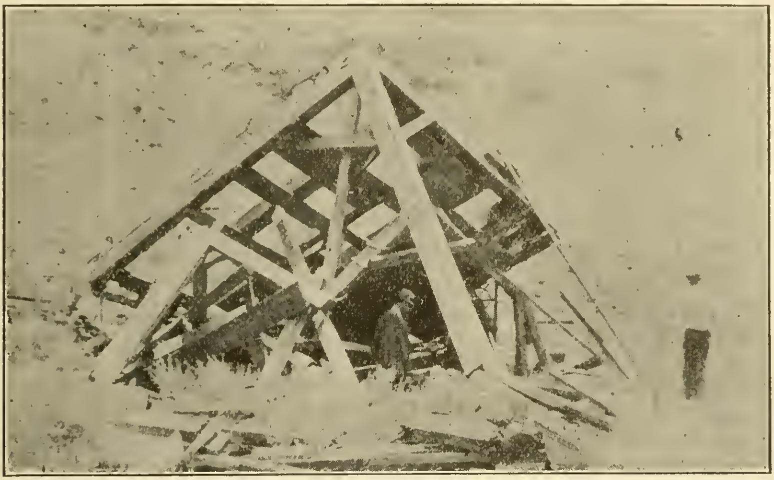


FIG. 103.—An abandoned shaft in the bottom of the crater.

the southwest. Very many fragments of the meteoric rock were examined by the author, the largest weighing eighteen hundred pounds, being so heavy that three strong men were unable to turn it over. These are carefully kept under guard by the mining company, which still controls the spot, and except on the rarest occasions are nearly all locked in a heavy stone building on the north rim of the crater. The photographs accompanying this article show this remarkable phenomenon from various points on the inside and outside of the crater.

FURTHER NOTES ON HELICINA OCCULTA SAY

B. SHIMEK

Few American mollusks equal *Helicina occulta* Say in interest. It is an operculate species which has been reported at times as aquatic, though it is strictly terrestrial; its living representatives are distributed over widely separated areas in restricted local colonies, and evidently represent a declining race; and it is a common fossil of the loess of peculiar signifiacnce, of much more general distribution in the loess-covered portions of the upper Mississippi-Missouri basin, failing to reach the region of the northernmost living colonies, but extending well beyond them westward.

The writer discussed this species quite fully in two earlier papers.[1] Fourteen years have passed since the publication of the later one of these papers, and much additional information concerning the species has been gained since both by the writer and by others.

Some of this information is here presented, together with corrections and modifications of certain previous statements.

THE RECENT COLONIES

Few localities have been added since the former reports, and most of these are within counties in Iowa already represented in the previous reports.

The northeasterly range in Iowa has been slightly extended by the discovery of the species in Allamakee county, along Upper Iowa river.

The most notable discovery was that of a series of colonies in Madison county, southwest of Winterset. This extends the westward and southwestward range perceptibly. The species is here found abundantly in the usual habitat, on steep wooded slopes usually more or less covered with scattered fragments of limestone. The specimens vary from 5.5 to 7.0 mm. in greater diameter. The recent forms hitherto reported from Iowa range from 5 to 7.25 mm. in greater diameter, while North Carolina specimens reach a size of 8 mm.

[1]Helicina occulta Say: Proc. Davenport Acad. of Sciences, vol. IX, pp. 173-180, 1904.
Additional Notes on Helicina occulta Say: Journal of Geology, vol. XIII, pp. 232-237; 1905.

In a set of more than one hundred specimens collected near Winterset nearly one-half are lemon yellow, and the remainder are a lighter dull red than is usual. In a number of the latter the color of the body whorl shades into yellow towards the aperture.

Most of the shells from other Iowa localities are dull-red, often with the body-whorl lighter towards the aperture, and but few in large sets are yellowish or horn-colored. So far as is known no other locality presents the variation in color reported by Wetherby. Describing his Roan Mountain, North Carolina, specimens he says:[2] "I have found the species somewhat rarely. The shells are more carinate than the typical *occulta,* and of all shades of color, varying from bright yellow to greenish, through darker shades to brown and red." Walker and Pilsbry[3], who found the species sparingly on Mt. Mitchell, seventy-five miles southwest of Roan Mountain, report that "there was no apparent tendency to the great variation in color noted by Wetherby in the Roan Mountain specimens." It is evident that the color variation is very local.

For the benefit of those who may not have access to the earlier papers, and as a convenient summary, the localities in which the species has been found living are here recapitulated:

Minnesota: Stockton; Winona.

Wisconsin: Sheboygan; White-fish bay north of Milwaukee; De Pere.

Iowa: Hardin county, near Eldora; Linn county, north of Cedar Rapids; Johnson county, north of Iowa City; Howard county, northwest corner, along Upper Iowa river; Winneshiek county, Plymouth Rock, Kendallville, Bluffton, Decorah, etc.; Allamakee county, along the Upper Iowa; Clayton county, southcentral part; Dubuque county, northwest corner; Delaware county, northeast corner; Lee county; Madison county, southwest of Winterset.

Illinois: Mound county, near Athens.

Pennsylvania: Western part, Alleghany county.

Virginia: Lexington; Natural bridge.

North Carolina: Roan Mountain; Mitchell.

Tennessee: South Pittsburgh, Marion county; Harriman.

FOSSIL FORMS.

As has been previously noted the fossils are more generally distributed than the recent forms. They are usually found only in

[2]A. G. Wetherby, Jour. Cincinnati Society of Natural History, vol. XVII, p. 77, 1894.

[3]The Mollusca of the Mount Mitchell Region, North Carolina: Proc. of the Academy of Natural Sciences of Philadelphia, 1902, p. 421.

the loess, and excepting in rare cases they should be specifically designated as loess fossils rather than by the indefinite term "Post-pliocene", which is used in many papers on Mollusks. The writer has found but one specimen in the alluvium of western Iowa (in Harrison county), but this is evidently a fossil washed out of the loess in which it is frequently found in this region.

The distribution of the fossils is almost coextensive with that of the northern loess, excepting northward and westward. In a northerly direction they do not extend as far as the living colonies. The writer has collected numerous loess fossils in southeastern Minnesota, southwestern Wisconsin, and northeastern Iowa, within the territory over which numerous colonies of living *Helicina occulta* are scattered, but among them were no specimens of this species. This suggests that these colonies have advanced into this region quite recently, or that they occupied areas over which no loess was deposited. The loess of this section is patchy, and does not cover the uplands generally, as was formerly supposed. It is quite evident that the upland deposits, such as those between Postville and Waukon, are not loess. They contain no fossils, and differ from loess in physical properties.

The northern limit of the fossils, so far as observed, is approximately indicated by a series of loops drawn from Ponca, Nebraska, to Carroll, Des Moines, Colfax, Iowa City, Muscatine, and Davenport, Iowa; Rock Island and Joy, Illinois, and Sullivan county, Indiana. The fossils have been found at all the border localities mentioned in this discussion, and at many points within that border.

Westward the fossils extend into eastern Nebraska (as far as the writer has been able to determine) to a line drawn from Ponca through West Point, Bruno and Lincoln to Peru. Numerous collections of loess fossils have been made by the writer west of this line, notably at Beemer, Howells, Clarkson, Milligan, Abie, Atlanta, Oxford, North Platte, etc., but not a single *Helicina* was found among them.

The report by W. H. Russell (The American Geologist, vol. VII, p. 40, 1891) of the occurrence of this species in the beds of uncertain age in the southwestern part of Howard county, Nebraska, is open to question. It is evident that the list of accompanying species was not accurately determined, though this species may be correctly identified, as it is well marked. The deposit appears to be loess, though the author himself questions it. It is well within the loess area. This may be an outlying colony similar to some of the modern ones.

This locality lies nearly a hundred miles west of the above-defined line.

The species is rather abundant in the loess along Missouri river from near Sioux City, Iowa, and Ponca, Nebraska, to St. Joseph, Missouri, at some localities being more common on one side of the river, and at some on the other. It also extends back from the river, especially along the larger tributaries, for many miles,—in Nebraska to the line indicated, and in Iowa to an irregular curve drawn from Hamburg to Carroll, and thence to Sioux City and Westfield. The latter curve practically forms the eastern limit of the main body of the Missouri valley loess on the east side of the river in Iowa, and our species has been found in every county within that area south of Sioux City.

South of the Iowa line the loess is more nearly limited to the bluffs of the Missouri valley. The species is common in Atchison county, Missouri, at Peru, Nebraska, and St. Joseph, Missouri, and extends thence locally along the Missouri to St. Louis county, Missouri. It has been reported specifically from Jackson, Howard, (Sampson), Cooper (Sampson), and St. Louis counties, being designated as a "Pleistocene" fossil by Sampson.

The known southern limit of the fossil form has been extended along the east side of the Mississippi almost to the south line of Tennessee. In the second of the writer's papers (1905) the following statement occurs on pages 233 and 234: "Owen also mentions *Helicina,* without specific name, as occurring in Hickman, Ky. This is probably *H. orbiculata,* as Dana reports this species from Hickman, Ky., on the authority of Wetherby, though Hickman county is so near the southern limit of fossil *H. occulta* that it may have been the latter species." Since that statement was written the writer has made extensive collections of loess fossils in and near Hickman, and among them are numerous specimens of *Helicina occulta,* ranging in size from six to seven and one-half millimeters. While several hundred specimens of this species were collected, not a single specimen of *H. orbiculata* was found. The latter species, if present, must be very rare, and it is possible that Wetherby's report is an error.

Not only is our species common at Hickman, but the writer collected numerous specimens in Tennessee, at Dyersburg, Ashport bluff, near Covington, and at Fulton. The Dyersburg specimens range from six to eight millimeters in greater diameter, thus equaling the largest recent specimens reported by Walker and Pilsbry from Mount Mitchell, North Carolina. Below Dyersburg the species is less common, and ranges from six to seven and one-half millimeters in diameter. It should be noted that *H. orbiculata,* the southern species, was not found in any of the Tennessee localities here cited.

In this connection it is desirable to correct another error which was made in the same paper. On page 234 this statement appears: "It is safe to say that all specimens of fossil *Helicina* reported from south of Kentucky are *H. orbiculata,* fossils of that species being known only from loess bluffs along the Mississippi to Kentucky. Recent specimens of the species may be found from southern Florida to Texas, and northward to Tennessee, and Jasper county, Mo., the latter being the most northerly locality known." The southernmost locality in which the writer has found fossil *Helicina occulta* more recently is southwest of Covington, about forty miles north of the south line of Tennessee. He has not found fossil *H. orbiculata* north of Vicksburg, Mississippi, (about 200 miles south of the Covington locality), though it is reported from Hickman, Kentucky, as noted, and from Providence, Boone county, Missouri, by Sampson, who reports the variety *tropica.*[4] The latter locality is near the center of the state of Missouri, and is far removed from known localities in which living or fossil forms appear. (Since this paper was written the writer has visited the Providence locality and found that this *Helicina,* with other terrestrial mollusk shells, is found in a talus-like deposit along the bluffs on the north side of the Missouri. These banks consist of a mingling of fragments of local rock with a yellow loesslike material which covers the uplands to the north, but which differs from loess in texture, and which is non-fossiliferous on the uplands so far as the writer was able to ascertain. It is clearly not loess, and the shells, evidently much more modern than the upland deposit, are found only in the younger talus near the base of the bluffs.) Sampson also reports typical living *H. orbiculata* from Stone county, and the variety *tropica* from Jasper, Barry, MacDonald, and Christian counties—all in Missouri. This indicates an overlapping of the areas of distribution of the two species, though so far as is known, they do not occur together, either living or fossil.

The vertical distribution of the fossils is also of great interest, but this will be discussed in greater detail in a subsequent paper. Suffice it to say that the species is found in both of the common

[4]F. A. Sampson, Trans. of the Academy of Science of St. Louis, vol. XXII, p. 71, 1913.

loesses of the upper Mississippi valley. At some places it is in the lower, gray loess, at some in the upper, yellow loess, and at others in both, in the same exposure.

In all discussions of this species it must be borne in mind that it is strictly a deep-woods form. Where loess accumulated on the prairies it contains no fossils of this species, and so far as we can judge from the habits of the living representatives, its presence is conclusive evidence of well-developed forest conditions.

Department of Botany,
The State University.

NOTE ON CONDITIONS AT THE HEAD OF FLOOD PLAINS

JOHN L. TILTON

Flood plains are said to exist along the courses of rivers where in time of flood deposits are laid down on the flooded areas. Following such a flood plain up-stream the plain is said to become narrower till reduced to zero. In working along tributary ravines in Warren and Clarke* counties, Iowa, a different relation is noted that it appears to the writer should be emphasized. Here in the course of four to six miles gradations may be seen from the flat surface of the upland to the alluvial flood plain by the rivers. Starting with the upland, the rain water flowing along gentle depressions previously made begins to erode in spots, first by undercutting the sod here and there, the process of undercutting working headward uniting several of the eroded patches till a small gully results. Somewhat further downstream the volume of storm water is sufficient to overflow the small trench and take short cuts from one bend to the next, eroding a shallow channel by the side of and above the small trench. A little mud is deposited, but the dominant effect is here erosional. Following down this portion of a flood plain where erosion is in excess of deposition the flood plain gradually becomes wider, and gradually changes into a flood plain of the recognized type, where deposition is in excess of erosion, and where meanders begin to be evident. This gradual change is a common feature along the chief ravines in southcentral Iowa. Degradation is in progress near the heads of the ravines and aggradation is marked along the lower courses of the same ravines. In texts generally head water erosion and erosion by mountain and other streams is described, and the building up of flood plains in the lower courses of rivers, but I do not find the *gradation* from one extreme to the other treated. Along large rivers this change may not be noticeable for many miles; but here in southcentral Iowa it may be seen in the course of a few hours' walk.

Department of Geology,
Simpson College.

*See Geology of Clarke county, Iowa, chapter on Physiography, Iowa Geological Survey, vol. XXVII.

THE INTERPRETATION OF CERTAIN LEACHED GRAVEL DEPOSITS IN LOUISA AND WASHINGTON COUNTIES, IOWA.

W. H. SCHOEWE.

During the field season of 1917, the writer examined two exposures of stratified sands and gravels, which, in age, may probably be correlated with the close of the Nebraskan stage of glaciation and with Aftonian times.

The first of the two exposures, which are separated by about two miles, is located in Washington county in the extreme southeast corner of section 36, Iowa township. The other outcrop is found in Louisa county in the northwest quarter of the southwest quarter of section 8, Union township, Township 76 North, Range 5 West. In both cases, the exposures are in banks of streams, the first forming the north bluff of Davis creek, the second, the south wall of Goose creek. The base of the two sections lies practically at the level of Iowa river which is about one-eighth of a mile farther to the east and which, according to barometric readings, is at 620 feet above sea level.

As the two sections are very much alike, a detailed description of but one will be given, and only the points of differences of the other one will be brought out. The exposure to be described is the one in Washington county at the location cited above.

The section is as follows:

	Feet
3. Light ash-colored drift	10
2. Leached and oxidized sands and gravels	20
1. Dark bluish calcareous drift; compact, unoxidized and containing small pebbles	4

Towards the base of the sand and gravel deposit, the gravels predominate. The textural range of the gravels is rather high, the pebbles varying from small fragments the size of a pea to pieces several inches in diameter, the finer material, however, being in excess. The gravels are cross-bedded.

The sands which are highly oxidized and have a brownish color are fairly fine and have a low textural range. In structure they are highly contorted, dip at high angles, are cross-bedded and at places, especially in the middle of the deposit, are more or less horizontal. A lens and pocket structure is conspicuous throughout the exposure in which occasionally leached mud or clay balls are found.

Although but ten feet of the ash-colored drift is exposed, the slope of the hill is covered by drift to a height from forty to fifty feet above the section. The exposed portion of the till contains limestone pebbles and is filled with many concretions. Higher up the slope of the hill, the drift is leached. The entire outcrop is from 150 to 250 feet long.

The other section differs but little from the one just described, except that it contains less gravel and no drift is exposed beneath the sands. However, it contains near the base several thin leached layers of till from one to two feet thick. Here and there, a well weathered limestone pebble occurs in it, nor are lime concretions entirely wanting.

On the whole, the stratification of the sands and gravels of the exposure in Louisa county is more horizontal than that of the one in Washington county. Barometric readings show that the two sections lie approximately at the same elevation: namely, from 620 to 630 feet above sea level. The length of the second outcrop is the same as that of the first and the exposure is forty feet high.

INTERPRETATIONS OF THE DEPOSITS.

The deposits above described may be interpreted in either of the following ways:

1. The sand and gravel deposits are inclusions incorporated in the Kansan drift.

2. The sands and gravels are interbedded outwash material between two drifts which are of the same age and therefore Kansan as the uppermost till is known to be of Kansan age.

3. The sand and gravel deposits lie between drifts of two different ages, the gravels and sands having been deposited in connection with the lower till, but having been weathered during interglacial times or before the deposition of the upper drift.

VIEW 1.

The sand and gravel deposits are inclusions incorporated in the Kansan drift.

Discussion.—Sand and gravel pockets incorporated in tills are familiar to all. But whether large stratified inclusions of leached and oxidized sands and gravels in fresh drift are common is very doubtful. If the inclusions are contemporaneous with the deposition of the fresh drift, why then are the inclusions oxidized and leached?

As inclusions incorporated in the Kansan drift, these large leached and oxidized sand and gravel deposits can best be explained as pre-Kansan material which before being picked up and later being deposited by the Kansan ice sheet were frozen into a solid mass. Should this view be correct, the deposits would still be evidence of a long interglacial stage.

In any event, if there were but one exposure, one might be tempted to favor the view set forth above. However, since there are at least two exposures, separated by two miles, and having the same stratigraphic and topographic relationships, one is led to conclude that the sands and gravels are not merely large sand and gravel pockets incorporated in a till of the same age, but rather outwash deposits lying between two drifts either of the same or of two different ages.

VIEW 2.

According to the second view, the sands and gravels are but the interstratified outwash deposits between two drifts of the same age and therefore represent the following conditions:

1. An advance of the Kansan ice sheet and the deposition of the lower drift, then
2. A retreat of the ice sheet accompanied by a deposit of outwash material covering the recently deposited fresh till.
3. A readvance of the ice depositing drift over the sands and gravels which presumably were frozen into a solid mass on the last advance of the ice sheet.
4. The disappearance of the Kansan ice sheet.

Discussion.—The above view would satisfactorily explain the origin of the interbedded sands and gravels if the latter were fresh as the two drifts are, above and below. If the sands and gravels are contemporaneous with the two tills, then one would expect the interbedded deposit to be fresh also. Is it possible that the outwash material was all leached at the time of its deposition? It hardly seems conceivable that this could have been the case. Why should they have been leached when the drifts are highly calcareous?

Were the sands and gravels leached since the deposition of the overlying drift? Hardly so, for the lower part of the upper till is fresh; besides this drift acted as a protecting cover for the underlying deposit. The till above the sands and gravels is fresh, but is oxidized and leached farther up the slope of the hill.

The only other way to explain the origin of the sands and gravels in the light of their being of Kansan age is as follows:

After the outwash material had been deposited, a time elapsed sufficiently long enough during which the sands and gravels were leached before the readvance of the ice sheet. This latter view might explain the origin of the interbedded deposits. The question, however, arises at once, how much time would be required to have elapsed before the entire twenty feet were leached and oxidized? And is there any other similar case known to glacial geologists? The so-called Aftonian sands and gravels are fresh. Do they really represent interglacial times?

In the first place, it is not certain whether the twenty-foot layer of sands and gravels represents the original thickness of the deposit. Thus the leaching of these materials may not necessarily record the entire length of time that elapsed between the two oscillations of the Kansan ice sheet, as some of the leached sands and gravels may have been eroded away before and at the time of the second advance of the ice sheet. It seems, however, that a considerable time must have elapsed before the uppermost till was deposited, if we can draw conclusions from the kame and esker deposits of Wisconsin age. Inspection of such well-known deposits in Wisconsin show that little if any leaching has taken place since the time of their deposition. Furthermore, the gravel and sand deposits south of DeWitt, Iowa, which are either of Illinoian or of Iowan times are still fresh. These gravels as well as those of Wisconsin age have no protecting cover of drift and therefore have been exposed to the oxidizing and leaching processes for a considerable length of time. Are we to assign a period of at least as long a duration as all of post-Wisconsin time to the interval between the two oscillations of the Kansan ice sheet? Hardly so.

VIEW 3.

The third view regarding the sand and gravel deposits explains the deposits as Nebraskan outwash materials which were exposed for some time to the elements of weathering before the coming on of the Kansan ice sheet.

The following steps are represented:

1. An advance of the Nebraskan ice sheet and the deposition of the lower till.
2. The retreat and disappearance of the Nebraskan ice sheet accompanied by a deposit of outwash material.

3. A long interglacial period during which the outwash material was thoroughly oxidized and leached.
4. An advance of the Kansan ice sheet and the deposition of the upper drift.
5. The disappearance of the Kansan ice sheet.

Discussion.—This view is the only one which will satisfactorily account for all the conditions as they exist in the field: namely, an upper till the top of which is oxidized and leached and whose lower portion is fresh, then an oxidized and leached stratified deposit of sand and gravel beneath which is an unoxidized fresh till. Presumably as the Kansan ice advanced over the outwash deposits, the sand and gravel were frozen into a solid mass.

OTHER EVIDENCE BEARING ON THE PROBLEM

A study of the gumbotils in close proximity to the described sections shows that there are two distinct gumbotils, one lying at an elevation of about 710 feet and the other from 620 to 640 feet above sea level. The higher lying gumbotil is the Kansan, and the lower one the Nebraskan. There never has been any doubt regarding the Kansan gumbotil, but it has just recently been established that the lower gumbotil is the Nebraskan. Now the noteworthy point is that the elevations of the sand and gravel deposits are approximately the same as those of the Nebraskan gumbotil near by. This coincidence of elevations seems to signify that the sands and gravels were lying on the same surface as that of the Nebraskan drift and that while the till was being oxidized and leached to form the Nebraskan gumbotil, the sands and gravels were also undergoing the same processes of leaching and oxidation and hence represent the same interglacial interval.

CONCLUSIONS

We have here the following facts:

1. The stratified sands and gravels are oxidized and leached.
2. These deposits lie between two fresh drifts of which the upper part of the overlying till is leached, hence presenting a section as follows:

Drift	leached
Drift	unleached
Sand and gravel deposit	leached
Drift	unleached

3. There are two such exposures, separated by several miles and having the same elevation as well as the same stratigraphic and topographic relationships.

4. The elevations of the sand and gravel deposits and the Nebraskan gumbotils are approximately the same.
5. View 3 best explains and accounts for all of the conditions as seen in the field.

The writer is of the opinion that the lower drift is Nebraskan, that the sand and gravel deposits are Nebraskan outwash materials, that these outwash sands and gravels were oxidized and leached contemporaneously with the formation of the Nebraskan gumbotil and that the upper till is the Kansan.

Ever since the history of the origin of the gumbotil has been worked out by Professor Kay,* the value of interbedded sand and gravel deposits between drifts has lost its significance as a criterion of interglacial times. It is only when such deposits are oxidized and leached and lie between fresh drifts that any positive value can be attached to them as recording an interglacial interval.

Department of Geology,
State University of Iowa.

*Kay, G. F., Gumbotil, A New Term in Pleistocene Geology: Science, New Series, Vol. XLIV, Nov. 3, 1916.
Kay, G. F., Pleistocene Deposits Between Manilla in Crawford county and Coon Rapids in Carroll county, Iowa: Iowa Geol. Survey, Vol. XXVI, pp. 217, 218, Ann. Rep't. for 1915.

THE IOWAN-WISCONSIN BORDER

E. J. CABLE

Workers of the Pleistocene of Iowa must use several criteria for distinguishing the different drift sheets. The working criteria are, (1) surface topography of the drift, (2) distinctive lithological characteristics, (3) degree and depth of leaching and oxidation, (4) distinctive interglacial deposits and, (5) pronounced erosional and weathered zones. It was formerly thought to be quite an easy matter to distinguish one drift sheet from another by means of criteria (1), (2) and (3), with great emphasis upon (1) and (3). Too much emphasis, however, cannot be placed upon the lithological characters, since a careful study of the drift sheets, with the possible exception of the Wisconsin, has revealed a certain consanguinity existing among them.

The general composition of the drift being indistinctive where two or more drift sheets are contiguous or are overlapping, it is necessary to apply all of the above criteria where possible to discover them.

In attempting to determine the boundary of the Iowan-Wisconsin drift sheets, all of the above evidences should be carefully applied where possible.

The Iowan-Wisconsin border has been located largely upon the basis of topographic evidence. This has been due, no doubt, to, (1) lack of sufficiently deep cuts where the relation of one drift to another may be seen, and, (2) the greater emphasis that was earlier placed upon lithological characters and surface topography.

After having spent some time in studying carefully the Iowan-Wisconsin drift border from where it enters Iowa in northwestern Worth county to northern Hardin county, the writer feels confident that there are many places where changes in the position of the border should be made. Detailed investigation was made to determine, first, if possible, whether the Iowan drift extended westward beneath the Wisconsin drift. Many difficulties are encountered when an attempt is made to secure data to determine the relation of the Iowan drift to the Wisconsin drift, as, (1) the great thickness of the Wisconsin drift at its eastern margin, (2) the absence of deep road or valley sections where the two drift sheets are contiguous and, (3) the small relative value of well logs. Investigation was carried on some distance back from the Wisconsin border, well within the Wisconsin drift plain. Well logs were examined carefully, where possible to secure them, public road sections, railway cuts and river valley sections were studied, with the result that not a single instance was obtained where it can be affirmed positively that Iowan drift exists beneath Wisconsin drift.

The eastern line of demarcation between the Iowan and Wisconsin drift sheets was studied carefully and, where possible, all evidence was applied to determine any errors. For great distances the margin can be detected by the striking difference in the topography of the two drift sheets. From the northern border of Worth county, to Hanlantown, Danville township, the line between the two drift sheets is not pronounced except to the northwest, west and southwest of Northwood. In this vicinity, the Wisconsin border is characterized by a prominent terminal moraine, which meets the level Iowan drift plain very sharply. This sharpness is emphasized by the absence of any outwash. Elsewhere in the county the Wisconsin drift margin meets the Iowan drift plain in a greatly softened topography so that it becomes more difficult to outline definitely the border of the Wisconsin drift. The lack of reliable well logs and drift sections of sufficient depth, makes the location of the margin difficult. Many well logs were examined, some to the east of the mapped margin, and others to the west of the margin. Many of the wells to the west of the Wisconsin margin are shallow and are of no value. The following well log was secured west of Kensett, Kensett township, and is quite typical of many others examined east of the Wisconsin margin.

	Feet	Inches
1. Black soil	1 to 2	....
2. Clay, yellow, noncalcareous	8	....
3. Clay, blue, calcareous	23	....
4. Sand and gravel	....	4 to 6
5. Clay, blue, highly calcareous	30	....
6. Sand and gravel	....	6
7. Bed rock.		

The well records reveal two drift sheets to the east of the Wisconsin border. The upper drift sheet is unquestionably Iowan, and the lower is probably Kansan.

In the vicinity of Hanlantown, the Wisconsin border should be extended eastward as shown in figure 117.

Here may be found good evidences of outwash and lake deposits which are unquestionably of Wisconsin age. The upper terrace north of Lime creek, Lime creek valley, section 35, Fertile township, and section 36, Danville township, is lake deposit, is highly fossiliferous, and is of Wisconsin age.

The Iowan-Wisconsin border in Cerro Gordo county is everywhere quite well defined. The Altamont moraine within this county presents an area of heterogeneously grouped knobs and undrained basin-like depressions. The margin of the moraine meets the gently

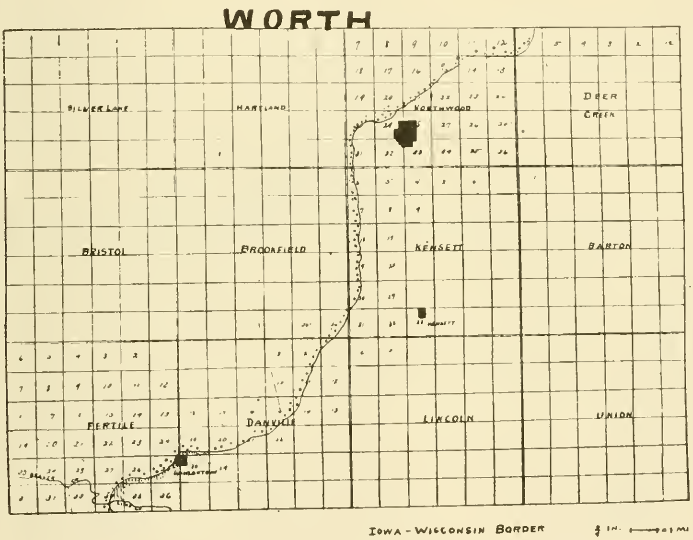


FIG. 104. Map of the Iowan-Wisconsin border in Worth county.

undulating Iowan drift plain with a rather sharp line of demarcation. In the northwest part of the county, where the Altamont moraine enters the county, its surface irregularities are very pronounced, while in the central and southern parts the surface irregularities are less marked. Little or no outwash material is to be seen. Drainage from the ice margin was along stream courses that were determined previous to the Wisconsin ice invasion. Gravel trains are prominent along many of these streams leading eastward from the Wisconsin margin.

In Franklin county the boundary line between the Iowan and Wisconsin drift sheets is quite conspicuous, except locally. There are local areas where the marginal front of the Altamont moraine shows pronounced outwash. Such an area is to be found in sections 5, 8, 9, 15 and 16 of Reeve township. Here the Wisconsin border should be extended eastward as shown in figure 118.

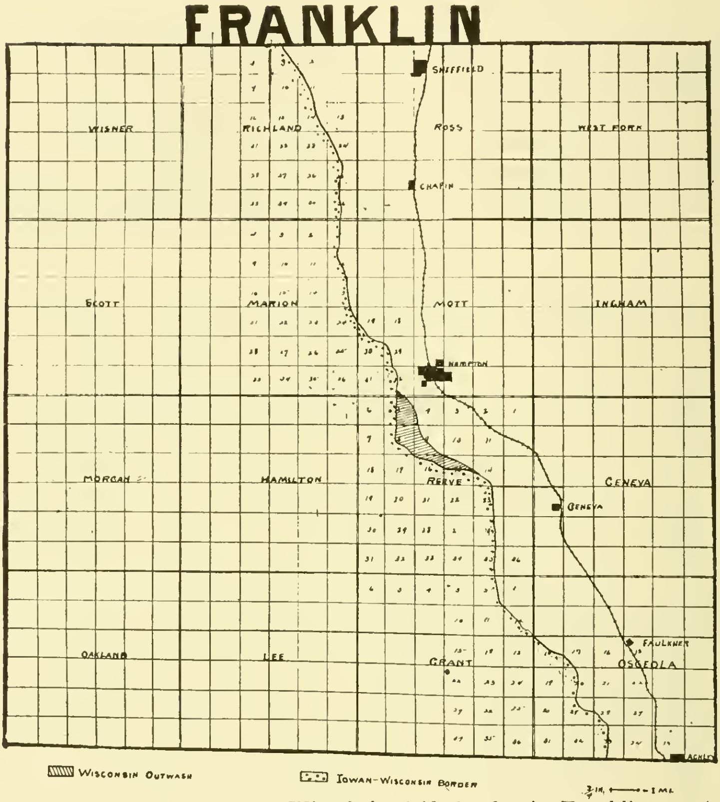


FIG. 105. Map of the Iowan-Wisconsin drift border in Franklin county.

A careful study of the drift in this area was made through borings, valley sections and tile ditch sections. The following two sections are typical of the drift in this vicinity.

