PROCEEDINGS

OF THE

Iowa Academy of Science

FOR 1918

VOLUME XXV

Thirty-second Annual Session, Held in Ames,
April 26 and 27, 1918

Published by
THE STATE OF IOWA
Des Moines

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THE ACADEMY OF SCIENCE

Officers of the Academy

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.

1917-1918.

President—Professor L. S. Ross, Drake University.
First Vice-President—Professor S. W. Beyer, State College.
Second Vice-President—Professor C. E. Seashore, State University.
Secretary—James H. Lees, Iowa Geological Survey.
Treasurer—Professor A. O. Thomas, State University.

EXECUTIVE COMMITTEE.

Ex-officio—L. S. Ross, S. W. Beyer, C. E. Seashore, James H. Lees, A. O. Thomas.
Elective—Professor Nicholas Knight, Cornell College; Professor H. E. Jaques, Iowa Wesleyan; Mr. R. I. Cratty, Armstrong.

PAST PRESIDENTS

Osborn, Herbert.........1887-1888
Todd, J. E...............1888-1889
Witter, F. M............1889-1890
Nutting, C. C. (2 terms) 1890-1892
Pammel, L. H............1892-1893
Andrews, L. W.........1893-1894
Norris, H. W. (1 term) 1894-1896
Hall, T. P..................1896
Franklin, W. S..........1896-1897
Macbride, T. H..........1897-1898
Hendrixson, W. S........1898-1899
Norton, W. H...........1899-1900
Veblen, A. A.............1900-1901
Summers, H. E...........1901-1902
Fink, Bruce.............1902-1904
Shimek, B. 1904-1905
Arey, M. F..............1905-1906
Bates, C. O..............1906-1907
Tilton, John L..........1907-1908
Calvin, Samuel 1908-1909
Almy, Frank F..........1909-1910
Houser, Gilbert L.......1910-1911

PAST PRESIDENTS—Continued.

Begeman, L..............1911-1912
Bennett, A. A..........1912-1913
Kinney, C. N............1913-1914
Conard, Henry S........1914-1915
Kelly, Harry M.........1915-1916
Stewart, George W......1916-1917
Ross, L. S...............1917-1918

MEMBERS OF THE IOWA ACADEMY OF SCIENCE

LIFE FELLOWS

Beyer, S. W.................Ames
Clarke, J. Fred..........Fairfield
Conard, Henry S.........Grinnell
Erwin, A. T................Ames
Fitzpatrick, T. J...............
..........Sta. A., Lincoln, Nebr.
Greene, Wesley.......Des Moines
Houser, G. L............Iowa City
Kay, George F...........Iowa City
Kuntz, Albert, St. Louis Univ.,
.................St. Louis, Mo.
Lees, Jas. H..........Des Moines
Norton, W. H.........Mt. Vernon
Pellett, Frank C....Hamilton, Ill.
Ricker, Maurice......Des Moines
Ross, L. S............Des Moines
Seashore, C. E..........Iowa City
Shimek, B..............Iowa City
Summers, H. E.............Ames
Sylvester, R. H........Iowa City
Thomas, A. O..........Iowa City
Tilton, J. L............Indianola
Williams, Miss Mabel C.......
......................Iowa City
Wylie, R. B...........Iowa City

FELLOWS

Aitchison, Alison E...Cedar Falls
Albert, Henry..........Iowa City
Almy, F. F...............Grinnell
Anderson, J. P.....Juneau, Alaska
Arey, Melvin F.......Cedar Falls
Baker, J. A.............Indianola
Baker, R. P.............Iowa City
Bakke, A. L...............Ames
Ball, E. D.................Ames
Bates, C. O..........Cedar Rapids
Begeman, Louis......Cedar Falls
Bond, P. A..............Iowa City
Boyd, Mark F.....Galveston, Tex.
*Brown, F. C...........Iowa City
Brown, P. E................Ames
Brumfiel, D. M.........Iowa City
*Buchanan, R. E...........Ames
Cable, E. J...........Cedar Falls
Carter, Charles.........Fairfield
Chaney, Geo. A.............Ames
Chaney, Ralph W......Iowa City
Coffin, Chas. L.........Oskaloosa
Condit, Ira S.........Cedar Falls
Cratty, R. I.................Ames
Davis, W. H...........Cedar Falls
Dieterich, E. O.........Iowa City
*Dodd, Lawrence E.....Iowa City
Dodge, H. L.............Iowa City
Doty, H. S..........Emporia, Kas.
*Dox, A. W.................Ames
Edwards, John W.....Mt. Pleasant
Evvard, J. M.................Ames
Ewing, H. E................Ames
Faris, Ellsworth.......Iowa City
Fay, Oliver J..........Des Moines
Finch, Grant E......Dillon, Mont.
Fordyce, Emma J....Cedar Rapids
Gaessler, Wm. G............Ames
Galpin, Sidney L.............
......Hutchinson, Kan., Box 242
Getchell, R. W........Cedar Falls
Goodell, F. E...........Iowa City
Guthrie, Jos. E.............Ames
Hadden, David E.............Alta
Hance, Jas. H.....Ardmore, Okla.
Hayden, Ada................Ames
Hendrixson, W. S........Grinnell
Hersey, S. F...........Cedar Falls
Higbee, F. G...........Iowa City
*Hinman, J. J., Jr.....Iowa City
Jaques, H. E........Mt. Pleasant
Jenner, E. A.......La Crosse, Wis.
Jewell, Susan G...........Tabor
Job, Thesle T., Loyola Medical
Coll................Chicago, Ill.
Kelly, H. M..........Mt. Vernon
Keyes, Chas. R........Des Moines
King, Charlotte M..........Ames
Kinney, Chas. N.......Des Moines
Knight, Nicholas....Mt. Vernon

FELLOWS—Continued.

Kunerth, Wm. . . . . Ames
*Lamb, Alvin R. . . . . Ames
Lazell, Fred J. . . . . . . Cedar Rapids
Learn, C. D. . . . . Stillwater, Okla.
Leighton, M. M. . . . Columbus, Ohio
McClintock, Jno. T. . . . . Iowa City
*MacDonald, Geo. B. . . . . Ames
McKenzie, R. Monroe. . . . Fairfield
Martin, John N. . . . . Ames
Melhus, I. E. . . . . Ames
Miller, A. A. . . . . Davenport
Morehouse, D. W. . . . . . Des Moines
Mueller, H. A. . . . . St. Charles
Norris, H. W. . . . . Grinnell
Nutting, Charles C. . . . . Iowa City
Oleson, O. M. . . . . Ft. Dodge
Orr, Ellison. . . . . Waukon
Overn, O. B. . . . . Decorah
Pammel, L. H. . . . . Ames
Pearce, J. N. . . . . Iowa City
*Pearson, R. A. . . . . Ames
Peck, Morton E. . . . . . . Salem, Ore.
Pew, W. H. . . . . Ames
Plagge, H. J. . . . . Ames
Pomeroy, J. C. . . . . Charleston, S. C.
Reed, Charles C. . . . . . . Des Moines
Reilly, John F. . . . . Iowa City
Roberts, Marie M. . . . . Ames
Rockwood, E. W. . . . . . . Iowa City
Sanders, W. E. . . . . Des Moines
Sieg, L. P. . . . . Iowa City
Smith, Geo. L. . . . . Shenandoah
Smith, Orrin H. . . . . Mt. Vernon
Spencer, Clementina S. . . . . Cedar Rapids
Spinney, L. B. . . . . Ames
Stange, C. H. . . . . Ames
Stanley, Forrester C. . . Oskaloosa
Stanton, E. W. . . . . Ames
Stephens, T. C. . . . . Sioux City
Stevenson, W. H. . . . . Ames
*Stewart, Geo. W. . . . . . . Iowa City
Stiles, Harold. . . . . Ames
Stoner, Dayton . . . . Iowa City
Stookey, S. W. . . . . . . Cedar Rapids
Stromsten, F. A. . . . . Iowa City
Thompson, Geo. E. . . . . Ames
*Trowbridge, A. C. . . . . . . Iowa City
Van Hyning, T. . . Gainesville, Fla.
Van Tuyl, F. M. . . . . . . Golden, Col.
Walters, G. W. . . . . Cedar Falls
Watson, E. E. . . . . Fairfield
Webster, R. L. . . . . Ithaca, N. Y.
Weld, L. D. . . . . Cedar Rapids
Wentworth, E. N. . . . . Manhattan, Kan.
Wickham, H. F. . . . . Iowa City
Wifvat, Samuel J. A. . . Des Moines
Wolden, B. O. . . . . Wallingford
Woodward, S. M. . . . . Iowa City

ASSOCIATES

Abbott, Roy L. . . . . Cedar Falls
*Baker, Norval E. . . . . Burlington
Baldwin, F. M. . . . . Ames
Bancroft, Ross L. . . . . Ames
Barnhart, Frances E. . . . . Omaha, Nebr.
*Belanski, C. Herbert. . . . . Nora Springs
*Bennett, Walter W. . . . . Wilder, Minn.
Berninghausen, F. W. . . . . New Hartford
Berry, E. M. . . . . Iowa City
Betts, Geo. H. . . . . Mt. Vernon
Bleasdale, B. T. . . . . . . Des Moines
Boot, David H. . . . . Iowa City
Breitbach, Jno. J. . . . . Dubuque
Briggs, Leo. . . . . Indianola
Brown, F. E. . . . . Ames
Brown, Howard C. . . . . Charles City
Buchanan, L. L. . . . . Iowa City
Butterfield, E. J. . . . Dallas Center
Carter, Edna M. . . . . Fayette
Case, Chauncey. Ellsworth Sta. O.
Cavanagh, John A. . . . Des Moines
Cavanagh, Lucy M. . . . . Iowa City
Conklin, R. E. . . . . Des Moines
*Corson, Geo. E. . . . . Ames
Cotten, Ruth H. . . . . . . Iowa City
Coover, W. F. . . . . Ames
Cross, H. A. Jr. . . . . Grinnell
Cummins, Earl H. . . . . Storm Lake
Curran, E. . . . . Cedar Rapids
Davis, Jas. M. . . . . Dallas Center
Dempster, J. B. . . . . Iowa City
Dershiem, Elmer. . . . . . Urbana, Ill.
Dewey, Arthur H. . . . . . Iowa City
Diehl, William. . . . . Ames
Dill, Homer R. . . . . Iowa City
Dole, J. Wilbur. . . . . Fairfield
Durrell, L. W. . . . . Ames
Eckerson, Ray. . . . . Humeston
Edmundson, Sophia. . . . . Ida Grove
Ellyson, C. W. . . . . Waterloo
Emery, Geo. V. . . . . Ames
Fakkenberg, H. G. . . . . . Davenport
Fees, L. V. . . . . Denver, Col.

*Engaged in defense work for the Federal Government or in the U. S. Army.

Associates—Continued.

Fish, Don E.........Mt. Pleasant
Flint, C. W...........Mt. Vernon
Foft, S. F..............Waukee
Fortsch, Arthur R.....Iowa City
Foster, Clarence L...........
..............Yaanshien, China
Fraser, Charles M..........
................Nanaimo, B. C.
Frazier, Zoe R..........Oskaloosa
French, R. A..........Des Moines
Fulcher, J. E.........Des Moines
Gabrielson, Ira N.............
..............Corvallis, Oregon
Giddings, L. A................
...........Salt Lake City, Utah
*Glomset, D. J........Des Moines
Gose, C. Bert.........Indianola
Goss, C. A............Des Moines
Griffith, Ora M.......Pocahontas
*Grissel, Earl.......Cedar Rapids
Grueb, Aubrey C.............
................Lafayette, Ind.
Hadley, S. M...........Oskaloosa
Hagan, Wayne............Clinton
Harrison, Bruce M.........Ames
Hart, Irving H........Cedar Falls
Hartzell, Albert...........Ames
Hastings, Jessie P.....Iowa City
Hawk, Grover C........Oskaloosa
Hayer, Walter E...Garden Grove
Hayward, W. J........Sioux City
Hehner, Nelson E.....Mt. Vernon
Heitkamp, G. W..........Dubuque
*Helmick, Paul S......Iowa City
Himmel, W. J...........Radcliff
*Hoersch, V. A.........Davenport
Hoffman, W. A...Monticello, Fla.
Horsfall, John L........Dubuque
Howell, J. V.......Wichita, Kas.
Hughes, Sally P.........Grinnell
*Hughes, U. B.........Fulton, Ky.
Jeffs, Royal E.....Norman, Okla.
*Jessup, W. A..........Iowa City
*Jordan, R. L.........Burlington
Julian, A. E...........Burlington
Kenoyer, L. A....Allahabad, India
King, Inez N.....Langdon, N. D.
Kingman, R. H.......Storm Lake
Kirby, R. S.................Ames
Knoll, Wm. V.............Ackley
Krall, J. A...........Manchester
Kuzirian, S. B.....Jamaica, N. Y.
LaBreck, Velma ....
..............Bloomington, Ill.
Larson, G. A.........Des Moines
Lindsey, Arthur W....Sioux City
Lorenc, F. A..........Loma, Nebr.
McGaw, F. W.........Mt. Vernon
McKinley, Lloyd......Iowa City
*Maxwell, H. L.......Mt. Vernon
Merrill, D. E., State College...
...................New Mexico
Millen, F. Eric............Ames
Miller, J. C.............Dubuque
Mock, Chas. A............LeMars
*Moore, Wm. A.....Hampshire, Ill.
Moon, Helen ....Vinton
Morbeck, Geo. C.............Ames
Mortimer, F. S..........Iowa City
Muilenburg, G. A.......Rolla, Mo.
Mullin, Catherine.....Iowa City
Noll, W. C................Toledo
Oncley, Lawrence........Fayette
Overholt, Sigel.........Kirkman
Paige, F. W.............Ft. Dodge
Palmer, E. L.........Cedar Falls
Perry, Winifred...........Boone
Pieterpol, Henry W.........Pella
Plagge, Homer H...........Ames
Quigley, T. H........Fargo, N. D.
Read, O. B...........Cedar Falls
Rees, Marie................Ames
Ressler, I. L................Ames
Reynolds, O. E.........Iowa Falls
Ritchie, Geo. E.......Mt. Vernon
Roberts, T.......Los Angeles, Cal.
Robinson, C. L...........Norwalk
Rogers, W. E.................
..........New Wilmington, Pa.
Rohret, Marguerite B...Iowa City
Rowe, Paul.............Glenwood
Salter, R. C..........Cedar Falls
Sargent, Louise.........Grinnell
Sawyer, M. Louise......Grinnell
Sayre, B. K...............Decorah
Sayre, A. Raymond.....Indianola
Schell, E. A.........Mt. Pleasant
Schoewe, W. H..........Iowa City
*Schriever, William....Iowa City
Scott, Helen............Grinnell
Shane, Adolph........Des Moines
Shimek, Ella..................
...........Grand Junction, Col.
Shippee, Vernon C.....Mt. Vernon
Shipton, W. D.....St. Louis, Mo.
Simpson, Marjorie......Iowa City
Smith, Donald M.........Zearing
Smith, John E..............Ames
Snider, Frank J..........Kalona
Somes, Melvin P...............
................Kalispell, Mont.
Stahl, E. R...........Storm Lake
*Stainbrook, M. A........Brandon
Starin, L. M...............Ames
Stuhlman, Otto, Jr.....Iowa City
*Swenson, L. G.....Detroit, Mich.
Taylor, Beryl......Cedar Rapids
*Tenney, Glenn I.....Des Moines
Thomas, E. H.............Tabor
Thomas, Wilbur A.......Grinnell

ASSOCIATES—Continued.

THOMPSON, L. D.......Mt. Pleasant
THONE, F. E. A.......La Jolla, Cal.
TILSON, AGNES........Des Moines
TISDALE, WILBUR E......Iowa City
TORRANCE, MERRILL....Mt. Vernon
TREGANZA, J. A..............Britt
TUTTLE, MRS. F. MAY........Osage
UTTLEY, MARGUERITE..Cedar Falls
VAN WAGENEN, GERTRUDE.Iowa City
VOLKMER, ALBERT W..Cedar Rapids
WAIT, G. R............Iowa City
WALTER, OTTO...........Dubuque
WEBSTER, C. L........Charles City
WEHMAN, H. J.........Iowa City
WEIGLE, O. M..........Fulton, Mo.
WERNER, HERBERT R.........Ames
WESTER, C. W.........Cedar Falls
WHIPPLE, ELIZABETH S....Wapello
WILCOX, A. C.........Mt. Vernon
WILLEY, FLORENCE S.........Ames
WILLIAMS, A. J.....Norman, Okla.
WILSON, BEN H.......Mt. Pleasant
WINTER, C. L.............Le Mars
YOCUM, L. EDWIN..........Ames
YOTHERS, J. F..............Toledo
YOUNG, V. H.........Moscow, Ida.
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
TRELEASE, WILLIAM...............State University, Urbana, Illinois

CORRESPONDING FELLOWS.

ANDREWS, L. W.........................440 W. 61st Pl., Chicago, Ill.
BAIN, H. F............U. S. Bureau of Mines, Washington, D. C.
BALL, C. R..........Department of Agriculture, Washington, D. C.
BARBOUR, E. H.....................State University, Lincoln, Nebr.
BARTSCH, PAUL..........Smithsonian Institution, Washington, D. C.
BRUNER, H. L.........................Butler College, Indianapolis, Ind.
CARVER, G. W....................................Tuskegee, Ala.
COOK, A. N..........University of South Dakota, Vermillion, S. Dak.
DREW, GILMAN C...................................Orono, Maine
ECKLES, C. W................University of Missouri, Columbia, Mo.
FINK, BRUCE......................................Oxford, Ohio
FRANLIN, W. S.........Massachusetts Institute of Technology, Boston
FRYE, T. C.........................State University, Seattle, Wash.
GILLETTE, C. P.................Agricultural College, Fort Collins, Colo.
GOSSARD, H. A....................................Wooster, Ohio
HANSEN, N. E..................Agricultural College, Brookings, S. D.
HAWORTH, ERASMUS................State University, Lawrence, Kan.
HITCHCOCK, A. S.........Department of Agriculture, Washington, D. C.
HUME, N. H.....................................Glen St. Mary, Fla.
LEONARD, A. G.................State University, Grand Forks, N. Dak.
LEVERETT, FRANK..............1724 University Ave., Ann Arbor, Mich.
MILLER, B. L................Lehigh University, South Bethlehem, Pa.
NEWELL, WILMON................State Plant Board, Gainesville, Fla.
PRICE, H. C.........................Evergreen Farm, Newark, Ohio
SAVAGE, T. E.......................State University, Urbana, Ill.
SIRRINE, EMMA..Dept. Agri. Washington, D. C.; Residence, Dysart, Iowa
SIRRINE, F. A.....................79 Sound Ave., Riverhead, New York
TODD, J. E.........................State University, Lawrence, Kan.
UDDEN, J. A.......................University of Texas, Austin, Texas

TITLES OF PAPERS RECEIVED

The number following a title indicates the page of the Proceedings on which it may be found.