	Feet	Inches
NORTHEAST QUARTER, SECTION 8, REEVE TOWNSHIP.		
1. Peat, compact, uneven and ridgy......	2 to 4	....
2. Limelike clay, finely pulverized, white in color	....	6 to 10
3. Gravel, evenly bedded, limestone pebbles predominant	2	....
4. Sand and clay, bluish green in color..	....	2 to 4
5. Sand, white, even-grained, horizontally bedded	....	4
WEST HALF, SECTION 9, REEVE TOWNSHIP.		
1. Peat, compact, highly fossiliferous....	2 to 4	....
2. Gravel, one-fourth to one-half inch in diameter, chiefly limestone.........	....	2 to 6
3. Sand and clay, greenish blue in color	....	2
4. Sand, fine-grained, evenly bedded, white in color.....................	2	....

From a study of the sections, it would seem that during the time that the Wisconsin ice sheet margin was in a halting state, a lake was formed immediately to the east of the ice margin in which the above materials were deposited by the glacio-fluvial waters.

That the Iowan drift is overlapped by the Wisconsin drift in certain areas within the township is suggested by the fact that in sections 8 and 9 of Osceola township, and section 12 of Grant township, loess was observed mantling the hills of presumably Iowan drift, but when traced westward to the Wisconsin drift margin, it was observed to disappear rather sharply. The lack of sufficiently deep cuts and reliable well logs, together with the great thickness of the Wisconsin drift where the supposed overlapping takes place, make positive statements impossible.

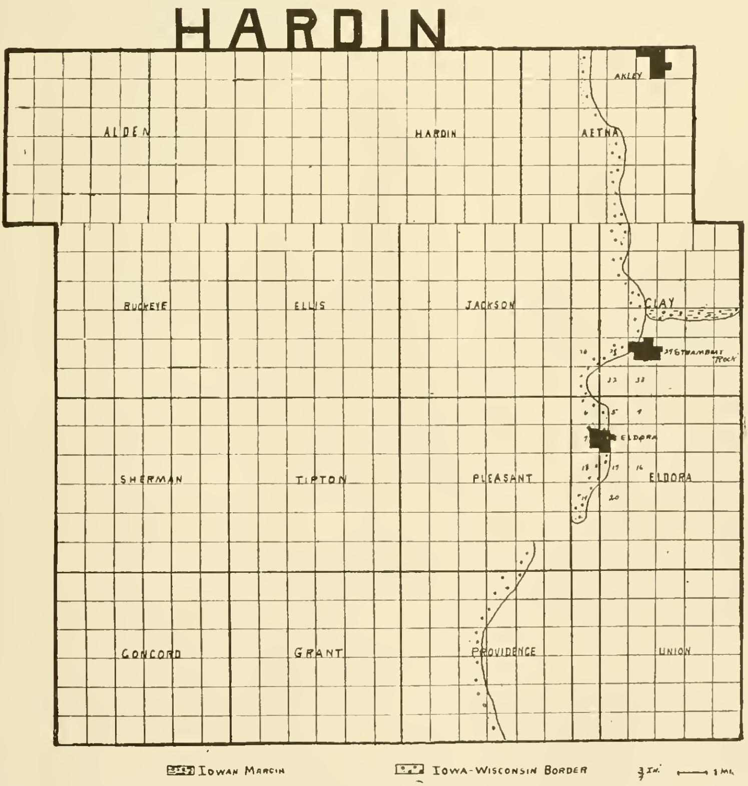


FIG. 106.—Map showing the Iowan-Wisconsin border in Hardin county.

The Iowan-Wisconsin border in northern Hardin county is well defined, though the relief of the Altamont moraine is not so pronounced as farther to the north. In Clay township, the Iowan border, figure 106, according to earlier workers of the drift, has been drawn to the east. After some detailed study of the Iowan border in this vicinity, the writer is convinced that it extends much farther to the south. From investigation in the vicinity of Eldora, it would seem as if a tongue of the Iowan extends as far south as the new bridge across Iowa river, south of the city. Further study will be necessary before any definite line can be drawn. There are many difficulties in the way of fixing positively the Iowan border. The Iowan drift thins out gradually so that it becomes difficult to distinguish, (1) its topography, in many places its surface features being determined by the topography of the underlying drift, (2) its complete state of oxidation, owing to its thinness, and, (3) its great similarity in lithological characters to the Kansan. Much more detailed work must be done before the boundary of the Iowan can be drawn definitely.

THE DEEP WELL AT LAURENS, POCAHONTAS COUNTY

E. J. CABLE

The town of Laurens is located in the northwest corner of Pocahontas county. The surface drift within the county is Wisconsin, while the underlying drifts are probably Kansan and Nebraskan.

	Feet	Inches
1. Black shale	3	6
2. Yellow calcareous clay	10	6
3. Blue clay, calcareous	206	....
4. Sand and gravel	10	....
5. Blue clay, compact, calcareous	20	....
6. Sand	150	....
7. Blue shale	50	....
8. Limestone	285	....
9. Blue shale	15	....
10. Limestone	260	....
11. Blue shale	80	....
12. Sandstone	35	....
	1,125	

Horizons (1) to (3), inclusive, are Wisconsin drift. Horizon (4) is probably interglacial and equivalent in time to the Aftonian or Buchanan gravels. Horizon (5) is either Kansan or Nebraskan drift with a strong probability of being Kansan. Horizons (6) and (7) are undoubtedly Cretaceous, as Cretaceous deposits, consisting of sand and shales, are found immediately beneath the drift in the county. Horizon (8) may be Mississippian in age. Horizon (9) has not been found previously in the county at this depth. The assignment of horizon (9) to the upper Ordovician, Maquoketa shale, may be a possibility. If horizon (9) is Maquoketa shale, horizons (10) and (11) are possibly Galena to Platteville, inclusive. Horizon (12) is unquestionably Saint Peter sandstone, which is an aquifer for deep wells in this locality.

The Saint Peter is encountered at Emmetsburg, Palo Alto county, at a depth of 864 feet, while at Laurens, it is reached at a depth of 1,100 feet. The Saint Peter sandstone descends 252 feet in 21¼ miles, or at the rate of 11.85 feet to the mile.

Department of Geology,
The State Teachers College.

A CENTURY OF IOWA GEOLOGY

CHARLES KEYES

Prologue.

The first centennary of a science in Iowa is upon us. History of the sciences in the commonwealth now goes back beyond the span of our statehood. It transgresses a date when even a name for our state was yet unknown. In Iowa, by many years, claims to first recognition for geology antedate those of every other natural science. Curiously enough this earliest Iowa episode is also the most important geological event for the entire continent during a hundred years. It is even worldwide in some of its aspects. Nor are these early observations alone in their great significance. During the century just passed Iowa has been the field wherein a score or more far-reaching generalizations on geologic themes have had birth. That our state should be thus so intimately associated with the growth of American geology is surely a circumstance of much satisfaction to all Iowan scientists and laymen alike.

Amidst the multitudinous distractions of the world war Iowa's geological centennary has been allowed almost to pass unheeded. Yet, it is not too late to call attention to some of the outstanding features of a hundred years. Our accomplishments in this branch of science might have been much less.

At one time the great industrial importance of the Dubuque lead district naturally led to its systematic geological consideration. This, however, was more than two centuries after the discovery of the mineral there by Europeans, and twenty-five years subsequent to the first real geological investigation undertaken within the limits of our state. From the year 1634, when the French adventurer, Jean Nicollet,[1] penetrated from Quebec to southwestern Wisconsin, until 1839, when Dr. D. D. Owen made the maiden publicly supported survey of Dubuque, the lead region was of commercial solicitude only.

[1]Shea: Discov. and Explor. Mississippi Valley, p. 20, 1853.

INITIATION OF MODERN GEOLOGY IN THE NEW WORLD

Old Wernerian influences which dominated geological science throughout Europe and colonial America during the eighteenth century and the early decades of the nineteenth only barely touched Iowa. When William McClure, who, a hundred years ago, was long president of the American Philosophical Society, in Philadelphia, and who was in his day the foremost exponent of the German school in this country, prepared a general geological map of eastern United States, the formations afterwards called the Paleozoics are represented as reaching the Mississippi river.[2] Before these formations could be actually traced beyond, the determination of fossils from the Iowa side by Thomas Nuttall, forever barred the further spread of Werner's conceptions to trans-Mississippian territory. It is with these new and modern principles that Iowa entered upon her geological career.

By singularly happy chance Iowa was, in a very unusual way, closely identified with the establishment of modern geology. It was on Iowa soil that there was first application in the new world of the novel principles of identifying and correlating geological formations by means of the organic remains entombed within them. This was a full quarter of a century before the method, which has since become universal in use, was practiced anywhere else on the American continent. It was, moreover, the first attempt ever made to correlate by fossils geological formations of different continents.

Those remarkable precepts formulated by William Smith, which lie at the base of our accepted scheme of geological correlation and chronology, are thus practically tested in America, and in Iowa if you please, almost as soon as they are in England the land of their birth. That America should so early and from such an unexpected quarter as Iowa, furnish material aid in support of the newly announced principles is a fact worthy of more than passing notice. The circumstances are long since all but forgotten. In the few casual references made to them in after years either their true import is misunderstood or familiarity with the attendant conditions is entirely lacking. Both as the first successful application of modern geological principles in the new world and as the maiden effort, as it proved to be, at world-wide stratigraphical correlation, the event must ever remain one of the outstanding features in the history of geological science.

Nuttall's paleontological correlations antedate by fifteen years

[2]Trans. American Philos. Soc., Vol. VI, p. 411, Phila., 1809.

Samuel Morton's similar efforts on the Tertiaries of our Atlantic coast, commonly regarded as the initial attempts in America along these lines.[3] By two decades they were in advance of the first work of that pioneer paleontologist, Lardner Vanuxum.[4] They anticipate by a full generation the famous investigations of Thomas Conrad and James Hall, of New York. Nuttall was an English printer who came to this country in 1808, and who during the following year made a western trip in quest of scientific information, reaching the Mississippi river at Prairie du Chien and descending the great stream in canoe to St. Louis.[5]

FIRST RECOGNITION OF CARBONIC ROCKS IN AMERICA

Another conspicuous feature of rather peculiar significance connected with this earliest geological investigation within the boundaries of our state, is the determination of the presence of rocks of Carbonic age for the first time in this country. In the course of his explanations of the geological characteristics along the banks of the Mississippi river, Nuttall rather naively observes that he is "Fully satisfied that almost every fossil shell figured and described in the *Petrifacta Derbiensia* of Martin was to be found throughout the great calcareous platform of Secondary [Paleozoic] rocks exposed in the eastern part of the Mississippi valley."[6] Thus by means of the contained organic remains he parallels these Mississippi limestones with the Mountain limestones of the Pennine range of England, to which several years later Conybeare gave the title by which we now everywhere know them.

At this late day we can hardly appreciate the scant state of knowledge concerning the geological column a hundred years ago. When Nuttall arrived on the scene Iowa-land was a perfect *terra incognita*. No scientist had yet laid eyes on the field. Along the Mississippi river, as we now know, the Englishman collected fossils from rocks which are mainly if not entirely Early Carbonic in age. So his identifications of forms were with a few possible exceptions doubtless correct. Moreover, it must be remembered that at that time and for many years afterwards the inferior rocks of not only this country but throughout Europe were entirely undifferentiated. The great succession of older stratified formations which were subsequently successively separated from one another were jumbled together under the title of Transition Group. It was not until a

[3] Jour. Acad. Nat. Sci. Philadelphia, Vol. VI, pp. 72-100, 1829.
[4] Jour. Acad. Sci. Philadelphia, Vol. VI, pp. 59-71, 1828.
[5] Observations on Geological Structure of Valley of the Mississippi; Jour. Acad. Sci. Philadelphia, Vol. II, pp. 14-52, 1821.
[6] Jour. Acad. Nat. Sci. Philadelphia, Vol. II, pt. i. p. 14, 1821.

full generation later that out of them, in Britain, Murchison, Sedgwick and Lonsdale resolved the Silurian, Cambrian and Devonian systems, titles which still hold today.

The analogy established by Nuttall between the general Carbonic section of Iowa-land and of the upper Mississippi valley and that of northern England is one of far-reaching consequence. Its great significance is pointed out by Owen a couple of decades later. Its historic value grows with the advancing years. It is one of the important geological discoveries in America.

These early interpretations were the means of actually and correctly determining the true positions and the biotic relations of the Carbonic rocks of the continental interior a half century before their geologic age was otherwise generally admitted. These Mississippian limestones, as the rocks are now designated, remain today as compact and as sharply delimited a sequence of geologic terranes as they appeared when first recognized in that memorable summer of 1809.

DISCOVERY OF AMERICAN CRETACIC DEPOSITS

Credit for another shrewd guess in world-wide correlation is to be ascribed to Nuttall. On a second trip on western waters, in 1810, he ascended the Missouri river to the Mandan villages, near the Big Bend, where Bismark, North Dakota, now stands. This voyage was made in company with John Bradbury, a Scotch naturalist. Especial mention is made of the Omaha Indian settlement situated below the mouth of the Big Sioux river.

A short distance upstream from the Omaha tepees Nuttall examined strata exposed in the bluffs which by means partly of the fossils and partly of lithologic resemblance he was inclined to refer to the Chalk Division of the Floetzgebirge, or Secondary rocks, of northern France and southern England.[7] So utterly dumfounded was this observing naturalist at finding real chalk so far from home that he hardly believed his own senses; and he entered into prolix argument in support of his determinations, yet remained to the last somewhat skeptical as to the correctness of his conclusions.

This is the earliest definite recognition of beds of Cretacic age in America. It precedes by a decade and a half the separation, by John Finch, of the newer Secondary rocks from the Tertiary section in the Atlantic states; and Lardner Vanuxem's and Samuel Morton's references of the same deposits to the Cretaceous age. Thus, also, is another great succession of one of our main geologic

[7]Jour. Acad. Nat. Sci. Philadelphia, Vol. II, pt. 1, p. 25, 1821.

periods discovered in a then remote part of our continent years before it is recognized in the East.

PRIMARY GEOLOGICAL CROSS-SECTION OF MISSISSIPPI VALLEY

Iowa was still primeval wilderness when first attempts were made to decipher the geological substructure of her broad prairies. In those early days the construction of a geologic cross-section from verge to verge of the vast Mississippi valley was an undertaking of no mean proportions. Following closely in the Wernerian footsteps of William McClure, father of American geology, Dr. Edwin James, who was surgeon, botanist, and mineralogist of the famous Long Exploratory Expedition to the Rocky Mountains, in 1819-20,[8] endeavored to extend McClure's section of the forty-first parallel, from the Alleghany Mountains to the Rocky Mountains.

Crude as the results appear at this day the simplicity of structure largely obviates serious error that otherwise might have been made. This parallel of latitude crosses the southern part of our state. Although Doctor James afterwards lived in Iowa, near Burlington, for more than a quarter of a century, at the time of the Long trip he traversed only the southwestern corner of the state. A similar cross-section was executed along the thirty-fifth parallel, which was intended to be a continuation of McClure's "Fifth" section.

In spite of his strong Wernerian predilections an important observation was the recognition of the coal formation. He made the prediction that some day these coal deposits would prove to be of very great value.

The striking feature brought out in the cross-section was the fact that throughout the breadth of the Mississippi basin the strata reposed practically undisturbed. This condition contrasted strongly with the tilted beds at either side. Thus was early although faintly adumbrated that basin-shaped form of the continent of which in later years Dana made so much.

As a matter of fact James' work was really one of the larger undertakings in the geological field of his day.

TERRANAL CORRELATION OF ORE DEPOSITS

Although erroneous in principle early application of the idea that mineral deposits are in some way genetically connected with specific geological formations under certain limitations proved to be unexpectedly fruitful in ore exploration. Its first presentation was a

[8]Account Exped. Pittsburg to Rocky Mts., in 1819-20, Vol. I; Philadelphia, 1823.

direct result of investigations in the Dubuque lead region. So far as we know the conception originated with Henry Schoolcraft, a naturalist of singularly wide accomplishments, who was the narrator and mineralogist of the Cass expedition to the sources of the Mississippi river in 1820.

On the return journey of the Cass exploring party Schoolcraft left his companions when Prairie du Chien was reached and made a side trip to the Iowa mineral district. Of this he gave the best detailed description up to that time and for a generation thereafter. This traveler had previously investigated the lead mines of southeast Missouri and had published full accounts of them and of the methods of mining and treating the ores.

As an outcome of his Iowa visit Schoolcraft conceived the notion that the Iowa and Missouri mineral belts were genetically related. He fancied that the lead-bearing strata of the two widely separated localities were stratigraphically identical.[9] In this opinion he was doubtless largely influenced by Nuttall's parallelism of the Iowa rocks with the English lead-bearing rocks of Derbyshire. The fact that he designated the formation the Metalliferous Limestone is significant. In after years both Keating and Featherstonough fell into the same error by calling the Iowa lead rocks the Magnesian Formation and the Galeniferous Limestone, in commemoration of the fact that in England the same names were used for the lead-bearing formations above the Mountain Limestone, which were regarded as Permian in age. The statement was repeated as fact for many years afterwards.

Schoolcraft's idea was from time to time elaborated, until its necessary consequences had to be finally supported by the assumption that the ore bodies were primarily deposited under the influence of favorable local currents on the floor of the ancient ocean. In some form or other this curious notion quite generally prevailed for more than half a century. Even at the present day it is in some quarters seriously upheld.

With certain severe limitations Schoolcraft's theory is still one of the most useful geological tenets in mining.

GEOGRAPHIC DELINEATION OF IOWA

So soon as Congress, in 1838, made provision for erecting a new territory under the name of Iowa the engineering corps of the United States army sent out a party to prepare a detailed map of

[9] Narrative Journal of Travels etc., to Sources of Mississippi River, Cass Exped., 414 pp., Albany, 1821.

the country. This work was intrusted to Joseph N. Nicollet, a French geographer.

Along with his geographic and engineering abilities Nicollet possessed a keen appreciation for matters geological. His practical familiarity with fossils was quite extraordinary. He was acquainted with Murchison's then new classification of rock-terranes. Notwithstanding the fact that his strictly geological observations in Iowaland were incidental only to his special work in hand, he presented a wealth of interesting items concerning the geology of the region. He was the first to announce that in the lead district of Dubuque the main mineral-bearing formation should be correlated with Locke's Cliff limestone of Ohio, and Hall's Trenton limestone of New York. Calcareous rocks outcropping near the mouth of the Big Sioux river were shown, by microscopical examination, to be composed largely of minute shells like those occurring in typical chalk and to be of Cretacic age.

Nicollet's physiographic descriptions are notable productions. His finished map was a real marvel.[10] According to the high authority of Warren this map was "One of the greatest contributions ever made to American geography."

PRIMAL CLASSIFICATION OF IOWAN GEOLOGICAL FORMATIONS

First efforts to arrange the rock terranes of Iowa in orderly succession according to modern criteria was by Dr. D. D. Owen, in 1840.[11] This scheme grew out of his examination of the mineral lands of the Dubuque district, as a part of a comprehensive plan adopted by the Federal government to separate the mining properties from those which were not ore-producing.

Owen's subdivision of the Cliff limestone into Upper, Middle and Lower sections proves to be valid. This scheme having passed every test stands today essentially as originally proposed. These subdivisions are respectively the Devonic, Siluric and Ordovicic successions of later nomenclature. In the second and revised edition of the report these names actually appear.[12] Thus four major subdivisions of the Paleozoic sequence are upon strictly faunal grounds firmly established in the West. The rocks of the Cambric system, as it is now called, could not very well have attracted Owen's

[10]Rept. Intended to Illustrate a Map of the Hydrographic Basin of the Upper Mississippi River: Twenty-sixth Cong., 2nd Sess., Sen. Doc. Vol. V, pt. ii, No. 237, 177 pp., 1843.

[11]Rept. Geol. Expl. Iowa, Wisc. and Ill.; Twenty-sixth Cong., 1st Sess., House Doc., No. 239, 161 pp., 1840.

[12]Thirtieth Cong., 1st Sess., Sen. Ex. Doc. No. 57, 1848.

attention at this time, since they are exposed mainly outside of the field in which he then worked.

At a somewhat later date[13] Owen further elaborated upon his classificatory scheme and instituted a parallelism between the Iowa and the New York sections.

INTRODUCTION OF THE ENGLISH ROCK-SCHEME INTO AMERICA

Although the English classification of geological terranes was not yet a decade old Owen already incorporated it in his Iowa work. Up to the time of the appearance of Owen's report (1844), Thomas Conrad seems to have been the only American geologist who was at all inclined to recognize the new English classification. His application of it to the New York rocks was surprisingly unfortunate. During the time that he was superintendent of the New York Geological Survey and the annual reports of the four districts were being published, an attempt was made to harmonize the New York section with that of England. The effort was far from proving satisfactory. Partly for this reason and partly, perhaps, on account of the fact that the New York geologists, after Conrad had left the survey, were carried away with the idea of establishing instead of a Paleozoic sequence, a "New York System," the final reports came out, in 1843, with Conrad's plans entirely abandoned.

When, then, the second and revised edition of the "Report of the Geological Exploration of Iowa, Wisconsin and Illinois" appeared, in 1844, Owen was the only geologist in this country who had with any degree of success adapted the novel English classification of rock formations, and who had accurately determined their stratigraphic delimitations in a definite section. His earlier subdivision of the Cliff limestone into three parts of Upper, Middle and Lower, were here called Upper Shell Beds, or Devonian, the Middle Coralline Beds, or Upper Silurian, and the Lower Lead-bearing Beds, or Lower Silurian. These several subdivisions were, he astutely remarks, also distinguished by their contained fossils; and he enumerated and illustrated some of the most characteristic forms.

As pioneer of pioneers Owen was a man of remarkably keen insight into matters geological. The acumen which he, in a perfectly virgin country, displayed in deciphering the problems which successively presented themselves would have done credit to any one, even the geologist of today. In our state, in Missouri, and in Minnesota, I have personally in the field gone over much of his work, and I have had repeated occasion to verify his recorded results in

[13] Rept. Geol. Surv. Wisc., Iowa and Minn., 638 pp., 1852.

detail. I cannot but express the warmest admiration for his great skill in unravelling difficult problems, his remarkable accuracy of observation, and his invariable sound geological reasoning. In his methods of investigation three unique features are conspicuously presented. His plan of correlating geological outcrops more or less widely separated geographically by means of the combined evidences of lithologic resemblance, stratigraphic continuity, and continuity of lithologic sequence, and of plotting sections along exposed lines of streams, preceded by a generation their general adoption by American field geologists. By half a century he anticipated modern geologic requirements, when he defined his terranes by clearly noting, as essential elements of exact definition, their topographic expression, their geographic extent, their lithologic character, their stratigraphic delimitation, their biotic definition, and their economic content. In soundness of logical deduction his generalizations stand every test. All of these characteristics are repeatedly displayed for the first time in the published results of his investigations in Iowa.

One of the curious analogies which his keen penetration established was a remarkable parallelism which he seemed to find existing between the sequence of Carboniferous limestones as displayed in Iowa and the succession worked out by Phillips in England. The comparison clearly indicates the great influence which his English training in geology had upon him.

GOVERNMENTAL LEASING OF MINERAL LANDS

A recent proposal, which has been received by the public with great acclaim, is for the government to hold the control of mineral lands as public domain and lease claims to miners and operators. Whatever may now be the merits of the plan it is certain that it once had fullest trial in Iowa and proved to be a most dismal failure. Its immediate effects upon the mining industry, which at that time was quite flourishing, were the most disastrous ever experienced. Mining in this state never recovered. For long years it was practically ruined.

It was in 1807, soon after taking possession of the Louisiana Purchase, that the United States government announced a new policy respecting the development of mineral lands. It was a number of years before the scheme could be put into operation. Such lands were especially reserved. In Iowa-land nearly 200,000 acres were thus set aside. A system of leases was ordered. By paying the government a royalty of 10 per cent individuals were permitted to extract ore for a period of three or five years.

During the years immediately following the promulgation of the new ruling large numbers of prospectors and miners entered the region. Curiously enough they made agreements with the Indians rather than with the government. It was not until 1816 that the Indian rights were definitely defined and a "tract five leagues square on the Mississippi river, to be designated by the President," which the Indian treaty provided, was located in the lead region. The first leases from the government were not executed until the beginning of 1822, when four miners from Kentucky located 160 acres each. They were protected by a detachment of United States soldiers.

After granting the leases the government often failed to stand by the owners thereof. Soon continuous strife prevailed among the miners. They began to pay little attention to the regulations, but carried on operations without license, and with the aid of the Indians. Where there was one lease granted there were a score of unlicensed miners. So disastrous to all concerned was the experiment of leasing and so inconsequential was the revenue derived from this source that Congress finally, in 1846, abandoned the plan, and a year later placed the lands on the market for sale. Little wonder that during these years such remarkable industry was displayed by the "Indians," as was from time to time reported. A United States Indian agent, who passed through the region in 1810, recorded that the Indians were finding mining more profitable than hunting and were producing during that year 400,000 pounds of the metal.

INAUGURATION OF THE NEW YORK SYSTEM IN THE WEST

In the third and fourth decades of the last century New York geologists were enaged in working out a detailed stratigraphic section of their rocks. So complete was this sequence that they became ambitious to establish for the world at large a New York System, after the fashion of Murchison's Siluria and Sedgwick's Cambria in England. But the New York section proved to be too large, and to embrace a succession of superior rank. It was found to be about the equivalent of what we now call the Paleozoic section, thus including Murchison's, Sedgwick's and Lonsdale's systems. Following Murchison the New York geologists gave geographic titles to their formations, which names have spread to all parts of the country.

When, then, at the solicitation of Governor Grimes, James Hall was called from New York to conduct the newly established geological survey of Iowa, he at once proceeded to transplant the New

York rock-scheme and nomenclature to our state.[14]. Hall was not entirely unfamiliar with the western field. Some time previously he had made an extensive geological trip through the upper Mississippi valley with the special object in view of extending the New York System. He had already the aid of Nicollet, Owen and others, who had established a close parallelism between eastern and western sections. So, when he reached Iowa, as state geologist, matters were already disposed very much to his liking.

In introducing the New York classification into Iowa Hall appears to have displayed the same intense prejudice against the new English scheme that he did a decade earlier in his eastern reports. There is no mention of the English systems in his table of geological formations. The noting of them on the accompanying map seems to have been done by other hands. For many years the New York formational names given by Hall to western terranes were much in evidence in the geological literature on the region. Gradually these titles were displaced as unsuitable, until at the present time few of them remain.

But the English scheme proved fundamental and in its essentials was adopted the world over.

DETERMINATION OF THICKNESS OF IOWA ROCK FORMATIONS

The conspicuous service which Dr. C. A. White rendered the state was the determination of the thicknesses of the various geological formations. In the main these figures were reasonably correct. Without any deep-well records to serve as checks on the estimates the results are often surprisingly close. The vertical extent of the Cretacic rocks of the northwestern parts of the state and of the coal measures of the southwestern portions are especially noteworthy.[15]

The great economic value of White's estimates of rock thicknesses was, of course, the purposes which they served in furnishing clues to local underground geology. They were especially helpful in a region so deeply mantled with glacial drift as Iowa is. As guides to boring deep wells for artesian waters, to prospecting for coal and to search for other mineral wealth deeply hidden, their wide serviceability was in after years recognized by the present state survey and similar work was entered into exhaustively. White's work served its purpose for a period of more than twenty-five years, until newer figures could supplant the older ones.

[14]Geology of Iowa, 2 vols., Albany, 1858.
[15]Geology of Iowa, 2 Vols., Des Moines, 1870.

EVOLUTION OF PALEOZOIC FISHES

When in the early '70's of the last century Orestes St. John, an Iowa youth, first attacked the problems concerning the ancient fishes few forms were known to occur below the Carbonic horizons. The great wealth of material of this description was just beginning to be discovered in Iowa and the adjoining states. After completing his work on the Iowa geological survey, St. John turned his attention to the fossil fishes. Large collections had been made at Burlington, Keokuk, and other parts of southeastern Iowa. Under the tutelage of the elder Agassiz, the foremost authority on fish life, our Iowan began his labors along these lines.

The measure of St. John's wide researches on the character and development of the Paleozoic fishes is found in the numerous memoirs which were issued in rapid succession and the several more pretentious monographs, all of which amply testify how extensively he contributed to our knowledge of the subject. Although working so long and so far from his native state it is a singular coincidence that he should have found in these distant places that the main collections consisted of materials obtained from his old home. Through his almost uncanny skill in reconstructing these ancient organisms Iowa became famous the world over.[16]

St. John's efforts did not stop at merely pointing out the genetic relationships of the old fishes, or in delineating their structures. His descriptions are complete, lucid, illuminating. Few of the forms which he described need redefinition—even after the elapse of fifty years. Large numbers of forms were noted and pictured as new to science.

GARDEN OF STONE LILIES

As is now generally known, Iowa is the most celebrated district in all the world on account of the prolific occurrence of remains of those beautiful fossil forms popularly called stone lilies or stemmed feather-stars. It is to Iowa men that we are mainly indebted for a monumental work on these curious forms of bygone life. Already three large volumes are published. "North American Fossil Crinoidea Camerata"[17] is one of the unique literary productions in new world paleontology. Although the senior author, Charles Wachsmuth, of Burlington, was not permitted to see the completion of this prodigious work, the investigations go on with unabated vigor under the undefatigable labors of the junior colleague, Frank

[16] Illinois Geol., Surv., Vol. VI, 1875.
[17] Memoirs of Mus. Comp. Zool., 3 Vols., Cambridge, 1895.

Springer, another Iowa scientist. In direct continuation of this paleontological *chef d'ouvre* other volumes are now in press.

Notwithstanding the fact that the work is first of all morphological in character from the foundation up, and the product of inquiries more thoroughly grounded in biological philosophy than any other research perhaps ever undertaken in this country, the published results are of such high utility in stratigraphy, especially in the broad Mississippi basin, that it may be truly said no other one publication has ever furnished so valuable criteria for the purposes of exact correlation of geological formations.

Of all fossil remains of organisms none are more admirably adapted to morphological study than those of the echinoderms. On account of their abundance, their peculiarities in geographic and geologic distribution, and their notable structure, the stalked featherstars, or stone liles, are pre-eminent. With the skeletal parts composed of regular plates, or ossicles, definitely grouped and frequently highly sculptured, all structural changes are readily traced.

The systematic arrangement of the crinoids as proposed by Wachsmuth and Springer is one that will require but few material modifications for a long time to come. Based, as it is, upon morphological principles, with a completeness and wealth of ontogenetic and phylogenetic data that are rarely obtainable among fossil organisms, the essential elements of classification are more firmly grounded than perhaps in any other group. No attempt in recent years towards a natural and orderly arrangement of a large and complex assemblage of organic remains has been so signally successful. Nor has the evolution of the various types in time and space been neglected.

Although the morphological and classificatory chapters of the monograph on North American Crinoids appeal more directly to paleontologists interested in the biological side of the subject, the descriptive portions are of greatest practical value to stratigraphical geologists. This portion of the volumes is a complete revision of the different forms up to the time of publication. Every species is fully and clearly described, compared with closely related forms, beautifully illustrated, and referred to its proper geological horizon. All the forms are described anew from the most perfect materials that could be found in all museums and private collections.

DUALITY OF THE GLACIAL PERIOD

Admitting that Louis Agassiz's theory of continental glaciation to be one of the most brilliant generalizations of modern science, it is neither so complete nor so widely applicable as was at first supposed. What is even more important to its scientific value than the mere statement of the conception alone is the recognition of the fact that there is not one, but many, glacial epochs in the earth's history. Of course Croll's hypothesis provides the necessity of successive glacial periods, but it soon becomes apparent that his astronomical dates are too far apart to satisfactorily account for the vicissitudes of the epoch which we are now mainly studying. So we have to go back to the testimony of the glacial deposits themselves for our fundamental data.

The arguments for a dual glacial period, and at the time of its proposal, for a multiple ice age, were based chiefly upon the fact of the presence in certain till sections of thin black soil-streaks, replaced here and there by thicker peat-beds. That there might be such a thing as extensive interglacial sands or loams was not thought of. Yet they were actually observed, recorded and fully described a complete decade prior to the time when their true significance was pointed out. Such an interglacial loam deposit, intercalated between two thick till-sheets, is the one exposed on Capitol Hill, in the city of Des Moines. It was fully described[18] in great detail by W. J. McGee so far back as 1882. It seems to be the first expression of the phenomenon ever recorded the stratigraphic relations of which were unmistakable.

At the time when these observations were made the possible complexity of the Glacial Period was not even yet surmised. Possibilities of a Second Glacial Epoch were only vaguely being considered. The prolix and bitter controversy on the duality versus the unity of the Glacial Period was just beginning. Under these circumstances it was not at all surprising that some of the phenomena observed on Capitol Hill were partially misinterpreted; and that the true significance of others was for a considerable time overlooked. Then, too, the prevailing theory of the lacustrine origin of the loess tended to obscure the proper understanding of the accurately recorded data.

Notwithstanding the fact that McGee was inclined at the time to attach rather slight importance to his observations and to regard the phenomena as indicating merely local advance of the ice-sheet, it soon became manifest that the two till-blankets separated by a thick loess deposit was impeachable testimony in support of two distinct and great ice movements within the span of what was previously

[18] American. Jour. Sci., (3), Vol. XXIV, pp. 202-223, 1882.

regarded as a single one. So far as is known this appears to be the first and most important recorded evidence showing conclusively the complex character of the Ice Age.

Of similar import was the somewhat later description of a great drift section several miles farther south on the Des Moines river. In a paper read before our Academy, in 1890, it was shown that there was still another thick interglacial member to be reckoned with below the till-sheet underlying the loess. In later years officers of the Geological Survey were inclined to regard it as representing the pre-Kansan Aftonian sands and gravels.

As it is, our fellow Iowan narrowly escaped making one of the great half dozen geological generalizations of the nineteenth century—the establishment of the fact of the complexity of the great Ice Age.

PHYSIOGNOMY OF ANCIENT CONTINENTAL GLACIERS

The landscape expression of our state during glacial times is vividly set forth in fancy by W. J. McGee, in his great memoir[19] on the "Pleistocene History of Northeastern Iowa." At the time when the fieldwork was chiefly done the idea of a possible duality of the Glacial Period was new. Suitable criteria for correlating observations had yet to be formulated. The character of the phenomena were also unique in the annals of geological science. Here are McGee's own words as he pictures the conditions: "The most startling induction of geology, if not of modern science, is the glacial theory; but in the solution of the problem it is necessary to do more than assume the existence and action of the great sheet of ice hundreds or thousands of feet in thickness and hundreds or thousands of miles in extent. In order to explain the sum of the phenomena it is necessary to picture the great ice-sheet not only in its general form and extent but in its local features, its thickness, its direction and rate of movement over each square league, the inclination of its surface both at the top and the bottom, and the relation of these slopes to the subjacent surface of the earth and rock; and all this without a single stria or inch of ice-polish, save in one small spot, in the whole tract of 16,500 square miles. It is necessary to conceive not only the mode of melting of the ice at each league of its retreat, but also every considerable brook, every river, and every lake or pond formed by the melting, both at its under surface and on its upper surface; it is necessary to restore not only the margin of the *mer de glace* under each minute of latitude it oc-

[19]Eleventh Ann. Rept. U. S. Geol. Surv., pp. 110-577, 1893.

cupied, but, as well, the canons by which it was cleft, the floe-bearing lakes and mud-charged marshes with which it was fringed, each island of ice, and each ice-bound lake formed within its limits. And it is not only necessary to reconstruct the geography of a dozen episodes, as does the anatomist the skeleton from a few bones, but to develop the geography such as civilized eye has never seen, and which could exist under conditions such as utterly transcend the experience of civilized man. All this has been done. The trail of the ice monster has been traced, his magnitude measured, his form and even his features figured forth, and all from the slime of his body alone, where even his characteristic tracks fail."

COMPLEXITY OF THE GREAT ICE AGE

Iowa's role in the establishment of glacial succession was peculiarly fortunate. In the world-wide controversy which raged for more than a generation our state bore a conspicuous part. It was in Iowa that the first real evidences were found indicating a multiple instead of a unal character for the Glacial Period. They were Iowa men who made this telling discovery. In Iowa were differentiated not one but five prodigious drift sheets marking successive advancements of the vast fields of northern ice. On Iowa men devolved mainly the responsibility of first working out the complete and genetic relationships of these remarkable till mantles. Today the Iowa classification of the great Ice Age epochs is accepted by the whole world.

In order fully to appreciate the genuine importance of the Iowa results bearing upon glacial complexity as opposed to glacial unity the facts leading up to the birth of the conception may be briefly reviewed. So early as 1870 Edward Orton observed peatbeds intercalated in the glacial deposits of Ohio, and he rightly concluded, as it afterwards proved, that this feature indicated a warm interglacial epoch. He stated that evidences were now at hand for an orderly arrangement of post-Tertiary deposits. This dual aspect of the glacial debris was further substantiated by Leverett, Chamberlin, Gilbert, McGee and others. In the prolix discussion which necessarily followed, on the duality of the Glacial Period, the real facts were overlooked or misinterpreted, and the possibility of a multiple instead of either a unal or dual Ice Age was lost sight of completely. Once suggested, however, the multiple hypothesis, about the year 1893, gained general acceptance among scientific men.

It is a quite noteworthy circumstance, as Prof. R. D. Salisbury recently points out, that Prof. Samuel Calvin, of Iowa, who, after a lifetime's devotion of his geological energies to investigation in totatally different fields, should suddenly turn to glacial geology with such signal success, and such notably productive results. In his presidential address before the Geological Society of America, at Baltimore, Professor Calvin gives a summary of the "Present Phase of the Pleistocene Problems in Iowa,"[20] in which the five subdivisions of the Glacial Period are distinctly outlined. These furnish the clue to the glacial history of our entire continent and of the world. Comparing these results with what was known twenty years before, it is forecast that another twenty years of effort will disclose other ice advancements of which we now know nothing.

CLIMATIC INDEX OF INTER-TILL DEPOSITS

Notwithstanding the fact that continental glaciation is a topic of absorbing interest, it is one of the grand triumphs of modern science to furnish such indisputable proofs that there existed in late geological times a prodigious polar ice-cap reaching so far down as the Ohio and Missouri rivers. Even until a generation or two ago few persons had intimation that an arctic climate had prevailed so recently over so large a part of the northern hemisphere. The conception of this veritable Ice Age stands out as one of the scientific novelties of which, says a recent writer, "our century may boast and which no previous century ever so much as faintly adumbrated."

While the majority of the glacialists were studying the evidences of glaciation one of our own Iowan sons, Prof. Frank Leverett, was directing much of his attention to the consideration and analysis of the deposits separating the several till-sheets.[21] So important were his conclusions that we now seem justified in assuming that the warm periods between the successive ice advances were as pronounced in their duration as the respective epochs of arctic climate. The necessary inference is that today we are living in the very midst of a typical interglacial time.

The evidences of these warm interglacial climates are now as abundant and as complete as are those of refrigeration. In supplying facts bearing upon this vague phase of the subject Iowa takes first rank.

SYSTEMATIC REVISION OF THE FOSSIL CRINOIDS

Since the lamented demise of Doctor Wachsmuth the latter's co-worker, Mr. Frank Springer, has carried on the investigations

[20]Bull. Geol. Soc. America, Vol. XX, pp. 133-152, New York, 1909.
[21]Mon. U. S. Geol. Surv., Vol. XXXVIII, 817 pp., Washington, 1899.

long ago jointly begun. Although Mr. Springer has delved alone into the subject for more than twenty years his results cannot be very well separated from those which were formerly carried on with his distinguished colleague.

The second installment of the great publication is now about to leave the press. All of these unique *recherches* from beginning to end may be regarded as having been initiated and accomplished in our state. It is to be regretted that Iowa could not have the pride to give birth in print to the grandest scientific and philosophic offspring she ever conceived. A distant state and a guardian government less slow to recognize the spark of genius, snatches from her the one greatest honor of a century.

All in all the systematic description, classification and illustration of the fossil crinoids is the most conspicuous single effort of the kind ever undertaken in this country. It is truly a colossal contribution to our knowledge of ancient life. Of all places of earth Iowa is the one from which it ordinarily might be least expected to emanate.

The continuation of the work soon to appear will equal that already published.[22] It is devoted entirely to the Flexibiliate forms, and will be superbly illustrated by an atlas of 100 large plates.

GENESIS OF THE SILICIOUS LOAMS

With the establishment by Iowa of systematic investigation of the natural phenomena under the ægis of a state survey the larger geographical problems rapidly took form. As data accumulated the various themes became circumscribed, and resolved themselves into fields all their own. Were it not for the tutelary supervision of the survey our geological knowledge might be still floundering in the slough of medievalism. First announcements of the results of many of these inquiries which were of more than local import or of worldwide interest, appeared in the Proceedings of our Academy.

Among the first of these moot questions to be imposed upon the attention of the officials of the survey was the derivation of the vast deposits of fine silicious loam, which we designate by the title of loess, and which mantle so much of our state.

The belief almost universally held by earth students that the deposits of silicious marls associated with the till-sheets were of glacial or lacustral origin long prevailed. In China it was long ago suggested that this loess was wind-derived, but the idea never, until recently, gained foothold elsewhere.

[22]North American Crinoidea Flexibilia, 3 vols., 4 to. Washington 1920.

Nevertheless, in Iowa, in spite of an adverse consensus of opinion, the peculiar distribution of the loess loams appeared to be such as seriously to call into question the verity of the accepted notion. On Capitol Hill, in Des Moines, thick loess deposits were displayed interbedded with tills. Later these sections gave first intimation of the possible wind-born character of the formation.

In after years loess was observed in the actual process of formation by means of the dusts blown off the Missouri river sandbars and from the dry upland plains of Kansas.[23] Still later the loess was identified with the adobe soils of western deserts.

It was on Capitol Hill, also, that first clues were found pointing to that wonderful interlocking of the continuous adobe mantle of the Southwest with the glacial till sheets of the Northeast.[24].

DIASTROPHIC TAXONOMY OF ROCK TERRANES

One of the larger problems connected with the coal investigations undertaken by the state survey was following the strand-line of the continental interior seas. The usual criteria of fossils proved unavailable partly because of the relative shortness of the time involved and partly for reason of the constant recurrence of the faunas. Although the reappearance of organic forms at successive horizons was no doubt a direct function of the oscillation of the old shore-line the nature of the biotic changes admitted of no definite characteristics upon which classificatory schemes could be established.

Recourse, therefore, had to be made directly to the coal measures themselves for testimony concerning their history. It so chanced that upon the epicontinental sea area the episodes of stratigraphical development proved to be unusually well marked. The practical outcome of the new plan was strongly contrasted by comparison of the resulting summary[25] of the Iowa formations with the general sections previously outlined.

The principles involved promised to be more than merely local in application. In recent years they were widely applied to distant parts of our continent. They were finally recognized the world over. It is probable that before many years have passed they will have entirely supplanted the usual criteria of the organic remains. In stratigraphy, therefore, diastrophism takes on a fundamental and genetic character.

[23]Am. Jour. Sci., (3), Vol. VI, pp. 299-304, 1898.
[24]Am. Jour. Sci., (4), Vol. XXXIII, pp. 32-34, 1912.
[25]Iowa Geol. Surv., Vol. XXII, pp. 154-155, 1913.

TERRANAL EQUIVALENCY OF UNCONFORMITY

Iowa's coal measures, as is now generally known, rest with marked discordance of strata upon the rough, tilted and beveled edges of all the older geological formations of the region. These unconformable relations are very widespread. This break in continuity of succession at the base of our coal-bearing series clearly represents an old land surface that was subjected to the forces of erosion for a period long enough for sloping strata to be planed off from the Carbonic limestones down to Cambric sandstones. In the interval between the deposition of the last of the early Carbonic formations and the coal measures of the upper Mississippi basin enormous regional denudation really took place. The magnitude and stratigraphic significance of this erosion was long little appreciated.

Commonly the phenomenon under consideration was regarded as local in its nature. Unconformities occurred at many different horizons in the coal measures. That this basal discordance was really a great hiatus was never fully considered. That the space represented an epoch much longer in duration than that in which was formed all the coal measures above it was a most startling phase of the problem presented.

The base of the Des Moines series, or lowest horizon of the coal measures of Missouri, was believed to extend southward beyond the Arkansas river, where it appeared to coincide with the Grady coal, or base of the Cavanoil formation. With the base of the Des Moines series of Missouri thus approximately located in the Arkansas section, and the top of the early Carbonic horizon well defined, it left in the south an immense thickness of nearly 19,000 feet of coal measures sediments that were entirely unrepresented in the north.

The magnitude of the hiatus at the base of the coal measures in Iowa, Missouri and Kansas, is the more readily comprehended when we find a place where uninterrupted sedimentation attained such vast proportions as 19,000 feet in vertical measurement. The epoch of which there is no measurable record in one part of the region finds in the adjoining district sediments of greater stratigraphic significance than all the coal measures above the break.[26] It is a case in which on one side of an old shore-line is the land area that suffered profound denudation, and on the other the water area in which sedimentation was carried on to a prodigious extent. In point of time the one is the exact equivalent of the other.

[26] Bull. Geol. Soc. America, Vol. XII, pp. 173-196, 1901.

SCHEMATIC STANDARD FOR AMERICAN CARBONIC ROCKS

As the Iowa Carbonic section began to expand it became manifest that there were considerable portions of it which were to be found in better representation elsewhere. When, finally, certain guide-horizons were traced from outcrop to outcrop southward across Missouri into Arkansas and southwestward into Kansas the section gradually assumed extraordinary completeness. It resolved itself into what was the most perfect section of the entire country, perhaps of the world. This fact at once pointed out its possible availability as a standard scheme for the American continent.[27]

Nine-tenths of this great section are represented in our state only by an unconformity plane; yet taking into account its southern extension its chief merit is its exceptional completeness. No other section of the Carbonic rocks on the continent possesses such an enormous thickness. The several series of the general succession appear to be more sharply defined than anywhere else. Few columns have the base so abruptly cut off from the Devonic terranes below. At the top Cretacic strata often rest upon it in marked unconformity. Instead of attempting to fit the Mississippi valley section into that of Pennsylvania, as is usually done, effort is far more fruitful of satisfactory results by bringing the rock succession of the latter into accord with the former. Also, in place of trying to extend the Mississippi basin classification to the Rocky Mountain region the formations of the latter are best apposed to those of the first mentioned.

Until recently, more or less difficulty in securing results that are even approximately satisfactory have always attended the efforts to parallel the various provincial sections of the Carbonic succession. The sections of the East, of the Interior, and of the West appear at first glance to have no comparable elements. These discrepancies are now all removed. The out-standing features are the completeness and great thickness of the Mississippi Valley succession. It is most imposing rock section of which we know.

Apparently influenced mainly by such consideration as these Professor Chamberlin is inclined to emphasize the time significance of our coal measures depositions and in the general classificatory scheme give the span they occupy an exalted taxonomic rank equivalent to Period. There are, however, essentials other than those of thickness. The mere fact that the column of sediments measure 20,000 feet does not necessarily remove the terrane from the serial class.

[27]Iowa Geol. Surv. Vol. II, Coal Deposits, pp. 162-171, 1894.

EXPANSE OF COAL HORIZONS

Very unexpectedly Iowan coal measures in yielding up their secrets lately brought into perfect harmony the two diametrically opposed hypotheses concerning the disposition of coal beds, a problem which was the subject of bitter controversy for many years the world over. On the one hand it was contended that there existed a strict parallelism in the stratigraphic relations of coal seems. On the other hand it was held that coal beds were always set at an angle to one another; they split, came together, diverged.

Stratigraphic analysis of a circumscribed Iowa coal basin disclosed the fact that the two opposed views were not really contradictory. Paradoxically as it seemed both were true. The main difficulty was that the two conclusions had only resulted from an approach of the theme from distinct angles. The one idea proved to represent a cross-section of the coal-bearing strata taken parallel to the general course of the shore-line; the other conception represented the structure at right angles to the strand-line.[28]

In other words approach to parallelism, or divergence of coal seams is a direct function of local diastrophism during Carbonic times. Instructive and interesting as this generalization is its practical aid to prospecting and development is of infinitely greater significance. Its importance in mining economy can hardly be over estimated.

Thus practically visualized coal horizons come to have an industrial meaning not usually ascribed to them. In stratigraphy, a geological horizon is a level recognizable over a considerable area, having a more or less well-defined stratigraphical position, distinctive as to lithologic features, and characterized by a particular set of fossils. In a broad sense the term is almost equivalent to formation, and is used about as indefinitely. In its more limited meaning it is applied properly to a minor part, or zone, of the smallest stratigraphic unit having a commonly accepted specific name. Understood in the same way, a "Coal Horizon" represents an even more limited expansion, where coal-forming materials have accumulated. In reality it is one of the greater planes of sedimentation, marking an episode in the deposition of a series of strata. Theoretically it represents not a phenomenon but rather a set of conditions, or a period during which the physical circumstances were similar over a considerable marginal portion of a geologic province. From an economic angle it stands not for a

[28]Journal of Geology, Vol. II, pp. 178-186, 1894.

continuous bed of mineral fuel but for a stratigraphic level where workable coal is to be especially sought for in a wide belt fringing a great basin.

CONTINENTAL TERRANAL CORRELATION BY OROTAXIS

What continues today to bother the geologist more perhaps than any other subject relating to earth knowledge is the problem of exact stratigraphic correlation. It is, indeed, a phase of geology which has been a source of embarrassment ever since the science's birth two centuries ago. When, during the last quarter of the last century, stratigraphy began to demand quantitative rather than qualitative results other stratal criteria had to be found which in the field are of even greater practical value than could be hoped for with the fossils. When comparisons are made with other criteria the shortcomings of the paleontologic methods become glaringly unsatisfactory. Closely examined the paleontologic scheme of geologic classification is found to be not an arrangement of terranes at all, nor a logical table of historic events, but merely a rather imperfect grouping of faunas. The question arises whether in stratigraphy we should not be better off today if we were to ignore the fossils altogether, or recognize them only in a general way.

As originally defined[29] orotaxis, or stratigraphic classification upon the basis of diastatic or diastrophic movements is essentially as follows: Immediate cause for the changes which take place in the relations of the land and the sea areas is is to be sought in orogenic and epeirogenic movements. Since, however, the two kinds of crustal oscillation cannot be readily distinguished practically, and as it is of small advantage to separate them theoretically, the structural results produced may be regarded as arising from the same cause—that is, from mountain-making forces. The greatest and most abrupt modifications in sedimentation, and consequently in lithologic, faunal and, in fact, all characters, are those connected directly with diastatic activity, producing depression of some areas and the uprising of others. Geologic chronology is believed, therefore, to find true and rational basis in those changes which primarily control sedimentation, and which are intimately connected with the genesis of mountains. It is proposed to emphasize this feature as fundamental by marking out the leading subdivisions of geologic time and to define general stratigraphic succession in accordance with the cycles of orogenic development, calling the classification a systematic arrangement of mountains, or orotaxis.

[29]American Geologist, Vol. XVIII, pp. 289-303, 1896.

The nicety and rapidity with which the orotaxial principles act in practice are indicated by a number of specific determinations. Furthermore, in the Upper Mississippi Valley the relative values of the different methods of correlation are capable of exact comparison.

In the present advanced stage of stratigraphical science, when reconnaissance work is no longer needful over a large part of our country, it appears that we have reached a point at which classification of geologic terranes begins to follow definite rules in accordance with the taxonomic ranks of the several geologic units, much in the same way that it is accomplished in botany or zoology. We may arbitrarily recognize the larger subdivisions as world-wide time units; and regard the sediments as deposited during certain cycles, or periods. The latter may also be again subdivided and still retain the time criterion. Below the taxonomic rank period, or sub-period, geologic sections become provincial in character. By clearly distinguishing between geologic history and biotic history geologic correlation is placed upon a rational, genetic, and philosophic foundation. Thereby is stratigraphy immeasurably advanced.

MOUNTAIN STRUCTURES UNDER THE PRAIRIES

That mountains should once spring forth where now is level land is one of the scientific novelties of our State. Of all places on earth the flat and monotonous plains are the last place where one would be inclined to look for traces of Alpine scenery. Yet mountains here there once surely were, albeit they now are completely vanquished, leveled to the sea, lost and forgotten. That there lie buried under the surface of the smooth illimitable prairie land the remains of a high and mighty range is a circumstance almost inconceivable. Although at the present day the suggestions of these old mountains are inconspicuous they are many. Through means of records of deep-well borings and other data, the height, extent, and form of the ancient mountains are fully figured forth and their characteristic features pictured out.

This great earth-wrinkle, which sprang from the sea in Mesozoic times, extended from the east shore of present Lake Superior southwestward beyond the path of the Missouri river. Medially the strata were bowed up more than a mile above the existing level of the prairies. In their prime these Siouan Mountains rivaled in scenic beauty and stately grandeur the Adirondacks, the southern Appalachians, or the Juras of today.

The sudden appearance and rapid decline of the Siouan Mountains on the mid-continental horizon is an incident of a by-gone age. Brief, brilliant, almost pathetic are the succession of chief events. The main uplifting took place during the Triassic period. In the succeding Jurassic and Comanchan times all of the ranges were completely razed to the present plains-level. During Cretacic time the waters of the sea again rolled unbrokenly over the old base-leveled plain, and the bared foundations of the former lofty mountains made up the bottom of a broad epi-continental sea. No great orogenic uplift was ever more rapidly or completely obliterated. It was one of the marvelous episodes in the long history of the North American land contest.[30]

SUBEQUAL SPACING OF CRUSTAL RUPTURES

Profound faulting is commonly associated with mountain development. In a plains region, and especially in sea-level basins of a continental interior, notable displacement of strata is about the last tectonic feature that one expects to encounter. The recent location in the Upper Mississippi Valley of a number of fault lines of considerable moment is one of the surprises of geologic inquiry in this region. Singularly Iowa appears to have been the locus of repeated crustal rupturing on a large scale.[31]

Both in our own state and in neighboring states, lately, some of the long neglected problems of regional tectonics have been attacked from new and unexpected quarters. Novel data have been obtained. Long known but isolated facts have been reviewed, reinterpreted, and re-correlated. The trend of the most fruitful lines of investigation has been pointed out. In Iowa, particularly, results quite disconcerting have been reached. Attention already has been directed to the vast Triassic mountain-building which took place within our boundaries. Especial interest, also, has been attached to the recent determination of the distinct synclinorial character of the Iowa coal-basin. Further, note has been made of another instructive phase of regional tectonics and the discovery of what has appeared to be two well-defined systems of faulting on a major scale, that has heretofore eluded detection.

The lines of faulting of the two systems trend nearly at right angles to each other. In the system which prevails in the eastern part of the state the direction of fracture is northwest and southeast. The amount of displacement is large. The spacing is wide.

[30]Proc. Iowa Acad. Sci., Vol. XXI, pp. 181-187, 1914.
[31]Proc. Iowa Acad. Sci., Vol. XXIII, pp. 103-112, 1916.

The ruptures are long and somewhat curved. In the other set, which is confined to the western portion of the state, the value of the movement figures is not nearly so great as in the case of the other; yet it is still quite notable. The space between faults represents a distance of about twenty-five miles. This figure suggests the spacing value of the entire system. Plotting upon the map of the state other lines to mark possible positions of other faults we find abundant indications of the presence of such features.

In partial explanation of this phenomenon we get an inkling from a neighboring source. It is a well known fact, established through extensive experience in mining operations, that when the interval between two parallel faults is determined other faults are expected to exist at like intervals. This circumstance is directly traceable to the nature of the tortional strains which rock-masses undergo. Whether or not such a high spacing value as twenty-five miles is actually possible remains to be determined theoretically. The problem is readily susceptible of mathematical demonstration, as in the cases of fault-systems of much closer pattern. It would be exceedingly instructive to apply the principles involved to the Iowa situation.

ANTIQUITY OF IOWA'S OLDEST ROCKS

Of late years the stratigraphic level of our lowest rocks is pushed back immeasurably. Now they rank with the oldest of any of which we have knowledge on the face of the globe. Terranes older than those of the Paleozoic age occupy in Iowa a very small surface area. Attention which is bestowed upon them is about commensurate with their relative surface extent. Heretofore, one finds that little attempt has been made to determine their broader stratigraphic relationships, their real position in the general geologic column, their possible subdivision, or their role in the geotectonics of the region. It seems all sufficient merely to note the existence of these rocks in the extreme northwestern corner of the state. Yet these very rocks now appear to have a history longer, more complicated, and more vicissitudinous than that of any other terrane represented within our borders.

For the first time we recently learn that some of these pre-Cambrian rocks are very much younger than was once thought to be the case; and that others are very much older. For the first time, also, we are now able to compare them with a standard section of the most ancient sediments known, that very complete and satisfactory classificatory scheme of the Lake Superior region adapted from Lawson's scale. Our rocks prove to be really an integral part of these northern masses, a long tongue of which extends from the Great Lake southwestward into Iowa and South Dakota.

The stratigraphic aspect of the Iowa pre-Cambrian rocks is fundamental. At this time the special geologic significance of the terranes of which they are an integral part, lies in the circumstance that they have suddenly acquired world-wide interest on account of the fact that they supply critical data for evaluating the duration of the pre-Cambrian periods. They give us a basis of comparison of the mid-continental section with the Paleozoic successions as we best know them. They enable us to formulate a systematic scheme of pre-Cambrian stratigraphy that is comparable in its variety, its complexity, its detail and extent, with the post-Cambrian standard which has been evolved during the course of the past century.

That wide interest aroused by the recent discoveries of abundant well-preserved organic remains in rocks of undoubted pre-Cambrian, and hence pre-Paleozoic, age is secondary only to the enthusiasm produced a few months ago by the actual location of the fossiliferous horizons in the general geological column. As definitely determined these oldest fossil-bearing levels are stratigraphically more than two miles beneath all other known horizons yielding traces of life. These revelations are, of course, as important biologically as geologically. They materially modify all of our previously held views on the subject. They open up a more inviting field of investigation than awaited the paleontologists of the first half of the last century when they started to unravel the life record preceding Cretacic time. They promise even greater triumphs than when the Paleozoics first revealed their secrets to Murchison, Sedgwick and Lonsdale.[32]

Thus to the bottom of the general geologic column as usually presented in the textbooks of the science, we are inserting a scale of fossiliferous formations the time-span of which equals or even surpasses in duration that covered by the entire Paleozoic succession.

ORIGIN OF EPIROTIC DEPOSITS

In commenting upon the potency of the wind as an erosional agent the late W. J. McGee astutely observes that the satisfactory disposal of the rock-waste of the desert by prodigious eolic exportation supplies the missing link to a rational explanation of all those

[32]Proc. Iowa Acad. Sci., Vol. XXIV, pp. 53-60, 1917.

long puzzling pheneomena presented by arid regions throughout the world. With the exportation and disposal of the dusts of the desert comes their disposition elsewhere. It is in connection with the last mentioned phase that Iowa plays such an important role.

In the recent consideration of subærial formations so many novelties enter that in many an old and familiar field a new interest is aroused. Prominent among such tracts is the country lying between the Rocky mountains and the Mississippi river. Both for the origin of the plains surface itself, and the unconsolidated deposits which immediately underlie it, no very satisfactory explanation is found except recently.

On a grand scale the Great Plains seem to introduce to us a mode of terranal genesis that has long passed unrecognized. Continental deposits thus begin to assume in this country an importance never before accorded them. The constant aggradation of the region appears to be due mainly to the potent activity of the winds.[33]

Concerning epirotic, or continental deposits several essential points are to be noted. They are as important as either marine or lacustrine terranes. On the whole American eolic deposits are of vast extent. They are being formed under conditions whereby they may be preserved through the geologic ages as effectually as any of the Cambrian formations have been. In this new century the theory of eolic planation, transportation and deposition promises to be one of the great and novel thoughts in the domains of geology.

PRE-GLACIAL CROSS DRAINAGE OF IOWA

Assuming with Powell that of all physiographic features the rivers are the most permanent one looks about for clues to what might be the drainage expression of our state before the continental ice-sheets covered the land. Present drainage is, we know, entirely a post-Glacial consequence; so there is manifestly no relation between it and that which existed prior to Glacial times. Except the small area around Dubuque every vestige of the ancient river courses is more or less deeply hidden by the till. In order to get at what prevailed before the coming of the glaciers we have to remove in fancy the great drift mantle.

Some insight into the character of Iowa's pre-Glacial waterways is obtained by consideration of the present streams which are outside of the drift-mantled area. In Tertiary times the lowest line of the continental interior depression was no doubt occupied

[33]Bull. Geol. Soc. America, Vol. XXII, pp. 687-714, 1911.

by a master-stream much in the same position as it is today. By the elevation of the Rocky mountains the rivers in the west must have been directed eastward down the long gentle slope until they finally reached the old Mississippi. Their present ending with the Missouri river is a later, or Glacial, consequence. At any rate several of the primitive streams must have continued entirely across the states of Iowa and Missouri.[34]

In marked contrast with the present smooth surface of our state the relief which prevailed at the end of Tertiary times and immediately before the first great ice invasion presents extreme differences of altitude of between 300 and 500 feet. Over the old elevations the drift is often scarcely more than a score of feet in thickness. In some of the old depressions and valleys the Glacial deposits are as much as 500 feet thick. The disposition of the low places is such that they lie in long belts or gorges having relatively steep sides. Some of these primitive troughs are manifestly the paths of extinct rivers. The one so well know at Des Moines is now followed far beyond that neighborbood. Its narrow belt is traceable northwestwardly to Sioux City where it unites with the gorge of the Missouri river.

EPI-CONTINENTAL ORIGIN OF GYPSUM DEPOSITS

Iowa's massive beds of gypsum being among the most famous in the country the mode of genesis attracts wide attention. So closely is their deposition always associated with the drying up of empounded waters of the ocean that any possibility of their having been formed under conditions other than those involved in the evaporation of sea-water is expressly precluded.

Quite recently to be sure, we now find that gypsum beds accumulate on a large scale far away from the influence of the sea. They are being extensively developed today on the highest and driest part of our continent. Dunes of gypsum sands that are vastly more pretentious than any of our Iowa beds accumulate under the activity of the winds. The fact that in Tertiary times western deserts probably extended eastward over the state suggests that our gypsum deposits, too, may have been segregated under conditions of excessive aridity.

The recent determination of the geologic age of the Iowa gypsum deposits, that the date of their origin is not Carbonic, nor Permian, nor Triassic, nor even Cretacic, as has been repeatedly advocated

[34]Proc. Iowa Acad. Sci., Vol. XXV, pp. 551-561, 1919.

at different times, but that it is probably Miocene, or Mid-Tertiary, has deep significance. It places at once the gypsum and associated Pink shales among true continental, or epirotic, deposits—accumulations on dry land and entirely independent of sea, lake, or river.[35]

FACETED FORM OF A COLLAPSING SPHEROID

Comparable with some of the work in the physical, chemical and engineering laboratories are some of the recent experimental inquiries initiated in geology in our state. It sometimes seems strange that in a prairie state like Iowa this laboratory experimentation should take the trend of the larger problems in geotectonics. In a line of research such as geology presents where the materials used are so largely dependent upon the immediate surroundings the selection of a topic that rests not upon place, matter or method is a decided novelty. Several widely different experiments have been recently completed.