Botany.

Chemistry and Agricultural Chemistry.

Ames and Iowa Sections American Chemical Society.

Geology

PROCEEDINGS OF THE THIRTY-SECOND ANNUAL SESSION

Held in Ames, April 26 and 27, 1918

The Iowa Academy of Science held its thirty-second annual session at the Iowa State College at Ames, beginning at 1:30 P. M. on Friday, April 26. After the general program in the Assembly Room of Agricultural Hall sectional meetings were held for the reading of papers of special interest and these were resumed on Saturday morning. The general business meeting was held on Saturday morning at 11 o'clock. Dean E. A. Birge, of the University of Wisconsin, gave the annual address at 8 P. M. Friday, on "The Warming of an Inland Lake." The Iowa Section of the Mathematical Association of America and the Ames and Iowa Sections of the American Chemical Society held their meetings in connection with the sessions of the Academy. President Ross delivered his presidential address: "Does the History of Science have a place in the College Curriculum?" at the general meeting on Friday afternoon.

REPORT OF THE SECRETARY.

Members of the Iowa Academy of Science:

The Academy is to be congratulated that at this time, when so much stress and anxiety is weighing on all hearts and minds, so great interest is manifested in the progress and advancement of scientific achievement. Our program is a little shorter this year than last, it is true, but this is of itself a matter for felicitation and pride, for it indicates how many of our members are occupied with the public good in the widest fields and how much of our energy is being devoted toward making the world "a decent place to live in." We are proud of the work which our fellow members are doing in their service for their country and ours and we rejoice that their scientific attainments and training are of such value in a time of so great need. The scientific fraternity can always be depended upon to do its utmost in patriotic service, unstintingly and unreservedly.

The usual business has been transacted by the officers of the Academy during the year just passed. Certain matters which could not be carried to completion at the last meeting have been followed up during the year and will be brought to your attention at this meeting. The annual canvass for new members, for the transfer of Associates to the class of Fellows, and for the stimulating of those who have been slow in fulfilling their full duty—all of this has brought good results and the Academy continues its healthy, vigorous growth. In accordance with the provisions of the constitution several Associates have been admitted to membership by the Executive Committee during the year. Among these were President Jessup of the State University, Professor S. L. Galpin of the State College and Miss Winifred Perry of Boone High School.

At the Drake meeting in 1916, the Academy revised those sections of the constitution referring to classes of membership and dues. In accordance with section three as revised the Academy, at the Grinnell Meeting, last year, elected unanimously as Honorary Fellows Professors T. H. Macbride, Herbert Osborn, Wm. Trelease and J. C. Arthur, all of them except one formerly workers in science in Iowa but now residing outside the state. These four gentlemen, all of them well known for their scientific contributions, have accepted their election with great pleasure, as evinced by their answers to the letters of notification which were sent them.

During the year an invitation was received from the Kansas Academy of Science to join with it in celebrating the semicentennial anniversary of its establishment. Professor J. E. Todd, the second president of the Iowa Academy of Science, and long one of the Corresponding Fellows of this Academy, now connected with the University of Kansas, was asked to represent our Academy as its delegate. This he consented to do and in due time submitted to the secretary a report of the meeting which will be presented later.

There are certain matters of policy which have come to the attention of the Secretary and which may well be brought before the Academy for its consideration. It is the custom in some learned societies to allow the privilege of presentation before them and of publication in their publishing medium of papers by persons who are not of their membership. Other societies do not extend this privilege. So far as the Secretary is aware this Academy has never taken any definite action on this subject. When the membership was small the number of papers presented was correspondingly small. There was no urgent necessity for raising the question, perhaps. Today our membership is well over three hundred, the number of papers presented for publication will be seventy or thereabouts, and the question of what to include and what to exclude is of some importance, in the mind of the editor at least. It is true, on one hand, that there is no limit placed on the size of our Proceedings, that they are published without cost to the Academy and that we are left free to publish whatever we see fit. It is equally true, on the other hand, that all of these liberties carry with them an equal responsibility for extreme carefulness and appreciation of our favored position. It seems also that no one who has scientific inclinations, and who has scientific achievements to make known to a scientific public would regret the investment of the small amount represented by the annual dues of such a scientific association as ours. Some definite statement on the part of the Academy would help the editor in the settlement of this question when it arises.

At the time of revising the sections of the constitution relating to classes of members and dues provision was made for annual dues from Corresponding Fellows and a committee was selected to write to our Corresponding Fellows informing them of the action of the Academy and asking if they wished to continue their relation to it under the new provision. The class of Honorary Fellow was instituted in part to provide for those Corresponding Fellows who had been elected as such as an honor to them and to the Academy alike. Three men have been transferred from the class of Corresponding Fellows to that of Honorary Fellows. Otherwise the list of corresponding Fellows has not changed. Is it desirable to carry out the provisions of the constitution or is it better to let the matter stand as it has for years past? This quesion arises also in connection with the distribution of the all-too-limited cloth bound edition of our Proceedings, as well as with the all-too-limited condition of our bank account.

The Treasurer calls attention to the fact that a number of our members are at present enlisted in the army and raises the question of their relation to the Academy during their enlistment. Should they be put in an "inactive" list, or should they be carried as regular members without the payment of dues, or should they be considered as regular members and be dropped from our lists if they do not pay their dues? For the benefit of the Treasurer as well as the Secretary it would be well for the Academy to take some action. It seems but little for the Academy to do in recognition of the services of these men to carry them as active members without payment of dues until they return to civil life. However, this, as well as other matters mentioned earlier, is for you to dispose of at your discretion.

Respectfully submitted.

James H. Lees,

Secretary.

REPORT OF THE TREASURER, 1917-1918.

RECEIPTS.

Cash on hand, April 23, 1917	$ 38.35
Dues from members	174.00
Entrance fees, Fellows	6.00
Entrance fees, Associates	61.00
Transfer fees, Associates to Fellows	52.00
Sale of Proceedings	3.08
Total	$334.43

DISBURSEMENTS.

Honorarium and expenses of Speaker, 31st Meeting	$ 15.00
American Lithographing Co., 450 programs	9.00
Supplies and postage for Treasurer	11.50
Telephone and telegraph expense, G. W. Stewart	1.75
Honorarium to Secretary	25.00
To Miss Newman, wrapping, tying and distributing Vol. XXIII	10.00
Refund to Stechert on Proceedings	.92
To Mrs. Laura Ansell, Stenographic Work	2.19
Supplies and postage for Secretary	13.27
State Binder, binding volume XXIII and separates	95.00
To Professor A. C. Cumming, painting the Calvin Portrait	123.50
Total	$307.13
Balance on hand	27.30

A. O. Thomas,

Treasurer.

The Auditing Committee find the accounts of the Treasurer to be correct.

A. L. Bakke,

G. C. Hawk.

April 27, 1918.

REPORT OF PROFESSOR TODD.

I hereby report on my pleasant duty as delegate of the Iowa Academy of Science to the Semi-Centennial Anniversary of the Kansas Academy of Science, held at Lawrence, March 15 and 16.

The weather was auspicious and the exercises were well attended. Those celebrating the Anniversary were mainly on the 15th. The morning was given to President Agrelius's address, A Half Century of Bacteriology, to the greetings and congratulations from sister organizations and to a Symposium, Fifty Years of Scientific Development in Kansas, according to the program.

The chief attraction of the afternoon was the Lecture by Dr. S. W. Williston of The University of Chicago, on The Growth of Science during the Last Half Century. It was specially enjoyed because of its frequent references to Kansas where the Doctor has spent many fruitful years both as a student and as a university professor.

The evening was devoted to a banquet and post-prandial speeches with Dr. E. H. S. Bailey as toast-master. Many interesting reminiscences were told of the founders of the Academy, particularly of Professor Mudge, Chancellor Snow and Mr. James Savage, by their former students and relatives. Stories of scientific trips when hostile Indians were abroad, of scientific zeal inspired by a friendly hint of the master, or of ever open hospitality to Government explorers of early days, all these helped to explain why and how Kansas Academy has reached its jubilee so much sooner than those of some older States.

The home of the Academy has been recently moved from Topeka to Lawrence, where it expects to have commodious quarters in the Administration Building of the University, which is now in process of erection.

All of which is very respectfully submitted, J. E. Todd,
Delegate.

THE REPORT OF THE COMMITTEE ON SECRETARY'S REPORT.

Your committee would heartily commend the report of the Secretary for its clearness and completeness.

In the matters of policy brought to the attention of the Academy by the report we would recommend:

1. That papers by others than members may be presented, as has been the custom of the Academy, on introduction by a Fellow of the Academy. Papers by others than members are to be published in the Proceedings only on recommendation of the Executive Committee.

2. (a) That the Secretary be added to the committee on "Annual dues of Corresponding Fellows," that the committee be asked to carry out the instructions of the last meeting of the Academy.

(b) That Corresponding Fellows will be carried on our list if they so desire; the payment of annual dues to be required of those who are to receive the publications of the Academy.

3. That members in National Service shall be carried "in good standing" without payment of dues throughout the duration of their National Service.

Frank F. Almy,
J. E. Guthrie.

ELECTION OF MEMBERS.

Elected Fellows: R. W. Chaney, Geological Department, Iowa City; Miss Maria M. Roberts, State College, Ames, Iowa.

Transferred from Associates to Fellows: G. E. Corson, Ames; E. O. Dieterich, Iowa City; L. E. Dodd, Iowa City; Wm. G. Gaessler, Ames; S. L. Galpin, Ames; T. T. Job, Iowa City; S. B. Kuzirian, Ames; A. R. Lamb, Ames; Orrin Lloyd-Jones, Ames; G. C. Morbeck, Ames; F. S. Mortimer, Oskaloosa; Miss Clementina S. Spencer, Cedar Rapids; Harold Stiles, Ames; G. E. Thompson, Ames.

Elected as Associates: R. L. Abbott, Cedar Falls; Francis Marsh Baldwin, Ames; R. L. Bancroft, Ames; F. E. Brown, Ames; W. F. Coover, Ames; Earl H. Cummins, Buena Vista College, Storm Lake; J. B. Dempster, Iowa City; Don E. Fish, Mt. Pleasant; Miss Ora Griffith, Ames; Bruce Magill Harrison, Ames; Albert Hartzell, Ames; Nelson E. Helmer, Mt. Vernon; W. A. Hoffman, Ames; Fred Jansen, Pocahontas; R. H. Kingman, Storm Lake; Miss Velma La Breck, Mt. Pleasant; Andrew C. McCandlish, Ames; Lloyd McKinley, Iowa City; Wm. A. Moore, Mount Vernon; Miss Catherine Mullin, Iowa City; Homer H. Plagge, Ames; R. S. Potter, Ames; Miss Marie Rees, Ames; George Edgar Ritchey, Mt. Vernon; Miss M. Louise Sawyer, Grinnell; Vernon C. Shippee, Mount Vernon; Miss Marjorie Simpson, Iowa City; John E. Smith, Ames; Frank J. Snider, Kalona; E. R. Stahl, Storm Lake; Otto Stuhlmann, Iowa City; Miss Agnes Tilson, Drake University, Des Moines; Merrill Torrance, Mt. Vernon; Miss Gertrude Van Wagenen, Iowa City; Albert W. Volkmer, Iowa City; G. R. Wait, Iowa City; H. J. Wehman, Burlington; Miss Florence Willey, Ames.

LIST OF MEMBERS AND VISITORS IN ATTENDANCE.

Frank F. Almy, E. D. Ball, Mrs. E. D. Ball, Edith J. Bailey, A. L. Bakke, F. M. Baldwin, S. H. Beach, S. W. Beyer, E. A. Birge, F. E. Brown, P. E. Brown, R. E. Buchanan, Geo. A. Chaney, Henry S. Conard, W. F. Coover, R. I. Cratty, C. F. Curtiss, E. O. Deiterich, H. L. Dodge, L. W. Durrell, G. V. Emery, John M. Evard, H. E. Ewing, Annie W. Fleming, Raymond French, S. L. Galpin, C. Bert Gose, Agnes I. Guthrie, J. E. Guthrie, B. M. Harrison, Grover C. Hawk, Ada Hayden, Anson Hayes, W. S. Hendrixson, Walter Hoover, J. L. Horsfall, H. D. Hughes, Mrs. H. D. Hughes, Sally P. Hughes, H. E. Jaques, E. A. Jenner, G. F. Kay, Harry M. Kelly, Charlotte M. King, C. N. Kinney, Nicholas Knight, S. B. Kuzirian, A. R. Lamb, James H. Lees, Andrew C. McCandlish, R. Monroe McKenzie, John N. Martin, I. E. Melhus, Cora B. Miller, Helen Monsch, D. W. Morehouse, I. F. Neff, H. W. Norris, Ruth O'Brien, Anna M. Olsen, O. B. Overn, L. H. Pammel, E. A. Pattengill, Winifred Perry, H. H. Plagge, H. J. Plagge, R. S. Potter, R. R. Renshaw, Maria M. Roberts, L. S. Ross, Paul Rowe, A. W. Rudinck, R. C. Salter, M. Louise Sawyer, C. E. Seashore, B. F. Simonson, Margery Simpson, John E. Smith, Emma Sparks, L. B. Spinney, Maud St. John, T. C. Stephens, W. H. Stevenson, Harold Stiles, Otto Stuhlman, Jr., E. H. Thomas, George E. Thompson, John L. Tilton, I. H. Vogel, E. E. Watson, R. L. Webster, H. R. Werner, C. W. Wester, Mrs. C. W. Wester, Florence Willey, G. M. Wilson, L. E. Yocum.

REPORT OF THE COMMITTEE ON RESOLUTIONS.

The members of the Iowa Academy of Science in their Thirty-second Annual meeting held at Iowa State College at Ames resolve as follows:

That the visiting members thus attempt to express to their Ames colleagues their earnest appreciation of their carefully planned and successfully executed program of entertainment and especially for the cordial welcome and spirit of comradeship they have shown.

That the Academy assure Dean E. A. Birge of the University of Wisconsin of their deep appreciation of the honor he has shown us in his attendance at the session and his interesting and profitable lecture.

That the Academy endorse the request of the Secretary of Agriculture and the action of the State Council of Defense in requesting the removal of the tall Barberry from the Wheat growing region of the upper Mississippi valley.

That we renew our pledge of loyalty to the government in this time of stress and danger and are in hearty accord with President Wilson when he declares that the Imperial German government must be overthrown before the liberties of democratic nations can be secure.

That a copy of the foregoing resolutions be forwarded by the Secretary to President Wilson.

H. E. JAQUES,
NICHOLAS KNIGHT,
H. W. NORRIS,
Committee.

THE WHITE HOUSE WASHINGTON

August 3, 1918.

My Dear Mr. Lees:

The President is most appreciative of your letter of July 31st, and he asks me to assure you and all concerned that he is very much gratified by this pledge of cooperation and support.

With cordial thanks in the President's behalf for your kindness in the matter, I am,

Sincerely yours,
J. P. TUMULTY,
Secretary to the President.

Mr. James H. Lees,
Iowa Academy of Science,
Des Moines, Iowa.

IN MEMORIAM

J. HOWARD FRAZIER.

The subject of this sketch was born at Natrona, Pennsylvania, November 1, 1891, and died at Johnson City, Tennessee, on September 11, 1917. He was a young man of unusual promise, self reliant and always able to do the work allotted to him.

He attended the pubic schools of Elizabeth, New Jersey, Argentine, Kansas, and Kansas City, Missouri, where he completed the grade schools. He then attended the high school of Bristol, Virginia, and Allegheny, Pennsylvania. He was a student at the A. and M. college of Mississippi, 1909-1910, and came to Ames as a student on February 22, 1913. While at Bristol, Tennessee, he also attended the Sullins Musical College, where he devoted much time to the study of violin music, becoming an unusually good player. When not at school he was a cash boy in Kansas City in a Department Store, an office boy in a tannery at Bristol, Tennessee, a clerk in a freight office, later a clerk in a music store at Bristol and later had charge of the department of musical instruments in "The Fair Store," Chicago. During his first summer vacation in Ames he worked at various kind of mechanical labor. During the second summer he became the official slide maker of the Department of Botany. He was most efficient in this work and as student assistant in Morphology, later as assistant in the two-year botany course, he did splendid work, always doing his work in a most efficient and careful manner. Owing to ill health he resigned his college work and went to one of the Des Moines hospitals. When in somewhat improved condition he moved to Bristol, Tennessee, to live with his sister. Here he made, for the Department of Botany, a fine collection of oaks. At the advice of the doctors he went to Miami, Florida, where he paid some attention to botany, so far as his health would permit. He then moved to Johnson City, where he died.

At Ames Mr. Frasier was active in musical circles and was a member of the Colonial Club. Mr. Frazier became a most enthusiastic botanist. In reply to a little remembrance sent to him by the Department of Botany (a copy of Gray's Manual) he wrote in April, 1916, "It is certainly a remembrance worth while, especially to one who has learned through the Department of Botany to appreciate the wonderfulness of life by means of plant and nature study in general. There is quite a large ridge of mountains just eighteen miles south of Bristol and later in the summer I expect to get acquainted with many new plants in that district." Then he goes on to say something about a collection of plants made in the Niagara region the previous summer, which he sent to the Department of Botany.

What more can we chronicle of a young life on the threshold of doing much useful botanical work? He was a man of noble and fine sentiments, of fine character, of a sunny disposition and was liked by all. His associates at Ames will not forget the cheer he brought into the laboratory and work shop.

L. H. PAMMEL.

GLENN L. TENNEY

IN MEMORIAM

GLENN I. TENNEY

When Glenn I. Tenney of Des Moines became a member of the Iowa Academy of Science at the 27th annual meeting in 1913, he was, as far as the writer knows, the youngest member the Academy has ever had on its list. In the preceding summer he had attended the Macbride Lakeside Laboratory at Lake Okoboji. When he presented himself for admission the director was naturally hesitant for here was a boy who had just completed his second year in the high school while the classes were made up quite largely of college graduates. His probationary admission, however, was not a mistake, and he soon won the admiration of everyone by his enthusiasm and untiring industry. Early and late he collected hand specimens of the boulders about the lake, he tramped to far away swamps for shells, he broke up limestone boulders by the hour for fossils; minerals, rocks, mollusc shells, leaves, flowers, and so forth, he collected in profusion and it was more than a boyish whim for he arranged and labelled them, he learned them, he asked questions all day long. Few acquired more knowledge there that summer and to none did it come with greater freshness and pleasure.