In certain experiments lately performed in which heavy, rolled paper was used, the amount of collapse is measured by the diurnal change in the humidity of the air. On wet days the result is a surface of singularly large and perfect rhombohedrons. With paper not so tough relatively, or with the use of some brittle substance, no doubt rupture would take place along the edges of the facets. In all practical respects the lines of the great mountain upheavals of the globe are exactly located.

The application of the principles to teluric conditions is obvious. It is not necessary to postulate a cooling globe in order to consider the geometric effects of partial collapse. Because of the fact that with a given mass the body with the greatest surface area is a sphere, and the one with the least surface a four-sided form, it is sometimes argued that our planet is tending towards a tetrahedral earth. In the final analysis, however, it is indicated that the crystallographic form could hardly be so simple, but would result in a shape in which each facet of the ground-form consists of a number of smaller facets. The rhombic dodecahedron best fits the figure which the major mountain chains outline on the surface of the globe.[36]

MERIDIANAL DISPOSITION OF THE CONTINENTAL MASSES

In its basal significance our prevailing notion concerning continental mass is strictly geographic. In its definition tectonics finds

[35]Eng. and Mining Jour., Vol. C, p. 466, 1915.
[36]Bull. Geol. Soc. America, Vol. XXIX, p. 76, 1918.

no place. Relation of land and sea is made causal and essential; whereas it is only accidental and trivial. The outstanding feature is a broad basin with high mountainous rim, and low sea-level interior. Recent experimental reproductions of those broad basinal tracts which correspond to the oceanic depressions of the geoid are accompanied by results having curious significance. They point to the fact that we shall have to modify our fundamental conceptions concerning all the major deformations of the earth's crust.

Instead of distinguishing between continental elevations and oceanic depressions the proper discrimination to be made is between the cordilleran ridges of the continental borders and the intervening lowlands whether above the level of the waters in the continental interior, or below sea-level in the existing oceanic areas. The meridional disposition of the continents then comes to be readjusted as relatively narrow orographic ridges in place of broad basin-shaped plateaus.[37]

OROGRAPHIC DEFORMATION THROUGH DIMINISHING RATE OF EARTH'S ROTATION

From the results of recent curious experiments in geotectonics conducted within our boundaries it is inferred that the larger relief features of our globe are not really the complex dynamical phenomena commonly fancied but that they are all merely somewhat different expressions of the same simple tangential force and direct resultant of the earth's rotation.

Inquiry into the immediate origin of the great earth wrinkles is usually approached from an astronomical angle. Since on the assumption of a cooling globe the contractional hypothesis takes form it is premised that the earth passes through much the same course as does a shriveling apple.

As is well known, a rotating spheroid possessing notable elasticity does not have the geometric radius coincident with the radial line of molar equilibrium, or repose from stress. The first is a straight line; the second a section of a parabolic curve the focal coefficient of which varies with the rate of revolution. For obvious reasons the spheroid of the laboratory acts as a homogeneous body. Extending these physical principles to the earth complications at once set in. The zones of rock-flow and rock-fracture necessarily behave differently. The former acts as a homeogeneous body under hydrostatic pressure. The latter develops the characteristics of a heterogeneous body: it flexes, faults, and shears; and gives rise to all of

[37]Science, N. S., Vol. L, p. 413, 1919.

those tectonic phenomena which are commonly accounted for on the hypothesis of a contracting nucleus. Tangential compression thus may be initiated without regard to a cooling globe.

In laboratory experimentation on curved prisms, with bands corresponding to gravitational control, and with conditions under which there is gradual release of rotational stress analogous to retardation of the earth's rotation, there is reproduced to a nicety all of those larger structural features of the earth such as the ocean basins, the continental arches, cordilleran corrugations, and orographic foldings. The effects of tangential creeping which many mountain structures display thus appear to be not necessarily the result of earth's contraction but of direct cumulative stress-release due to secular retardation of the earth's rotation.

The bearings are far reaching. On this new basis, with the force and rate of retardation, and the amount of crustal shortening capable of exact expression by mathematical equations a ready means is provided for realizing not only something of Elie de Beaumont's fantastic dream of orographic symmetry, but for gauging in units of human time the age of every mountain uplift, for determining within very narrow limits in like terms the periodicity of every diastrophic movement, and for evaluating in years not only the span of every era and period, epoch and stage of the stratigraphic record since life appeared on our globe, but stratigraphic chronology long antedating the life record.[38]

GEOLOGICAL SURVEY OF IOWA

The collection of data concerning the mineral features of our state has now been carried on systematically and without interruption for more than twenty-five years. These have been years of exceeding productivity. Along with the more strictly scientific phases have gone on hand in hand an exhaustive investigation of our mineral resources. Thirty sumptuous volumes amply attest the vigor with which the work has been prosecuted. Many different workers have been engaged upon the myriad of problems presented. Varied as the results have been it has been surpassed by novelty.

Monumental inquiry of this kind is, of course, necessarily composite in character. The investigations are conducted by all earth students of the state, reinforced at times by chemists, physicists and engineers, and even by zoologists and botanists. Altogether the combined efforts make a most creditable showing. No other state

[38]Bull. Geol. Soc. America, Vol. XXX, 1919.

in the Union matches ours in the volume and general excellence of the published results. Of the geological information published relative to our state a digest alone covers a large volume of nearly a thousand pages.[39]

That a public scientific work should endure for a quarter of a century without interruption and without sudden changes of policy, weather the vicissitudes of unsympathetic legislatures, and overcome the prejudices of an indifferent people, is a circumstance mainly due to protective clauses in the organic law establishing the organization. Directly under the ægis of our Academy and our two great universities, capable scientific men guide its activities. The highest scientific talent of the state is always at command. By the simple provision of an *ex-officio* board of management control of the survey is entirely removed from insidious political influences, and the selfish interests of local cliques. Support of the work being by annual appropriation it is unnecessary to beg before an occupied legislature every biennium.

EPILOGUE.

Several years ago one of our Academy's worthy presidents, a zoologist by the way, in attempting to measure up the annual output of creative endeavor, incidently resorted to some comparative statistics. Unwittingly he drew attention to the fact that of Professor Cattell's eight "starred" men of science apportioned to our state, four were geologists. This remark called forth rather bitter response from the chemists, who would ascribe the ascendency of the earth students to the public financial aid which they received. A little reflection disclosed to all present that there is deeper reason than this really inconsequential material advantage.

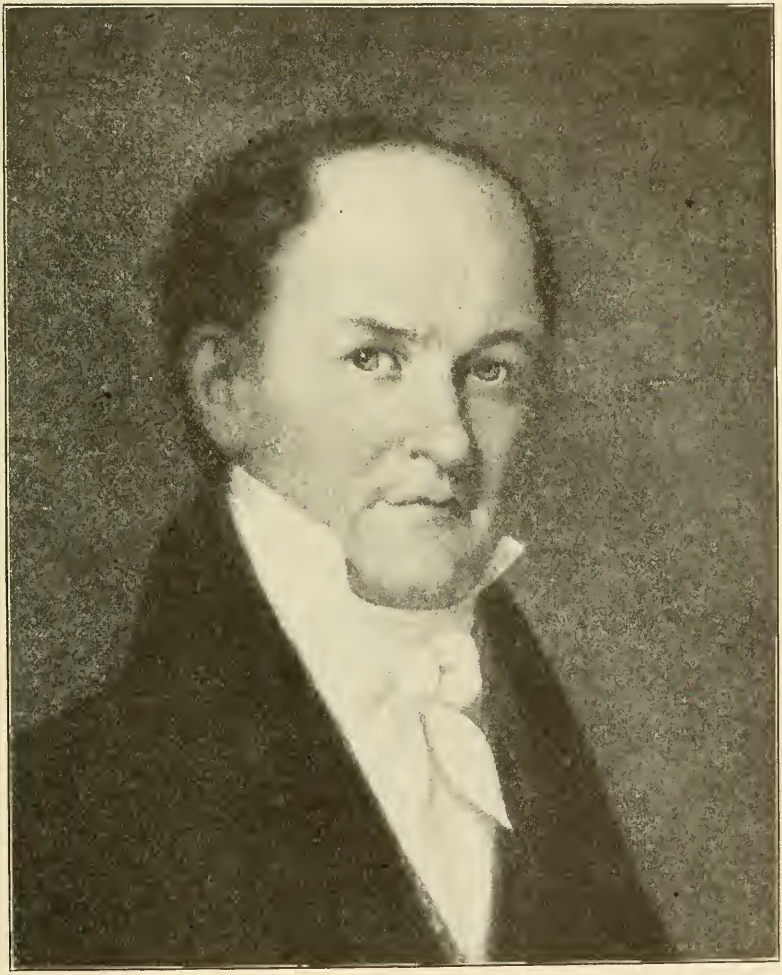
Singularly, Iowa geologists are prone to hook up their local *recherches* with problems of world-wide significance. In attempting to unravel the earth puzzles at home they also, by showing their bearing upon the broader problems, tend to do their bit in promoting knowledge generally. Their work thus becomes a part not altogether of curious home information alone, but an addition to the sum total of philosophical knowledge. Iowa takes active part in world discussions. Provincial workers pass from mere local to national or even world-wide sympathies. If, therefore, the Iowa geologists have any appreciable advantage over their *conferes* in other branches of science it is not due so much to slight material help, but principally to the acquirement of catholicity of sympathies

[39]Iowa Geol. Surv., Vol. XXII, 908, pp. 1913.

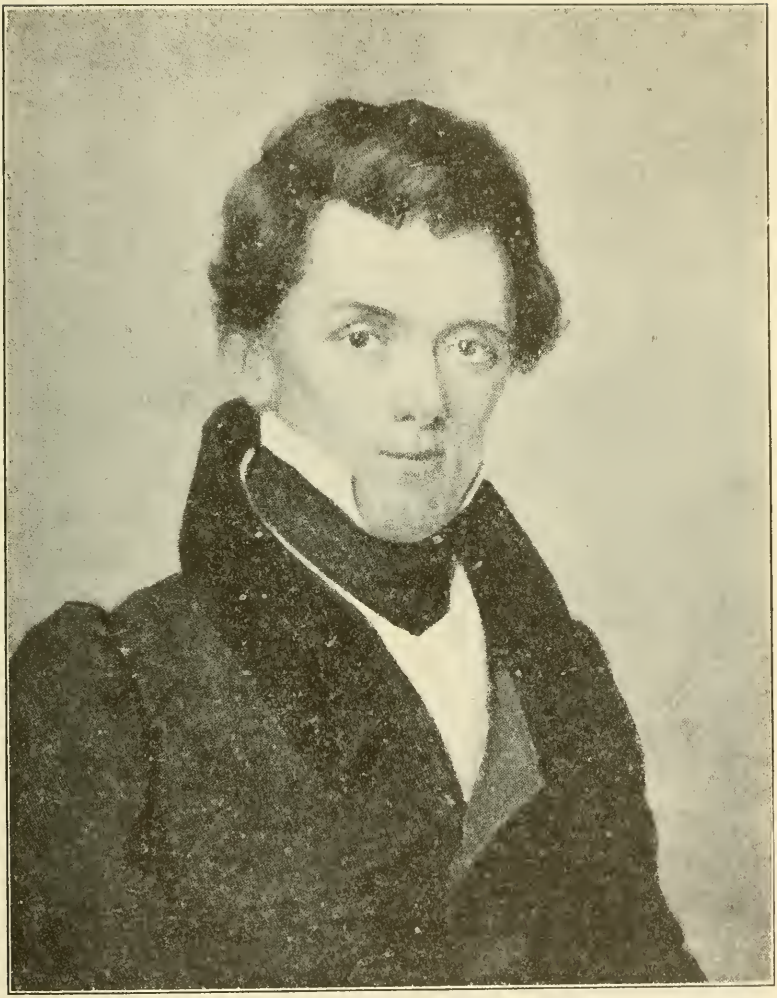
and of a broad and comprehensive manner of doing things of universal interest.

If fifty per cent of Iowa's "starred" men of science are geologists it is equally noteworthy that one-half of them do not happen to be connected with public bureaus or universities at all. The honor of becoming a "starred" man in any department of intellectual activity is certainly great. That all of Iowa's leading men of science are active members of this Academy is a matter of considerable state pride. It is surely a distinct personal achievement for any one of us to win a place for himself among the one thousand leading men of science in a country of a hundred million people, to attain during his generation especial eminence, to maintain himself as a commanding figure in the advanced thought of the nation, and to acquire something of a reputation throughout the world.

Iowa's geological century seems unusually replete with achievements of large moment.



Tho^s Nuttall



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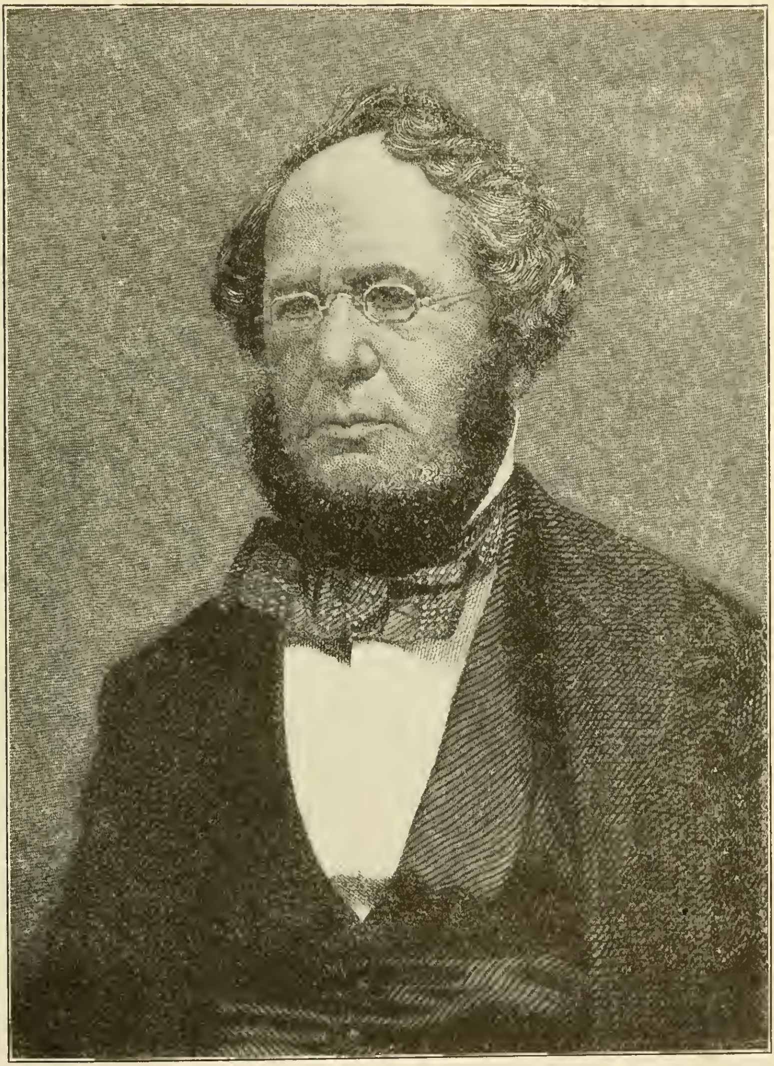
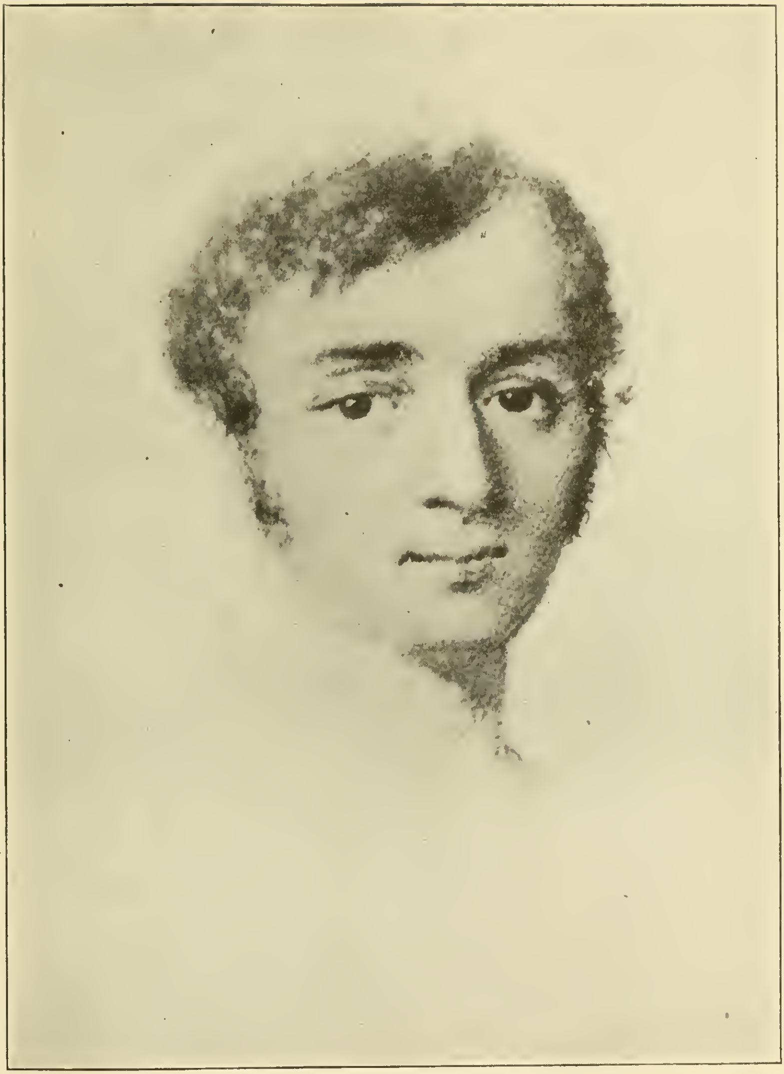


Henry R Schoolcraft



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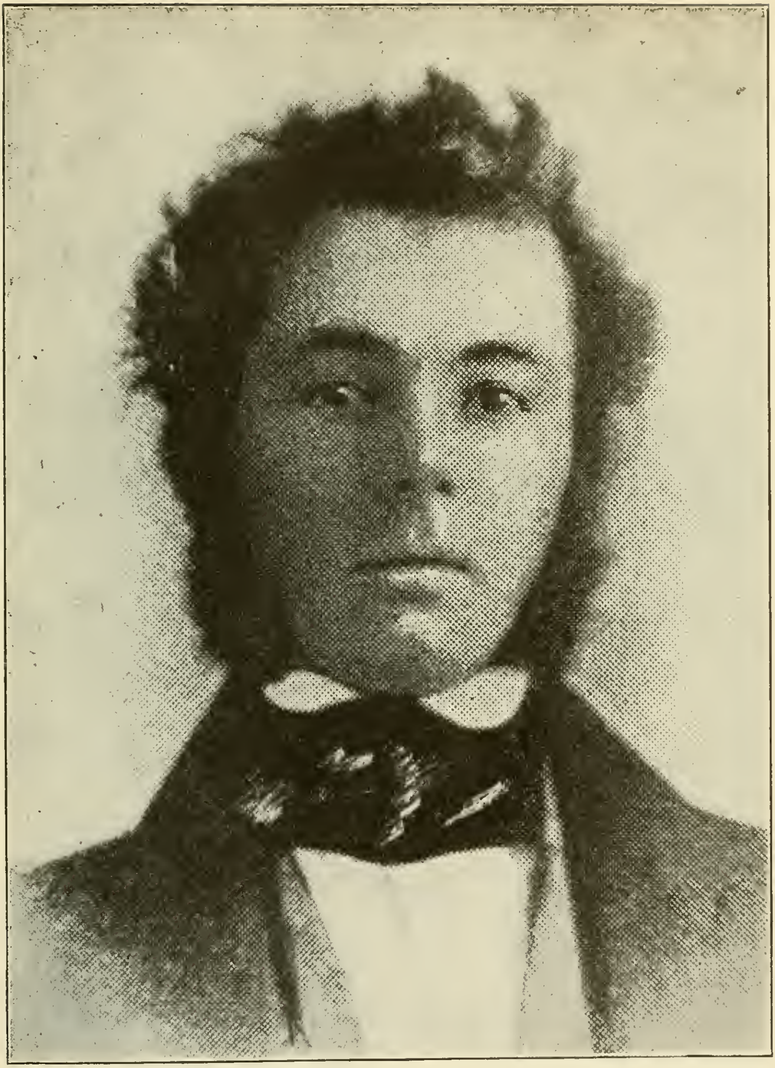
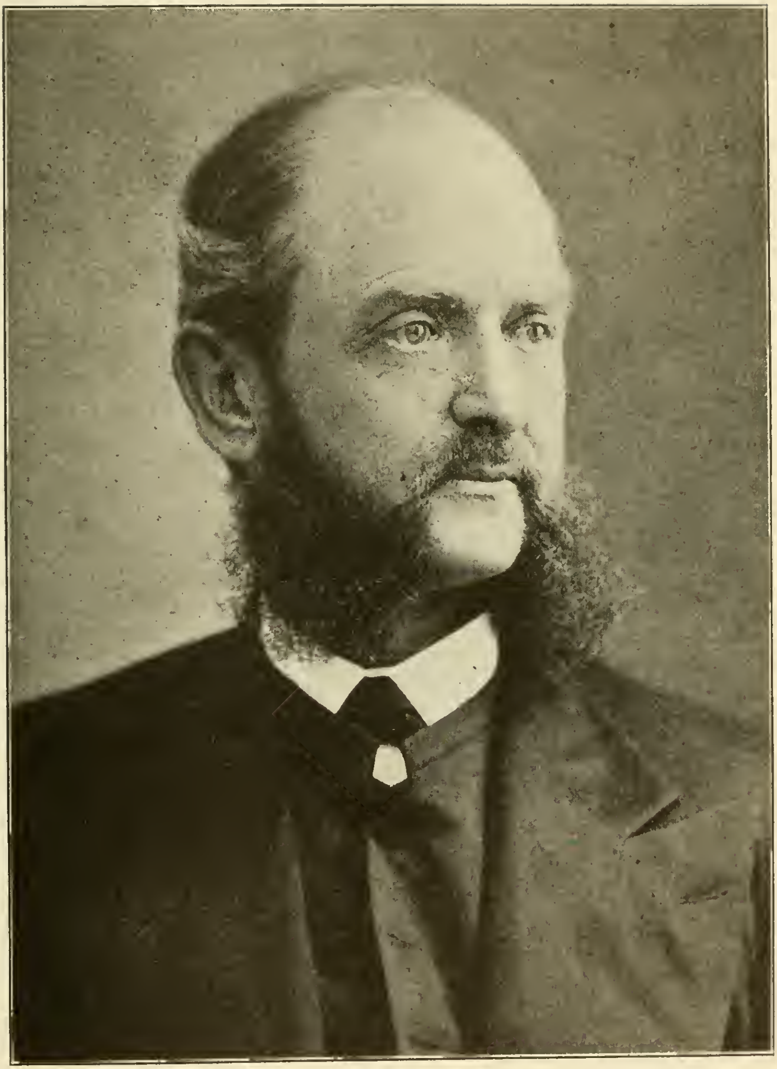
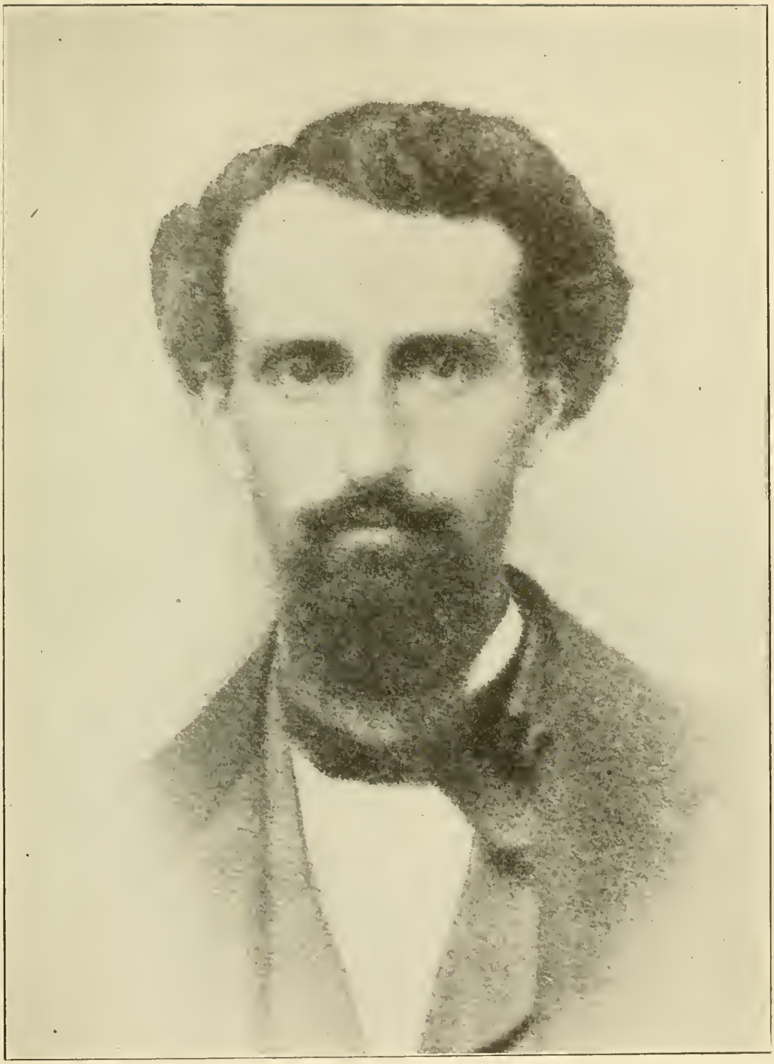
D. D. Owen.



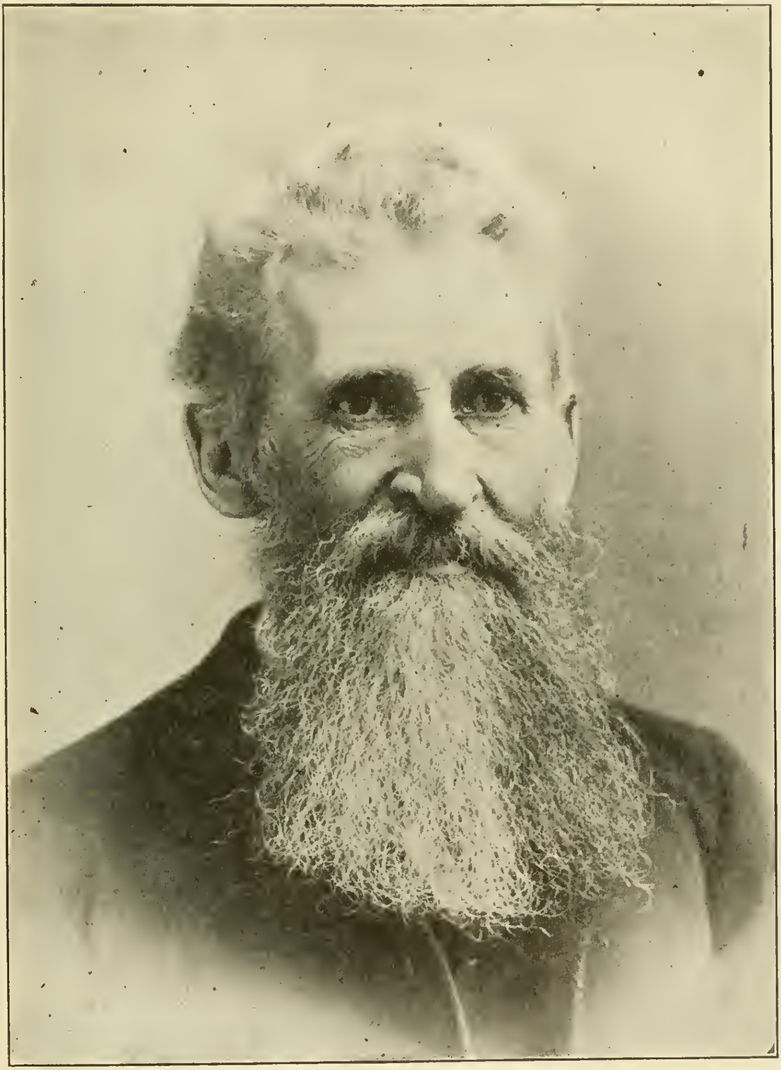
James Hall
State Geologist



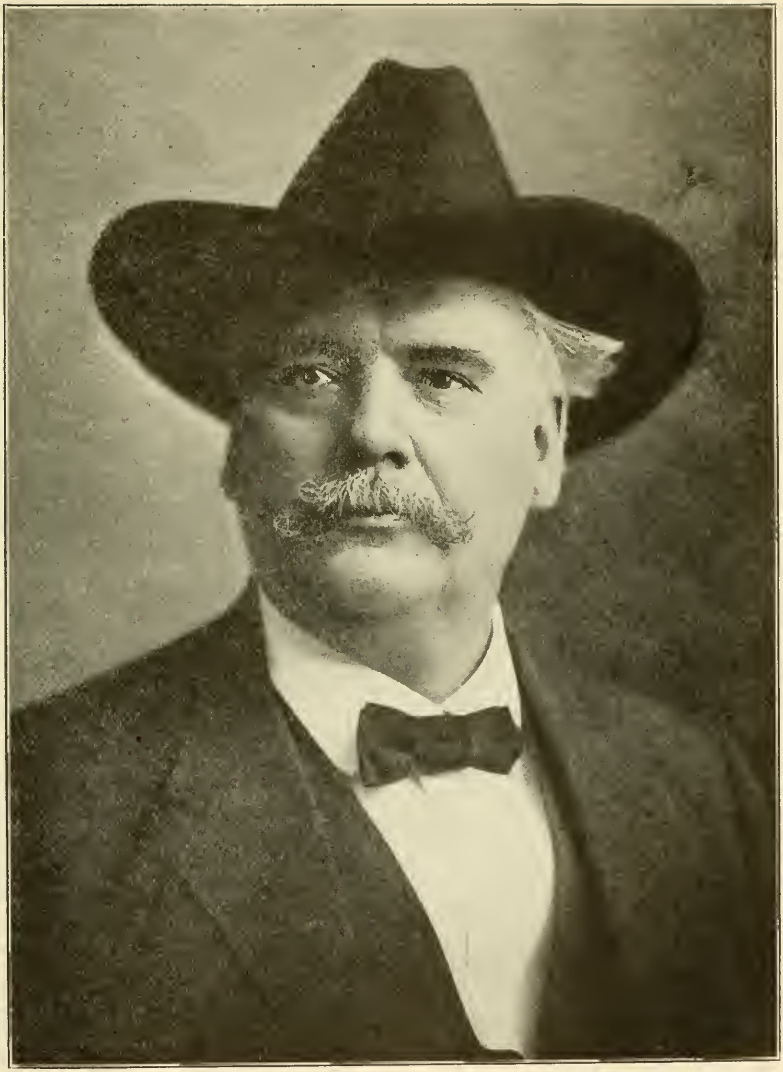
C. A. White



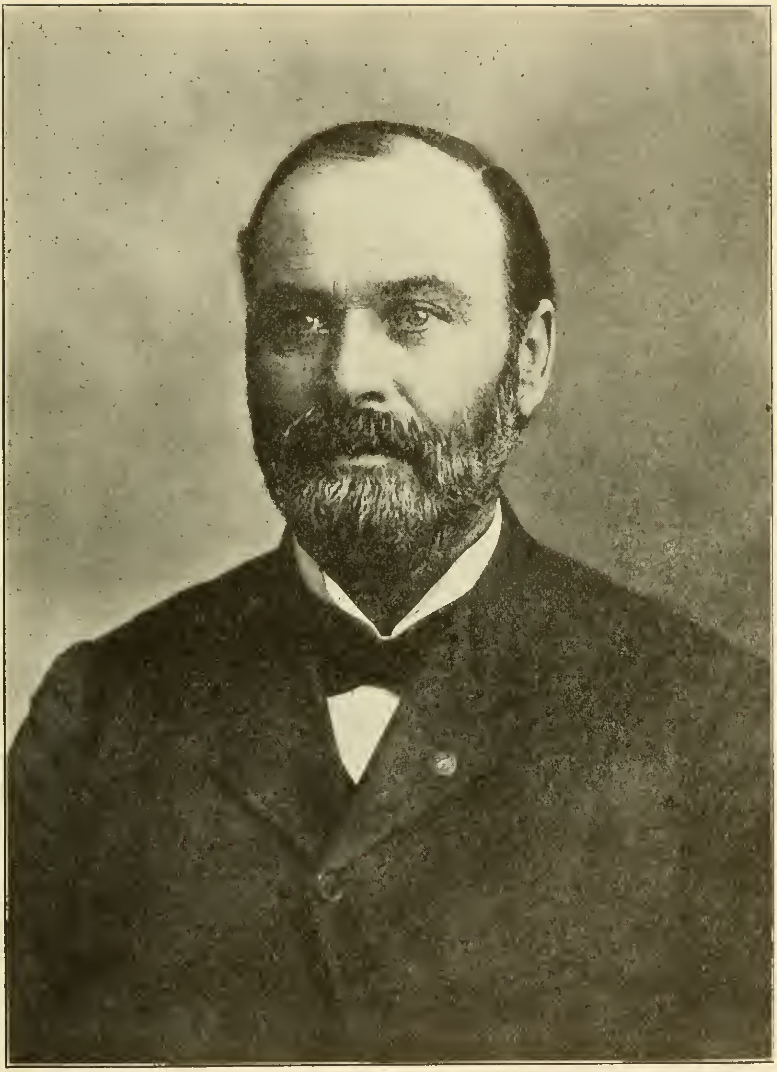
Yours most sincerely,
Orestes St. John.