Upon finishing high school he entered Greenville College, Illinois, and a year later he matriculated at the University of Chicago where he specialized in chemistry and geology. At the close of his junior year, in June, 1917, he entered the employ of the Roxanna Petroleum Company, working for a time in Kentucky but was soon transferred to the Rocky Mountain Division with headquarters at Cheyenne, Wyoming, serving as assistant geologist until May, 1918, when he was made chief geologist in charge of the work in the Laramie Basin,—an unusual responsibility for a young man of twenty-three years. Because of the importance of this work he was placed on the deferred list by the draft board, but he resigned in October and entered the Naval Aviation Branch of this service. While on his way to the training camp at Seattle he became ill with influenza and died at Salt Lake City on October 31.

During his brief life he endeared himself to everyone who ever met him; clean of mind and body, full of vigor and buoyancy whether on the track, where he won some of the highest secondary school and college honors of America; or in the class room, where he strove to excel; or in the service of his country, he gave gladly the best that was in him. He planned great things for the rest of his school career and life, and those who knew him best, know that science has lost a most promising worker and the Academy has lost a very sincere friend.

A. O. THOMAS.

ROBERT B. DODSON

IN MEMORIAM

ROBERT B. DODSON

1894-1918

Scientific men everywhere realize that with the exception of creative work the most important task is the discovery and encouragement of those very unusual minds that seem to have a peculiar adaptability to productive research. Mr. Robert B. Dodson, who was a graduate student in Physics and Mathematics at the State University of Iowa from the fall of 1916 until his death in December, 1918, proved himself to be one of those unusual men who are worth capturing and encouraging. Mr. Dodson's mind showed not only the ability to follow the analyses of another, though intricate, but also that he was capable of independent thinking. In all his work he was thorough-going. Had he lived he would without question have made a distinct place for himself in the creative work in Physics of this country. His scientific promise gives his death a peculiar sadness to his friends engaged in scientific work. Both his associates and his teachers recognized his character to be thoroughly genuine and his life to be motived by the highest ideals.

G. W. STEWART.

Papers Presented
at the Thirty-Second Meeting
of the Academy

THE PRESIDENT'S ADDRESS.

DOES THE HISTORY OF SCIENCE HAVE A PLACE IN THE COLLEGE CURRICULUM?

L. S. ROSS.

In order to understand a government at any stage of its existence it is necessary to understand how it came to be, what were its antecedents and under what conditions it was developed. In short its inheritance and its environment must be known. No complete understanding of present day civilization is possible without a knowledge of the civilization of the "Men of the Old Stone Age" and of the various phases of man's attempts, failures and successes, between these two stages. In other words the master anatomist and physiologist must be an embryologist. To comprehend and understand the completed structure thoroly necessitates a knowledge of its beginning and of its progress toward completion, whether the structure be a battleship, a government or a science.

Science is not the handmaid of civilization, it is more. Nor is it the mother of civilization, it is somewhat less. I do not claim it to be the "allmacht" of civilization, but it is impossible to think of the world's material development in terms other than those of science. Agricultural processes, manufacturing, mining, commerce, sanitation, all the common activities of life —these are all applied science. It is impossible to write the history of a people without recording directly or indirectly the history of their scientific achievement. The advancement of ethical, social and religious ideals carries with it a great debt to science and its methods.

The history of governments is fundamentally the history of thought changes and development, that usually take place slowly, accumulating enough energy to overcome the tenacious hold of established ideas. Time tends to tighten the hold of an idea until it become almost unthinkable to doubt an authority. "It hath been said by them of old time" is a bulwark that has been almost impregnable and it required a bold and independent spirit to attack that bulwark with, "but I say unto you." Yet as much as this inertia has retarded thought it has exerted a steadying influence that may have prevented stampedes whenever some cried aloud, "Lo, here" or "lo, there." Autocracy of thought should not be confused with the inertia of conservatism. There is great difference between conditions when we are told "you have no right to think" and when we passively accept the thoughts of others. In the first case we are restrained from action, and in the second we have no desire for action. Both of these influences affect the evolution of thought. Probably no better illustration of this can be found than in the history of science.

The Greek philosophers evidently were fearless and independent thinkers; independent insofar as independence is possible. There seemed to be no ancient authority back of them. They were not bound by tradition. A result of their freedom and their vigor was that they added a sum total of incalculable value to our intellectual inheritance. In the zoological pathway, Aristotle tells us that his was the first step and that it must be judged accordingly. The "Golden Age" passed but it left a legacy to all future generations. And in the time when autocracy of thought became powerful it unconsciously paid tribute to democracy of thought when men were practically told that Aristotle and Galen were infallible. But, in the early centuries A. D., soon after the time of Galen, the educated men of the world for some inexplicable reason forgot a fundamental teaching of a man of the common people of the Jews, that the truth shall make you free; or possibly instead of forgetting, they never fully comprehended its import. The right of every individual to search for the truth was denied. Only a chosen few were to think for the world, and their activity was self limited for they believed it was not allowable to wander far afield from the accepted authorities of the olden time. The struggle that gradually assumed form, the struggle between the inquiring mind and the autocracy of authority, the struggle between democracy and autocracy of thought, was to continue for centuries; a struggle that was to develop the idea that the torture of the physical man could control the thought processes of the intellectual man. Social ostracism, loss of place and fortune, and physical torture had a temporary effect in suppressing publicity, but the divine intellectuality of man could not be conquered. As time passed there was enforced yielding of autocracy here and there, attempts at compromise, retreat, loss of old entrenched positions, democracy in the ascendency, autocracy waning, final retreat before the overwhelming power of democracy, and destruction of autocratic power.

The final great battle occurred recently, a portion of it within memory; the battle over evolution, in the 19th century. This chapter, covering a period from the latter part of the 18th century to the latter part of the 19th, is a chapter interesting beyond compare. The prolog was the preparation of the world for the "Origin of Species." The great contribution of Darwin and his coworkers was not that they compelled attention to the theory of evolution but that they compelled recognition of the right to think. Buffon, Erasmus Darwin, Lamark, received attention in their day that was only scant in comparison with their desserts. They were not so compelling as Darwin nor was the world ready. In fact the world was not able to receive them. Evolutionists and anti-evolutionists reached a short period of truce in the cataclysm theory as advocated by Cuvier and others. But forces were quietly working that were preparing for a mighty offensive movement. James Hutton in Scotland, the obscure surveyor William Smith in England, and the mighty Lyell had been accumulating the forces that were to effect the annihilation of the cataclysm theory. The Principles of Geology appearing in 1830-32 and the Vestiges of Creation in 1844 completed the preparation of the way for the Origin of Species in 1859. The battle that followed after 1859 was violent, fast and furious. But the forces on the side of democracy of thought were speedily victorious. Now, a man may think according to his own inherent ability.

The history of law and order and government has no chapter more interesting or more vital than this chapter in science. Yet what percentage of intelligent, of educated men are fully conversant with it. The status of democracy of thought is of fundamental importance to democracy of government. Recognizing as I do the necessity of a knowledge of the history of political theories and of nations and governments, yet in my opinion a knowledge of the history of thought struggles, defeats and victories, as recorded in the history of science is also an essential part of mental equipment. Whether it be from the standpoint of culture or from that of the practical, a knowledge of the history of the evolution of science should have a place in the curricula of our colleges and universities. The modern physician does not follow the methods of Hippocrates but he loses nothing and gains much by knowing what those methods were. The first aid worker or the surgeon may apply aseptic dressings without knowing of the work of Lister and Pasteur, but with such knowledge he understands his own work better. The surveyor may run as straight a line, or the bond holder may compute his interest as accurately without a knowledge that men named Euclid, Napier, Newton or Gauss ever existed, as he could if he had such knowledge. But I can conceive of some mental satisfaction in the possession of such knowledge. Even just a little acquaintance with the persistent and intensive labors of some of the great leaders in science, of their self sacrifice, of their heroism creates a profound respect and admiration, and causes one even to marvel at the wonderful power and possibilities of the human mind. If the superman has ever appeared I think he was exemplified in Adams, or Leverrier who did a little figuring with reference to a planet that did not behave just as it apparently should and then told an astronomer to look at a certain place at a certain time there to find a planet. It would not be very difficult, I suspect, to convince me that Wallace was not far wrong in his inference that the mathematical faculty owes its origin to something outside natural evolutionary forces. I confess to a slight feeling of uneasiness when in the presence of a mathematician, as if something uncanny were near by. I find myself wondering as to the kind of nerve cells that make up his brain and then the query insidiously creeps in "according to the law of probabilities what chance is there of him becoming dangerously violent!"

Our school histories give us accounts of Napoleon's running rampant over Europe in a career of slaughter. Wouldn't the cultural and refining influence upon young minds be as marked at least, if they were given accounts of the work of Lister that saved more lives than Napoleon ever destroyed and that is continually saving lives, thousands of them, in the mad carnage of today. College histories of the next generation will devote chapters to the wild insane orgy of blood of William II. I wonder how much space will be given to the life saving work of Robert Koch. In the realm of fact the work of Koch is as truly a fact as the work of William II. As items of knowledge the student should know both. There is no question as to which will have the more humanizing effect. In my opinion the student has as perfect an intellectual right to be conversant with the scientific methods of a Harvey, a Redi, a Newton, or an Edison as he has to know the details of the division of all Gaul into three parts. Isn't there a place for the history of science, a need for it in all our colleges and universities? A full knowledge of the history cannot be attained by one who knows little about the sciences but that does not preclude the mastery of some elementary generalizations. One cannot comprehend to the fullest the debates between Huxley and Wilberforce without previously having a knowledge of the theories of evolution, yet he can comprehend enough to understand that here was a great struggle for liberty of thought. One can read an elementary history of mathematics without being an expert mathematician. Not every one is a statesman who studies the history of national organization. We are now sufficiently removed from the rancorous controversy between science and theology that an unprejudiced view of the contention of the past centuries may be possible. It would be to the advantage of theologians, both old and young, to have a comprehensive knowledge of that struggle. Such a course could well find place in the curricula of theological seminaries and colleges.

In recent years attention has been turning to the advisability of teaching the history of science in our colleges, both as undergraduate and graduate courses. Attempts to organize classes have been made with success in varying degree. In 1915 more courses in the history of mathematics were offered in the association of standard colleges of this country, 113 in number, than in any other science. The others follow in the order—chemistry, physics, zoology including evolution, biology including evolution, astronomy, psychology and botany and geology with the same number each. The total number of courses offered was 162, about 15 per cent of which were given in alternate years. The average number of students per course offered was eight. In some instances courses were abandoned because of insufficiency of demand for them. The courses in general history were more popular than those in the more special. Hence a natural question is: Which should be emphasized? The answer to this depends entirely upon the aim in view, special courses being more suitable for students majoring in one or two sciences. For those taking elementary courses in science the general history is better adapted. At least nine schools in Iowa, and possibly more, offer history courses, including mathematics, biology and evolution, chemistry, physics and botany, with the number of courses in mathematics leading.

My opinion is that courses in history have been monopolized too long in only one line of study. When mention of history is made one thought occurs to all: The history of nations and governments. Mention of any other history must contain a modifying clause. We should fully realize that the history of peoples is dependent fundamentally upon the development and progress of thought and of its practical applications; upon the struggle of the mind toward self realization and expression, and its attempt toward self adjustment in relation to the general welfare of humanity.

Department of Zoology, Drake University.

TEMPERATURE-TIME RELATIONS IN CANNED FOODS DURING STERILIZATION.

GEORGE E. THOMPSON.

Bacteriologists have found that the death rate of the bacteria which cause spoilage in canned goods depends upon the temperature to which the bacteria are subjected. In order, therefore, to establish the bacteriology of canning on a firm scientific basis it is necessary to know the time at which certain critical temperatures are attained by the foods which are subjected to the sterilization process. This paper shows the result of an attempt to work out by a combination of mathematical theory and experiment the temperature-time curves for certain foods in containers of any size and for any practical temperature range.

Apparently very little experimental work has been done along this line, and no attempt has been made, to the author's knowledge, to apply well known mathematical theory. J. Kochs and K. Weinhausen[1] have measured with maximum thermometers the temperatures attained in given times under certain practical conditions, in cabbage, carrots, asparagus, apple musk and green peas. A. W. Bitting and K. G. Bitting[2] have published temperature-time curves for pumpkin, sweet potatoes, tomatoes, peaches, etc., while being heated in a water bath. Aside from the reports of these men very little seems to have been published.

MATHEMATICAL THEORY.

In developing the mathematical thoory it will be assumed that heat penetration is entirely due to conduction. This is obviously not true except in very pasty substances, such as pumpkin, mashed sweet potatoes, etc., but it is thought that in such cases as corn and peas where the convection currents must be mostly very local in character the theory will still apply approximately enough for practical purposes, the convection being in effect equal to an increase of conduction. Also since the center of the can is last to become heated and last to cool off, it is the most important point to be considered and attention will be confined entirely to it.

In order to make the mathematical theory apply without too much complexity, it is necessary to assume rather ideal conditions, namely, that the contents of the can are of uniform temperature throughout before immersion in the sterilizing bath, and that the can is suddenly immersed in a bath which is maintained at a constant temperature.

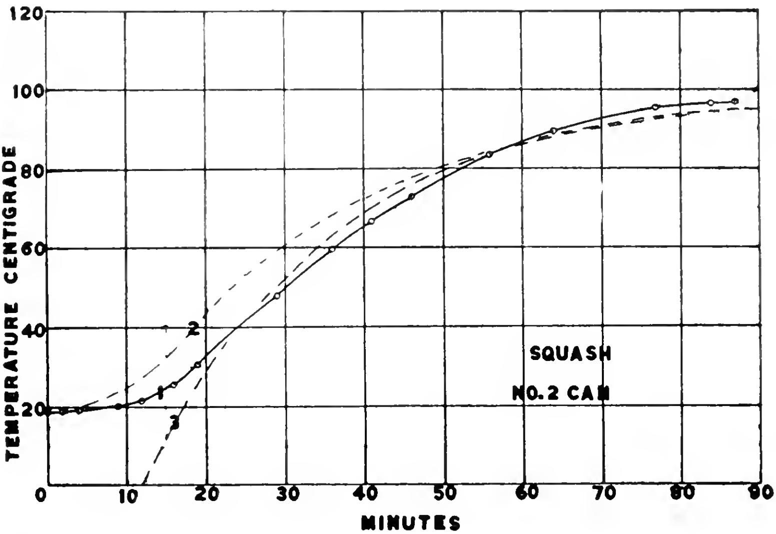

Fig. 1.

The general differential equation of symmetrical heat conduction in a right circular cylinder expressed in cylindrical coordinates is

$$\frac{\partial v}{\partial t} = k \left(\frac{\partial^2 v}{\partial r^2} + \frac{1}{r} \frac{\partial v}{\partial r} + \frac{\partial^2 v}{\partial z^2} \right) \text{-----} (1)$$

v being the variable temperature at any point in the cylinder, r the perpendicular distance of this point from the axis of the cylinder, z the distance from the center of the cylinder along the axis of the base of r, and k the diffusivity $\left(\frac{\text{conductivity}}{\text{density x specific heat}}\right)$ of the material, and t the time[3].

The initial conditions which must be satisfied under the assumed ideal conditions are that

$v = o$ at $r = a$ .... (2)
and $v = o$ at $z = \pm l$.................................. (3)
and $v = v_0$ at every point of the cylinder when $t = o$........ (4)

where a is the radius of the cylinder, 2 l the length, and v_0 the initial temperature of the cylinder.

A general solution of equation (1) satisfying all initial conditions is

$$v=v_o\left[A_l J_o(\mu_1 r)e^{-k\mu_1^2 t}+\cdots\right]\left[B_l \sin\lambda_1(z+l)e^{-k\lambda_1^2 t}\cdots\right] \quad (5)$$

from which

$$v=v_0\left[A_l e^{-k\mu_1^2 t}+A_2 e^{-k\mu_2^2 t}+\cdots\right]\left[B_l e^{-k\lambda_1^2 t}-B_2 e^{-k\lambda_2^2 t}+\right] \quad (6)$$

when $r = z = o$.

μ is a root of $J_0(\mu a)=o$ and λ a root of $\sin 2\lambda l=o$.

EVALUATION OF CONSTANTS.

The roots of $J_0(\mu a) = o$ found in the tables[5] are given in the following table. The values of λ which satisfy $\sin 2\lambda l = o$ are $\lambda_n = \frac{n\pi}{2l}$ where n is any positive integer. These are also given below. The values of A are obtained[7] from

$$A_\mu = \frac{-2}{(\mu_n a)\, J_o(\mu_n a)}$$

and the values of B are $\frac{4}{\pi m}$ where m has all odd positive integral values from 1 to infinity.

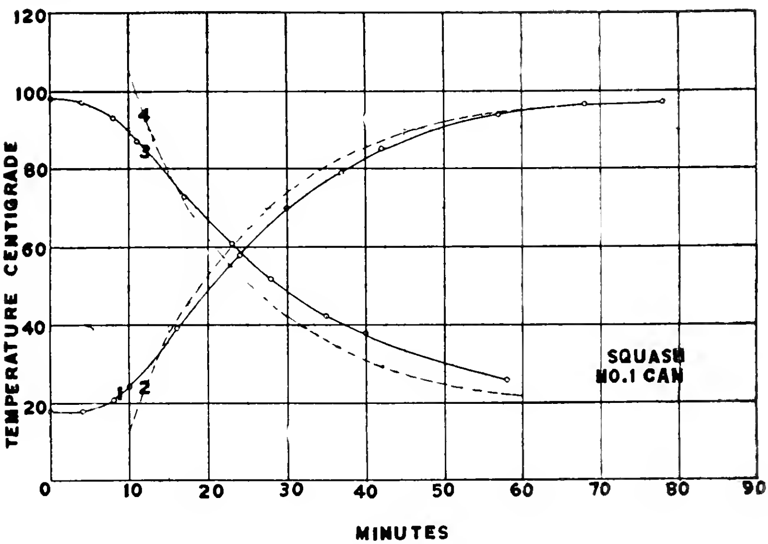

Fig. 2

It will be seen, therefore, that μ depends upon the radius of the cylinder, λ on the length, A and B on the initial conditions.

In table 1 are given the dimensions of commercial tin cans Nos. 1, 2, 2½ and 3, together with the values of μ and λ corresponding. The values of A and B computed from the relations already given are appended.

TABLE I.

		No. 1	No. 2	No. 2½	No. 3
μa	a l	3.35 cm. 5.00	4.2 cm. 5.7	5.16 cm. 6.03	5.2 cm. 6.1
2.405 5.520 8.654	μ_1 μ_2 μ_3	.718	.572 1.312 2.13	.472	.463
	λ_1 λ_2 λ_3 λ_4 λ_5	.314	.275 .550 .825 1.100 1.375	.262	.258
	A_1 A_2 A_3	1.602 —1.065 .851	B_1 B_2 B_3 B_4 B_5	1.273 .424 .254 .182 .141	

APPROXIMATE EQUATION.

After considerable time has elapsed all terms after the first in each bracket in equation (6) become negligible and the equation takes the simple form

$$v = v_0 A_1 B_1 e^{-k(\mu_1^2 + \lambda_1^2)t} \qquad \text{.................(7)}$$

In the preceding paragraphs the temperature of the bath was considered to be zero so that v_0 represents the initial algebraic temperature difference between the bath and the contents of the can. Expressed in terms of thermometer readings the equation is

$$v^1 = v_b + A_1 B_1 v_0 e^{-k(\mu_1^2 + \lambda_1^2)t} \qquad \text{.................(8)}$$

v_0 being the negative for heating and positive for cooling. The use of this equation makes unnecessary any shifting of temperature scales. In this equation v^1 represents the variable temperature and v^b the temperature of the bath.

DETERMINATION OF k.

All of the constants except k have been determined; this must be determined experimentally. A sufficiently accurate value of k may be found by using the experimental curve shown in Figure 1 in connection with Equation (8) and the constants given in Table 1. Since sterilization begins at about 60°C., the important part of the curve will be that extending upward from 60°C. We may find the value of k corresponding to the average temperature of this part of the curve which is about 80°C. Figure 1 shows

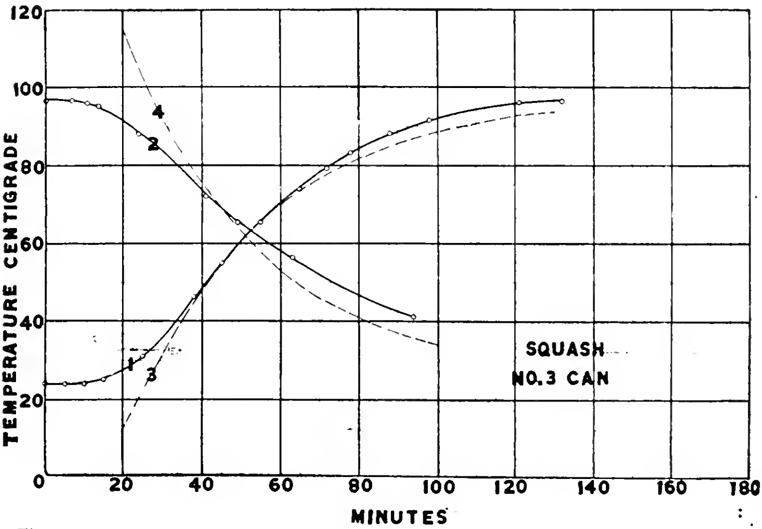

Fig. 3.

that 52 minutes were required for this temperature to be attained. Making appropriate substitutions in Equation (8) we have

$$80 = 98 - 1.602 \times 1.272 \times 8.05 e^{-k(\overline{.572}^2 + \overline{.275}^2)52} \quad \text{.................} (9)$$

from which k = .105.

GLASS CANS.

Extensive experimentation has not been done with glass cans but it seems that the effect of the glass is negligible, and that the rate of heat flow is about the same as in tin. From theoretical considerations this is to be expected because glass is at least as good a conductor as the contents of the can in the cases here cited, and being very thin as compared to the radius of the can very little effect is to be expected.

DISCUSSION OF CURVES.

Figure 1, Curve 1 shows the experimental heating curve for central point of a No. 2 can of squash. Curve 2 is the curve obtained for a No. 2 can by placing the appropriate constants in equation (6). Curve 3 shows the results obtained by using equation (8).

Figure 2 shows curves for a No. 1 can of squash, the theoretical curve being computed by use of the value of k previously found from the experimental curve of the No. 2 can.

Figure 3 shows similar curves for a No. 3 can.

Figure 4 shows a set of curves for squash cooked in a steam bath at 129°C. The value of k(=.105) previously used for the water bath was used here in computing the theoretical curves.

Similar results were obtained for corn.

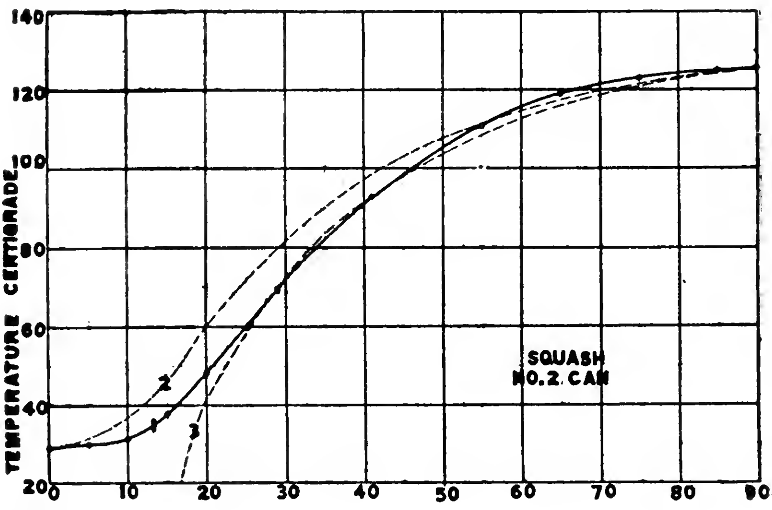

Fig. 4.

It is evident, therefore, that if the time required for a can of given dimensions to acquire a certain temperature be given, it is possible to construct a complete temperature-time curve for a can of any size and for any practical temperature range with a fair degree of accuracy.

ARRANGEMENT OF APPARATUS.

The hot water sterilizing bath consisted of a large open vessel about 32 cm. in diameter, and 31 cm. high filled with tap water.

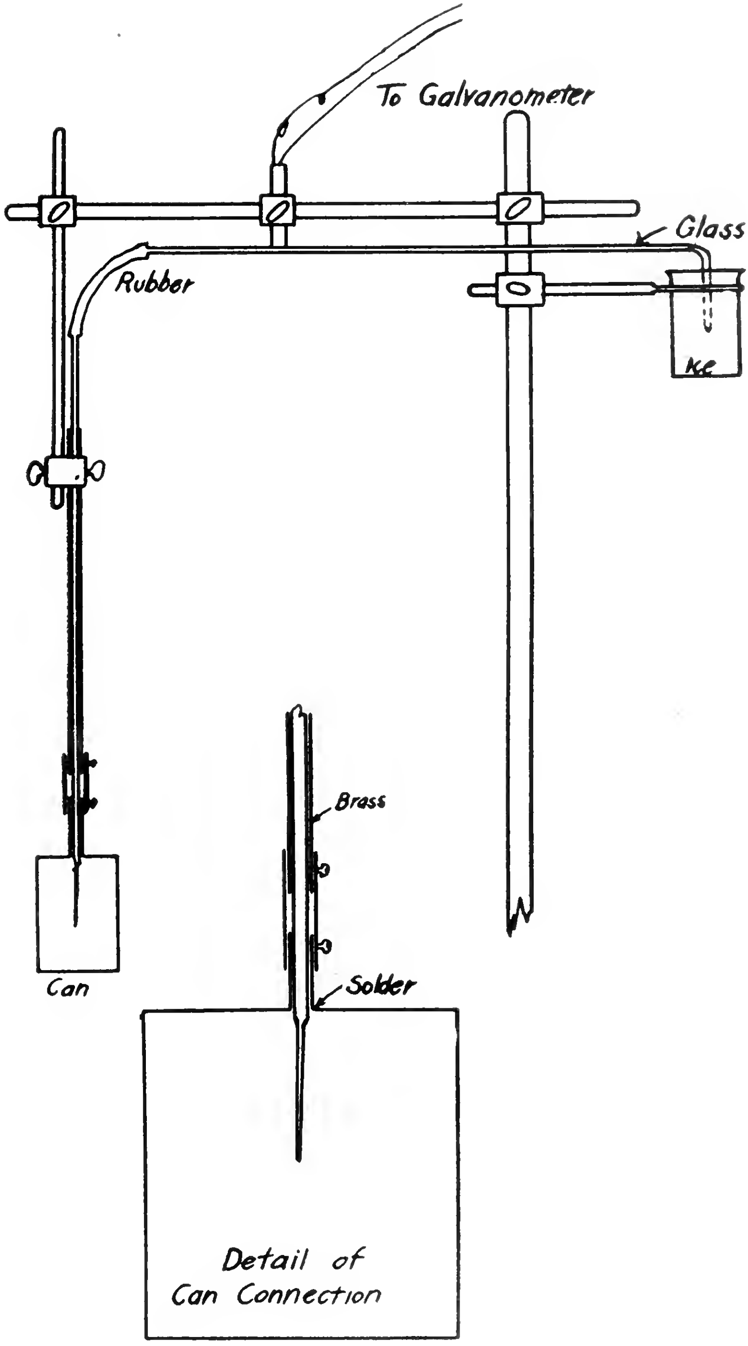
To Galvanometer
Glass
Rubber
Ice
Can
Brass
Solder
Detail of
Can Connection

Fig. 5.

The water was heated by a number of Bunsen flames. After the water had begun to boil the can was lowered suddenly into it, and the temperature readings made at frequent intervals.

The temperature readings were made with a thermocouple and sensitive galvanometer (1.88 x 10^{-6} volt/mm.) The thermocouple was of constantan (No. 27) and copper (No. 30) mounted as shown in Fig. 5. The wires were protected by enclosure in glass and rubber tubing. The glass tube was narrowed down to about 2 mm. diameter at the point where it enters the can. The can was supported by a brass tube held fast by solder. In order to make the interchange of cans easy the brass tube was made in two pieces and held together by a collar. The wires of the thermo-junction were allowed to project about 2 mm. beyond the end of the glass tube and were sealed in shellac. This did not form a permanent seal and was renewed for each set of readings. The whole outfit was mounted as compactly as possible by use of laboratory clamps and rods to enable the can to be lowered readily into the bath.

The temperature readings made with this arrangement are accurate to within about 1°C. For calibration purposes a mercury thermometer was used as a standard.

When the steam bath was used it was necessary to lead the thermocouple wires in through a steam tight joint capable of withstanding a pressure of twenty pounds per square inch gauge. This was accomplished by inserting the couple in a thin glass tube closed at one end, and held in place by a rubber gasket as shown in Figure 6; the closed end which contains and protects the junction being placed at the center of the can. The presence of the thin glass surrounding the junction did not prevent the junction from attaining the temperature of the surrounding material promptly. A test showed that in about one-half minute after immersion in boiling water the junction was practically at the temperature of the water.

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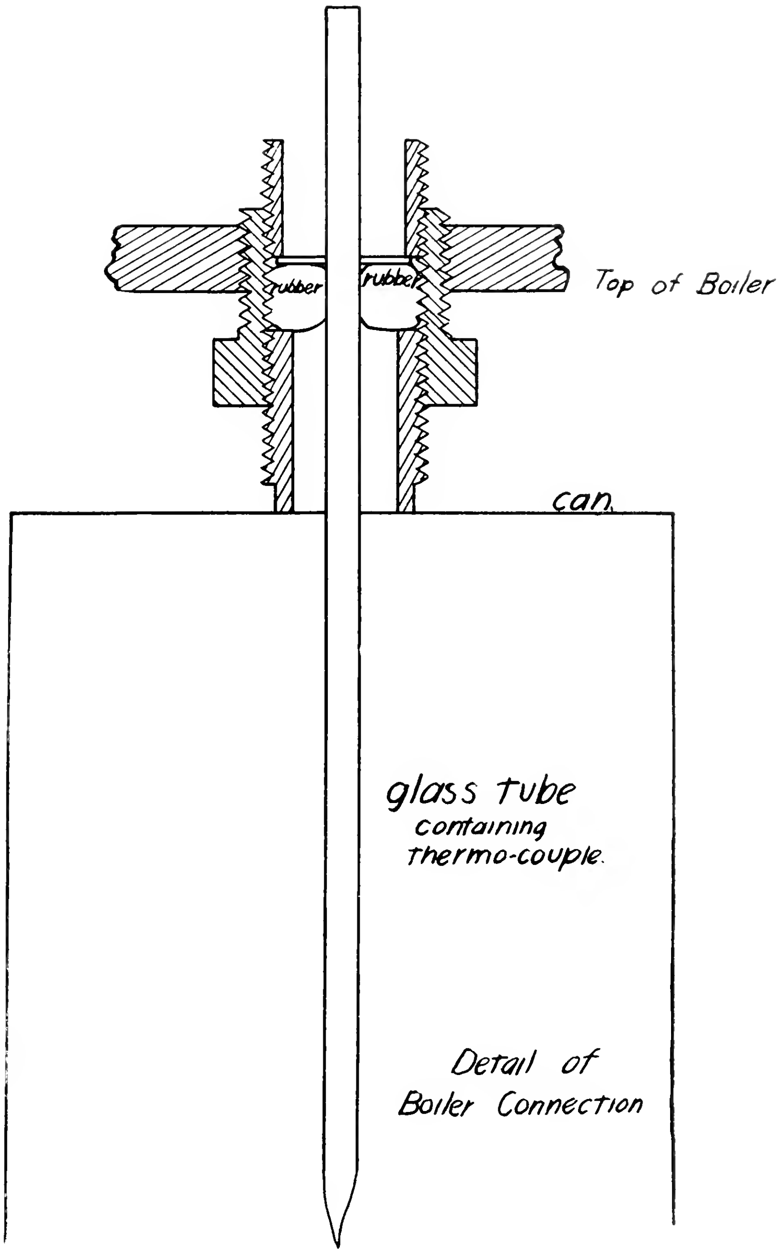
rubber
rubber
Top of Boiler
can.
glass tube
containing
thermo-couple.
Detail of
Boiler Connection

Fig. 6

Heat, pp. 542-3, Macmillan & Co., 1894. Ingersoll & Zobel, Mathematical Theory of Heat Conduction, pp. 9-14. Ginn & Co.

4. $$J_0\,(\mu r) = 1 - \frac{(\mu r)^2}{2^2} + \frac{(\mu r)^4}{2^2 \cdot 4^2} - \frac{(\mu r)^6}{2^2 \cdot 4^2 \cdot 6^2} +$$

See Byerly, an Elementary Treatise on Fourier's Series, etc., p. 219.

5. Byerly, l. c., p. 286.

6. Byerly, Harmonic Functions, p. 218. (Edited by Merriam & Woodward.) Published by Wiley & Sons.

Byerly, Introduction to the Theory of Fourier's Series, etc., p. 39.

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STROBOSCOPIC VELOCITIES IN THE TONOSCOPE.

H. R. FOSSLER and L. E. DODD

The characteristic equation for stroboscopic velocity is

$$v_s = (A - n/m \cdot B)\, D_o \qquad (1)$$

(see Proc. Iowa Acad. Sci., Vol. XXIV, 1917, p. 222), where v_s is the stroboscopic velocity, A the frequency of the stroboscopic figures, B the frequency of illumination, n/m a fraction at lowest terms, and D_o the distance of separation of the stroboscopic figures. Eq. (1) may be rewritten,

$$v_s = v - n/m \cdot D_o\, B$$

where v is the velocity of the stroboscopic screen. For the tonoscope,

$$v_s = 2\pi r\ (1 - n/m \cdot B/N) \qquad (2)$$

where r is radius of drum, and N is total number of dots around drum in a given row. Let f be the number per second of simple images in a given row passing the tonoscope scale. Then,

$$v_s = f\, D,$$

where D is distance of separation of simple images. Now $D = D_o/m$ (loc. cit.). Thus,

$$v_s = f\, D_o/m = f/m \cdot 2\pi r/N, \qquad (3)$$

for tonoscope. Equating (2) and (3),

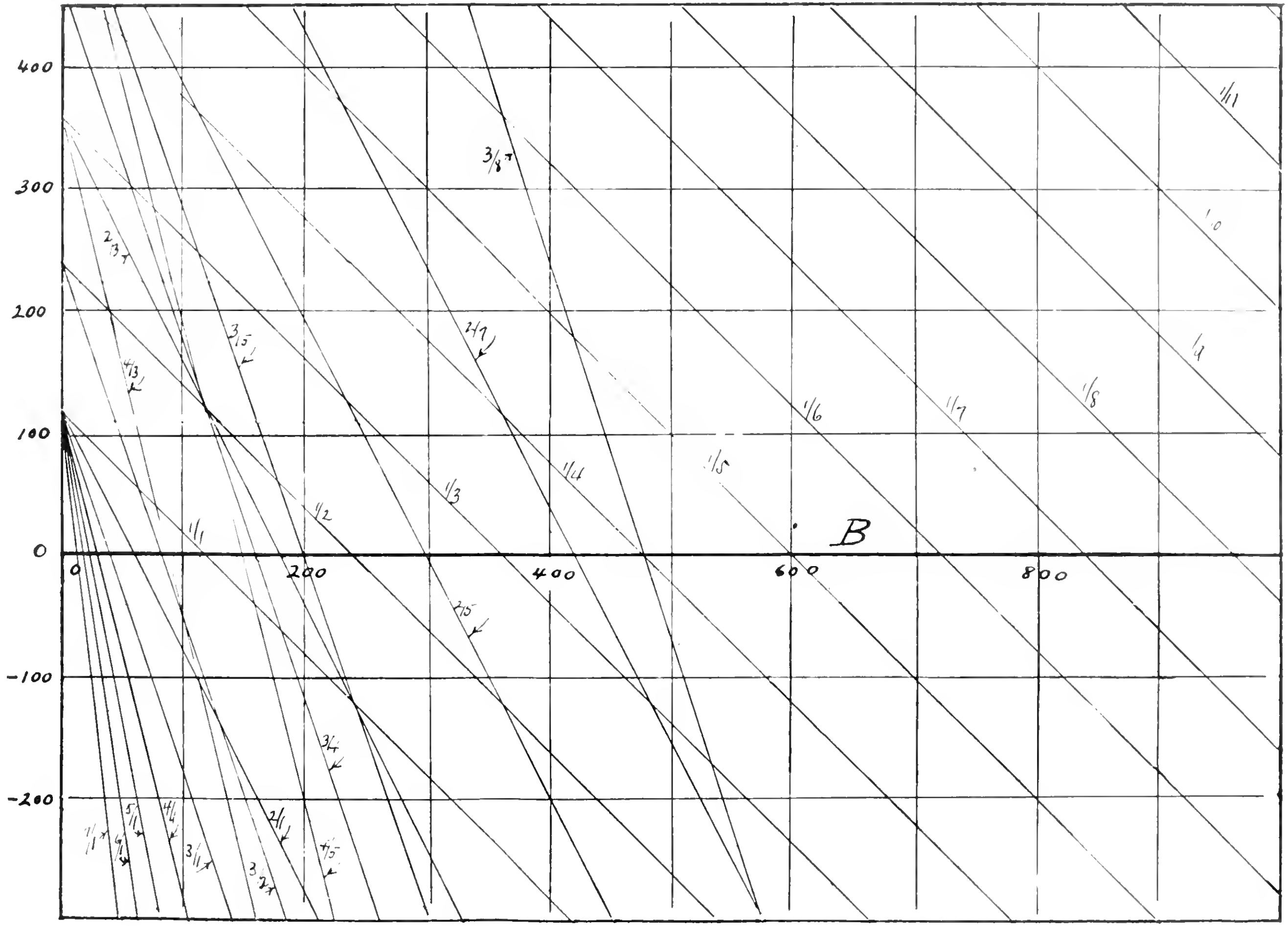
$$f = mN - nB, \qquad (4)$$

an equation that may be regarded as of the form y=mx+B. Although f is a frequency rather than a velocity, eq. (4) will be used as a special form to test eq. (1), because of the linear relation, and f will be referred to in this paper as the stroboscopic velocity. The value of v_s is readily found from the value of f by means of eq. (3).