Charles Wachsmuth



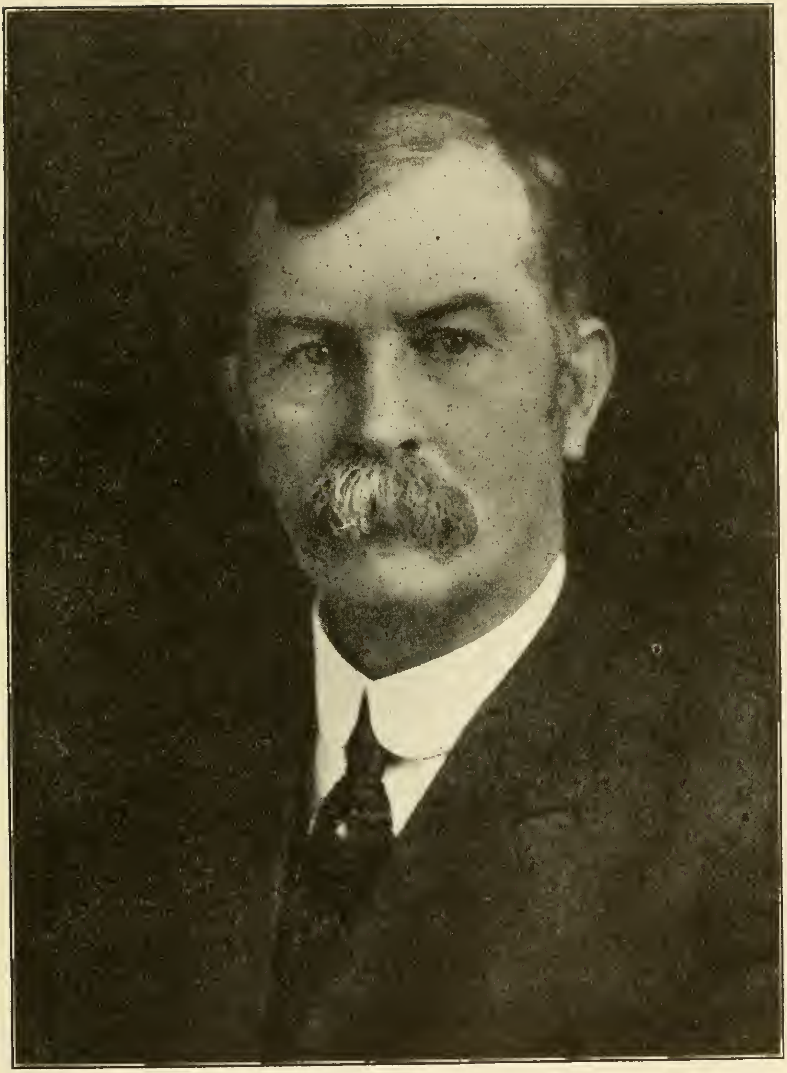
WJ McGee



Yours very truly,

Samuel Calvin.

Yours truly
Frank Leverett.



Frank Springer

SOUTHWARD EXTENSION OF THE BOZEMAN TERTIARIES INTO UTAH

CHARLES KEYES

(ABSTRACT)

Bozeman Beds is a term which is applied to certain gravel deposits that saddle the continental divide in Montana and Idaho. These beds are true epirotic accumulations. They appear to be mainly fluviatile in origin; although they manifestly are partly eolic in nature. Consisting of gravels, sands and silts they chiefly lie in old intermontane valleys. Their age is pre-Glacial.

Originally described and mapped in southwestern Montana and around the headwaters of the Missouri river they are traceable far beyond the confines of this basin. Inasmuch as the formations cover the flanks and crest of the Rocky Mountains it is inferred that they were laid down before that range was upraised. The peneplain surface so conspicuous in the Yellowstone Park may be the destructive contemporary of the constructive Bozeman deposits.

Since the time when the Bozeman Beds accumulated some curious physiographic changes appear to have taken place in the Missouri headwaters region. The Atlantic-Pacific drainage divide has shifted more than 150 miles to the westward. By headwater erosion the tributaries of the Missouri river have extended their valleys from Great Falls to the crest of the Bitterroot range. Thus the Missouri river has captured a large portion of the former catchment basin of the present Snake river. The latter was presumably the headwaters area of the old but now vanquished Virgen river, which formerly appeared as the twin branch of the Green river. As such it flowed through the Bonneville basin of eastern Utah, and united with Green river at the great bend in Arizona to form the Colorado river.

The extension of the Bozeman Beds of Montana over the Rocky Mountains into the valleys of the Salmon fork of the Columbia and the Snake river explains the presence of similar or identical deposits in the last named valley at Pocatello, Idaho. In the broad north and south valley south of that place the gravels and sands continue far into the Great Salt Lake basin. With this clue it is possible that

the Bozeman Beds may be eventually traced southward so far as the Arizona line.

The gravels of the Pocatello valley are sometimes regarded as having been deposited by the outlet of ancient Lake Bonneville. These coarse, fluviatile beds are well displayed near the Red Rock Pass, which, by the way, chances to be the present low-rim-point of the Bonneville basin. Singularly enough the Red Rock Pass presents none of the earmarks of a lacustral outlet. The manifest movement of the gravels and sands is directly opposite to that of the old lake's hypothetical discharge. To all appearances it is a point of stream entrance rather than of exit. As lately summed up the history of the ancient lake is as follows: The great body of water of which Great Salt Lake is a last vestige is not an anomaly among desert features, as is often regarded, but it merely represents a special phase of a through-flowing stream that was not quite large enough to master the orographic barriers which happened to arise athwart its path, while its nearest neighbor and parallel stream, the Grand river, reinforced by the Grand, and other eastern tributaries, proved sufficiently powerful to hold its own against all vicissitudes and to carve through the rapidly bulging Colorado dome a Titan among chasms. Blocked by such a formidable rampart as this great uplift the old Virgen river spread out behind the dam far and wide over the adjoining intermontane plains, until finally, after the stream's headwaters were diverted, it could no longer furnish the lake with its former supplies.

The main cause for the decline of ancient Lake Bonneville appears to have been the cutting off of the headwaters of the old Virgen river of which the lake was an inflated part. This depletion of water supplies seems to have taken place in two ways. The capture of its large gathering area by the Missouri river, by the Yellowstone river, by Clarke's fork of the Columbia river, and by the Salmon fork of the Columbia, a tract larger than the state of Massachusetts, displaced the larger part of the water supply. Choking of the old river channel at Pocatello by basalt flows completely eliminated the supply from this direction and turned the volume of the headwaters out over the Idaho lava plains where it finally gathered along the lowest line as the Snake river of today.

Now, the complex of headstreams which at the present time gather together to make up the Snake river of Idaho presents strong evidences of being a newly adjusted system. Traces of relatively recent diversions are indicated in many places. One of the principal tributaries, the Port Neuf river, after flowing due south for many miles, sharply swings around to the northwest and empties into the Snake river near Pocatello town. Another stream, the Bear river, likewise turns squarely upon itself, its upper half running parallel to the lower half but in a diametrically opposite direction. Other streams of the region have equally erratic courses.

Near Pocatello the Port Neuf river crosses an old stream channel of large size which is now filled high with lava, for the ancient drainage-ways and valleys of southern Idaho seem to have often flowed with liquid rock as well as water. This old channel apparently extends far to the northward. Southward it reaches the Red Rock Pass, and there coincides with the old river bed which Gilbert interpreted to represent the position of the outlet of Lake Bonneville. That this old channel belonged to a south-flowing, and not a north-running, river of considerable size seems to be clearly indicated by the disposition of the old stream gravels. The pebbles composing these gravels are not chiefly derived from local rock ledges, but from pre-Cambrian crystallines, such as characterize the Yellowstone Park region. They are numerous, of nearly uniform measurement, and of a size that suggests their removal a distance of about one hundred miles from their parent ledges.

While, then, there is not much doubt but that the Bozeman Beds extend well into Utah the further problem is their tracing southward to their ultimate limit.

STRATIGRAPHIC DELIMITATION OF ST. LOUIS FORMATION

CHARLES KEYES

Were it not for the fortunate circumstance that our early Carbonic section of the Mississippi valley is already split up and its long recognized geographic title Mississippian Formation restricted in its application to a minor part more nearly coinciding with the original proposal of the name, it is probable that this familiar term would now have to give way to an older designation. In the sense of a sub-periodic title St. Louis, or Louisian, has precedence by many years over either Mississippi, or Mississippian.

In the title St. Louis is focused the complete history of the differentiation of the Paleozoic rocks of not only the Mississippi valley, but of the American continent.

At the time when the name first came into use as a geological title St. Louis Limestone covered all the sequence of rocks lying between the coal measures and the St. Peter sandstone. This procedure was a direct outcome of the first attempts to correlate the Carbonic rocks of the Mississippi valley with the then recently established section of England. Thomas Nuttall[1] who had collected extensively the fossils along the Mississippi river between Dubuque and St. Louis, had found that the forms were similar to, or identical with, those described from the Mountain Limestones of Derbyshire. Although most of his collections were from the middle and southern sections of his Mississippi River trip this explorer, who was primarily a botanist and ornithologist, inferred that all of the limestones which he had encountered were of the same age. This idea seemed to be further supported by the presence of the lead deposits in both Iowa and Missouri. It was this circumstance mainly which later led Schoolcraft[2] to announce the parallelism of the Dubuque dolomites and the Metalliferous (Carboniferous) limestones of England. This, also, was the opinion of Featherstonaugh.[3] Curiously enough, the last mentioned author's elaborate discussion of

[1]Journ. Acad. Nat. Sci. Philadelphia, Vol. II, pt. i, pp. 14-52, 1821.

[2]Narrative Journal of Travels, etc., to Source of Mississippi, Cass Exped., 414 pp., Albany, 1821.

[3]Geol. Rept. Exam. made in 1834 of Elevated Country between Missouri and Red Rivers, 97 pp., 1835. (Twenty-third Cong., 2nd Sess., House Exc. Doc. No. 115.)

Murchison's and Sedgwick's rock formations of England had no connection with the geology of the region which he traversed.

In Ohio, Locke[4] and Mather,[5] and in Indiana, Owen,[6] had already used the term Cliff Limestone for what they thought was the stratigraphical equivalent of the English Cliff formation. This name was an adaptation of the Scottish word Scar Limestone, and Sedgwick's designation of the Carbonic limestone of the Lake District and of Yorkshire. Even so late as 1840 Owen[7] was inclined to regard the Mountain Limestone section as extending downward to what was afterward known as the St. Peter Sandstone, which latter he then considered to be the Old Red Sandstone or Devonian. It was only years subsequently that the Cliff Limestone was, after repeated restrictions, finally made the equivalent of the Niagara Limestone of New York. It was Owen,[8] also, who, suspecting something wrong in the prevailing correlations, proposed to call the section between the Coal Measures and the St. Peter Sandstone the sub-Carboniferous limestones.

This, then, was the state of knowledge concerning the formations below the Coal Measures when the term St. Louis Limestone first appeared as a distinctive geological title. When, in 1847, it was thought necessary especially to designate "the thick limestone which underlay the western edge of the great Illinois coal field," and Dr. Henry Englemann[9] proposed therefor the title St. Louis Limestone, its terranal limitations were, according to present day standards, rather vaguely defined. The then recent efforts of Dr. David Dale Owen, in his Iowa work, to introduce the English classification of geological formations had a profound influence upon the little coterie of geologists which was beginning to occupy the field of the Mississippi valley and which made its headquarters in the city of St. Louis. The naming of the St. Louis Limestone was a phase of the American sub-Carboniferous question, and the problem of the American Paleozoic. It was an attempt at adjustment of the rocks of the continental interior with the general section of Europe.

Two years later, in a letter dated January 14, 1849, to the distinguished paleontologist, Dr. Verneuel, of Paris, Owen uses the term St. Louis Limestone. Shortly after its receipt this letter was pub-

[4]American Jour. Sci., (1), Vol. XL, p. 128, 1838.
[5]Ohio Geol. Surv., 2nd Ann. Rept., pp. 1-40, 1838.
[6]Indiana Geol. Surv., 2nd Rept., p. 17, 1839.
[7]Rept. Geol. Expl. Iowa, Wisconsin and Illinois, p. 14, 1840.
[8]Rept. Geol. Reconnoissance of the State of Indiana, etc., 44 pp., 1839.
[9]Am. Jour. Sci., (1), Vol. III, p. 119, 1847.

lished by the French geologist[10] in the publication of the Société Géologique de France.

Just what were the exact vertical limitations assigned to the St. Louis Limestone section by Englemann is not a matter of very clear record. Other St. Louisians at that time used the term freely. Most specific, perhaps, is Dr. Henry King. According to him[11] the title covers the entire section between the Coal Measures and the St. Peter Sandstone. The thickness of the formation is estimated to be between 500 and 600 feet. Although King elsewhere mistakes the St. Peter Sandstone for another sandstone lying at the base of the Coal Measures he is still led to believe that there were represented 200 to 300 feet of the Carboniferous limestones, which, however, were found to carry Devonian fossils at the base. Therefore, it may be considered that finally King included in his St. Louis Limestone only those beds between the bottom of the Burlington limestone and the base of the Coal Measures.

Singularly enough when Englemann proposed the title St. Louis Limestone it was generally believed that the formation which today we know under this name rested upon the Kaskaskia limestone. This belief was probably held by St. Louisians of that day for many years, until Shumard finally demonstrated the true relations of the two terranes.

Inasmuch as Owen[12] several years previously had restricted the application of the term sub-Carboniferous to the section between the top of the Devonian limestones and the base of the Coal Measures, whereas prior to that time it had been made to include very much more, even all below to the Blue, or Trenton (Galena), Limestone, it is not improbable that the St. Louis geologists were endeavoring to fix the section to a restricted succession by giving it a definite geographic title. In his Iowa work[13] Owen calls what is now generally termed the St. Louis Limestone, at Keokuk, the Concretionary Limestone; but he specifically correlates it with the "Bedded Limestone of St. Louis." It was three years later that Swallow[14] and Shumard[15] at last restricted the term to the limits now commonly accepted.

At the time, therefore, when the title St. Louis Limestone was proposed for a definite geological formation, and for a full decade thereafter, it seems that the term covered approximately the early

[10]Bull. Soc. geol. de France, t. VI, p. 419, 1849.
[11]Proc. American Assoc, Adv. Sci., Vol. V, pp. 182-201, 1851.
[12]Twenty-eighth Cong., 1st Sess., Sen. Doc. No. 407, pl. 3.
[13]Geol. Surv. Wisconsin, Iowa and Minnesota, p. 92, 1852.
[14]Missouri Geol. Surv., 1st and 2nd Ann. Repts., p. 4, 1855.
[15]Ibid., p. 170.

Carbonic section of the region. This is exactly the section which recently we are in the habit of calling the Mississippian formation, the adaptation of Winchell's name[16] of 1869. Being the name of a strictly provincial series the policy of the United States Geological Survey to elevate it to the continental dignity of an abstract time unit of sub-periodic rank appears unavailing.

In the interests of exact synonymy, of the proper appreciation of the canons of priority, and of a just credit to the pioneer workers in a particular provincial field it may be that we shall have to, in the end, recognize for the early Carbonic section of the Mississippi valley the terminology of Englemann and his co-workers, if we finally find it really advisable to retain a definite geographic title for what is really a time-division. By this line of action Louisian would find satisfactory substitution for Mississippian; and this title would have priority over Winchell's name by twenty years. To be sure, both terms have been used in varied senses. Even with the latest tendency to establish a three-fold division of Early Carbonic rocks in the Mississippi valley Louisian would appropriately take precedence over Mississippian as a serial title, for the median number.

The severe restriction of the term St. Louis Limestone to the formation generally known under that title today is probably due primarily to the interpretation of Owen. As already intimated, in his Report on the Geological Survey of Wisconsin, Iowa and Minnesota,[17] published in 1852, he specifically designates the bed the Concretionary Limestone, at the same time parallelling it with the "Bedded Limestone of the City of St. Louis."

At this time the Archimedes Limestones were regarded as the same formation in place of three widely separated strata as subsequently proved to be the case. The present St. Louis formation was thought to overlie it. In this connection, also, there was much confusion existing concerning the Ferruginous Sandstone. The latter was located at the bottom of the Coal Measures, and at the mouth of the Missouri river it was above the St. Louis Limestone. Farther south, near the mouth of the Ohio river, a lithologically similar formation, now called the Aux Vases Sandstone, was erroneously paralleled with the basal Coal Measures bed. For the honor of discovering the true order of succession A. H. Worthen laid claim. This worker, somewhat peeved at Prof. James Hall for first publishing correct details of the section without giving him especial

[16]Proc. American Philos. Soc., Vol. XI, p. 79, 1869.
[17]p. 92.

credit for pointing out the situation stated[18] that he unravelled the puzzle as early as the spring of 1853, while assistant on the Illinois survey, although he could not then publish the facts.

It is probable that Hall, while state geologist of Iowa, gathered his facts on this subject from numerous sources, and that Worthen was only one out of many persons with whom he talked over matters. Moreover, at the very time when Worthen, in company with Hall, visited the Chester locality the triple nature of the Archimedes Limestone was being widely discussed, and doubt was already being thrown upon the generally accepted interpretation. Otherwise it is difficult to understand just why Dr. Norwood, the State Geologist of Illinois, should especially charge his assistant Worthen with the duty of determining the relations of the St. Louis Limestone as recently restricted and the Ferruginous Sandstone.[19]

Although Swallow[20] adhered to the old idea of the location of the St. Louis Limestone (restricted) above the Chester beds, Shumard, in the county reports made at the same time, but the publication of which was held up by the Civil War for fifteen years, clearly recognized the true sequence. Furthermore, in the South, in Ste. Genevieve county, he subdivided the section between the first and third Archimedes limestones (Keokuk and Kaskaskia) into three members: The white oolite below (Spergen), the St. Louis Limestone (proper), and the Ste. Genevieve Limestone.[21] This procedure perhaps led Worthen to include the Spergen and Warsaw in the St. Louis Limestone as he understood it.

[18]Illinois Geol. Surv., Vol. I, p. 42, 1866.
[19]Illinois. Geol. Surv., Vol. I, p. 41, 1866.
[20]Missouri Geol. Surv., 1st and 2nd Ann. Repts., p. 60, 1855.
[21]Missouri Geol. Surv., 1855-1871, p. 292, 1873.

AN ILLUSTRATION OF THE WEDGE-WORK OF ROOTS

A. O. THOMAS

The wedge-work of roots is a powerful and effective agent of weathering and performs an important part in breaking up solid rock. Since the indurated rocks, as a rule, are covered by mantle rock of considerable thickness the actual penetration of their seams, joints, and crevices by roots is concealed. In some cases, too, the mantle rock is of so great thickness that even the longest roots fail to reach the solid rock below. On bare rocky cliffs where there is sufficient moisture, trees, in some cases of large size, grow from crevices and joints where their seeds have sprouted. As they grow their roots penetrate the openings and wedge their sides apart sometimes prying off unstable rock masses and toppling them over—the final overthrow occurring oftentimes during a windstorm which may blow down the trees.

Not only does the wedge-work of roots shove the rocks apart but the enlarged crevices, becoming the repositories for soil and debris blown in by the wind or washed in by the rain, are further widened when the water and soil thus admitted freeze. Furthermore, when the tree eventually dies the decaying roots form passageways which water readily enters and assisted by the acids of decay may further disintegrate the rock by solution. Even the living roots secrete acids which have a very great effect on the undecomposed minerals or rocky materials.

The wedge-work of roots as a mechanical action is not of the same strength in all plants though all roots possess the power to some degree. In some of the tropical and subtropical parts of the world man makes use of the prickly pear cactus in preparing soil on stony land. The roots of this plant have a remarkable power of penetrating and wedging rock apart and especially in converting fresh lava rock in this manner into soil. Ordinary weathering requires a century to accomplish on such lava what the cactus can do in a few years.[1] Everyone is familiar with the wedging power of roots in heaving walks, in cracking walls of masonry, and in breaking, entering, and even clogging sewer and drain tile. This force,

[1]McConnell, P., Elements of Agricultural Geology, London, 1902, page 48.

expended by growing plants and their roots, is almost incredibly strong. A recent textbook[2] gives an illustration of a millstone ten and one-half inches thick cracked in two by an elm tree in thirteen years after it had sprouted through the central opening.

Some idea of the shoving power in growing plants may be had from a few illustrations of cell pressure. "The root of the garden pea, for instance, has a wedging force equal to 200 or 300 pounds a square inch."[3] I am informed by Dr. R. B. Wylie, of our State University, that the osmotic pressure of the plant cell of a sugar beet is as high as twenty-four atmospheres. Concerning the action of roots Doctor Stockbridge, a careful student of their effect upon rocks and soils, says, "roots permeate the rock-mass wherever the slightest crevice offers an entrance; and then, by the expansive force of the growing tissue, the most tenacious of rocks are rent and torn asunder, no power in nature being able to withstand the force of this slow-working but resistless expansive action." And again, speaking of the power of the root system in forcing the soil-water upward, he says, "the pressure exerted by a birch-root severed from its connection with the tree was equal to a column of water 85 feet in height; and that of a squash-plant eight weeks old, soft, open in its texture, and very tender, exerted a force equal to a column of water 45.5 feet high."[4]

During the winters in our latitude living tree trunks contract at times of very low temperatures and expand again as the thermometer rises. At times frost cracks appear and disappear in some trunks under these conditions. The actual volumetric decrement or increment is of low amplitude but the force is inexorable and no doubt plays a small part in the wedge-work of the larger roots near the surface and of the base of the trunk when the latter is obstructed. The reader is referred to some interesting observations on "The Coefficient of Expansion of Living Tree Trunks" which appeared in a late number of Science.[5]

In discussing the agents of weathering textbooks of physiography and general geology in many cases give illustrations of rocks or boulders which have been cleft by the wedge-work of roots—the cuts usually showing a tree growing out of the cleft. Boulders, however, exhibiting this feature are not common. In spite of the fact that glacial boulders are numerous and widely distributed in

[2]Ries and Watson, Engineering Geology, New York, 1914, Pl. XXXIII, fig. 2.

[3]Cleland, H. F., Physical Geology, Chicago, 1916, page 33.

[4]Stockbridge, H. E., Rocks and Soils, 2nd Edit., New York, 1906, pp. 111, 112, and 184.

[5]Trowbridge and Weil, Science, new series, Vol. XLVIII, Oct. 4, 1918, pp. 348-350.

Iowa it was not until recently that the writer's attention was called to a tree-split boulder in our state. Mr. Harold Corey, a member of the writer's physiography class at the University a few years ago, produced a photograph which he had taken of such a boulder which he modestly contended was as good an example as his textbook illus-

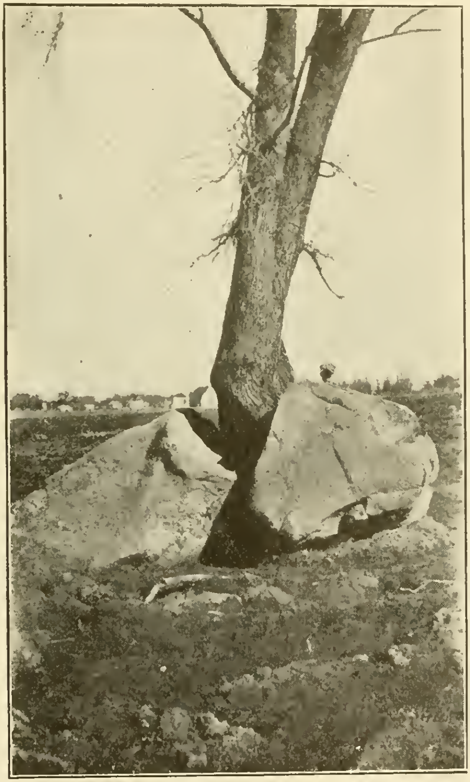


FIG. 120.—A granite boulder at Nashua, Iowa, which has been split in two by an elm tree growing from a crevice in the stone. Photo by Harold Corey.

tration "taken," as he said, "from some other state." Mr. Corey's boulder is located within the corporate limits of the town of Nashua in Chickasaw county. It is situated in a cultivated field on the Greeley estate in the northwest part of the town about one-fourth mile west of the Catholic church. The field is in the southwest quarter of section 18, township 94 north, range 14 west.

The stone is a coarse-grained feldspathic granite, somewhat decayed and of the type that is very common on the surface in Chickasaw and Floyd counties. It measures approximately 11x17x5 feet above the ground. The cleft divides the stone into two unequal parts; the smaller part, which is approximately 10x7x5 feet in maximum dimensions, has sustained all the movement since it rests on top of the ground while the larger part penetrates the soil to an unknown depth. The faces formerly in apposition and now separated by the trunk are readily distinguished. The original cleft in which the sapling sprouted was at an angle of about 45 degrees. The effect of starting its growth in this unnatural position is still apparent in the trunk whose lower part is permanently bent. As the tree grew the smaller part of the stone was not only shoved over but was also rotated through an angle of over 45 degrees since the face against which the trunk shoves is now vertical or slightly beyond that position. The volume of the smaller part, according to the dimensions cited above, is 350 cubic feet. Dividing this by two to allow for the irregularities of the stone, its weight, at 175 pounds per cubic foot, would be over fifteen tons. This figure gives some conception of the shoving power which this particular tree has exerted during its growth. Many of the larger roots of the tree have grown out of one end of the cleft and thence into the earth to avoid the main mass of the stone which extends not only directly under the tree but also into the earth beneath the smaller part of the stone.

The tree is a thrifty elm, *Ulmus americana,* about fifty feet high. The trunk within the cleft and for some distance above the stone is rounded-flattened or oval in cross-section and its dimensions at the top of the boulder are four and one-half by two and one-half feet.

This example of a split boulder, possibly the only one illustrating this feature in Iowa, compares favorably with those illustrated in current textbooks. It is hoped that the good citizens of Nashua and vicinity may long preserve it from injury. Students of natural phenomena for decades to come will marvel at the power of the seedling elm which has rent the massive boulder in twain.

The Department of Geology,
The State University.

A HERPETOCRINUS FROM THE SILURIAN OF IOWA

A. O. THOMAS

Recently while the writer was sorting some collections which he and some of his students had gathered a few years ago at Monticello, he came upon a specimen of the rare crinoid Herpetocrinus. The specimen was almost wholly covered by the matrix and it was removed only after much patient cleaning. Further search among the material added three short pieces of stems while a drawer of specimens from the same locality, collected by Mr. J. V. Henley about 1907, contains a coiled stem labeled, "Crinoid stem, Monticello, Iowa, J. V. H." This, too, belongs to Herpetocrinus. As far as known, this is the first reported occurrence of this very unique crinoid from the Iowa Silurian.

With very few exceptions the crinoids, or sea-lilies, of the Paleozoic were stalked forms, that is, the crown, composed of the arms and the body, was supported upon a stem of varying length; its lower end may or may not have been attached. In fact, some genera had the power of freeing the lower end of the stem and later of reattaching it thus permitting a certain amount of migration. To the latter kind, it is thought, our Herpetocrinus belonged. In this highly specialized genus the crown consists of a small elongated cup, a long narrow anal tube, and long attenuated simple arms. The most remarkable feature is the coiled stem in whose coils the crown could be completely enveloped. At times the animal straightened out its coiled stem, expanded its arms, and assumed the conventional attitude of its more stiffly-stemmed neighbors belonging to other genera. When coiling, the arms folded into a slender bundle about the anal tube, the crown bent back against the stem, and the latter rolled itself up in the opposite direction into a flat spiral with the body at the center much as a garter snake coils itself to conceal its head, hence the name, Herpetocrinus, meaning serpent crinoid.

The stems of crinoids are made up of a series of flat segments which ordinarily are round or somewhat pentagonal in cross section. The coiling habit, however, had so modified the stem of Herpetocrinus that while it is practically round in cross section near the cup, distally it becomes concave on one side, the segments being crescentic in section "and bearing on the horns of the crescents two longitudinal rows of strong cirri."[1] These cirri embraced the crown and the inner coils and afforded still further protection to the vital parts of the animal. The nearly circular segments next to the crown do not bear cirri. It is obvious that the concave side of the stem is found on the inside of the coils and that when closely enrolled

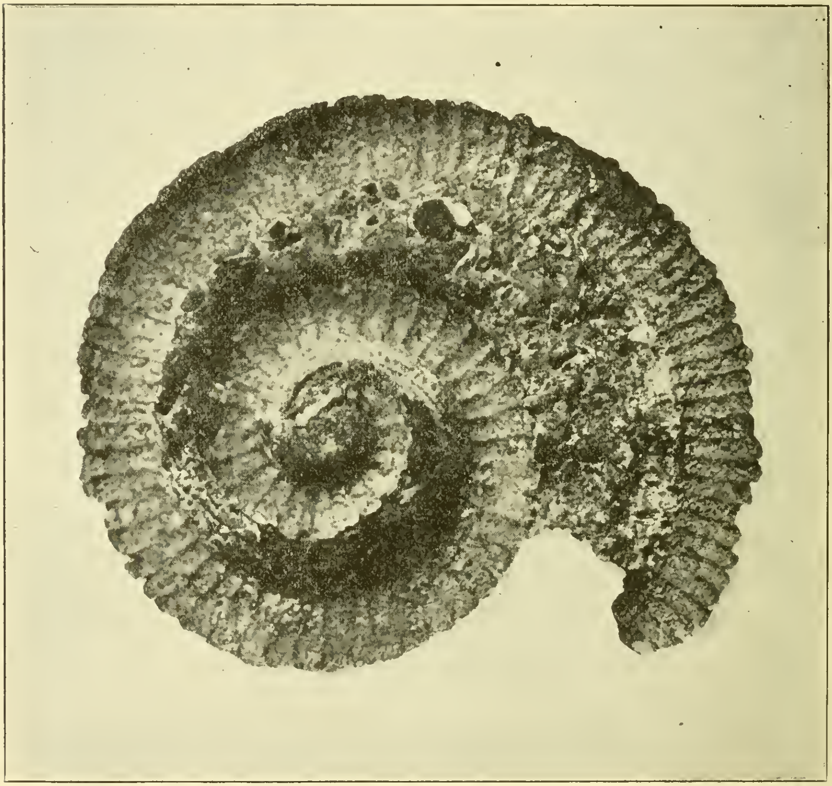


FIG. 121.—An illustration of a specimen of Salter's genus Herpetocrinus from the Niagaran dolomitic limestone near Monticello, Iowa. Total length 83 millimeters; greatest diameter across the coil, 20.6 millimeters, shortest, 16.0 millimeters. Length of the distal missing part of the stem unknown. Magnification a little more than four and one-half times.

the concave side fitted more or less snugly over the convex side of the next coil within.