Eq. (4) contains two independent variables, N and B. Two sets of curves are drawn, with N and B respectively constant, and with some of the unlimited number of possible values of n/m. For these two cases (4) is put into the respective forms:

$$f = (m)N + (-nB), \qquad (5a)$$

$$f = (-n)B + (mN). \qquad (5b)$$



f-B Curves, Π constant

Thus the curves from (5a) have slope m and y—intercept (—nB), and those from (5b) have slope (—n) and y—intercept (mN). The values of n/m for the comparatively few curves actually drawn are indicated on them.

The meaning of curves from (5a), where B is taken constant for the plotting of the curves, is that if we had a continuous tonoscope drum, instead of a drum with but a single octave, which included values of N from 1 to infinity, the x—intercepts of the straight lines would give the values of N (=n/m·B) for rows stationary by stroboscopic response for the particular value of B, while the f values on the straight lines would give the stroboscopic velocities. For the actual tonoscope we are limited to the tonoscope octave. The visible stroboscopic response for a given value of B is of course limited to segments of such straight line curves, which segments include the zero value for f.

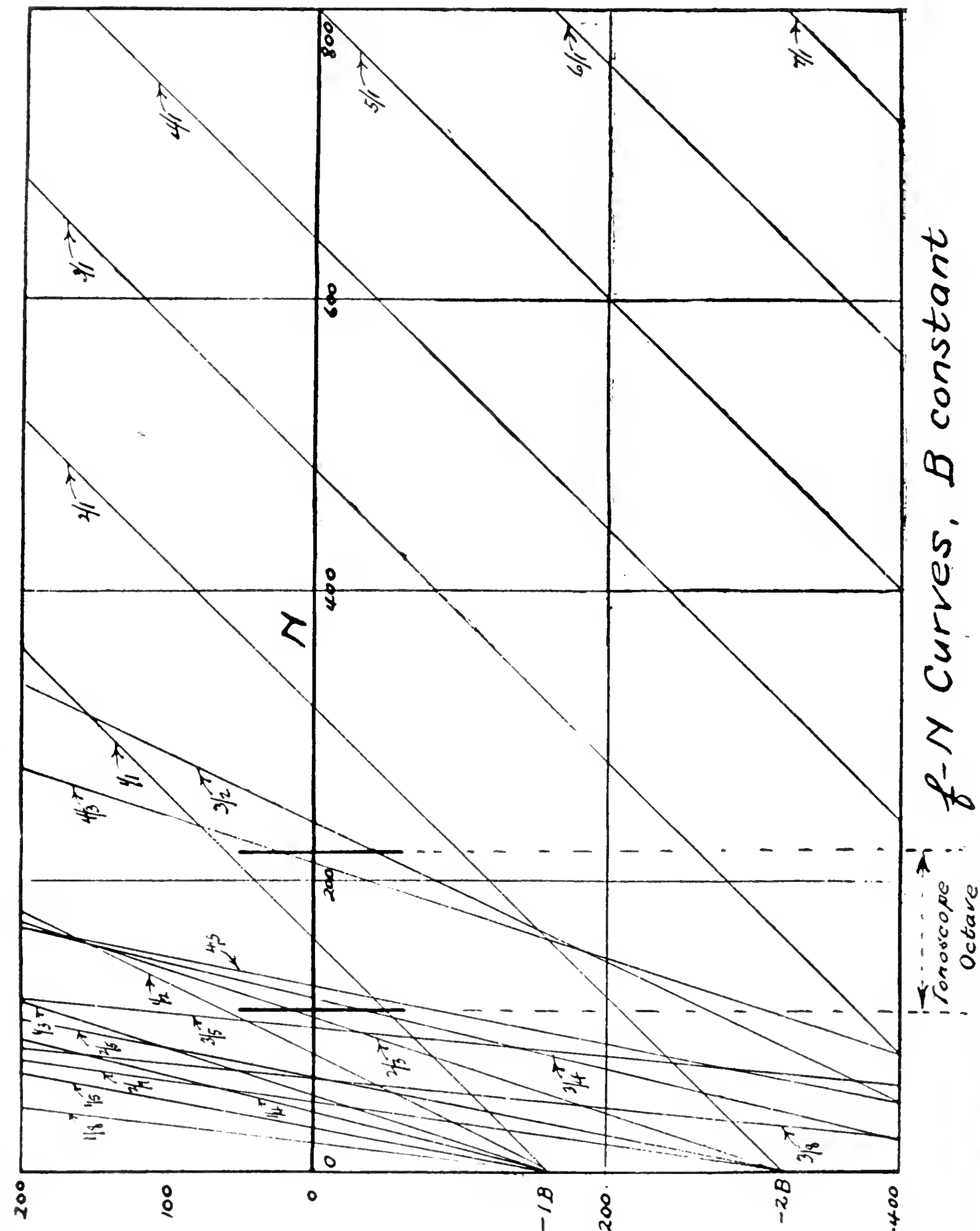
The meaning of curves from (5b), where N is taken constant for the plotting of the curves, is that for a given row (definite value of N) the x—intercepts give the values of B (=m/n·N) which are able to make that row stationary by stroboscopic response, and the other points on the curves give the finite stroboscopic velocity in terms of f as a function of B for that row.

For the curves from (5a), Fig. 1, B is taken equal to 160, so that the value of N_0 for which n/m=1/1, falls within the tonoscope octave. For any other value of B the set of curves would be slipped either up or down along the y—axis, with the angular relations remaining unchanged. The values of n/m most used practically in the tonoscope are: 2/1 (bass voice), 1/1 (where pitch of sounded tone lies within tonoscope octave), 1/2, 1/4 (soprano voice).

Similarly, for the curves from (5b), Fig. 2, N is taken equal to 120, so that the value of N_0 for n/m=1/1, falls within the tonoscope octave. For any other value of N the set of curves is slipped either up or down the y—axis, while the angular relations remain unchanged.

EXPERIMENTAL.

Nine cases, affording five different values of n/m, viz., 1/1, 1/2, 1/3, 2/1, 3/2, are experimentally investigated by observation on the tonoscope. The curves, Fig. 3, for these cases are drawn from eq. (5a), and the small circles indicating points on the curves give experimental values. The agreement between



f-N Curves, B constant
N
Tonoscope Octave
200
100
0
-1B
-200
-2B
-400
0
200
400
600
800

Fig. 2.

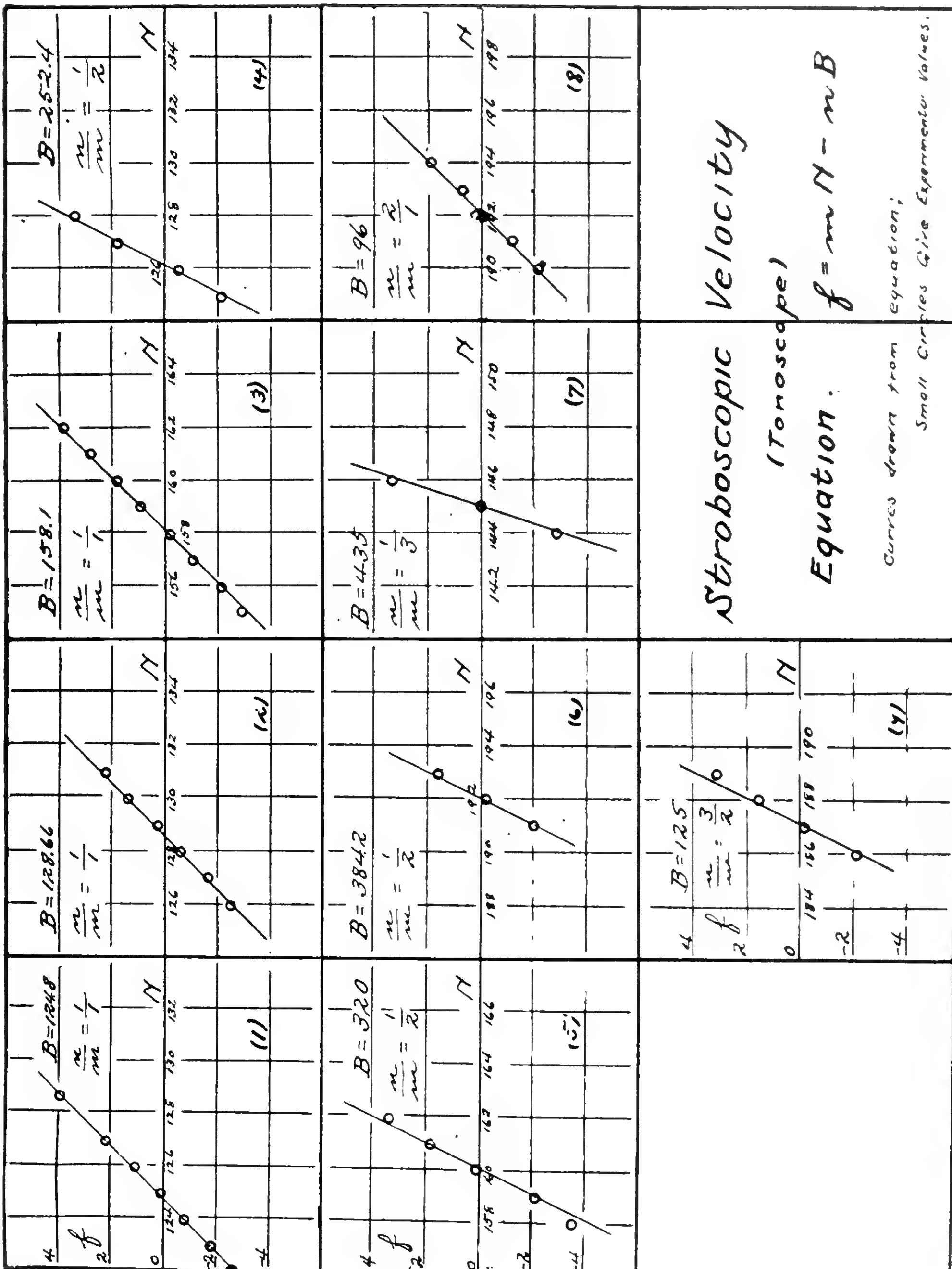

Stroboscopic Velocity
(Tonoscope)
Equation.
f = mN - nB
Curves drawn from equation;
Small Circles Give Experimental Values.

Fig. 3.

the equation and the experimental values is good in each of the nine cases. It will be noted that the slope changes with m alone. The data are assembled in Table I. How nearly the linear relation appears to hold is seen from the column of values of the constant, $(f+nB)/N$, which is equal to m the slope, and is derived from the experimental values. The extremely slight variation is regarded as entirely due to observational error, which increases with f.

CONCLUSION.

Secondary regions of stroboscopic response present during a reading on the tonoscope, particularly when a fork is used, are thus seen to be in accord with the demands of equation (1), or its special form (4), rather than due to harmonics. That is, a pure tone will produce secondary responses in addition to a primary response. By "primary response" is here meant the region of rows of dots in response containing the stationary, or nearly stationary row that is being read, which region has one of the values of n/m already mentioned for voice pitch readings on the tonoscope. However, there appears to be nothing to prevent a harmonic from producing its own primary and secondary regions of stroboscopic response, provided either that it has sufficient energy itself to actuate the manometric flame, or other device for changing the frequency of the sounded tone into luminous frequency, or that such device possesses on its part unlimited sensitiveness to sound vibrations. Mathematically, at least, the condition exists of a fundamental producing a primary (term restricted here to $n/m=1$) and an unlimited number of secondary stroboscopic responses, and each one of all its possible harmonics simultaneously doing the same thing.

In conclusion of this paper, thanks are due Dean C. E. Seashore, head of the Department of Psychology at the State University, for his kind permission to make this experimental test of the stroboscopic velocity equation with the tonoscope, and for use of forks belonging to that department.

TABLE I.

(f′=total number of simple images counted in t secs., by stop watch)

Fork (B)	N	f′	Observer	t	f	f(av.)	$\frac{f+nI}{N}$
124.8	122	20	D	7.4	2.70	....	......
....	....	20	D	7.2	2.77	(—)2.73	1.0008
(1)	123	10	D	5.6	1.78	....	......
....	....	20	D	11.4	1.75	(—)1.76	1.0008
....	124	8	D	10.2	0.78	....	......
....	....	8	D	10.2	.78	(—)0.78	1.0000
....	125	....	D	Slow	motio	n up	......
....	126	10	D	9.0	1.11	....	......
....	....	10	D	8.6	1.16	....	......
....	....	10	D	8.8	1.13	1.13	0.9992
....	127	15	D	7.0	2.14	....	......
....	....	16	D	7.2	2.22	....	......
....	....	20	D	9.4	2.12	....	......
....	....	15	D	7.0	2.14	2.15	.9992
....	128	Motion	too rapi	d for	accur	ate count	......
128.66	125	30	D	10.2	2.94	Count	......
....	....	30	F	9.6	3.12	uncertain	......
(2)	....	31	D	10.8	2.87	....	......
....	....	30	F	10.0	3.00	(—)2.98 (?)	......
....	126	30	F	13.0	2.31	....	......
....	....	20	D	7.8	2.56	....	......
....	....	30	F	12.0	2.50	....	......
....	....	30	D	11.6	2.58	....	......
....	....	30	F	12.0	2.50	(—)2.49	1.0007
....	127	20	F	12.2	1.63	....	......
....	....	20	D	12.0	1.66	(—)1.64	1.0000
....	128	10	F	15.0	0.66	....	......
....	....	10	F	15.0	.66	....	......
....	....	10	D	15.0	.66	(—)0.66	1.0000
....	129	10	D	30.6	0.326	....	......
....	....	10	F	30.0	.333	0.33	1.0000
....	130	20	D	15.0	1.33	....	......
....	....	20	D	15.8	1.26	....	......
....	....	20	F	15.4	1.29	1.29	0.9992
....	131	30	D	13.4	2.24	....	......
....	....	30	F	13.5	2.22	2.23	.9992
....	132	30	D	11.8	2.54	Count	......
....	....	30	F	10.0	3.00	uncertain	......
....	....	30	D	12.2	2.46	....	......
....	....	30	F	10.6	2.83	2.71	......
158.1	155	15	D	5.6	2.67	....	......
....	....	17	D	5.6	3.03	....	......
(3)	....	16	D	5.4	2.96	....	......
....	....	15	D	5.0	3.00	(—)2.91	1.0012
....	156	10.5	D	5.4	1.94	....	......
....	....	12.5	D	5.8	2.15	....	......
....	....	10.0	D	4.8	2.08	....	......
....	....	10.0	D	4.6	2.17	(—)2.08	1.0000
....	157	5	D	4.6	1.08	....	......
....	....	5	D	4.6	1.08	....	......
....	....	6	D	6.0	1.00	(—)1.05	1.0000

TABLE I (Cont.)

Fork (B)	N	f'	Observer	t	f	f(av.)	$\frac{f+nB}{N}$
....	158	0.5	D	4.2	0.12	(—)0.12	1.0000
....	159	5	D	6.2	0.806	....	......
....	....	4	D	4.2	.952	....	......
....	....	4	D	4.0	1.000	0.92	1.0000
....	160	9	D	5.0	1.80	....	......
....	....	9	D	5.2	1.73	1.76	0.9987
....	161	10	D	3.6	2.77	....	......
....	....	10	D	3.4	2.94	....	......
....	....	15	D	5.4	2.77	....	.9993
....	....	15	D	5.4	2.77	2.81	......
....	162	16	D	4.6	3.47	....	......
....	....	17	D	4.2	4.04	....	......
....	....	17	D	4.2	4.04	3.85	.9993
252.4	125	19.5	D	8.6	2.26	....	......
....	....	30.0	F	13.4	2.25	(—)2.25	2.0016
(4)	126	10	D	24.0	0.416	....	......
....	....	10	F	23.0	.434	....	......
....	....	10	D	27.4	.365	....	......
....	....	10	F	23.0	.434	....	......
....	....	10	D	23.0	.434	....	......
....	....	10	F	21.5	.465	....	......
....	....	10	D	23.0	.434	....	......
....	....	10	F	23.0	.434	(—)0.427	2.0000
....	127	14	D	8.4	1.66	....	......
....	....	20	D	12.0	1.66	....	......
....	....	30	F	17.2	1.73	....	......
....	....	25	D	15.0	1.66	....	......
....	....	30	F	17.0	1.76	....	......
....	....	25	D	15.6	1.60	....	......
....	....	25	F	16.0	1.56	....	......
....	....	15	F	9.6	1.56	....	......
....	....	20	D	12.6	1.59	1.64	2.0000
....	128	30	D	10.8	2.77	....	......
....	....	30	F	8.5	3.53	....	......
....	....	30	F	8.8	3.40	3.23	1.9968
320	157	10	F	2.4	4.16	Uncertain	......
....	....	10	F	2.2	4.54	(—)4.35	......
(5)	158	10	F	2.8	3.57	....	......
....	....	10	F	3.3	3.03	....	......
....	....	20	D	5.4	3.70	(—)3.50	2.0031
....	....	25	D	6.8	3.67	....	......
....	159	10	F	4.8	2.08	....	......
....	....	10	F	4.9	2.04	....	......
....	....	10	F	5.0	2.00	....	......
....	....	20	D	9.8	2.04	....	......
....	....	20	D	9.6	2.08	....	......
....	....	20	D	9.8	2.04	(—)2.05	2.0000
....	160	0	F	....	0.000	....	......
....	....	1	D	7.4	.135	0.07	2.0006
....	161	10	F	5.5	1.81	....	......
....	....	15	D	8.2	1.82	....	......
....	....	15	D	7.8	1.91	1.85	1.9987
....	162	10	F	3.0	3.33	....	......

TABLE I (Cont.)

FORK (B)	N	f'	OBSERVER	t	f	f(av.)	$\frac{f+nB}{N}$
....	....	10	F	3.0	3.33	....	......
....	....	10	F	2.8	3.57	3.41	1.9962
384.2	191	8	D	4.0	2.00	....	......
....	....	7	D	3.6	1.94	....	......
(6)	....	8	D	3.6	2.22	....	......
....	....	6	D	3.2	1.87	(—)2.01	2.0010
....	192	1	D	4.0	0.25	(—)0.25	2.0000
....	193	10	D	6.6	1.51	....	......
....	....	7	D	4.2	1.66	....	......
....	....	5	D	3.2	1.56	....	......
....	....	6	D	3.6	1.66	1.60	1.9989
435	143	10	....	2.8	3.57	Uncertain	......
....	....	10	....	3.0	3.33	....	......
(7)	....	10	....	2.8	3.57	(—)3.49	......
....	144	12	D	4.0	3.00	....	......
....	....	13	D	4.4	2.95	....	......
....	....	8	D	3.2	2.50	(—)2.82	3.0013
....	145	0	....	....	0.00	0.00	3.0000
....	146	10	D	3.6	2.77	....	......
....	....	15	D	5.0	3.00	....	......
....	....	11	....	3.2	3.43	....	......
....	....	10	F	3.1	3.22	....	......
....	....	10	F	3.2	3.12	....	......
....	....	10	F	3.2	3.12	3.27	......
96	190	10	D	4.4	2.27	....	......
....	....	12	D	5.2	2.30	....	......
(8)	....	8.5	D	4.4	1.93	....	......
....	....	8	D	3.8	2.10	(—)2.15	0.9994
....	191	6	D	4.8	1.25	....	......
....	....	8	D	6.6	1.21	....	......
....	....	5	D	4.6	1.09	(—)1.18	.9989
....	192	0	D	...	0.00	0.00	1.0000
....	193	4	....	5.0	0.80	....	......
....	....	5	....	7.0	.71	0.75	.9984
....	194	10	....	5.2	1.92	....	......
....	....	10	....	5.6	1.78	1.85	.9989
125	186	10	D	4.6	2.17	....	......
....	....	9	D	4.0	2.25	....	......
(9)	....	10.5	D	4.8	2.19	....	......
....	....	10	D	4.4	2.27	(—)2.22	2.0043
....	187	1	D	4.0	0.25	....	......
....	......	1	D	4.6	.22	(—)0.23	2.0042
....	188	6	D	4.0	1.50	....	......
....	....	5	D	4.0	1.25	....	......
....	....	7	D	4.2	1.66	....	......
....	....	6	D	3.6	1.66	....	......
....	....	5	D	3.6	1.38	1.49	2.0026
....	189	10	D	3.4	2.94	....	......
....	....	10	D	3.4	2.94	....	......
....	....	10	D	3.0	3.33	3.07	2.0005

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NOTE ON THE TUNGSTEN X-RAY SPECTRUM (L-SERIES).

O. B. OVERN

A rather incomplete report of the work of Dershem on the X-ray spectrum of tungsten has appeared in the proceedings of the Iowa Academy of Science. A complete report is to be found in the Physical Review of June, 1918, where he finds this spectrum to contain 19 lines in the L region.

Further experiments have been carried on using the same apparatus and method as used by Dershem, but increasing the time of exposure, with the result that six new lines have been discovered.

These results are tabulated below, giving Dershem's results for reference.

TABLE

Wave lengths in 10^{-8}cm.

Grating constant for rock salt being 2.814×10^{-8}cm.

DERSHEM	OVERN	DERSHEM	OVERN
1.482^8	1.483^9	1.129^2	1.130^2
1.472^2	1.473^1	1.095^7	1.096^7
1.416^3	1.419	. . . . .	1.079^4
1.297^7	1.298^4	1.070^5	1.072^4
1.286^8	1.287^2	1.064^8	1.065^9
1.278^4	1.279^3	1.058^7	1.059^6
1.258^6	1.259^8	1.042^7	1.044^6
1.241^6	1.243^4	1.025^3	1.026^3
. . . . .	1.235^5	. . . . .	$.792^8$
1.220^2	1.221^2	. . . . .	$.710^8$
. . . . .	1.213^2	$.706^8$	$.706^5$
1.209^8	1.209^7	. . . . .	$.629^1$
1.177^3	1.202^1		

Accuracy of above figures assumed to be one-tenth per cent.

The table shows that Dershem's results have been verified except in the case of one line mentioned below.

It is the writer's opinion that the wave length 1.419 listed by Dershem as 1.416^3 is the second order of the line $.706^5$ found on most of the plates. This line has appeared on only one of my plates sufficiently strong to admit of measurement. This plate was exposed in a small apparatus and the measurement is therefore not considered as accurate as the others. If this is a second order line its true wave length is .708 (using Dershem's value 1.416) which compares well with the wave length .706[5]. The fact that this line lies in the second order bromine absorption band makes it difficult to observe.

The line listed by Dershem as 1.177[3] has been found to have a wave length 1.202[1]. A comparison of photographs shows that these two values are meant for the same line. Since Dershem's value was found from observations on only one plate and mine from observations on four plates, which agree well together. Dershem's value for this wave length is undoubtedly in error much beyond his limit of experimental error.

The line of wave length .792[8] appears light on the plates in contrast to the others which appear dark. There may be two explanations for this.

1. It may be the edge of an absorption band due to some substance through which the rays pass before reaching the plate. The rays pass through glass, air, and paper. The edge of the absorption band would be the short wave length end of the spectrum, but it would appear that the K-series wave lengths of these substances are far too large for this region. The "J radiations" found by Barkla and White[1] for carbon, oxygen, and aluminum have wave lengths far too short for this region. This assumption is therefore not very probable.

2. It may be the convergence wave length of a series as yet unknown. The end of a series would appear as a dark band with a lighter region at the short wave length end. This sudden change from black to light is probably what has been observed here. This line is in the region of the bromine absorption band and the general blackening of the plate makes it hard to observe.

The line of wave length 1.213[2] makes a close doublet with the line 1.209[7] already found by Dershem. The close proximity of these two lines, which were clearly resolved, shows that the resolving power of the apparatus was at least 336 for that wave length.

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ON THE COEFFICIENT OF ABSORPTION OF PHOTO-ELECTRONS IN SILVER AND PLATINUM.

OTTO STUHLMAN, JR.

The coefficient of absorption can be defined by the constant α in the exponential relation $N=N_0e^{-\alpha t}$. The precise physical interpretation of such an exponential law when applied to a beam of electrons moving through a metal plate of thickness "t" is not so simple as its mathematical expression would lead one to suppose. It may, however, be interpreted if we assume that there exists no "scattering" or energy transformation as the beam of electrons passes through the metal. If αx is taken as that fraction of the number which is absorbed when the beam of electrons passes normally through a very thin screen of thickness x (cm), then for a plate of thickness t (cm), $N=N_0e^{-\alpha t}$, in which N_0 is the intensity of the beam when it enters, and N that of the beam when it emerges from the slab of material in which the absorption has taken place.

A more convenient form for experimental use is, however, the following. $\alpha = \frac{2.3}{t}$ (log N_0-log N) where the logarithms are taken to the base 10. Hence given a set of observations with homogeneous (i. e. electrons of the same initial velocity) rays, if log N is plotted as ordinate against t, the thickness of the slab through which the electrons pass, the graph is then a straight line and α is 2.3 times the slope of this line. If large values of α are obtained, this is an indication of easily absorbed electrons (velocity small) while if α is found to be small it indicates the presence of penetrating rays or fast moving electrons.

In some cases it is, however, easier to think of the absorption coefficient in terms of the thickness t which reduces the number of electrons to half value. Since $\frac{1}{\alpha}$ represents the distance to which the electrons penetrate before their number is reduced $\frac{1}{e}$ of the original value, then α may be written in the form, $\alpha = \frac{0.693}{t}$ where $e^{-0.693}=0.500$. In the following observations this expression was used in determining the coefficient of absorption of electrons liberated in a metal by monochromatic ultra violet light.

A Cooper-Hewitt, quartz, 110 volt, mercury vapour lamp served as a source of ultra violet light. This passed through a Hilger monochromatic illuminator with a quartz optical system.

The image of the particular wave length under investigation was reduced to 8x0.23 mm and focused on the metal under examination. The metal in the form of a wedge, semi-transparent at one end and opaque at the other, was deposited by distillation from an incandescent wire in vacuo. The technique of obtaining the metal in the form of a wedge was described in a recent article by the writer.[1] The method consists essentially of a wire heated to incandescence by means of an electric current, while a quartz plate upon which the wedge is to be deposited is placed below and to one side of it. If the whole is now placed in vacuo, the metal will vaporize and condense upon the quartz surface. Since there is no reflection of metal from the walls of the inclosure it can be shown that under these circumstances a section of the surface thus developed upon the quartz plate is of the form $y = \frac{8a^3}{x^2+4a^2}$ where 2a is the height of the wire above the plane, y being the thickness of the deposit at any distance x out from the perpendicular dropped from the wire to the plane containing the plate. The section of the metal thus deposited, forms a surface at a distance of four centimeters from the wire (2a=2cm.), which approaches a right triangular wedge with a variation of five per cent at either end.

This wedge (1×2.5cm) was placed, metal side facing the light, along the axis of a Faraday Cylinder, having slits cut in its opposite sides to allow for the unobstructed passage of the light. This cylinder was electrostatically shielded and connected to an electrometer. The wedge was clamped at its thick end to an indicator which slid over an engraved scale. The rod carrying the indicator and the wedge could be moved so that successively thicker layers of the metal could be photoelectrically examined as it passed in front of the illumination. The wedge was thus exposed at millimeter intervals through its entire length with the result that successive increases in thickness of the metal exposed, gave the required in photoelectric current desired.

Plotting the resulting photoelectric current against thickness of the metal thus exposed, developed an exponential curve, which saturated at a point where further increase in thickness produced no further decrease in current. This gave a true

[1]Stuhlman Journal of the Optical Society, vol. 1, p. 78, 1917. On the Preparation of Metallic Mirrors, Semi-transparent and Transparent Metallic Films and Prisms by Distillation.

absorption curve between the limits of thickness investigated. A secondary phenomenon occurring for thicknesses of less less than 10^{-6}cm does not make its appearance in the region investigated here. The absorption coefficients were then computed from the half value relations by means of the equation $a = \frac{0.693}{t}$. Sample results are given in the accompanying table and show samples of the values which the limitations of the method allow.

VALUES OF a IN $uu^{-1}cm^{-1}$ FOR λ 2536

Silver	.0133	.0137	.0137	.0133			
Thickness in $\mu\mu$	55	60	65	70			
Platinum	.0331	.0301	.0346	.0333	.0331	.0331	.0347
Thickness in $\mu\mu$	40	50	55	60	65	70	75

Lenard[2] investigating the properties of cathode rays showed that their coefficient of absorption was very nearly proportional to the density "ρ" of the material. The maximum variation in his results for $\frac{a}{\rho}$ were 2070 and 5610, although the densities of the absorbing material varied between 3.6×10^{-7} and 19.3. Rutherford[3] found that a similar relation held approximately for the faster B rays from Uranium X. Though the elements of large atomic weight were found to possess a mass absorption coefficient $(\frac{a}{\rho})$ nearly twice as large as the lighter elements, Crowther[4] who extended these latter observations for thirty-two elements, found that the mass absorption coefficient exhibited a progressive increase from the lighter to the heavier elements. The following values of $\frac{a}{\rho}$ for B rays of platinum and silver quoted from his paper will give some idea of the magnitude of his results.

Metal	Atomic Weight	Atomic Number	Density	Brays $\frac{a}{\rho}$	Photo-electrons $\frac{a}{\rho}$	Photo-electrons a
Platinum	195.2	78	21.5	9.4	15400	331000
Silver	107.9	47	10.5	8.3	12850	135000
Ratio	1.81	1.66	2.00	1.13	1.19	2.45

For comparison the values of $\frac{a}{\rho}$ for photoelectrons (λ2536) are given and it is seen that the ratio of the mass absorption

[2]Lenard, Ann. d. Phys. 56 p. 275, 1895.
[3]Rutherford, Phil. Mag. 47, p. 109, 1899.
[4]Crowther, Phil. Mag. 12, p. 379, 1906.

coefficients for the two metals is nearly equal to the ratio of this same quantity as quoted from Crowther's paper, although the velocities of the B rays are a thousand times greater than the maximum velocity of the photoelectrons.

The values of p as tabulated are constant through quite a range in thickness. The constancy of the coefficient of absorption has been found to hold up to thicknesses limited by the depth of penetration of the incident energy. This indicates that the mean distribution of velocity of the electrons is the same whether they come from sheets of metal less than or equal to the depth of penetration of the light. ($t > 10^{-6}{}_{cm.}$)

The coefficient of absorption of silver ($a = .0135 \mu\mu^{-1}$) is less than that for platinum ($a = .0331 \mu\mu^{-1}$) which indicates that the velocity of the electrons, although excited by the same frequency, and hence starting initially from their respective atoms with the same velocity, do not in appearing at the surface of the metal, although coming from the same depth, give up on the average the same amount of energy in reaching that surface. Since a large value of corresponds to a small velocity it follows that electrons originating from the same depths in the two metals, appear at the surface of silver with greater velocities than those originating from the correspondingly placed platinum atom. This would imply that the distribution of velocity amongst the electrons would be totally different in these two metals and that the "distribution of velocity curve" for silver would lie to the left of that for platinum and hence would have a greater slope than the latter.

If it is the mass of the material alone that effects absorption then $\frac{a}{p}$ should be constant for all metals, since this socalled mass absorption coefficient gives a measure of the absorption per unit mass of the screen per unit cross section for a normally incident beam of electrons. The values of $\frac{a}{p}$ are, however, only superficially constant, so that it might be worth while giving some evidence for the argument that atomic structure and not density exclusively influences the absorption of the electrons as they move through the material. Unfortunately we are here confronted with a most difficult problem, because no allowance has been made for any scattering of the electrons. We know that scattering increases in amount with the thickness of the metal traversed. Just what contribution scattering has made towards the above data cannot be determined from them. An analysis of the behaviour of thin transparent metals of the thickness less than 10^{-6}cm just completed will, it is hoped, furnish the necessary data.

In a subsequent paper it will be shown that a varies very nearly as the cube of the thickness of the metal through which the electron passes when the value of a is small. The exact experimental relation between a and t is, however, given by the expression $a - a_0 = mt^3$, where $\frac{1}{a}$ represents the distance to which a homogeneous beam of electrons can penetrate before its intensity is reduced to $\frac{1}{e}$ of the original incident value. The data also showed that heavy atoms are not so effective in stopping an electron as light atoms.

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THE MEASUREMENT OF BASIC CAPACITIES IN MOTOR CONTROL

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The same principle that led the merchant to adopt the plan of making an inventory of his stock occasionally has led to the introduction of psychological methods in the rating of capacities for various kinds of service. Among these, perhaps the intelligence tests are the best known and most used at the present time, particularly as now employed for the entire United States Army.

Our laboratory has recently been at work on the development of a series of motor tests which are of a basic nature, so that the information should be of value in the diagnosis of fitness for various occupations requiring motor control. The selection has gradually simmered down to the following:

1. *Motor ability.* This is measured in terms of the speed and regularity of the simplest possible repeated movement. Ordinarily we use a tap with the tip of the finger. We assume, subject to further verification, that the ability shown in one part of the body is a reasonable index to corresponding ability in other parts of the body, provided we exclude special acquired skills. It is necessary that the test be equally fair to all in that no one will have had special practice. This should be equally true of all the tests.

2. *Timed action.* Here we require a person to mark time in some very simple but exact way at the rate of about one beat per second, and we measure the average deviation from the average time, which he himself sets, and use that as an index to his capacity for keeping time. This capacity is involved in many every-day reactions, *e. g.,* in music, marching, dancing, and in the work of a great many skilled operatives in the industries.

3. *A simple response to a simple signal—simple reaction.* A signal, such as a sound or a light or a touch, is given, and we measure the time that it takes to make a response to this signal. This is known as sensory-motor time or simple reaction time.

4. *A simple response to a complex stimulus—complex reaction.* It is agreed that the stimulus shall be, *e. g.,* a loud sound or a weak sound, the two sounds being alike in every other

respect. The instructions are: If the sound is strong do not respond, if it is weak, respond. This type of action requires a high form of mentality, the power of deliberation and choice. The observer has first to delay reaction and discriminate between a weak and a strong sound, and after this is done, choose either to act or not to act.

5. *A complex response to a complex stimulus—serial action.* The highest form of action may be represented in a generic way by presenting one from a group of stimuli calling for a particular one of a group of possible actions. For example, suppose four bells are located in different parts of the room and the observer is seated at a typewriter with two fingers of each hand on designated keys with the instruction that each bell shall be identified by a particular key so that, when that bell rings, the correct key is to be pressed. We then have a contrivance by which the pressing of the key rings another bell which calls for a similar action, and this keeps on indefinitely, making it possible to record the speed of action, the amount of action in a given time, and the degree of reliability in terms of errors.