The fossils from Monticello are highly silicified. The cirri are lost but the cirrus-articulations are plainly visible on several of the segments of the accompanying illustrated specimen as well as on the Henley specimen. In the better specimen the calyx is present and even the arms are represented by a series of ill-defined ossicles which

[1]Zittel-Eastman, Textbook of Paleontology, 2nd Ed., p. 212, 1913.

are almost pure quartz. The crown unfortunately is not well enough preserved for detailed study. The evolute and involute parts of the stem are so preserved as to show very well the relation of the two parts and the way in which the crown is tucked away in the concavity of the crescentic stem is better shown than would be the case were the cirri present. The Henley specimen preserves about a coil and a half of the involute part of the stem. This portion shows very well the cirrus-articulations, the position of the lateral sutures, and other features.

As stated above the specimens were collected in the Silurian (Niagaran) beds near Monticello, Jones county, Iowa, where they are associated with *Petalocrinus mirabilis, Pisocrinus* sp., *Goniophyllum pyramidale,* and others. These forms together with Herpetocrinus occur also in the Silurian rocks of the island of Gotland in the Baltic sea. The similarity of these two widely separated faunas has been pointed out by several writers. Herpetocrinus has been reported also from the Silurian of the Chicago area, from Tennessee, from New York, and from England. Later visits to the Monticello locality have not netted a trace of this crinoid in spite of most diligent search. It is evidently somewhat rare. Effort has been made to identify the material with some of the species already described but no definite report can be made at present.

THE DEPARTMENT OF GEOLOGY,
THE STATE UNIVERSITY.

THE INDEPENDENCE SHALE NEAR BRANDON, IOWA

A. O. THOMAS

On June 23, 1876, at the first annual meeting of the Iowa Academy of Science at Iowa City, Prof. Samuel Calvin read a paper entitled "Preliminary Notice of Some Dark Shales near Independence, Iowa." The paper was not published but early in 1877 an abstract of it appeared in the American Naturalist, Vol. 11, pp. 57-58. In this abstract the shale is referred to the Marcellus due to its position below certain limestones, then believed to be Hamilton, and due also to the presence of a shell presumably of Marcellus age. The shale had been discovered in the bottom of a more or less temporary quarry by Mr. D. S. Deering, one of Professor Calvin's students.

Calvin's more complete description[1] of the shale and its unique fauna appeared the next year. From this we infer that the shales were stratified and undisturbed while "In some of the beds are numerous remains of plants." Later, in the Buchanan county report, Calvin states that in "shafts sunk at the Kilduff quarry, ... the formation was penetrated to a depth of twenty feet and was found to consist of dark-colored shales, alternating with beds of limestone."[2] On page 229 of the same report Calvin adds that "It was in an abandoned pit a few rods west of the O'Toole (Kilduff) quarry, that the first shaft which brought to light the Independence shales of this locality was put down." Thus it will be seen that the earliest knowledge of this terrane and its fossils was gathered from artificial exposures which in a few years were completely covered up. From these exposures and supported by evidence acquired by a little digging, Calvin constructed a section of the Devonian rocks of Buchanan county placing the Independence shale below the Gyroceras beds.[3] The failure of the shales with their easily recognized fossils to appear in many places at this horizon in other counties along the eastern border of the Iowa Devonian belt has led workers—and correctly—to refer stratigraphically equivalent terranes, even though barren and lithologically different, to

[1]Bull. U. S. Geol. Geogr. Survey Terr., IV, pp. 725-730, 1878.
[2]Iowa Geol. Survey, Vol. VIII, p. 222, 1898.
[3]Amer. Geologist, Vol. VIII, pp. 142-145, 1891; also Vol. IX, p. 359, 1892.

the Independence. A well-known example is the Kenwood beds of Norton[4] in Linn county.

The fossiliferous facies of the formation has unfortunately been too meagerly known. Some years ago a typical Independence fossil, *Douvillina arcuata,* was brought up among well borings from a depth of one hundred feet near Walker.[5] Other borings have encountered shaly carbonaceous strata, believed to be the Independence from their position beneath the limestones. These finds, together with an outcrop that was soon covered by slump near Linn Junction found by Professor Norton several years ago,[6] prove that the dark facies has a fairly wide but perhaps irregular distribution. In spite of the readiness with which the unindurated shale slumps and is covered up it has been hoped that sooner or later natural exposures would be found. Fortunately a number of such outcrops occupying anomalous stratigraphic positions have been discovered.

In 1916-17, Mr. Merrill A. Stainbrook, one of the writer's pupils in historical geology, discovered a fossiliferous shale along Lime creek,[7] a tributary of Cedar river in the southwest corner of Buchanan county. The fossils which he collected are typical Independence forms. In company with Mr. Stainbrook, the writer visited the outcrop in the fall of 1917. Since that time the young man has found two other exposures which he reported by letter just before leaving for training camp. Later the three outcrops were studied in company with Professor Norton, of Cornell College.

Exposure No. 1.—Here the shale occurs in a sharp bend or reentrant on the right bank of the creek in the northwest quarter of section 26, about a mile northeast of the town of Brandon. Undercutting by the stream at this point has exposed from one to six feet of the shale for a distance of fifty to sixty feet. By digging back the sod above the shale the latter was traced about five feet higher up the bank, making a total thickness above the water of at least eleven feet. The digging, however, afforded no clue to the indurated beds, if any, which may overlie the shale at this point. The immediate bank of the stream here is close to twenty feet high while back from this the surface rises gradually to a height of nearly sixty feet. The outcrop is flanked by exposures of limestone; on the downstream side the shale and limestone are separated by about three feet of weathered shale intermingled with blocks and fragments of lime-

[4] Iowa Geol. Survey, Vol. IV, pp. 156, 157, 1895.
[5] Iowa Geol. Survey Vol. IV, p. 157, 1895.
[6] Private communication.
[7] This fifteen mile tributary of Cedar river is not to be confused with a stream of the same name in Cerro Gordo and Floyd counties. It is along the latter that the Lime Creek shale, mentioned later in this article, is found.

stone. For some twenty yards below this point the limestone is arched up into a low anticline and is considerably broken and jointed. This limestone contains Cedar Valley fossils characteristic of the lower part of that terrane. On the upstream side for a short distance the bank of the stream is sodded over. Still farther upstream the low limestone ledges are more weathered than in the anticline below and contain Cedar Valley fossils similar to those found back of the cemetery a half mile or more downstream.

The shale is dark bluish to gray in color, plastic and where weathered is yellowish with reddish streaks. It shows no bedding but there are occasional small blocks that show faint lamination and in some cases smoothed and slicken-sided faces. Irregular blocks of a harder, tougher, and more calcareous shale occur and there are also small nodules of pyrite and angular blocks of hard limestone. Fossils are fairly common and typical; to some of them cling crystals of pyrite as is the case with some of the fossils collected by Calvin and Deering at Independence. In the bend of the stream's bed and almost in contact with the shale is a large block of Lower Davenport limestone showing the characteristic brecciation and other unmistakable features of that formation. The block is angular, is three by five feet in dimensions, and is larger than any handled by the stream in flood. No exposures of the Lower Davenport are known up the valley. We must conclude that the block is intimately associated with the shale and is of the same derivation as the smaller angular limestone pieces incorporated in it.

Exposure No. 2.—This exposure is on the left bank of Lime creek a few rods down stream from No. 1 and near the south line of the northwest quarter of section 26. The bank of the creek here is flanked by a low ledge of limestone, a gap in which makes a sloping declivity for a distance of three or four rods. This slope is much trampled by cattle which use it as an approach to the water. At three or four places in this gap the shale is exposed, chiefly near the water's edge, but at one point near the upstream end the shale can be traced up the acclivity for six or seven feet. Digging exposed a width of nearly as much. At this point, too, the shale and limestone are separated laterally in much the same way as at the downstream end of Exposure No. 1 except that the zone of coarse material between them is narrower. Both the shale and the adjacent horizontally lying limestone pass beneath the drift.

The shale is gray, tough and plastic; it is unstratified and contains blocks of tougher clay and angular fragments of limestone.

Doctor Norton recognized some of them as blocks of the Otis calcilutite. Fossils are few but typical.

Exposure No. 3.—This outcrop is in Benton county on the left bank of Cedar river in the northwest quarter of section 9, township 86 north, range 10 west, and is about two miles south and one mile west of Brandon. The shale occurs in a re-entrant near the north end of a precipitous cliff close to fifty feet high, called by Savage,[8] in his Benton county report, the Cedar river section. To the north across a ravine is Long's quarry—both exposures are Cedar valley limestone. In the re-entrant among the tumbled blocks of limestone occurs the shale with its characteristic fossils. Three or four feet of the shale are exposed at a height of about ten feet above the water and separated from it by a gentle talus slope fifteen to twenty feet wide. The re-entrant is twenty-five to thirty feet wide and becomes wider within where its walls are largely joint faces in the limestone away from which the rock has slipped toward the opening due to sapping. The material from this large well or cistern-like hollow in slipping out has encroached on the shoreline in the form of a small talus delta. Within the "well" the talus rises away from the opening to the top of the cliff with a slope so steep as to be climbed with difficulty. The rock in the walls of the "well" are practically horizontal and but little disturbed. Between this exposure and the ravine to the north, however, there is evidence of considerable disturbance. Faulting here has brought up brecciated Davenport beds almost to the top of the cliff. The position of the ravine itself suggests a line of weakness. Brecciated blocks lying at all angles, slicken-sided faces, distorted and obscure bedding, and joints and fractures are some of the features which testify to the stresses which accompanied the displacement. Moreover, the rocks in the disturbed section are practically barren in comparison with the very fossiliferous Cedar Valley beds a few yards to the south as well as to the north across the ravine in Long's quarry.

Summarizing the three exposures of the shale we may note that they are alike in that they abut laterally against Cedar Valley limestone; in that the overlying beds are absent or unexposed, as far as could be determined, while the underlying strata at each place are inaccessible; in that each is a sort of shale breccia containing an admixture of blocks and fragments of sub-Cedar Valley limestones; and in that each carries the typical Independence fossils.

[8]Iowa Geol. Survey, Vol. XV, pp. 180, 181, 1905.

A list of the more common species collected at the three localities may be of interest. The brachiopods greatly predominate.

Zaphrentis sp.
Macgeea solitaria (H. & W.).
Orthis (Dalmanella) infera Calvin.
Schizophoria cf. *striatula* (Schlotheim).
Stropheodonta calvini S. A. M.
Strophonella reversa Hall.
Leptostrophia cf. *canace* (H. & W.).
Douvillina arcuata (Hall).
Douvillina variabilis (Calvin).
Productella hallana Walcott.
Strophalosia n. s.
Hypothyridina cuboides (Sowerby).
Atrypa reticularis (Linne).
Atrypa hystrix Hall.
Spirifer sp.
Martinia subumbona (Hall).
Cyrtina n. s.
Crinoid stems.
Plate of crinoid.
Tentaculites sp.
Ostracoda (undet.).

The low monoclinal dip of the Paleozoic strata of Iowa is to the southwest and amounts to ten to fifteen feet per mile. The Brandon exposures of the Independence shale are twelve to fifteen miles southwest of the artificial exposures at and near the O'Toole quarry. According to an unpublished topographic map of Iowa by Dr. James H. Lees, the altitudes of the Brandon and Independence exposures are each close to 900 feet above sea level. Hence, at Brandon, other things being equal, the Independence shale should be at least 125 feet below the surface. Its anomalous occurrence on a level with the basal Cedar Valley may be explained: (1) as a local unconformity in which the Lower and Upper Davenport beds are wanting and with the Cedar Valley resting on the Independence shale; (2) as a post-Cedar Valley deposit laid down in the erosion hollows or other depressions in its surface; (3) as a filling thrust up into irregular openings in the Cedar Valley at the time of the brecciation of the lower Devonian terranes.

A brief discussion of the three hypotheses brings out (1), at Independence only fifteen miles away the Davenport beds occur without a break below the Cedar Valley and at all other points where the basal beds of the Cedar Valley are exposed there is no erosion contact between them and the subjacent beds. Granted that the Brandon contact is an erosional unconformity, it would seem strange that the resistant Davenport beds should be entirely removed, leaving the relatively unresistant shale in the form of steep-sided remnants as we have it at each of the three exposures. Moreover, the shale must have been lifted by an upwarp of 125 feet to bring about the relations indicated; (2) the fact that the Sweetland Creek and State Quarry lie unconformably in depressions in the Cedar Valley and the additional fact that certain resemblances exist between the faunas of the Independence and Lime Creek shales lend plausibility to the view that the Independence shale deposits are remnants of a formerly wider distribution of the Lime Creek. Against this view it should be pointed out that where the Lime Creek shales are typically developed, as in Cerro Gordo, Floyd and Butler counties, the fossiliferous part of the Lime Creek—at least that part containing the Independence-like fauna—is underlain by scores of feet of relatively barren plastic shales and these in turn are separated from the Cedar Valley by the Nora limestone[9] which in places is twenty feet thick. It would seem that some part of the Nora or of the plastic blue shale should fill a part or all of these depressions rather than they should be filled with the fossiliferous shale occurring below the Owen limestone near the top of the Lime Creek section. The fossils of the Independence, when they are critically studied, are seen to be quite distinct from these of the Lime Creek. It is true that a few species, such as *Strophonella reversa, Douvillina arcuata, Atrypa reticularis, A. hystrix, Macgeea solitaria,* and possibly a few others occur in both formations. A brief study, however, enables one to distinguish those from either formation readily. The Independence species are invariably smaller and there are other differences. *Stropheodonta calvini* and *Douvillina variabilis* are the commonest species in the Independence—the forms which have gone under these names from the Lime Creek are specifically distinct from them and the same is true of some others. Moreover, the index fossils of the marly shales of the Lime Creek, *Spirifer hungerfordi, S. orestes* and *S. whitneyi* do not occur in the Independence, while the common little *Orthis* (*Dalmanella*) *infera* and the rarer *Gypidula munda* as well as the atypical *Martinia subumbona* have no representives in the Lime Creek. Other equally striking absences and differences could be given but the instances cited are sufficient to confirm

[9]Science, n. s. Vol. XXXVI, 1912, pp. 569, 570.

the usual opinion that the Lime Creek fauna is a greatly expanded and recurrent descendant of the Independence rather than a contemporary; (3) the brecciation of the lower Devonian terranes of Iowa has had a profound effect on their structure. Minor folds, flexures, distortion, obscured bedding, small faults with throws from a few inches to a score of feet or more, together with the cracking and breaking of the rock into angular fragments of all sizes are some of the features resulting from the stresses to which these terranes were subjected. The shaly portions of the Independence beds being plastic and incompetent under the strain were evidently squeezed up into crevices, pipes, and under arches. At exposures Nos. 1 and 2 the limestones are considerably flexured, broken and displaced. All along Lime creek in the vicinity of Brandon "the beds are folded, buckled and displaced on a scale sufficient to produce a complex series of alternations of lithological and paleontological characters at the same level along the hillside."[10] The prominent fault near exposure No. 3, the angular blocks of Lower Davenport and Otis limestones mixed throughout the shale at each exposure, the lack of bedding and continuity, and their anomalous position abutting against Cedar Valley limestones, all point to the reasonable conclusion that the shales have been forced up into their present position at the Brandon exposures by the forces which produced the brecciation. It is not urged from this that the shales have everywhere been so squeezed out of their natural position, in fact Calvin[11] calls attention to the point that the overlying Gyroceras beds at Kilduff's quarry are undisturbed and it is inferred from his note that the shales below, at this place, are also stratified and "alternating with beds of limestone" as quoted earlier in this paper.

In closing the writer wishes to acknowledge the valuable suggestions of Dr. William H. Norton with whom the outcrops were studied in the field. The conclusions arrived at are a result of this conference and to Doctor Norton, whose critical study of the brecciation of the Iowa Devonian is well known, should be given special credit for the suggestion that the present position of the shale at each outcrop is a result of the squeezing accompanying brecciation.

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[10]Calvin, Iowa Geol. Surv. Vol. VIII, 1898, p. 238.
[11]Amer. Geol., Vol. IX, 1892, p. 359.

THE HISTORY OF BOYER VALLEY*

JAMES H. LEES

One of the largest streams of the Missouri slope in Iowa, and one of much importance in its influence on topography is Boyer river. This streams takes its rise in the Kansan uplands south of Storm lake, flows a little east of south across Sac county past the town of Wall Lake where it turns abruptly southwest. In this direction it crosses Crawford county, which it divides into practically equal parts. In its course across Crawford county Boyer valley is of the normal mature type but in southern Sac there opens into the valley from the northeast a broad sag which extends southwestward from Wall Lake. Digitate alluvial plains also extend several miles up the valley of the Boyer above the mouth of this sag and up the valleys of two tributaries from the eastern flank of the high ridge east of Odebolt. The flat undrained sag, although it is two or three times as wide as Boyer valley at Herring or Boyer, is nevertheless a direct continuation of it. On the other hand the present course of Boyer river north of the sag is out of line and out of harmony with the valley below. (See figure 122.)

While, as will be explained below, Boyer valley in Crawford county and in southwestern Levey township of Sac county is flat-floored and steep-sided, above the junction with the sag the valley has a sloping floor and widely flaring walls. The two profiles across the valley given herewith will make this more clear than words can do. (See figure 123.)

In strong contrast also to the valley in Crawford county is the character of the sag in the vicinity of the town of Wall Lake. Its floor is almost perfectly flat and its sides slope rather gently away to the upland, especially east of Wall Lake. West of here they are somewhat steeper and higher, in the vicinity of the valley of Boyer river and of the high ridge west of the upper Boyer.

What seems to be the most reasonable explanation of this unoccupied sag is that it is a fragment of an ancient Boyer valley which once included the basin of Wall lake, or at least a part of it, and possibly Indian creek. An arm of the sag extends to the southeast as far as Carnarvon and may represent the lower part of another

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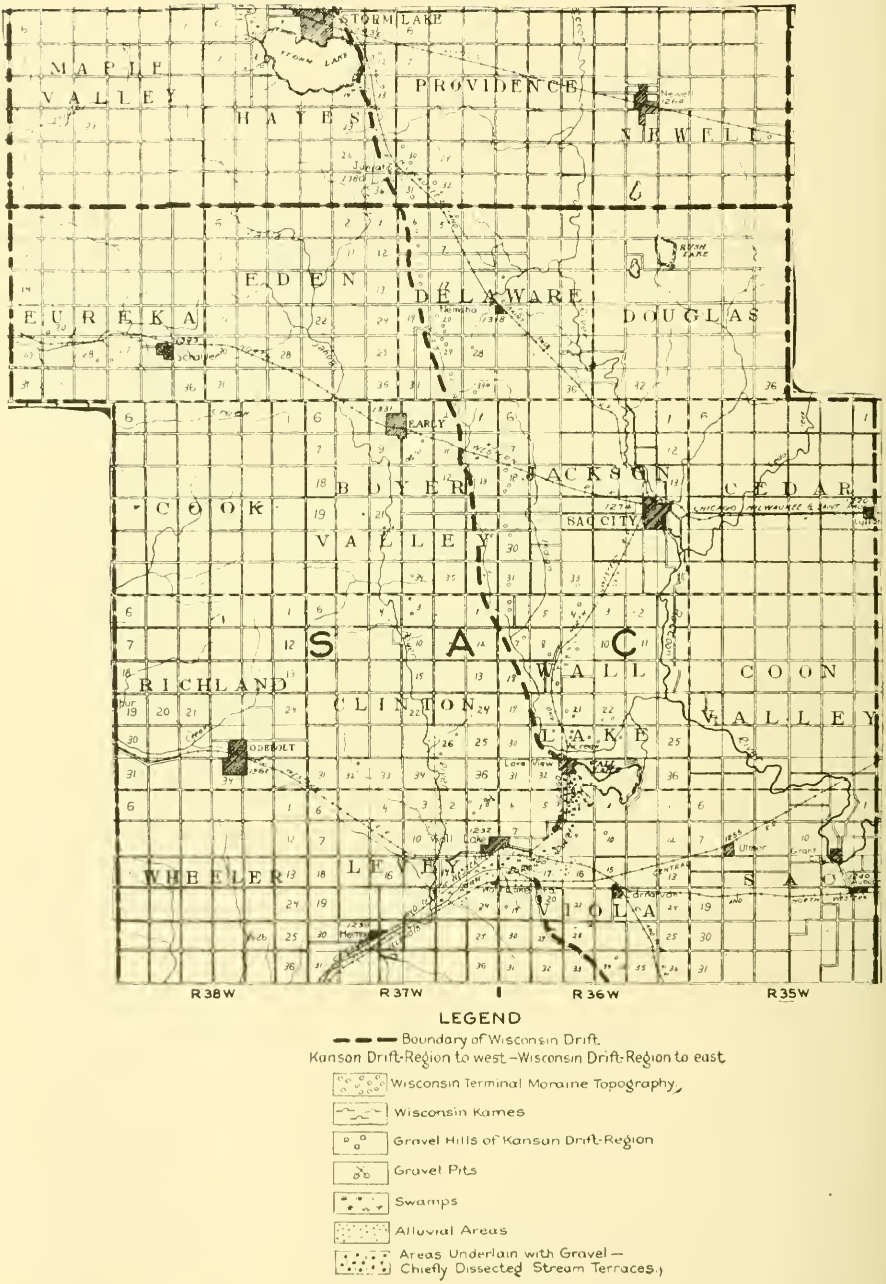

FIG. 122.—Map of Sac county showing the course of the upper part of Boyer river. Reduced from a portion of Carman's map of Northwestern Iowa as published in volume XXVI, Iowa Geological Survey.

branch of this old-time system. A little stream now comes down along this branch from the higher land near Breda in northwest Carroll county and empties, or did empty, into the southern arm of Wall lake.

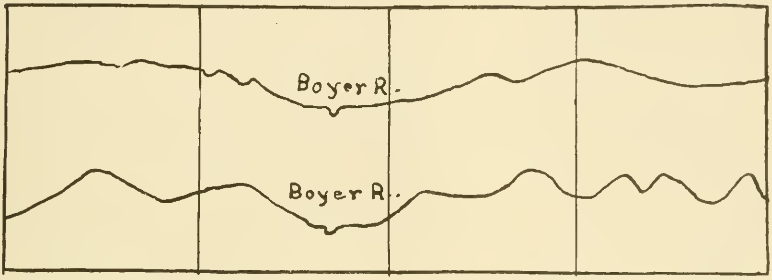

FIG. 123.—Profiles of Boyer valley. Upper profile, west of Lake View, Sac county. Lower profile, at Ells, Crawford county. Horizontal scale, one inch equals five thousand feet. Vertical scale, one-fourth inch equals one hundred thirty feet.

It is very natural to assume that the lower part of Indian creek valley, east of Lake View, and Raccoon river above the mouth of Indian creek may have formed the main upper Boyer river. However, there are several facts which seem to stand in the way of such an assumption. Opposite Lake View the valley of Indian creek is half a mile wide and fairly flat floored. It is capacious enough to accommodate a much larger stream than the one which now occupies it. But within a mile to the west the valley is shallower and the walls are gentler. This is perfectly normal, but it seems anomalous to find on descending the valley from Lake View that about a mile and a half below the town the valley walls approach each other abruptly and from here to the mouth are nowhere more than one-fourth mile apart and in many places are so close as to leave almost no room for a flood plain. The outlet creek of Wall lake is likewise a small stream in a narrow, rather shallow valley.

Indian creek northwest of Lake View lies just within the edge of a belt of rough country known as the Wisconsin moraine which forms the margin of a sheet of glacial drift which is called the Wisconsin. This moraine is much less prominent about the lower course of Indian creek, and the country here is much smoother and more level prairie.

Wall lake is separated from the valley of Indian creek at their closest approach merely by a strip of hills and hollows not over one-fourth mile wide. The lake level is about twenty feet higher than that of Indian creek, although this probably is due to the inequalities in the thickness of the moraine. The sag just south of Wall lake is filled with gravel to a height of thirty feet above the original floor and similar gravel no doubt underlies the lake. The assemblage of facts seems to indicate that while the ancient valley may have included the sag, the western part of Wall lake and the wide part of Indian creek near Lake View, it could hardly have included the lower part of the creek to the east.

If Raccoon river above the mouth of Indian creek once formed part of the Boyer system we should expect to find some differences in the character of the valley above and below this point. The valley above the creek mouth should show some evidence of being older than the lower part. But the evidence does not point in this direction.

Opposite the mouth of Indian creek valley Raccoon valley is remarkably wide, stretching nearly a mile from rim to rim. However, the actual flood plain is quite narrow, and is nowhere more than two hundred or three hundred yards wide. The remainder of the valley is occupied by a high second bottom or terrace which is really a valley filling of gravel and clay from the Wisconsin glacier. The old walls rise rather gently above this terrace and mark the former limits of the valley. A very significant feature of the valley filling is the fact that it extends from two miles above the mouth of Indian creek at least two or three miles below that point. That is, there is no change in the character of Raccoon valley near the mouth of Indian creek. In fact all along its course below here the valley shows evidences of its pre-Wisconsin age in its dimensions and its form.

Above the point already mentioned where the valley widens out and is partly filled by Wisconsin drift materials the valley is narrow and deep, steep bluffs flank the narrow flood plain and in its present aspects the gorge presents the appearance of post-Wisconsin age. Similar features are the rule in the valley from here to and beyond Sac City and as far at least as the north county line. In a few places, however, the valley shows what seem to be remnants of an original pre-Wisconsin drainage course. One of the best of these is in sections 25 of Delaware and 30 and 31 of Douglas townships, where the valley flares out into a wide open bay about a long oxbow. Another is just above Sac City, where the valley shows evidences of filling, and other indications of the incomplete filling of an old valley are not wanting.

The conditions seem to point, then, to a pre-Wisconsin age for Raccoon valley throughout its extent across Sac county. There can be no doubt of this age in its lower portions. If, therefore, Raccoon valley is pre-Wisconsin in origin and its stream flowed to the Des Moines then as now, where was the pre-Wisconsin course of the upper Boyer? In view of the width of the valley of Indian creek opposite Wall lake, although it is just within the terminal moraine where deposition would naturally be great, and in view also of the narrowness of the valley farther east and of the character of Raccoon valley, it seems as if we must look for the northward continuation of the ancient Boyer valley in this wide segment of Indian creek valley and possibly in the narrower portion to the northwest. Possibly, of course, the old valley above this larger segment may have been entirely filled up and obliterated.

It seems evident from the character of the modern upper Boyer valley that it has had a different history than the valley in Crawford county, and it probably was only a branch which united with another which came from the northeast. Macbride indeed sketched such a history as this in one of his reports,[1] but later in discussing Sac and Ida counties[2] he postulated an *eastward* flowing Boyer river whose headwaters were gathered from the ridge which stretches between Schaller, Odebolt and Herring and now is cut through at the latter village. This theory seems to be based on the narrowness of the valley at Herring and Boyer, but it seems as though this narrowness may well be explained by the presence of the high ridge which would naturally require more work to excavate and hence might well be cleft by a valley narrower than that above or below. It may freely be admitted that the unoccupied valley in the vicinity of Wall Lake is abnormally wide but this may be accounted for in part by the fact that several streams converged south of Wall lake, and in part by the greater ease with which the river could widen its valley here than in the much deeper and more steep-sided part between Herring and Deloit. On the other hand it is hard to believe that a stream would normally make such a sharp turn as would be necessary for the present upper Boyer if it had to flow eastward past Wall Lake to the Raccoon.

Again it is only since the time of the last glacial invasion that these drainage changes could have occurred and in view of the immaturity of much of the upper part of the Raccoon valley as sketched above we should according to Macbride's theory expect similar immaturity in the Boyer at Herring. However, the valley here is

[1]Geology of Cherokee and Buena Vista counties: Iowa Geol. Surv., Vol. XII, pp. 330, 331, 337.
[2]Geology of Sac and Ida counties: Iowa Geol. Surv., Vol. XVI, pp. 520, 523, 524, 537.

uniform with that below in its maturity, and it would be unlikely that either the very short stream postulated as rising on the eastern slope of the divide near Herring and flowing eastward past Wall Lake, or even the much longer one rising on the western side and flowing southwest, should, during the brief time allotted, have cut out such a wide valley and developed such a mature flood plain as now exist, both in the unoccupied sag valley near Wall Lake and in Boyer valley near Herring and in increasing measure to the southwest.

Professor Todd[3] has recently argued that Niobrara river of northern Nebraska, during pre-Pleistocene time "followed the courses of James and Missouri rivers as far as Onawa, Iowa, thence east and northeast through Ida and Sac counties past Wall Lake and thence southeast along the Raccoon river. This conclusion rests on a few apparently reliable reports from wells which show that the preglacial surface indicates a valley whose bottom is less than 900 A. T., in some cases less than 850." "The fact that Wall lake, lying on the summit, formerly drained into Boyer river and now into the Raccoon, and another fact that the Boyer rises east of the crest of the divide, has first a course east of south and at this point turns southwest" are considered to be explained by this theory. Such well records as are available to the writer do not indicate such a valley as Professor Todd postulates and while Wall lake and the sag valley doubtless partly suggested the theory it must be remembered that the lake is of late Wisconsin age while the valley is doubtless to be dated at the close of the Kansan. These facts seem to invalidate the whole argument since Professor Todd is discussing a preglacial stream.

Professor Todd further states that: "There was a fall of 350 feet from Sioux City to Wall lake." But at present the elevation of low water in Missouri river at Sioux City is 1,076 feet, while the elevation of Wall lake is about 1,225 feet. There is no indication of such a warping as would be necessary to equalize the discrepancy between these figures and the grade indicated by Todd. In fact, the evidence seems to point to uplift in northwestern Iowa during glacial times rather than to the depression which seems to be necessitated by Professor Todd's hypothesis.

Doctor Carman[4] has recently restated the theory of an eastward flowing Boyer in his report on the Pleistocene Geology of Northwestern Iowa. Carman emphasizes the facts that the Mississippi-

[3]Todd, J. E., The Pleistocene History of the Missouri River: Science: N. S., Vol. XXXIX, Feb. 20, 1914, pp. 263-274.
[4]Iowa Geological Survey, Vol. XXVI, pp. 318-320, 1915.

Missouri divide is lower than the minor divide a few miles to the west and that the pattern of drainage on opposite sides of the Mississippi-Missouri divide is the same while that on opposite sides of the minor divide is different. He states his theory in the following language: "In pre-Wisconsin time the Boyer river turned eastward and passed through the Wall lake outlet toward Raccoon river. When the ice-edge blocked this eastward drainage the ponded waters in the valley broke over a low place in the great watershed near Herring, in southwestern Levey township (Sac county), and escaped to Missouri river. This course was cut so low during ice-occupancy, and the old valley to the east was so much filled that the Boyer continued to flow to the southwest and did not again take its eastward course to the Raccoon."