6. *Precision of action.* The control of movement may be measured in terms of precision in direction, precision in distance, precision in force, and precision in time of movement. In measuring precision of direction we use a drill gauge so mounted with an electric pointer that the observer can put the pointer into the hole without touching the margin of the hole; if it touches the bell rings. The test consists in finding for a given form of movement how small a hole he can put the pointer into without touching the edge, using a steady regular movement. Similar tests may be made for distance, time, and force of action.

7. *Strength and endurance.—The ergograph.* Here we employ a new model of ergograph in which a person is required to make his maximum lift against the spring with the biceps and associated muscles in a given position, thirty consecutive times, and a graphic record is made showing the exact amount of each pull. The regularity and the rate in the falling off of the strength of the pull in thirty trials is a fair index to reliability and endurance.

In order to make these tests available on a large scale, we have encountered the very difficult problem of adapting instruments. The instruments which we employ in the Psychological Laboratory for these tests would cost over a thousand dollars and some of them are complicated and delicate. Fortunately, we have hit upon a sort of universal apparatus which can be used for most of these tests. It consists of an ordinary phonograph with a series of small attachments. During the year we discovered the surprising fact that the current phonograph motors have an extraordinary high degree of constancy. Under favorable conditions the variation from revolution to revolution of the disc in a good phonograph is less than one thousandth of a second. This is a higher degree of precision than we really need for the measurement of time. We then devised an electromagnetic marker carrying an ordinary fountain pen and mounted this on an endless screw so that it writes on a piece of white paper placed on the disc plate. With this marker we can connect the signal and the response apparatus so that a mark is made at the time of the stimulus and another at the time of the response. The reading is made simple and quick by the fact that the stimuli can be made at one point through an automatic key, and the time scale consisting of a circle divided into thousandths of a revolution can lie under the disc. In order to get the reading in a given record, all that we need to do is to run a guide lever from the central pivot and over the mark on the record. This will then point to the reading on the scale in terms of hundredths or even thousandths of a second.

By this means we measure the motor ability, timed action, simple reaction, and complex reaction in the series of motor tests. The same outfit is, however, available for many other measurements not belonging to the series and becomes a cheap and exceedingly valuable general instrument in the laboratory.

One of my students, Mr. C. F. Hansen, designed a very clever device for the serial action. It consists essentially of a four track contact strip attached to the carrier of a typewriter in such a way that, for every time a key is struck, a new signal will appear. It may be used in connection with any kind of electric exposing apparatus for visual or auditory stimuli.

For the measurement of endurance we have devised a new ergograph which makes use of the muscles of the forearm in the most natural position of pull. It is built on the principle of the spring dynonometer and makes an automatic ergogram.

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BIRD RECORDS OF THE PAST WINTER, 1917-1918, IN THE UPPER MISSOURI VALLEY.

T. C. STEPHENS.

This report, like the one for the preceding winter,[1] is a composite one. It includes the observations of a number of other field students besides myself. And I wish to acknowledge such assistance from Mr. A. J. Anderson, Mr. A. F. Allen, Mr. G. O. Ludcke, and Mrs. H. M. Bailey, all of whom have done more or less field work during the past winter season.

It has seemed proper to indicate in the title of the paper the wider range from which many of the specimens recorded have been received. Some of the specimens referred to have been received from Nebraska, Minnesota, North and South Dakota, and Iowa. Aside from the notes on this material, the paper is based upon local field work.

In nomenclature the writer has followed the A. O. U. Check List, except in the matter of subspecific designation. In a great many cases the subspecies can be determined only by experts at institutions where large series of skins are available for comparisons. As these notes are not intended as a contribution on the distribution of subspecies, it seems best to omit the trinomial designation, even where the subspecific rank might be fairly inferred on the basis of geographical location. Trinomials are used in two or three cases where the American form is regarded as a subspecies of an extralimital species.

This winter has been marked especially by the very unusual flight of several species of raptorial birds, especially of Snowy Owls and of Western Horned Owls. The American Game Protective Association has recently gathered information[2] which seems to relate these invasions of northern birds of prey to the periodical scarcity of rabbits in those regions. The facts thus presented indicate that there must have been a marked decrease in the numbers of rabbits and varying hares in the Canadian provinces and northern United States in the falls of 1916 and 1917. In the paper referred to it is suggested that the decrease in these mammals is due to a disease. At any rate it was during

[1]Bird Records During the Past Winter, 1916-1917, in Northwestern Iowa. By T. C. Stephens, Proc. Iowa Acad. Sci., XXIV, pp. 245-258, 1917.

[2]Why Grouse are Scarce. By John B. Burnham. Bulletin American Game Protective Ass'n., January, 1918.

the falls of these same years that the northern states experienced unprecedented invasions of northern birds of prey. In the fall of 1916 the flight of Goshawks extended from the Atlantic coast to California. Dr. G. C. Rich informs me of their occurrence in the latter locality, and numerous published records for other parts of the country are available. During this fall (1916) seven records were reported by the writer from Sioux City (op. cit., p. 249). Four records of the Goshawk for the winter of 1917-18 are presented in the present paper, all of which were late in the winter.

The number of Snowy Owls and Great Horned Owls taken here this winter has been very unusual. It is difficult to relate this movement of the birds to weather conditions. It is possible that the same cause suggested for the Goshawk flight will serve to account for the owl invasion of this winter. The number of Rough-legged Hawks taken this winter is also noteworthy.

Among the other records of especial interest we might mention the Horned Grebes, the Holboell's Grebe, the Duck Hawk, the Golden Plover, etc. The occurrence of the Purple Finch and of the Carolina Wren is probably accidental.

We may also note the absence this winter of the following species: the Crosbills, the Redpolls, the Bohemian Waxwings, and the Red-breasted Nuthatches, all of which were recorded a year ago in numbers. Fewer Golden Eagles were mounted by Mr. Anderson than a year ago.

Notes are included on certain species which may not be considered winter birds, in the usual sense; the ground for so doing was briefly given in the writer's paper above cited.

1. Horned Grebe. *Colymbus auritus*. This species occurred in considerable numbers in the vicinity of Sioux City during the last two weeks of October and early part of November. On October 21, 1917, Mr. A. J. Anderson collected four at Badger Lake (Monona county, Iowa) out of a flock of approximately fifty. Many of them were immature, as were two which he took. The length of the smaller one was 10.50 inches, while another one was 13.75 inches long. The two smaller ones had no ruffs at all, but the larger one did have very short ruffs, which were depressed and elevated by the bird when taken. An immature bird, which had been shot at Crystal Lake, in Nebraska, was received for mounting by Mr. Anderson on

October 31. On November 5 another trip was made to Badger Lake, when another specimen was taken, and two were found which had been shot. The writer has no knowledge of this species having been obtained or reported in this locality previously.

2. Holboell's Grebe. *Colymbus holboelli.* On November 7 a specimen was mounted by Mr. Anderson, which had been sent in from Page, Nebraska. Although the species is listed in "The Birds of Nebraska" by Bruner, Wolcott, and Swenk, it is considered a very unusual record in our locality.

3. Black Duck. *Anas rubripes.* A male specimen killed near Luton, Iowa, was mounted by Mr. Anderson on March 11, 1918.

4. Wood Duck. *Aix sponsa.* A specimen was shot by mistake by a hunter at Badger Lake on October 28, 1917.

5. Golden-eye. *Clangula americana.* Mr. Anderson mounted two male specimens; one on October 31, 1917, shot at Badger Lake; and one on November 18, 1917, sent in from Hull, Iowa.

6. Wilson Snipe. *Gallinago delicata.* These birds were noted in about the usual numbers in late September, throughout October and early November in suitable places.

7. Black-bellied Plover. *Squatarola squatarola.* A flock of a dozen, and one dead one were observed by Mr. Anderson at Badger Lake on October 21, 1917.

8. Golden Plover. *Charadrius dominicus.* One specimen was taken at Badger Lake on November 5 and mounted by Mr. Anderson. Later I heard that hunters had, on the previous day, November 4, killed nearly all of a flock of about twenty birds at the same place.

9. Marsh Hawk. *Circus hudsonius.* Noted as late as December 2 and as early as February 3. In other years we have not seen this bird in January or late December, and it probably does not remain through the winter.

10. Goshawk. *Astur atricapillus.* A few specimens were obtained this winter, though there did not seem to be any such wave as in the preceding season; and those which were obtained this year were all taken late in the winter, rather than early, as the year before. On January 4, 1918, Mrs. H. M. Bailey,

while up the Big Sioux valley, came across a Goshawk which had been shot a few days before by the farmer because it had been killing chickens. The following specimens were sent to Mr. Anderson for mounting:

No. 3010. A beautiful male from Wynot, Nebraska, February 7, 1918.

A spoiled specimen from Laurel, Nebraska, March 22, 1918.

No. 3094. A female from Page, Nebraska, March 27, 1918.

11. Red-tailed Hawk. *Buteo borealis.* This species was seen during the months of September, October, December, January, and February; and it has been seen during the winter months in other years.

12. Harlan's Hawk. *Buteo harlani.* On March 29, 1918, Mr. A. J. Anderson collected a male hawk of this species, which is probably simply a melanistic phase of *Buteo borealis.* This specimen was taken between Salix and Sergeant Bluff, and is now in Mr. Anderson's collection.

13. Rough-legged Hawk. *Archibuteo lagopus sancti-johannis.* This species is very easily identified while in flight because of the dark band across the belly, and the dark patch covering the under primary coverts of each wing; these marks are conspicuous at a considerable distance. Four field records and four specimens were obtained, as follows: On October 28, 1917, one individual was seen flying over Crystal Lake, Nebraska, by A. F. Allen and myself; on November 4 another was noted near Stone Park by Mr. Allen; and on November 5 two were seen at Badger Lake by Messrs. Anderson, Ludeke and Stephens. The following specimens were received by Mr. Anderson for mounting: on October 30, 1917, a male and a female from Sheldon, Iowa; on November 29 a male which had been shot in Bacon Hollow, Sioux City; and on December 1 a female which had been sent in from Ute, Iowa. Mr. Anderson has mounted only seven other specimens of this species since 1900.

14. Ferruginous Rough-legged Hawk. *Archibuteo ferrugineus.* Mr. Anderson mounted one on September 17, 1917, which had been shot at Brown's Lake (Woodbury county), Iowa. He also mounted another one on October 11, 1917, which had been sent to him from Warsaw, Nebraska.

15. Golden Eagle. *Aquila chrysaetos.* Only two specimens were mounted this season by Mr. Anderson, viz.,

No. 3019. February 12, 1918. A male, from Akron, Iowa.
No. 3054. March 4, 1918. A male from Alexandria, South Dakota.

16. Duck Hawk. *Falco peregrinus anatum.* A beautiful specimen of this species was received by Mr. Anderson from Page, Nebraska, on November 14, 1917. It had been shot while in the act of killing a Prairie Chicken. The latter, which had been killed by the hawk, was mounted with the hawk. This is a very unusual record for this locality, it being the first specimen which has ever come to Mr. Anderson.

17. Barn Owl. *Aluco pratincola.* Two specimens were received by Mr. Anderson, as follows:

No. 3095. March 27, 1918. A male from Waterbury, Nebraska.

No. 3118. April 3, 1918. A female from Smithland, Iowa.

18. Long-eared Owl. *Asio wilsonianus.* One was received by Mr. Anderson from Wynot, Nebraska, on January 11, 1918.

19. Short-eared Owl. *Asio flammeus.* Mr. G. O. Ludcke found one freshly killed near Luton, Iowa, on September 28, 1917. Mr. Anderson mounted two specimens as follows:

December 23, 1917. A male killed in Sioux City, Iowa.
January 1, 1918. A male killed at Cherokee, Iowa.

20. Screech Owl. *Otus asio.* It was noted in about the usual numbers throughout the winter.

21. Great Horned Owl. *Bubo virginianus.* The following specimens were received and mounted by Mr. Anderson during the past season.

No. 2233. November 11, 1917, a female from Schaller, Iowa.
No. 2239. November 17, 1917, a male from Bacon's Hollow, Sioux City.
No. 2240. November 17, 1917, a male from Centerville, South Dakota.
No. 2260. December 15, 1917, a female taken on Correctionville Road, four miles from Sioux City.
No. 2266. December 23, 1917, a female from Whiting, Iowa.

No. 2298. January 25, 1918, a female from Bridgewater, South Dakota.

No. 3067. March 13, 1918, a female from LeMars, Iowa.

No. 3092. March 23, 1918, a female from Ethan, South Dakota.

22. Western Horned Owl. *Bubo virginianus occidentalis* Stone. The nomenclature of the subspecies of *Bubo* seems to be in a state of utmost confusion. The designation here used is taken from Ridgway's *Birds of North and Middle America* (Part VI, pp. 736-756) rather than from the A. O. U. Check List. The general color of most of the following specimens was gray; the plumage contained considerable white, and very little black. The feet were white, though in one or two cases there were some dark spots present. There was much variation in these light specimens, but all were very easily distinguishable from *virginianus*.

The following specimens were mounted by Mr. Anderson.

No. 2232. November 10, 1917, a male from Kelly, Iowa.

No. 2238. November 16, 1917, a female from Page, Nebraska.

No. 2242. November 19, 1917, a female from Alta, Iowa.

No. 2253. December 4, 1917, a male taken seven miles east of Leeds, Iowa.

No. 2254. December 5, 1917, a male taken near Morningside, Sioux City.

A number of field records also were obtained. On December 16 Mr. Clifford Jones saw one near Sargeant Bluff. On several dates (December 23, December 30, January 20, February 17) one of this species, which may have been the same individual, was seen in certain ravines on the way to Stone Park (Allen, Ludeke, Stephens). Mr. Allen also saw one in the woods near McCook Lake, South Dakota, on March 3, 1918. It was a very noticeable fact that the owls of this race were much more easily approached than our native race of *virginianus*. Mr. Jones approached within twenty feet of his specimen; and the one noted on December 23, by Mr. Allen and myself allowed us to get within twenty-five feet before he flew. Of course, after he once flushed it was not possible to get near him again.

23. *Snowy Owl. Nyctea nyctea.* Perhaps the most interesting ornithological note of the season in this locality has been the flight of Snowy Owls. On November 25, 1917, a specimen taken

near Meckling, South Dakota, was offered for sale, but was not purchased or mounted so far as the writer knows. On December 21 the writer was informed of one which had been shot near McCook Lake, South Dakota, by farmers, because of alleged depredations on chickens. On January 20, 1918, Mr. Anderson was reliably informed that two had been seen sitting on a haystack between Leeds and James (near Sioux City). On February 1 Mr. Anderson learned of two specimens which were hanging on a fence post near Smithland, Iowa. In going over Mr. Anderson's records I find that he has mounted forty-six specimens of Snowy Owls between 1900 and 1917. While he has never had so many in one season as in this year, yet in the winter of 1905-6 he received thirteen specimens. For the winter of 1917-18, including the six mentioned above, the following forty specimens are here recorded.

SNOWY OWL.

1. No. 2242. November 21, 1917, male from Remsen, Iowa.
2. No. 2247. November 21, 1917, female from Brunswick, Nebraska.
3. Field. November 25, 1917, reported at Meckling, South Dakota.
4. No. 2252. December 4, 1917, male from Ethan, South Dakota.
5. No. 2256. December 5, 1917, female from Altamont, South Dakota.
6. No. 2257. December 8, 1917, male from Dakota City, Nebraska.
7. No. 2258. December 11, 1917, female from LeMars, Iowa.
8. No. 2259. December 11, 1917, female from Hinton, Iowa.
9. No. 2261. December 17, 1917, female from Onawa, Iowa.
10. No. 2261. December 19, 1917, male from Brownsville, Iowa.
11. Field. December 21, 1917, killed at McCook Lake, South Dakota.
12. No. 2263. December 21, 1917, female from Page, Nebraska.
13. No. 2264. December 22, 1917, sex? from Hawarden, Iowa.
14. No. 2265. December 23, 1917, male from Hinton, Iowa.
15. No. 2267. December 24, 1917, male from Winside, Nebraska.
16. No. 2268. December 24, 1917, male from Hawarden, Iowa.
17. No. 2269. December 24, 1917, male from Winnebago, Nebraska.
18. No. 2271. December 26, 1917, male from Beresford, South Dakota.
19. No. 2277a. January 2, 1918, male from............?
20. No. 2277b. January 2, 1918, male from Altoona, Iowa.
21. No. 2279. January 4, 1918, female from Burbank, South Dakota.
22. No. 2280. January 4, 1918, female from Randolph, Nebraska.
23. No. 2281. January 4, 1918, male from Lester, Iowa.
24. No. 2284. January 9, 1918, female from Bronson, Iowa.
25. No. 2287. January 16, 1918, male from Pomeroy, Iowa.
26. Field. January 20, 1918, two between Leeds and James.

27. No. 2297. January 25, 1918, female from Alton, Iowa.
28. No. 2299. January 25, 1918, male from Remsen, Iowa.
29. Field. February 1, 1918, two killed at Smithland, Iowa.
30. No. 3008. February 1, 1918, male from Kenneth, Minnesota.
31. No. 3017. February 11, 1918, female from West Point, Nebraska.
32. No. .... February 16, 1918, male from Oakes, North Dakota. (Spoiled.)
33. No. 3036. February 19, 1918, male from Hornick, Iowa.
34. No. 3037. February 19, 1918, from Schaller, Iowa.
35. No. 3041. February 20, 1918, male from Renville, Minnesota.
36. No. 3042. February 21, 1918, female from Zeeland, North Dakota.
37. No. 3063. March 5, 1918, male from Bridgewater, South Dakota.
38. No. 3065. March 13, 1918, female from Hinton, Iowa.
39. No. ..... March 13, 1918, male from Hinton, Iowa. (Spoiled.)
40. No. 3096. March 28, 1918, female from Remsen, Iowa.

24. Hairy Woodpecker. *Dryobates villosus.* Recorded in about the usual numbers. Specimens obtained do not measure up to *leucomelas.*

25. Downy Woodpecker. *Dryobates pubescens.* Subspecies *medianus.* Recorded in about the usual numbers.

26. Northern Flicker. *Colaptes auratus,* subspecies *luteus.* Noted with frequency and regularity throughout the winter; as many as thirteen individuals were noted on December 2 by Mr. Allen.

27. Prairie Horned Lark. *Otocoris alpestris,* subspecies *praticola.* Latest fall record was November 5; was next reported by Mr. Allen, who saw a flock numbering between seventy-five and a hundred on the hills north of Sioux City on February 3, 1918.