Some of the objections to this theory have been set forth in previous paragraphs. The fact that the pattern of drainage on opposite sides of the minor divide is different may be explained by the statement that the Boyer is close to the crest of this divide and there is little room for west-to-east tributaries to develop, while the Maple flows, in a nearly parallel course, be it noted, several miles distant from the crest, and therefore a well developed system of east-to-west tributaries drains this western slope.

The question arises as to why this overflow from the ice-ponded waters should seek escape over the highest part of the bounding rim rather than over some lower col. A study of the altitudes of the region shows that in northwest Carroll county along the margin of the Wisconsin moraine, the highest point reached by the railway between Carroll and Wall Lake is 1,366 feet, at Breda. This is practically at the upland level. The railway between Wall Lake and Odebolt crosses the high divide west of the Boyer at 1,378 feet. But in northeast Crawford county, where the Boyer has cut its valley through the ridge, the latter rises 1,500 feet or more above sea level east of the river and over 1,400 feet between the Boyer and Otter creek, while a little farther west, near Schleswig, the hills reach altitudes well over 1,500 feet above sea level. There is no obvious reason why this high plateau, apparently the highest land south of Alta, should be chosen as the locus of overflow for the glacial flood-waters. On the other hand, however, if the southwestward flowing post-Kansan Boyer be conceived of as extending its valley to the northeast by headward erosion there is apparently no reason why one of the vigorous members of its dendritic system should not work its way up the slopes of the highlands and eventually cut through what was once the real Mississippi-Missouri divide and so come to gather in a part of the run-off which really belonged to the Raccoon system, although perhaps the Boyer never actually tapped any of the feeders of that system. This would seem to account satisfactorily for the deep narrow valley through the ridge and the broader, shallower one to the northeast of it. Then when the Wisconsin glacier overwhelmed the main stream of the upper Boyer system and the moraine obliterated its valley the empty sag remained as a testimonial to former conditions and one of the tributaries became the main stream of the system.

Note may be made here of the presence in Porter creek valley, north of Boyer, as well as in Otter and Buffalo creek valleys and also in Boyer valley at several points, of gravels which are older than the Wisconsin stage and which therefore show that the present drainage features were established before the Wisconsin ice disturbed the pre-existing drainage. These gravels will be described elsewhere in connection with the geology of Crawford county.

It seems to the writer, then, to summarize, that Boyer valley originated sometime following the retreat of the Kansan glacier from western Iowa and that the river developed the course now occupied across Harrison and Crawford counties, while in Sac county there were two branches, the western of which is now the upper Boyer, while the eastern is represented by the empty sag extending from the river to Wall Lake, and beyond here perhaps by upper Indian creek. The Wisconsin glacier blotted out the upper part of this eastern branch, leaving the lower part as a partly filled, undrained marsh beyond the glacier's margin. It seems that the sag valley and the river valley as well are too mature to have been the result of Wisconsin and post-Wisconsin erosion alone. Their history goes far back of Wisconsin glaciation through the uncounted years and centuries of the development of the deep-cut topography on the Kansan plain.

SOME STRUCTURAL FEATURES OF SELENIUM DEPOSITED BY CONDENSATION FROM THE VAPOR STATE IN THE NEIGHBORHOOD OF THE MELTING POINT[1]

L. E. DODD

The primary object of this paper is to record some experimental observations. During work[2] on the vapor tension of the element selenium, above and below the melting point, where the Knudsen method of molecular flow was used, the condensed material deposited itself on the cooling tube of the apparatus in a noteworthy manner. Some numerical data on it in addition to that necessary for the vapor pressure measurements were obtained incidentally at the time of the experiments. A description of the behavior of the deposit, from run to run of the pressure measurements, is here given, partly by means of the accompanying tables, including the numerical data mentioned. The type of tube upon which the material condensed is described in the paper already referred to, on the sublimation curve. Dimensions of tubes E and F, used in two series respectively of pressure measurements, are stated in connection with figure 124.

Table I has reference to a series of eleven measurements on the hexagonal crystalline form of selenium as first produced by Major F. C. Brown,[3] and by him furnished to the writer, for the vapor tension work.

Table II presents the same kind of data for a similar series of thirty measurements on the vapor pressure above the melting point. The material evaporated in this second series was amorphous selenium obtained in stick form from Eimer and Amend.

There are at least two points of interest regarding the deposit, first, deposition in zones of the selenium as it condenses, and sec-

[1]The original title of this report as read by proxy before the Academy at its spring meeting, 1918, did not refer to the selenium deposits condensed from vapor on both sides of the melting point, but only above it. At the present writing (Sept., 1919), however, the data for a series of experiments below the melting point, as well as above it, are at hand, and the scope of the paper has been extended by insertion of Table I, while the discussion of an unusually heavy deposit, mentioned at that time, obtained by a special evaporation not belonging to either of the E and F series of pressure measurements, has been omitted.

[2]See paper on sublimation curve for the hexagonal crystals of selenium, this number of the Proceedings.

[3]With regard to the method of production of selenium crystals of large size see Brown's paper in Physical Review, 5, pp. 236-237, March, 1915.

ond, the existence of two general characters of the deposit in the E series.

The three zones can be readily distinguished in the photograph, figure 125, although they are actually much more sharply differentiated as to appearance than in the photograph. Figure 126 shows

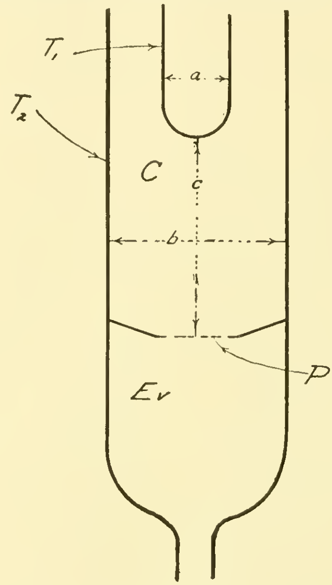

FIG. 124. See legend below.

Tube	Lengths in cms.		
	a	b	c
E	1.45	2.3	6.1
F	1.2	2.5*	4.3

*Outside measurement.

T_1=condensation tube
T_2=outside tube
C =condensation chamber
Ev=evaporation chamber
P =platinum partition

how the lengths of the zones are indicated in the tables. The zone nearest the end, or rather at the end and spreading up the sides of the tube for two or three centimeters, which will be referred to as zone 1, contains by far the greater weight of the condensed selenium, and is opaque over the major part of its length, with a dull lustrous appearance by reflected light. Zone 3 lies farthest up the tube, and farthest away from the apertures in the platinum partition where the molecules enter the condensation chamber. This upper zone has a dark, dirty color, and is fairly opaque by transmitted light. There is a possibility that this consists of impurity in the selenium, although this zone was present in some runs of the F series, where crystals supplied the vapor. Whatever the explanation, there must have been a separation from the others of the molecules making up this zone, by a process incidental to the condensation. It would seem that these molecules had been crowded out from below. The transparent middle zone may possibly be a continuation of the first zone, which becomes red, a characteristic selenium color, by transmitted light when opacity ceases. But since a thin layer of red material

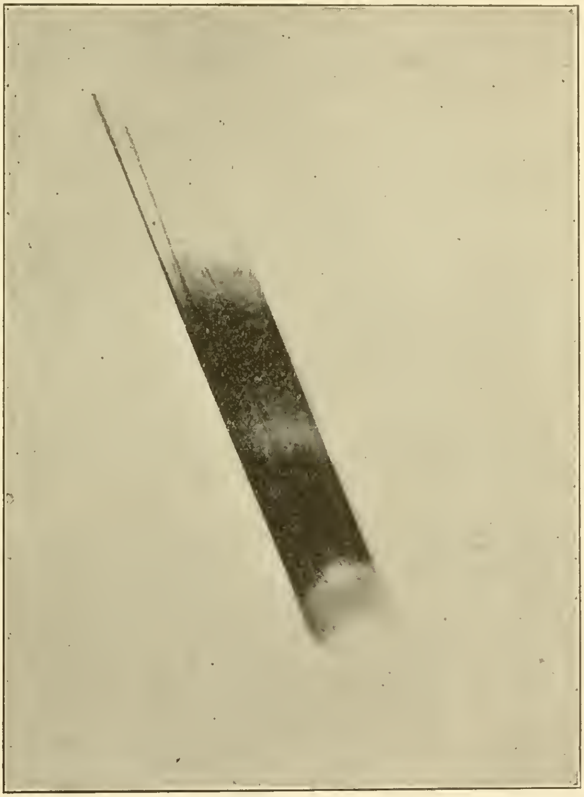

FIGURE 125

was frequently noted beneath the material of zone 1 and next the glass, there is some reason for doubting this. Conceivably both this red substratum and zone 2 are made up of substance deposited in the brief interval required for the vacuum to reach the required stage.

Egerton,[4] in describing similar work on the vapor tension of zinc and cadmium, using the same method of molecular flow, speaks of zones of different thicknesses on the condensation tube. But he makes no mention of differences in color, and suggests that mole-

[4]Phil. Mag., V. 33, 193, p. 33, Jan., 1917.

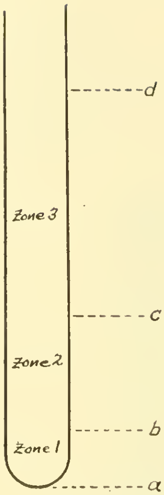

FIGURE 126

cules of different ranges are present in the vapor. It may be supposed that atoms in different states of aggregation in the molecules account for two or more different molecular types, and that these different types are re-evaporated from the condensation surface, according to Langmuir's view, before they finally settle permanently in position, such re-evaporation taking place with different degrees of ease for the various types, so that a kind of sifting of the molecules is effected. At any rate it would appear that molecular flow as applied in the vapor pressure work mentioned might be used for a separation of molecules of different types, mixed in the vapor state, whether these types belong to the same element, or substance, in different states of atomic aggregation in the molecules, or whether they are of different elements, or substances.[5] If such separation in reality occurs for the vapor molecules of different elements, then the method of molecular flow, with condensation at one end of the flow, ought to be available as a method of purification.

With special reference to the two general characters of series E, the runs not indicated in the tables as of character either "a" or "b," are probably in all cases "a," which was the usual form of the deposit. In fact, it was not until the sixth run that a new character, that subsequently designated "b," appeared. A note made at the time of this run, when the changed appearance of the condensed selenium could not escape notice, reads: "Character of zone 1 has changed somewhat. Instead of rather sharp margin this zone gradually shades off into zone 2, with the addition of an intermediate zone between the region of dull luster of zone 1 and the transparent zone 2, which appears black and glossy. This intermediate zone is translucent over much of its length. Nodules, small but distinct, and with fortuitous distribution, on end of tube, extending up over bend to sides." A similar note with reference to the eighth run of this series states: "Many nodules on end and sides in zone 1. Deposit more like that of E6 than of E7. Zone 3 noted to be opposite deposit on outside tube; but in E9, while zone 3 is about

[5]In this event an interesting question for experimental study would be, how susceptible to such a separating effect are molecules of mixed vapors of different elements, where the molecules all have the same number of atoms.

opposite lower part of deposit on outside tube, it extends farther down than the latter (less than ½ cm.) and not nearly so far up. Deposit on outside tube is [by this time] some 8 or 9 cms. long [much longer than usual]."[6] Still another note, referring to the tenth run, reads: "Zone 1 scrapes off harder than when deposit is of character 'a,' and in the transparent region of zone 2 the deposit has appreciable thickness and resists the knife. Zone 3 [which in this case appears to have been on the condensation tube itself] is fairly below the [previous] deposit on the walls of the outside tube. Zone 1 has nodules, on end and sides."[7]

Examination of the material in the two tables shows no marked effect of time on the character of the deposit, except of course to deepen it. There seems to be some increase in the total length with rising temperature. The two characters of the deposit in the E series appear to be unrelated to both time and temperature, and it is noticeable that the total length of the deposit does not depend markedly upon which one of the two characters is present. Also, the apparent transfer of zone 3 from the inside to the outside tube, observed in a few cases, is unexplained, although it was noted to occur, particularly in run E8, when the second character, b, was present. Whether it occurred only when this character was present is unknown.

Since the vacuum for by far the greater part of the time of each run was in all cases what may be termed "good," that is, a vacuum high enough to insure molecular flow, it is to be supposed that any variations of the vacuum over the small range of low pressures present had no effect on the nature of the deposit. Whether the relatively poor vacuum over a short part of each run before pressure conditions permitting molecular flow were established, had anything to do with determining which of the two general characters should prevail in a run of the E series, is undetermined. The cause of these two general characters does not appear to be cleared up by the present data on the basis either of varied temperature, of changing time of run, or of poor vacuum. They remain for the time being unexplained.[8]

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[6]The point corresponding to this run has been found to lie a little low on the vapor pressure curve, perhaps because the material condensed on the outside was not weighed. Condensation on the outside tube occurred in some of the runs, but the amount so deposited was usually small.

[7]Considerable light is thrown on this nodule structure appearing on the outside surface of zone 1, by a study of the special thick deposit, discussion of which has been omitted from the present paper, as already stated.

TABLE I

Run	ab	bc	cd	ad	Temp (°C.)	Time (secs.)	Vacuum (mm.)	Remarks
F 1					193.6	3000	n. r.* before end of run	Condensation tube discolored to about 10 cms. Three zones not noticed. Practically all of deposit within 2.2 cms. from end of condensation tube, or point "a", Fig. 126.
2					197.6	2760	n.r.– 9†	Condensation tube discolored to more than 9 1/2 cms. from point a. Deposit opaque to 2.5 cms. from a. Practically all of deposit in this region.
3 4					200.3	2205	good– 5	Deposit symmetrical, and opaque to 1.3 cms. from a. Discoloration of tube to 12 cms.
4	3.2 1.8‡	3.3	5.5	12.0	203.2	2370	fair– 4 good–13	Upper zone [zone 3] first makes appearance. Zone 1 lustrous [by reflected light] to 3.2 cms., and opaque to 1.8 cms. Zone 2 translucent.
5	2.5 1.8‡	4.5	4.0	11.0	204.4	2610	good–13	A little deposit on outside tube, 12 cms. from point a.
6	3.8 2.2‡	5.7	3.5	13.0	206.5	2445	good–14	
7	3.0 1.5‡	4.5	4.5	12.0	208.9	2130	good– 7	
8	3.5 2.3‡	5.0	4.5	13.0	210.6	2025	good–10	
9	5.0 4.0‡				212.5	1020	good– 8	Zone 3 not evident [due to its transfer to walls of outside tube (?)]. Discoloration to unknown point rather high up on condensation tube. Nodules appearing in zone 1.
10	4.0 3.0‡	7.0			214.0	1830	good–12 good–12 good–28	Zone 3 not evident on inside tube, but deposit [opposite its former position on condensation tube(?)] on outside tube, with lower margin 8 cms. from point a.
11	4.2	5.8			215.5	2070	fair–10 0.0008–20 0.0008–27	Nodules in zone 1. Zone 3 missing from condensation tube [probably again transferred to outside tube]. Poorer vacuum here than in preceding runs, but not preventing molecular flow.

*"n. r." means "not readable on MacLeod gauge."

†The dash and numeral in this column indicate the time in minutes from the beginning of the run, when the vacuum reading was taken.

‡The first of the two numbers in column ab for a given run gives the length of the zone determined by its characteristic lustrous appearance by reflected light, while the second number indicates the opaque length.

TABLE 11

Run	ab	bc	cd	ad	Temp (°C.)	Time (secs.)	Vacuum (mm.)	Char. of Dep	Remarks
E1	2.5	5.5	2.5	10.5	221.0	2055	0.0002– 7* .00016–14 .00016–27		
2	3.0	4.0	3.5	10.5	219.0	2950	not good–2 <0.0001–10 n.r.–22 n.r.–41		Zone 3 follows wiping marks other zones do not. Narrow ring around outside wall within 1 cm. of point a; cause(?), two resistance lamps of auxiliary heating circuit had been off during this run.
3	3.2	5.3	2.5	11.0	228.0	2520	0.0002– 6 n.r.–17 good–35		
4	3.2	4.8	3.0	11.0	226.8	2400	n.r.– 7 n.r.–30		
5	3.5	5.0	3.5	12.0	233.7	2430	n.r.– 7 n.r.–30		
6	1.8	6.7	4.0	12.5	238.0	2355	<0.0001– 5 <0.0001–12 better–23 good–35	b	(For note on this run see discussion.)
7	3.5	5.5	3.5	12.5	231.7	2210	<0.0001– 8 n.r.–28	a	Nodules on end of condensation tube.
8	2.0†	7.5	3.5	13.0	231.2	2520	n.r.– 9 good–29	b(?)	(See discussion.)
9	4.0	4.5	2.0	10.5	232.0	2400	0.0002–6 n.r.–21 good–35	a	See discussion, where note is given for E8.
10	1.5†	5.5	2.0	10.0	229.6	2400	n.r.– 9 good–26	b	(See discussion.)
11	3.0	3.5	3.5	10.0	222.7	2355	0.0001–10 n.r.–26	a	
12	3.0	5.0	2.5	10.5	222.2	2470	0.0001– 9 n.r.–21 good–30	a	Individual nodules in zone 1 not noticeable.
13	3.3	4.7	2.5	10.5	224.8	2400	0.00004– 7 good–24	a	Selenium below must have solidified very soon after removal of tube from oven.
E14	3.5	4.5	2.0	10.0	224.0	2460	0.0002– 7 n.r.–18	a	Fine nodules, zone 1.
15	1.5†	6.5	2.0	10.0	223.4	2400	0.0002–11 n.r.–21 good–30	b	Nodules, zone 1.
16					227.7	2400	n.r. –8 good–20 good–34	b(?)	No measurements on zones. Margins not defined (?). Deposit scrapes off like character b.
17	1.0†	6.5	2.0	9.5	227.5	2370	0.0002– 8 n.r.–17 good–30	b	Small nodules, zone 1.
18	3.5	3.5	2.5	9.5	225.5	2400	n.r.– 9 good–20 good–34	a	Small nodules, zone 1, a little larger than in E17

TABLE II—Continued

Run	ab	bc	cd	ad	Temp (°C.)	Time (secs.)	Vacuum (mm.)	Char. of Dep.	Remarks
19	3.5	3.5	2.0	9.0	225.8	1930	n.r.– 9 good–21	a	
20	3.5	3.5	2.5	9.5	224.8	2910	0.0001–10‡ good–22	a	Run interrupted after 8 1/2 mins., then resumed. Nodules, zone 1.
21	not taken		1.5	9.5	223.8	2430	good– 9 good–31	b	Deposit translucent, in spite of considerable thickness, nearly to end a
22	3.0	4.0	2.0	9.0	226.6	2460	good– 7 good–20 good–31	b	
23	3.0	3.5	2.5	9.0	224.1	1830	good– 8	a	
24	3.0	4.0	2.0	9.0	223.2	2385	<0.0002–8 n.r.–25	a	
25	3.0	4.0	2.0	9.0	221.3	2400	n.r.– 6 good–23 good–33	a	
26	3.0 to 3.5	4.0 to 3.5	2.0	9.0	222.0	2400	n.r.– 7 good–17 good–31	a	
E27	3.0	4.0	2.0	9.0	224.5	2430	0.00004– 9 good–24	a	
28	3.0	4.0	2.0	9.0	223.9	2400	n.r.– 7 good–23 good–36	a	
29	3.0	5.0	2.0	10.0	226.2	2430	n.r.– 8 good–25	a	
30	3.0	5.0	2.0	10.0	228.2	2400	good– 9 good–28	a	Excess heat from fan?

*See second note, Table I.
†Length of zone 1 to point where opacity ceases.
‡After second start.

THE SUBLIMATION CURVE FOR SELENIUM CRYSTALS OF THE HEXAGONAL SYSTEM

L. E. DODD

The type of apparatus used in the present work on the vapor tension of selenium, as well as the method, is due originally to Knudsen.[1] The apparatus in the form in which Knudsen used it was modified somewhat by Egerton.[2] Egerton's experimental scheme has been followed essentially in the present work.

The selenium was placed in the lower chamber of a glass tube, which in turn was set in place in a Freas electric oven, after the temperature had been adjusted. Tap water was run through the condensation tube for cooling. The apparatus was exhausted by oil pump, Gaede mercury pump, and Langmuir condensation pump, all in series, so that a good vacuum was obtained, as shown on the McLeod gauge. The saturated selenium vapor passed up through apertures in a platinum partition. This partition, as well as the tube itself, offered resistance to the vapor flow, which was of the molecular type described by Knudsen. The resistance is a constant of the tube, which includes partition with apertures. Its value was determined by measurements of the dimensions and calculation therefrom by the use of Knudsen's equations for molecular flow, and the calculated value was then checked by experimental values obtained with mercury as the standardizing material.

The vapor tension was computed from the Knudsen equation,

$$p—p^1=W/\sqrt{P^1}.G/T,$$

where p is the vapor tension whose value is sought, p^1 the vapor tension at the temperature of the condensation tube, regarded here as negligible, W is the tube resistance, G the amount in grams of selenium passing over in time T, and P^1 the vapor density at unit pressure and at temperature of the tube.

A considerable amount of data was taken on the vapor tension of selenium during the past year. One of the latest and best of the sublimination curves for selenium crystals of the hexagonal system is presented. The measurements, which will be found in Table I,

[1]Annalen der Physik, 29, p. 179, 1909.
[2]Egerton, Philosophical Magazine, V. 33, 193, p. 33.

TABLE I

W = 12.4; Tube, "F".

No. of Mes'ta	t (°C.)	T (secs.)	G/T ×10⁴	1/√p₁ ×10⁻⁴	p (diat. vapor)	1/T ×10³	log p
1	193.6	3000	0.1000	1.566	1.94	2.143	0.2378
2	197.6	2760	.1525	1.573	2.98	2.124	.4742
3	200.3	2205	.1795	1.577	3.51	2.112	.5453
4	203.2	2370	.2130	1.582	4.18	2.099	.6212
5	204.4	2610	.2550	1.584	5.01	2.094	.6998
6	206.5	2445	.2825	1.588	5.57	2.085	.7458
7	208.9	2130	.3240	1.592	6.40	2.075	8062
8	210.6	2025	.3950	1.594	7.81	2.067	.8926
9	212.5	2010	.4650	1.598	9.22	2.059	.9647
10	214.0	1830	.5000	1.600	9.92	2.053	.9965
11	215.5	2070	.5500	1.620	11.05	2.047	1.0433

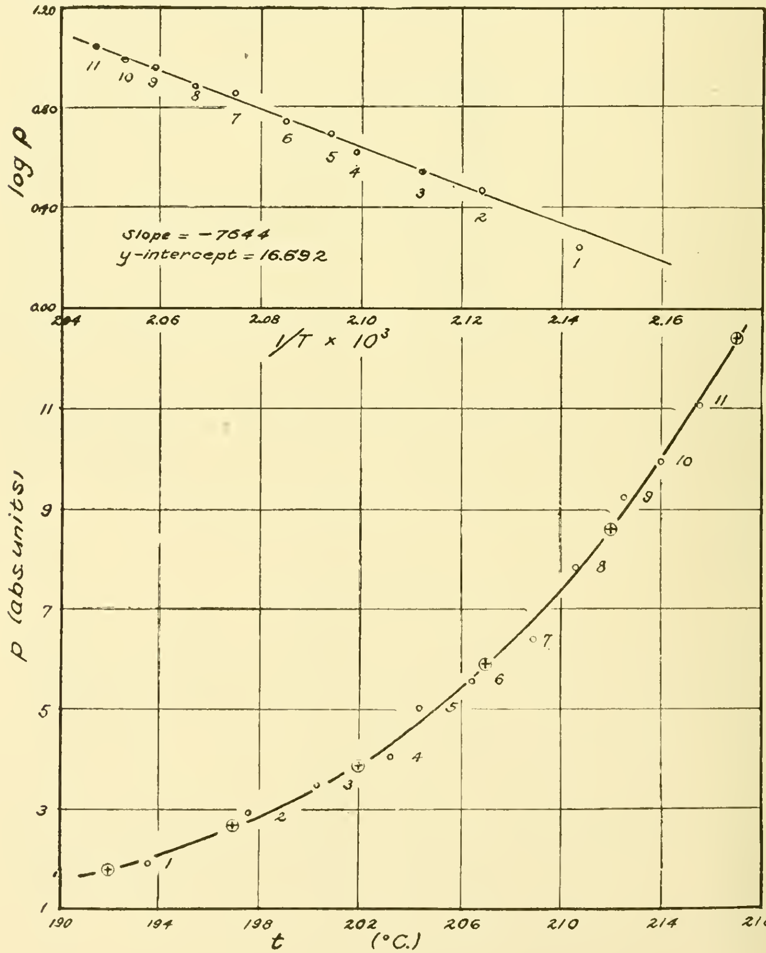

FIGURE 127

are treated on the basis of a diatomic vapor, in absence of knowledge as to the real state of aggregation of atoms in the molecule of selenium vapor at the temperatures of the experiment. Such treatment of the data gives a vapor pressure curve, figure 127, that, empirically at least, and for the present range of temperatures, can be expressed by a simple exponential relation, $p=C_1e[C_2/T]$. For selenium vapor treated as diatomic this becomes, on the basis of the present measurements, $p=4.92\times10^{16}.\ 10[-7644/T]$.

TABLE II

T	p
465	1.8
470	2.7
475	3.9
480	5.9
485	8.6
490	12.4
495	17.8

The pressures for six temperatures as computed from this empirical equation are given in Table II, and the corresponding points on the curve are indicated by the large circles, enclosing crosses.

If the relation is either exactly exponential or very nearly so, the only effect of regarding the vapor molecule as other than diatomic will be to change the magnitude of the constant C_1, which change will not destroy the characteristic exponential shape but only affect the computed pressure values, by decreasing them as the number of atoms taken per molecule is increased. Thus, the lower, p_1, and the upper, p_2, limiting pressure values for six different values of the number of atoms, m, assumed per molecule, are given in the following Table III, in absolute units.

TABLE III

m	Factor	p_1	p_2
2	1.000	1.94	11.05
4	0.707	1.37	7.81
6	.577	1.12	6.38
8	.500	0.97	4.96
10	.447	.86	4.43
12	.408	.79	4.05

SUPERPOSED STROBOSCOPIC VELOCITIES

L. E. DODD

The curves plotted from the stroboscopic velocity equation,[1] $v_s = (A - n/m.B)D_0$, (1) and from the derived form,[2] $f = mN - nB$, (2) show that from a given frequency of the stroboscopic figures there is an unlimited number of illumination frequencies that will give the stationary stroboscopic condition, and conversely, for a given value of the illumination frequency there is an unlimited number of frequencies of the stroboscopic figures that will make v_s equal to zero.

To restate the matter in more definite form and to fix ideas in the remarks that follow, reference will be made specifically to the tonoscope drum.[3] By eq. (2) above, for a given row of dots on the drum (definite value of N) there is an unlimited number of illumination frequencies that can produce the stationary condition ($f = O$), and conversely, for a given illumination frequency there is an unlimited number of rows on the drum (supposed of infinite extent) capable of reacting to that illumination frequency with a stationary stroboscopic response.

In the first case, where a fixed value of A (or N) is taken, it may be imagined that several of the unlimited number of illumination frequencies possible are operating at the same time. Mathematically at least, each of these frequencies will produce its own stationary effect, with the simple images caused by it alone having as their distance of separation the quantity D_o/m. If $m = 1$ for all of these several frequencies simultaneously present then the resultant effect will have one of two general characters. The first general character will show the appearance produced by one of the illumination frequencies alone, with the exception of a greater intensity of the simple images, and will be due to the several illumination frequencies all catching the stroboscopic figures in the same phase. (A definite "phase" in the sense here used is indicated by a fixed point near the surface of the drum, such as a point on the tonoscope scale.) The second general character will show the appearance of several rows of stationary simple stroboscopic images superposed so that

[1]Proc. Iowa Acad. Sci., XXIV, p. 222, 1917.
[2]Proc. Iowa Acad. Sci., XXV., p. 49, 1918.
[3]Proc. Iowa Acad. Sci., XXIV, pp. 223-224, 1917.

the individual members of a given row do not coincide with those of other rows. This mutual displacement of the stationary stroboscopic rows will be present where the several illumination frequencies do not catch the stroboscopic figures in the same phase, and the nature of the relative displacements depends on these relative phases. (If some of the illumination frequencies are in phase while others are not, the character of the effect is a combination of the two just described.)

In the second case, where a fixed value of B is taken, it may be imagined that several of the possible unlimited number of rows of dots on the drum are superposed to form a single resultant row. Mathematically at least, as many stationary stroboscopic effects will be produced as there are rows of dots superposed to form the one composite row of stroboscopic figures. The resultant stroboscopic effect thus produced by a single illumination frequency will be of the same general nature and have the same two general characters as in the first case. Here, however, it will be a question of the single illumination frequency catching the different rows of dots all in either the same or different phases. (If some of the dot frequencies are in phase while the others are not, the character of the effect is a combination of these two general characters, as in the first case.)[4]

In either of the two cases, v_s for each of the component stroboscopic effects may have a plus or a minus as well as a zero value. Thus, taking say any two of the component effects,[5] they may have the same positive, or negative, or different positive, or negative, velocities. Or one of the pair may have a positive and the other a negative velocity. Thus, where more than two component effects are present the resultant is the complex appearance of a number of rows moving through each other at different rates and in the same or both directions.

But a complex stroboscopic appearance is mathematically possible by a single illumination frequency acting upon a single row of dots on the drum. Thus, with reference to the f and B curves (loc. cit.), for a fixed value of B there are an unlimited number of f values possible, as is seen from the intersections of the line B=constant, with the velocity curves. These f values will in general be both positive and negative, and depending not only on the particular value of B but also on the value of N for which the set of curves

[4]A third possible case may be imagined, a composite of the two just described, where there are several illumination frequencies acting upon several different rows of dots that are superposed to form a single complex row.

[5]By "component effect" is here meant an individual row of simple stroboscopic images due to a given row of dots (given value of N) and a given frequency of illumination.

is drawn, may include the zero value, or stationary condition. Also, with reference to the f and N curves, with B constant, the same possibility is again obvious, from the intersections of the line N=constant, with the velocity curves. The actual production, through a proper choice of the necessary quantities in a suitable apparatus, of such a visual complex effect, confined to a single row of dots on the stroboscopic screen, and due to but one illumination frequency, is an undertaking that would appear to be worth while.

In conclusion, the several mathematical situations described suggest a definite line of experimental study, of possible interest in psychology.

WASHINGTON, D. C.
September, 1919.

THE RELATION BETWEEN VOLTAGE AND CANDLE-POWER IN MODERN INCANDESCENT LAMPS

WILLIAM KUNERTH

Among the operating characteristics of incandescent lamps, there are certain features which are often overlooked by the man using or dealing with lamps. The voltage is one of the chief factors upon which the behavior of a lamp depends. It is well known that under an excessive voltage, a lamp will not last long, but will last much longer than its normal life if the voltage is below normal. Mathematical formulæ have been deduced from experimental results to cover this relation.

It is frequently found desirable to tell what the candle-power of a lamp is when its voltage and the rated candle-power at some other voltage are known. The accompanying curves show this relation as determined experimentally from a considerable number of G. E. lamps. The Mazda B or Mazda vacuum lamps tested ranged from 20 watts to 100 watts; the Mazda C_2 or daylight lamps from 75 watts to 200 watts; the Mazda C or gas filled lamps from 75 to 100 watts, and the carbon lamps as indicated on the curve. It may be noticed from the curve that the 20-watt carbon lamp gives only 10 per cent as much light at 80 volts as it does at 110 volts.

Everyone knows that there is a great deal of fluctuation of line voltage on some commercial circuits. The candle-power of the lamp will rise or fall with the change in voltage as shown by the curve and this will have a corresponding effect upon the person using the light for reading or working.[1]

Curves of this kind have the advantage that the candle-power desired may be obtained with very little calculation. This is much simpler and quicker and more accurate than the mathematical relation which is also given herewith for the different lamps tested. In the expression $\frac{I}{I_{st}} = \left(\frac{V}{V_{st}}\right)^k$, I is the candle-power sought, V is the voltage at which the lamp is operated, Ist is the candle-power at

[1]See Iowa Acadamy of Science Proceedings. Vol. 22, p. 333.

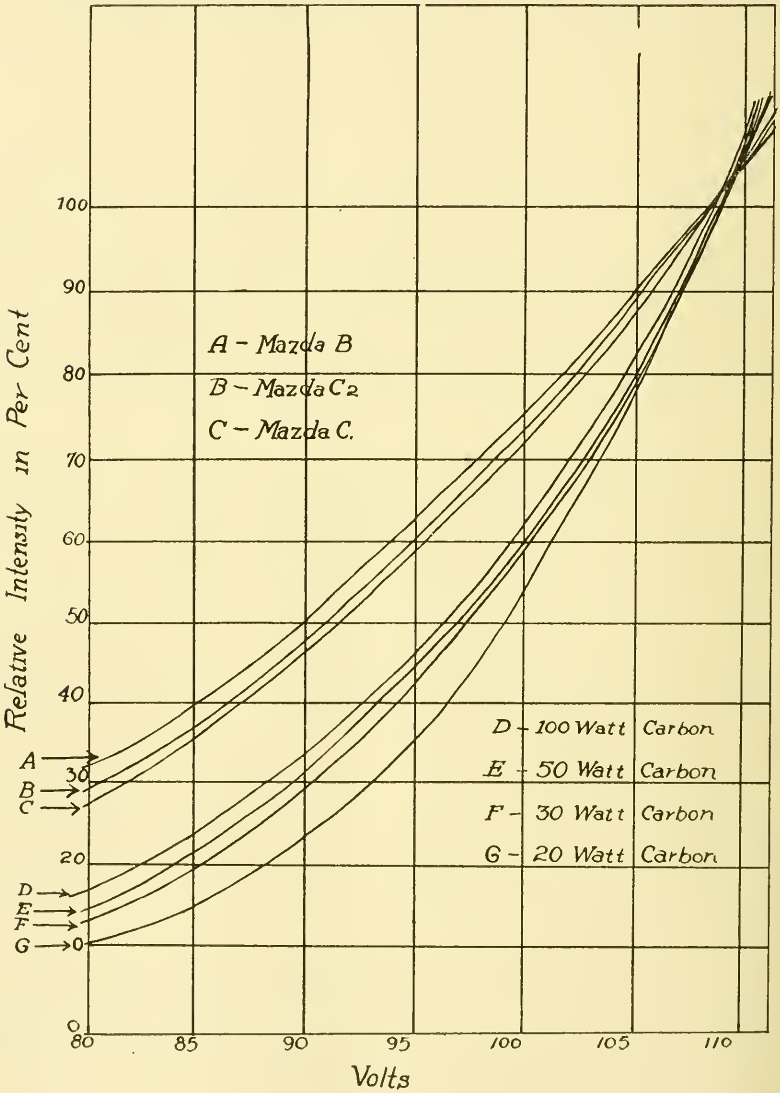
A - Mazda B
B - Mazda C2
C - Mazda C.
D - 100 Watt Carbon
E - 50 Watt Carbon
F - 30 Watt Carbon
G - 20 Watt Carbon
Relative Intensity in Per Cent
Volts
100
90
80
70
60
50
40
30
20
0
0
80
85
90
95
100
105
110
A
B
C
D
E
F
G

FIGURE 128

the rated voltage Vst, usually 110. The average exponent K is found to be as follows:

Mazda B lamps	3.6
Mazda C_2 lamps	3.8
Mazda C lamps	4.1
100-watt carbons	5.7
50-watt carbons	5.9
30-watt carbons	6.1
20-watt carbons	7.2

This relation, however, is not very reliable since the exponent k is not constant over a very wide range of voltage.

For the older forms of carbon lamps, the value of k is much higher. Even for those here used it is higher than for the modern Mazda lamps. For that reason much better regulation is required for the older types of lamps than for those most commonly used at present. As the curves indicate the Mazda B lamp permits of more variation in voltage for a certain change in candle-power than does any other type of lamp tested. In other words, the change in intensity of illumination will be less noticeable in the case of a Mazda B lamp for a certain change in voltage than in the case of any other type of lamp tested.

If the voltage changes came in very quick succession (say at half second intervals) the changes in illumination would make themselves felt much more for the small-sized lamps than for the big ones, because the filaments are thinner and hence cool off much more quickly. This, however, has no detrimental effects upon the results herein given.

Physics Laboratory,
Iowa State College.

THE ACTION OF CONICAL HORNS

G. W. STEWART

ABSTRACT

Conical horns possess two aspects of considerable importance. In the first place, they are an exceedingly important form of acoustical apparatus. Again, there is no exact theory of the action of conical horns and hence the only recourse for quantitative information is that of experiment.

Using two frequencies, i. e., 256 d. v. and 512 d. v., the following experimental results were obtained with conical horns:

1. If with a conical horn of fixed angle the length be altered with the frequency of the received sound constant, it is found that the intensity at the vertex of the horn passes through a series of maxima and minima with the peculiarities that the maxima are of the same order of intensity and the minima increase with the length of the horn, showing an amplification of the sound at all lengths greater than that for fundamental resonance.

2. There is an optimum angle for each of the frequencies, the greater frequency requiring a larger angle at fundamental resonance. For 256 d. v. the optimum ratio of radial length to diameter is about 5 to 1. With 512 d. v. this optimum ratio is about 4 to 1.

3. For a given frequency and varying lengths of conical horn the optimum angle decreases as the frequency becomes an overtone of a higher order. The rapidity of this decrease when expressed in ratio of radial length to diameter of opening as a function of the order of overtone, is approximately the same for the 256 and 512 d. v.

4. The variation of intensity with horn ratio is less marked the higher the overtone.

5. The resonance of any tube attached to a horn for listening purposes will be superimposed upon the characteristics of the horn itself but with resonance frequencies of the attachment modified in

a direction depending upon the slopes of the attachment and the horn.

6. The end correction of the conical horn in these experiments is shown to be approximately 0.7 times the radius.

Physical Laboratory,
State University of Iowa.

THE BINAURAL DIFFERENCE OF PHASE EFFECT

G. W. STEWART

ABSTRACT

The binaural difference of phase effect has become of increased importance in recent years. The following are the new facts obtained in recent experiments which are still in progress:

1. For a frequency of 130 d. v. the ratio between the phase and the apparent displacement from the median plane is approximately unity. The ratio will be called the "displacement ratio."

2. This "displacement ratio" is not the same for frequencies from 50 to 1,300 d. v. Present experiments indicate that this "displacement ratio" can be expressed approximately in the following equation:

$$\text{Ratio} = 0.5 + 0.0037 \times \text{frequency}.$$

3. This equation shows that the sensitivity of the ears as expressed by displacement is not strictly a time effect nor is it strictly a phase difference effect. At the lowest frequencies mentioned the change in displacement ratio is so slow as to indicate that, approximately, the displacement depends only on the phase and is independent of frequency. But in the higher frequencies from 500 to 1,000 the displacement is approximately inversely proportional to the frequency. This would represent equal sensitivity in equal difference in time of arrival of the waves.

4. When the sound listened to binaurally is complex, the tones in the lower range will have a different displacement. This has been verified and in addition it is found that the presence of an overtone tends to decrease the sensitivity for the fundamental. It is also found that if the overtone is faint enough, both tones are displaced together in accord with the displacement of the fundamental. In a similar manner if the fundamental is sufficiently faint, the displacement of the entire tone is that of the overtone.

Physical Laboratory,
State University of Iowa.

EFFECT OF TEMPERATURE ON RESISTANCE AND SPECIFIC RESISTANCE OF TELLURIUM CRYSTALS

ARTHUR R. FORTSCH

In his Master's thesis Dr. Tisdale[1] gives some results on the effect of temperature on the resistance of tellurium crystals. He finds a decided maximum at about zero degrees Centigrade. Inasmuch

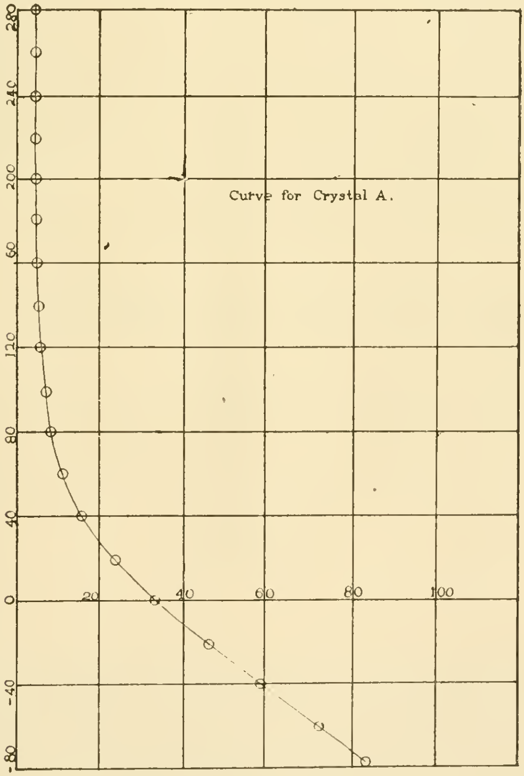

FIGURE 129

as tellurium crystals are supposedly homogeneous it was considered advisable to investigate the matter further. The crystals were mounted by fusing platinum wires into the ends and placing the

[1]Tisdale—"Tellurium Crystals"—Thesis—1915.

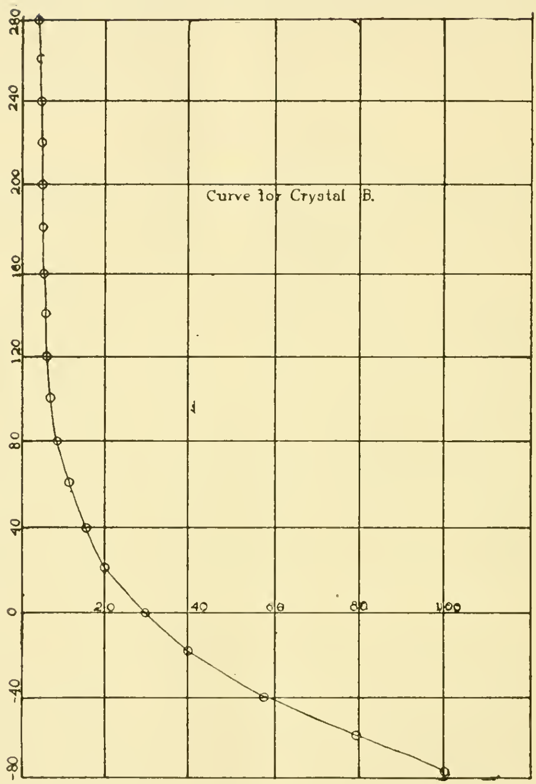

FIGURE 130

whole into evacuated glass tubes. They were then subjected to temperatures varying from —79 degrees C. to +280 degrees C. No maximum was found. Curves are given for three such crystals. The curve obtained by Tisdale[2] is also included for comparison. The maximum effect is probably due to the heating produced by the current used in the method of measurement.

[2]Loc. cit. State University of Iowa.

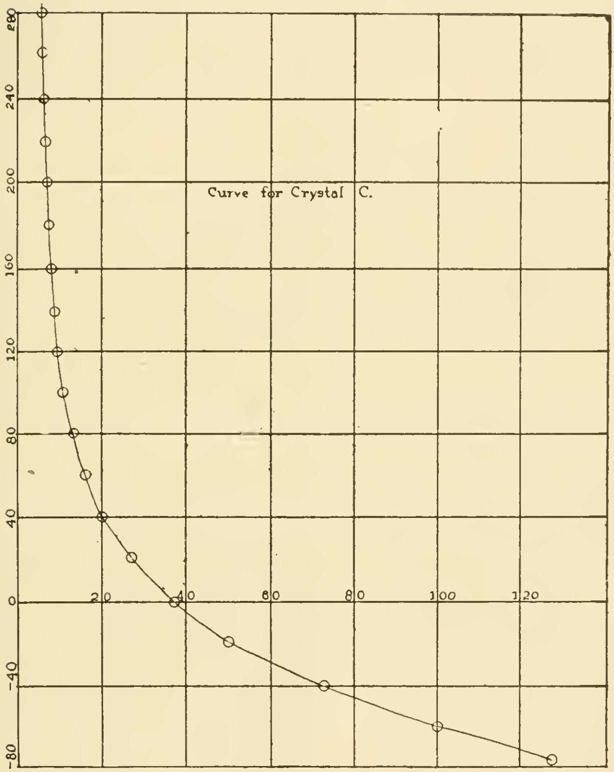

FIGURE 131

Measurements were taken of the dimensions of the crystals and the specific resistance was computed. The value found was .174 ± .004 ohms/cm. cube, at zero degrees Centigrade. The values of the specific resistance obtained by different authors do not agree. However, this is to be expected where mass tellurium is used. But when crystals are used we should expect agreement.

From the results obtained it appears that tellurium does not obey the Wiedemann-Franz Law, and that the resistance decreases with

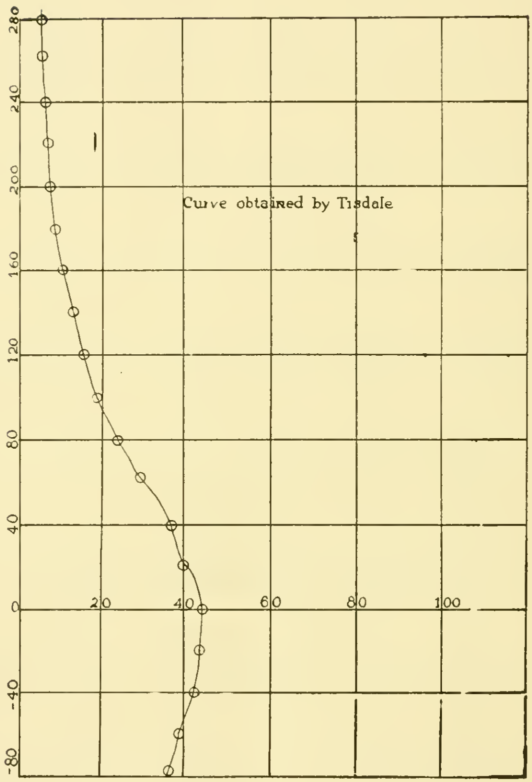

FIGURE 132

increased temperature. In these respects it does not appear to have the nature of metals. It is evident that the theory of conduction used to explain the conduction of electricity in metals cannot be applied to tellurium. The fact is also emphasized that no judgment may be made on results obtained with tellurium unless a complete history of the material and the method of procedure is at hand.

Department of Physics,
State University of Iowa.

OBSERVATIONS OF THE TOTAL SOLAR ECLIPSE OF JUNE 8, 1918, AT MATHESON, COLORADO

D. W. MOREHOUSE

The Drake University Observatory eclipse expedition occupied a very favorable site at Matheson, Colorado. It was wholly through the courtesy of Dr. Edwin B. Frost, Director of the Yerkes Observatory, who with Prof. E. E. Barnard, had selected this station as one of two very desirable locations, that the expedition was so happily situated.

There were four eclipse parties at this station. Prof. Frank H. Loud was in charge of the company from Colorado Springs, Prof. C. A. Chant represented the University of Toronto, Toronto, Canada. Prof. Edison Pettit, of Washburn College, directed the Yerkes Observatory detachment assigned to this site. The writer and his assistant manned the instruments of the Drake Observatory.

The center of the moon's shadow crossed the meridian 103° 59′ W. in latitude 39° 9′ N. The position of our eclipse station, as determined by Pettit and his party, was:

Longitude 103° 59′ W.
Latitude 39° 10′ N.

We were, therefore, one minute of arc (less than a mile) north of the central line. Matheson Station (Rock Island Depot) bears 50° 35′ East of North, distance 8,430 feet. The altitude is about 6,000 feet.

CONTACTS

The first and fourth contacts were observed by Pettit and myself through my three-inch finder attached to the equatorial, by the projection method. Professor Pettit caught the first glimpse of the moon at $4^h\ 13^m\ 49^s.5$ and I caught it a half second later. The computed times of contact for our station, after applying the correction published by Arthur Newton in the Astronomical Journal No. 733, are:

1st contact	4^h	13^m	$41^s.6$	Mountain Summer Time.
2d contact	5	23	50 .7	
3d contact	5	25	19 .6	
4th contact	6	28	03 .7	

We were a little surprised that we should have been nearly seven seconds slow in our observed time, for the contact was very sharp and easily detected. The second and third contacts were not observed directly, every observer being busy with his program. The fourth contact was observed in the same manner as the first, but the low sun together with the clouds, made the observations very uncertain, as the results show. Observed 4th contact 6^h 27^m 16^s, Mountain Summer Time.

BAILY'S BEADS

Baily's Beads were observed by Prof. C. C. Plitt, of Baltimore City College, Baltimore, Maryland, by projection on a white screen through my three-inch finder. He reports that they appeared at 5^h 23^m 51^s, Mountain Summer Time, which was just six seconds before time was called for the beginning of totality by the timekeeper. This agrees beautifully with the time for second contact, as computed by Professor Pettit. Professor Plitt said there were at least twenty-five beads and they were yellowish in color and very sharp. I have been unable to find much of a discussion of this phenomenon at previous eclipses. The earliest note I have found is by Lockyer, in 1836, who says, "Sometimes when the advancing moon has reduced the sun's disc to a thin crescent, or in the case of an annular eclipse, to a narrow ring, a peculiar notched appearance is presented in a part of the narrow strip, which makes it look like a string of beads. It is supposed to be the effect of irradiation." I know of no other station at which this phenomenon was observed at this eclipse.

THE FLASH SPECTRUM

This was observed visually with a small direct-vision, slitless ocular spectroscope (such as is placed over the eyepiece of the telescope for observing the spectrum of the stars) by my assistant, Mr. Donald Smith, who makes the following report: "The reversal of the Fraunhofer lines was observed at the instant preceding and at the instant following totality. The bright lines flashed out suddenly and lasted for approximately one second at each of the observations. Lines in the red and blue-green (probably due to hydrogen) and in the yellow (probably the helium line) were most conspicuous.

There was a very large number of small lines in the yellow and yellow-green especially. A faint continuous spectrum served as a background."

THE SHADOW BANDS

Mrs. Stella Meek Whisler, of Illinois College, Jacksonville, Illinois, observed this phenomenon by spreading upon the ground at the northwest corner of the shack a large piece of white oilcloth (about ten feet square). She reports as follows: "The shadow bands were very distinct and plainly visible just before and after the period of totality. They were black and white, each about one inch to one and one-fourth inches in width and three to four inches apart, and traveled in the direction of northwest and southeast, or parallel to the path of the shadow. Their direction of orientation was, northeast and southwest. They appeared by the hundreds and passed very rapidly, resembling ripples or waves on the water. They passed so rapidly I could not even guess at the number per second. The phenomenon of the shadow bands was one of the many beautiful and interesting sights observed during the eclipse. In both instances they passed in the same direction and at the same angle. They lasted for two or three seconds on each occurrence."

REPORT OF SHADOW BANDS IN THE TOTAL SOLAR ECLIPSE OF MAY 28, 1900

It is interesting to compare the above observations of the shadow bands with similar reports made by members of Prof. C. A. Young's party at Wadesboro, North Carolina, May 28, 1900. I quote Astrophysical Journal, Vol. 12, June-December, 1900: "These were satisfactorily observed by Mr. Reilly, Mr. Erdman and Mr. Meier upon two tent-flies, one inclined and nearly facing the eclipsed sun, the other lying upon the ground. The bands first appeared about a minute and a half before totality, lying in a plane nearly tangent to the uneclipsed arc of the sun's limb, about two inches wide, but wavy and irregular, separated by an interval of from five to seven inches and moving with a speed of about five or six miles an hour in the direction from southwest to northeast. As totality approached, the interval between the bands diminished, till they were only an inch or two apart, and the speed of their apparent motion increased enormously to the velocity of an express train. After totality, they were more irregular, close together, with no decided progressive motion but simply quivering or oscillating. They lasted about a minute and a half before fading out."

Prof. C. W. Crockett, of Rensselaer Polytechnic Institute, reports (see ibid) from observations at Juliette, Georgia: "A sheet was spread horizontally, the corners being tacked to stakes driven in the ground. The observers reported that the bands were about the width of a man's hand, wavy and indistinct, and that it was impossible to count them."

PHOTOGRAPHS OF THE CORONA

The three eclipse parties agreed upon a definite program. A break circuit chronometer owned by Professor Pettit operated three sounders, one in each shack. Prof. P. F. Whisler, of Illinois College, Jacksonville, Illinois, acted as official timekeeper. Beginning five minutes before the computed time of totality, he called each minute in the reverse order, as, five, four, three, two and one. Miss Vera Gushee, of Smith College, at the appearance of the corona, gave the signal to start by striking a large barrel with a hammer. This was the zero of our exposure time. At this signal, Professor Whisler called out the half beats of the chronometer, as zero, and, one, and, two, and . . . In our practice, I had been stopping on the eighty-sixth second, although our computed time gave us eighty-eight seconds.

With this program, I secured six photographs of the corona, one with the five-inch photographic doublet and five with the eight and one-fourth inch equatorial, which was provided with a photographic lens of 120 inches focal length by the John A. Brashear Co., and the regular driving clock. The photographic doublet was attached to the tube of the equatorial.

The photographs with the doublet and equatorial were taken simultaneously with forty seconds exposure, from the eighteenth to the fifty-eighth second of our program. The five-inch negative is badly overexposed. The corona merges into the sky effect and the prominences are reversed, that is, they are light in the negative. A slender halo, also reversed, standing out away from the moon's disc, connects the top of two prominences which are about sixty degrees apart. The corona is distinctly triangular in shape. The long eastern streamer forms the vertex of an isosceles triangle and the western streamers diverge to form the base. This is quite unusual. Most of the previous eclipses have shown a quadrangular or irregular four-rayed star shape. When we consider the position of the three great prominences and the fact that the longest streamers were directly above them, it seems not impossible that there is some connection between the prominences and the shape of the corona.

Only three star images (including Jupiter) are visible on this plate. Jupiter's image is very distinct, but too near the edge of the plate to be good. Beta and Zeta Tauri are at the very limits of the field, and their images appear as crescents.

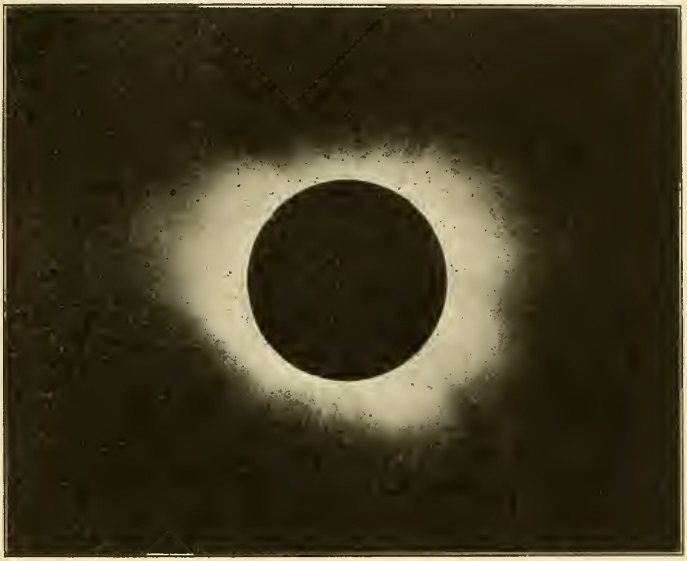

FIG. 133.—Plate No. 1. Exposure one second; $5^h\ 23^m\ 57^s$ to $5^h\ 23^m\ 58^s$.

Five photographs were taken with the eight and one-fourth inch equatorial with the following exposures:

No. of plate	Exposure time	Exposure interval	Make	Remarks
1	0 Sec. to 1 Sec.	1 second	Seed 23	Backed
2	6 Sec. to 11 Sec.	5 seconds	Seed 30	Backed
3	18 Sec. to 58 Sec.	40 seconds	Seed 30	Backed
4	63 Sec. to 74 Sec.	11 seconds	Seed 30	Backed
5	81 Sec. to 86 Sec.	5 seconds	Seed 23	Backed

The 1-second and the 5-second exposures are the best plates. They were developed with metol-hydrochinon developer. The structure of the corona is well shown on both plates. It is composed of interlacing rays radiating from the sun, giving a strong resemblance to the aurora. Some streamers are very much brighter than others and can be traced a distance of two diameters of the sun, over a million and a half miles. Those about the poles, the so-called polar fans, are very distinct and strong. At the north pole, they seem to be longer and not so sharply curved, and apparently more numerous, while at the south pole they are sharply curved, especially toward the west. The western half of the corona is full of detail. Three distinct, petal-shaped extensions radiate from the center, covering an arc of about 120 degrees. One quickly thinks of the appearance of the petals of a white wild rose. This petal-like formation has been observed in many previous eclipses, but its structure has not been so apparent. It is made up of these bright rays which seem to bunch around the sun-spot zone. The dark rifts described in our textbooks are very probably the spaces between these petal-like formations.

Two slightly curved rays, extending from the southwest quadrant, cross at a very definite, measurable angle. The eastern streamer has many straight rays, a little brighter than the general corona, extending through it at small angles to its general direction. Three remarkably bright prominences stand out over the moon's disc at approximately 120 degrees apart. One of the most remarkable features, and, so far as I know, one which has not been observed in previous photographs, is the arching of the corona around the prominences. The upper eastern prominence, which is the highest, has three arches, one above the other, but not in the same plane. The lower western prominence has still larger arches, but slightly fainter. A small prominence is located near each pole of the sun.

The 40-second and 11-second exposures were sent to Professor Barnard at Yerkes Observatory, who very kindly consented to develop them for me. As was expected, the 40-second plate was badly overtimed, indeed to such an extent that the prominences were reversed. Professor Barnard stated in a letter to me that he did not know of a similar occurrence in eclipse negatives. The corona is nearly lost in the sky effect.

The 11-second plate is much better, but not as good as the shorter exposures.

Plate No. 5 is quite interesting. As noted above, I stopped the exposure promptly at the 86th second, although the signal to stop had not been given by the timer. The chromosphere is distinctly visible at the western edge of the moon's disc and is reversed, that is, light in the negative. At either end of the arc of the chromosphere is a prominence. The one at the southern end is extremely delicate in structure, resembling the skeleton of some prehistoric bird.

The unexpected brilliancy of both the prominences and the corona was the universal comment of all observers. The apparent indentation of the moon's disc at the base of the prominences was so conspicuous that the bystanders were eagerly inquiring the cause.

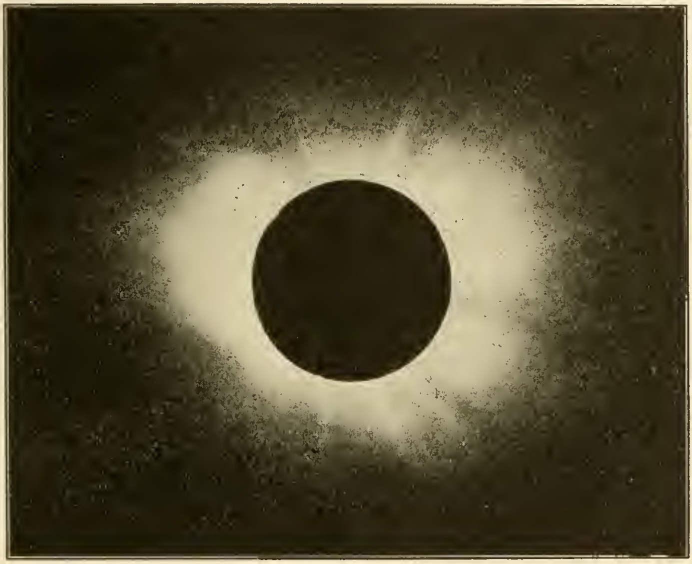

FIG. 134.—Plate No. 2. Exposure five seconds, $5^h\ 24^m\ 03^s$ to $5^h\ 24^m\ 08^s$.

THE WEATHER

The weather conditions on the day of the eclipse caused much anxiety. The day dawned with a cloudless sky, as most days do at this time of year in Colorado. The forenoon passed without the appearance of a cloud to mar the peace of mind of the observer or that beautiful blue firmament of which those western mountains alone can boast. A very gentle wind blew from the north, shifting slightly to the northeast. About noon, the usual white cloud banks began to appear on the horizon. By two o'clock, the sky was well dotted with large, cumulus clouds. It was dramatic, at least for the observers, as one by one these beautiful forms floated lazily over the sun. About four-thirty, thin cirrus clouds began to gather low on the western horizon. Several times between first and second contacts, the sun was completely hidden behind these slowly-moving clouds. However, not more than five minutes before totality, the sun came out between two great cumulus clouds and a large rift in the cirrus cloud bank floated leisurely over the sun. It was the most precious bit of blue sky, I think I have ever seen. My first photograph shows a trace of the haze on the eastern limb of the moon. The other plates, however, do not indicate the slightest trace of a cloud. The fourth contact was observed through rather thick haze.

The darkness did not seem as intense as I had anticipated. The observers seemed to have no difficulty in reading the faces of their watches. This is easily accounted for, not only by the comparatively short duration of the eclipse, for we must remember that the sun is still shining some forty miles away, but by the cloudy condition of the sky as well. The clouds seem to reflect the light into the shadow path. Just before totality, the temperature fell 5°F. The air felt very much like the air in a low swale or hollow at night. The prairie owls came out and gave their cries, and the night hawks circled overhead. I heard distinctly the roosters at a nearby farm house crow several times after the shadow passed.

The phenomenon of the approaching shadow was a disappointment to all. No distinct outline was seen, either in the distance or just at the moment of totality. Like a flash, the sun's light went out and we found ourselves in darkness. The receding shadow was more conspicuous. The sunlight seemed to be chasing the shadow over the distant hills. The weird, unnatural appearance of the landscape, which was so notable before totality, did not follow the re-appearance of the sun.

HISTORICAL

Solar eclipses, like many other astronomical phenomena, occur with a regular periodicity. All eclipses occurring at the same node at intervals of eighteen years ten and a half days form what is known as a series. Using the eclipse of June 8, 1918, as illustration, we find that it is the forty-first of a series which started as a very small partial eclipse near the south pole on March 10, 1179 (See F. E. Seagrave's article on "Recurrence of Solar Eclipses" in "Popular Astronomy," May, 1918), and that it has re-occurred every eighteen years, constantly increasing in magnitude until it became annular on June 4, 1323. The first total eclipse in this series was on April 25, 1846, and they will continue to be total until August 22, 2024, after which they become partial and disappear about the year 2278. We have, therefore, just celebrated the forty-first birthday of a phenomenon which gives substantial promise of living to a ripe old age.

It must not be inferred, however, that the entire earth is visited by eclipses only at such long intervals. Indeed, we have on the average forty-one solar eclipses in a single eighteen-year period, and of those about ten are total. But since the shadow track is not wide—from fifty to one hundred miles, in general—a total solar eclipse at any given locality is a rare sight, occurring on an average about once in three hundred and sixty years.

Department of Physics and Astronomy,
Drake University.

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