28. Magpie. *Pica pica,* subspecies *hudsonia.* One individual was observed about a mile east of Morningside on February 10, 1918, by Mr. Paul Jones.

29. Bluejay. *Cyanocitta cristata.* Noted with frequency throughout the winter.

30. Crow. *Corvus brachyrhynchos.* Noted in small numbers throughout the winter. An albino crow came into Mr. Anderson's hands through the Sioux City Robe and Tanning Company in the latter part of December (having been killed at Allen, Nebraska), but it was too far gone to mount.

31. Purple Finch. *Carpodacus purpureus.* On November 25, 1917, Mr. Allen and the writer saw a male of this species in one of the branches of the Cardinal Glen. It was in a Hop Hornbeam tree (*Ostrya virginiana*) greedily feeding upon the seeds. Although the bird was ten or fifteen feet up in the tree, we were about on a level with it because of the sloping hillside. We watched the bird for fifteen minutes or more. After reading my report on the birds of last winter in this locality, Dr. G. C. Rich called my attention to the fact that Lloyd and Clive Brown, formerly residents of Sioux City, took a female of the Purple Finch in the vicinity of Sioux City. This specimen was identified by Dr. R. M. Anderson, as Dr. Rich informs me, but the record was never published.

32. Goldfinch. *Astragalinus tristis.* Noted in considerable numbers (thirty and forty on two trips) throughout the winter.

33. Pine Siskin. *Spinus pinus.* The only note to be recorded on this species this winter is its scarcity A single individual was noted on December 23 (Stephens) and another on December 30 (Allen). Thus it bears out its reputation for irregular and erratic behavior.

34. Snow Bunting. *Plectrophenax nivalis.* The statement of a year ago that this species has never been recorded here (op. cit., p 247) must now be corrected.[3] Dr. Rich has written the writer (under date of March 11, 1918) that he recalls seeing and hearing these birds in Morningside on a cold, stormy day. He is not able to give the date, for his records have been lost. However, it was a number of years ago, before the suburb was built up as it is today. The Snow Bunting is listed also in the collection made by the Brown brothers in this vicinity between fifteen and twenty years ago. During the present winter the Snow Bunting has been reported at localities in the eastern portions of Woodbury and Monona counties, in Iowa. Mrs. Geo. Smith saw a flock of about thirty Snowflakes at a farm house between Castana and Mapleton on January 6, 1918. Another observer saw a flock of about ten in front of his barn in Castana one day during the week of February 3. Dr. W. H. Dewey reports that Snow Buntings were "fairly plenti-

[3]This statement was probably correct so far as any published record is concerned; but the writer was not aware at that time that the species had been observed at all.

ful" at Moville during the winter of 1917-18. It is through the kindness of Mrs. H. M. Bailey that these reports have been made available to the writer.

35. Lapland Longspur. *Calcarius lapponicus.* Similarly, in the previous paper (op. cit., p 247) the writer stated that Longspurs "have not been recorded here." This statement has drawn forth some pertinent information from two former observers in this region. Dr. Rich has informed the writer by letter that on November 8, 1905 he was collecting on the hills east of Leeds (suburb of Sioux City) and secured a Lapland Longspur which was made into a skin. On another date he saw the same species south of Morningside, and again in the vicinity of Dace and Chambers streets. Mrs. Kate Rahn reported the Lapland Longspurs at Smithland during the winter of 1917-18.

36. Smith's Longspur. *Calcarius pictus.* On February 3, 1918, Messrs. Allen and Ludeke saw four males of this species among a large flock of Prairie Horned Larks on the hills a few miles north of Sioux City. The observers were close enough to see distinctly the "horns" of the larks. They had a good view of the four male Longspurs, but thought there may have been more. Although there was a strong, cold wind they watched the birds for some time, and made a comparison with a colored picture of the species; and they were satisfied beyond a doubt as to the identity of the birds. While this species has not been previously listed for this locality, and the present record is only a "sight record"[4] it is here accepted for these reasons, viz., the observers are experienced and competent; the circumstantial evidence is favorable (see Goss: Birds of Kansas, page 435); the species was listed by Agersborg (Auk. II, 1885, page 280) for the vicinity of Vermillion, South Dakota, about fifty miles west of this point.

37. Harris Sparrow. *Zonotrichia querula.* This species was last seen in the fall of 1917 on November 18. Mr. Allen saw two individuals on February 17, 1918, in a ravine along Big Sioux river. The writer saw eight in the same ravine on March 11, this being only three days ahead of the previous

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[4]It may also be said that Dr. Witmer Stone, who has recently pointed out the objections to sight records, has allowed himself to publish an initial record for the state of Pennsylvania upon the basis of sight identification. (Auk, XXXV, p. 221, 1918.)

early record, however. Ordinarily the Harris Sparrow is not seen here after the middle of November; but in 1912 they were noted throughout December.

38. Tree Sparrow. *Spizella monticola.* In the fall of 1917 this species appeared at precisely the average arrival date, viz., October 21; and they were about as numerous as usual throughout the winter. The latest spring date in 1918 was April 8.

39. Slate-colored Junco. *Junco hyemalis.* This species was noted two or three days earlier than usual, viz., September 30, and was very numerous during October; the number then decreased during the cold weather. Late in March and early in April the numbers again increased. The Juncos remain a week or ten days later than the Tree Sparrows. The latest date for the Juncos in 1918 was April 22.

40. Song Sparrow. *Melospiza melodia.* Noted by Mr. Allen through November and December, and by the writer on February 11.

41. Towhee. *Pipilo erythrophthalmus.* A year ago the writer recorded the Towhee as a winter bird in this locality. This winter it was noted by several observers throughout November, December, and the early part of January, always in the same general neighborhood, namely, the sheltered ravines along the Big Sioux river valley.

42. Cardinal. *Cardinalis cardinalis.* Noted throughout the winter but in larger numbers during the colder months—because of their gregarious habits at this season. The largest number in one day was eighteen, on January 1.

43. Cedar Waxwing. *Bombycilla cedrorum.* As usual, these birds were not seen until the middle of February, and during March and April they were especially numerous.

44. White-rumped Shrike. *Lanius excubitorides.* The writer is aware that there may be a doubt as to the possibility of distinguishing this form from *migrans* in the field. However, some shrikes in this locality have a very white rump, while in others the rump is the same color as the back, bluish gray. If this character has any value in subspecific differentiation it is possible to recognize these two forms in the field. If the color of the rump is not a differential character between *excub-*

itorides and *migrans* there is probably no real difference at all. Individuals of *excubitorides* were seen in our locality as late as December 2.

45. Carolina Wren. *Thryothorus ludovicianus.* A year ago the writer published the first record of this species in this region (Proc. Iowa Acad. Sci., XXIV, page 257, 1917). On February 27, 1918, Mr. A. F. Allen saw a bird of this species at Seventeenth street and Summit avenue. On March 1 the writer went with Mr. Allen to this spot. We had not gone half a block from the street car before we heard the loud, full note of a bird wholly unfamiliar to me. Although I have seen the bird in Missouri, I had never heard the song until this time. We soon located the bird in the top of a tall cottonwood tree, two blocks from where we had first heard it. Mr. Allen told me that he had heard the song at a much greater distance than this. The song which we thus heard, if converted into words, would sound something like this:

Cher-wit, cher-wit, cher-wit, cher-*wit*,

the last "wit" syllable being cut off very abruptly and emphatically. The bird kept up this singing (at about 7:30 a. m.) continuously as long as we were there, which was probably twenty minutes. During this time he sat very erect, somewhat after the manner of the Cardinal, to whose song, also, there was a slight resemblance in tone and carrying power. In my brief acquaintance with the species in Missouri it was prone to frequent the brush piles and tangled tree roots exposed by eroding streams, etc. However, Mr. Allen informed me that at other times he saw this particular bird down in a small plum tree thicket not far from the cottonwood tree. Except for this thicket the locality was quite open and clear. Mr. Allen saw or heard the bird several times later (last time reported to me was March 21) as he passed the place on his way to his office. On the occasion when we were there together the bird gave several variations from the song noted above, but I did not attempt to record them. We did not think the identification could have been any more satisfactory with the bird in hand. Besides the description given above, it may be added that we saw clearly the white superciliary line, and the cinnamon-colored back and tail.

46. Brown Creeper. *Certhia familiaris americana.* Present throughout the winter, but in fewer numbers than in the previous year.

47. White-breasted Nuthatch. *Sitta carolinensis.* Present this winter in about the usual numbers; no increase in numbers at any rate. Observers in several localities complained that the nuthatches did not visit the suet stations as in other years.

48. Black-capped Chickadee. *Penthestes atricapillus.* The winter Chickadees of this region are provisionally recorded under this form. Specimens have been collected and will be passed upon in due time by competent authority. Their distribution here this winter was not different from usual.

49. Golden-crowned Kinglet. *Regulus satrapa.* Was seen twice in the early part of the winter by Mr. Allen.

50. Robin. *Planesticus migratorius.* Robins wintered in unusual numbers this year; or it may be possible that the observers are becoming more alert. But throughout November, December, January, and February Robins were seen by various observers in the ravines up along Big Sioux river, and most frequently in a large hollow known as Cardinal Glen by the devotees of winter bird watching. Mr. Anderson saw as many as nineteen in one flock along the Big Sioux on December 31. Mr. Clifford Jones saw six below Sergeant Bluff on December 16.

51. Bluebird. *Sialia sialis.* Bluebirds, like the Robins, were noted more frequently this winter. Mr. Allen saw them quite regularly on his weekly trips to Stone Park; and there seemed to be a little flock of six or seven in that vicinity. Mr. Anderson also saw a flock of six at Leeds on February 6.

DEPARTMENT OF BIOLOGY,
MORNINGSIDE COLLEGE.

NOTES ON THE BIRDS OF SOUTH DAKOTA, WITH A PRELIMINARY LIST FOR UNION COUNTY.

T. C. STEPHENS.

This paper is prepared for the primary purpose of publishing a few interesting or unusual records for the state of South Dakota which have been very kindly placed in my possession by Mr. A. J. Anderson, of Sioux City, Iowa. Mr. Anderson, in his professional occupation as a taxidermist, has received many specimens from a radius of two or three hundred miles, and the present paper was conceived for the purpose of placing on record such of these specimens from South Dakota (and two or three from North Dakota) as seemed worthy. At the same time it seemed that it might be worth while for the author to include such observations as he has, incidentally, made within that state; or has received from other observers.

Sioux City is peculiarly located in contact with three states, viz., Iowa, Nebraska, and South Dakota. Several lakes which are frequented by water fowl and shore birds, and which are easily reached from Sioux City, lie just across the river in Nebraska or in South Dakota. For this reason considerable field work has been done in these localities by local observers.

The annotated list which is here presented is not by any means complete, but may contain enough of value to justify its publication; especially since the writer has little expectation of doing more than sporadic work in this region in the future.

A brief statement may now be made as to sources of information, and as to the character of the region discussed.

The notes which compose the *raison d'etre* of this paper have come from the records of Mr. Anderson, as stated above. Mr. A. F. Allen, who has occupied a cottage at McCook lake during the summer season since 1915, has supplied much information concerning the summer species. He has also done more or less spring and fall work in the same vicinity. The writer has relied to a very considerable extent upon the information received from Mr. Allen concerning the status of the summer birds in Union county, and is therefore under great obligation. Mr. George O. Ludeke has hunted on the lakes in Union county more or less since 1910, and he has kindly given me numerous notes on the water fowl and other large birds. A few notes also have been received from Mrs. H. M. Bailey and Mrs. H. J. Taylor, of Sioux City. The writer should also not fail to acknowledge several very good notes received from Dr. Guy C. Rich, who made observations in the Sioux City Area for upwards of twenty years. My own desultory notes in Union county date from 1910.

All of the notes and records, except some of Mr. Anderson's, refer to Union county, which is separated from Sioux City and Woodbury county, Iowa, by Big Sioux river; it is separated from Dakota county, Nebraska, by Missouri river. Geographically, Union county tapers to a point which lies in the fork of Missouri and Big Sioux rivers.

Considerable care has been taken to make no statement without proper information or authority. Where the authority is not indicated, the writer assumes direct responsibility.

In the case of common birds, and where the knowledge is adequate, an attempt has been made to place an estimate on the relative abundance of species. In other cases, however, the writer has merely given the facts of particular records, and has omitted an estimate of relative abundance, even though our knowledge of the status of the species in adjacent localities might be ample to warrant such an inference. The purpose has been, therefore, to isolate the Union county work from that which has been done in adjacent counties.

It will be easily observed that the author has followed the nomenclature of the last Check List of the American Ornithologists' Union, except in the matter of trinomials. In a great many cases the subspecies which have been recognized have little or no biological significance. In many cases, also, even the taxonomist cannot determine the subspecies without the knowledge of its locality. Therefore, when the geographical ranges are once arbitrarily fixed, anyone can affix the appropriate subspecific term as correctly as can the author. Or, if it is objected that only through such local lists can the geographical ranges of subspecific forms be determined, then it might be answered that when skins are sent away to experts for determination, the results do not represent the knowledge or contribution of the author, and are, therefore, not required in his paper. It may also be a debatable question whether trinomial nomenclature and the further splitting of species, can contribute to the advancement of science, rather than to its embarrassment.

So far as the writer is aware, only two lists of birds have been previously published for the southeastern corner of South Dakota, although Coues included many notes in his work on "The Birds of the Northwest" which probably belong to this general region. One of these lists was written by Mr. Agersborg and published in 1885.[1] This list includes 226 named forms, some of which, however, belong in an hypothetical list, so far as the actual records are concerned. That is, some species were included on the strength of their occurrence across the river in Nebraska. The list is based upon observations made in Clay county, and portions of the adjoining counties of Yankton, Union, Lincoln, and Minnehaha. The paper does not indicate to what extent Union county was covered in field work, and one is naturally led to assume that it was limited in the main to the portions bordering Clay county.

The second list, by Dr. Visher,[2] covers Clay county only, and includes 255 forms. Although the list covers practically the same region as did Agersborg's, yet thirty years had elapsed between the two lists, and there are numerous important differences. A comparison of these two lists would be interesting, and the writer had entertained some thought of attempting such a discussion; but the limits of the present paper will not permit.

For convenience and accuracy the balance of the paper will be presented in two parts.

PART I.

In this division are listed a number of records for the state of South Dakota at large, not including Union County.

1. American Merganser. *Mergus americanus.* Mr. Anderson received one specimen for mounting on January 5, 1907, from Parker.

2. Red-breasted Merganser. *Mergus serrator.* Mr. Anderson received one from Zeeland, North Dakota, on May 20, 1914. Although this locality is just beyond the boundary of South Dakota, it is deemed desirable to include it in this list.

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[1]The Birds of Southeastern Dakota. By G. S. Agersborg. Revised by Prof. W. W. Cooke. The Auk, II, pp. 276-279, 1885.

[2]A List of the Birds of Clay County, Southeastern South Dakota. By S. S. Visher, Ph. D. Wils. Bull., XXVII, pp. 321-335, 1915.

3. Hooded Merganser. *Lophodytes cucullatus.* One from Parker, South Dakota, on November 1, 1905 (Anderson).

4. Mallard. *Anas platyrhynchos.* Mr. Clate Tinan, editor of the *Kimball* (South Dakota) *Graphic,* published in his paper a story of a mallard hen nesting in a tree twenty feet from the ground, in the summer of 1917. Inquiry by letter brought a very positive assurance of the correctness of the account. Ridgway (The Ornithology of Illinois, page 129, 1895) states that the mallard "has been known in rare instances to nest in a tree; in such cases occupying the deserted nest of a hawk, crow or other large bird." Eaton (Birds of New York) also makes a similar statement. Specific instances, however, are not easy to find in the literature.

5. Sandhill Crane. *Grus mexicana.* On April 14, 1911, one was received by Mr. Anderson from Aberdeen, South Dakota.

6. Dowitcher. *Macrorhamphus griseus.* Dr. Rich gives me the record of one being taken at Meckling on April 29, 1897. On the basis of locality this specimen may have been *scolopaceus.*

7. American Rough-legged Hawk. *Archibuteo lagopus sancti-johannis.* One was sent to Mr. Anderson from Beresford on March 17, 1916.

8. Golden Eagle. *Aquila chrysaetos.* Mr. Anderson has kindly allowed me to gather from his books the following records of specimens which have been sent to him from South Dakota points for mounting. The dates indicate the date of mounting rather than the date of capture.

October	24, 1907,	two from Wessington Springs.
May	17, 1909,	one from Alexandria.
May	2, 1909,	one from Emory.
December	16, 1910,	one from Cold Springs.
February	16, 1911,	one from Parkston.
December	2, 1916	one from Chamberlain.
March	4, 1918,	one from Alexandria.

9. Bald Eagle. *Haliaetus leucocephalus.* The following records also are taken from Mr. Anderson's books.

November	17, 1901,	one from Parkston.
October	29, 1904,	one from Oacoma.
November	3, 1909,	one from Beresford.
November	29, 1909,	one from Parker.
December	16, 1914,	one from Alexandria.
May	28, 1916,	one from Centerville.

10. Prairie Falcon. *Falco mexicanus.* On May 3, 1907, Mr. Anderson mounted one which had been taken about forty miles southwest from Rapid City. Four days later he received another specimen from the same locality.

11. Barn Owl. *Aluco pratincola.* The following South Dakota specimens were mounted by Mr. Anderson.

May	8, 1915, one from Centerville.
June	2, 1916, one from Ethan.

12. Great Horned Owl. *Bubo virginianus virginianus.* The following were mounted by Mr. Anderson.

November	17, 1917, one from Centerville (male, No. 2240)
January	25, 1918, one from Bridgewater (female, No. 2298)

13. Western Horned Owl. *Bubo virginianus occidentalis* Stone. This lighter owl is regarded as simply a subspecies, and has been variously designated by the terms *subarcticus, pallescens, etc.* The best the present writer can do is to accept Ridgway's diagnosis and nomenclature. Mr. Anderson mounted one on October 23, 1907, from Zeeland, North Dakota. (Recorded here because of proximity to region discussed).

14. Snowy Owl. *Nyctea nyctea.* The following specimens were mounted by Mr. Anderson. All the specimens were sent in from South Dakota towns, except the five from Zeeland, which is just over the line in North Dakota.

January	26, 1902, one from Mt. Vernon.
February	10, 1904, one from Parkston.
January	13, 1906, one from Menno.
February	13, 1906, one from Zeeland.
February	15, 1906, one from Zeeland.
February	26, 1906, one from Zeeland.
December	25, 1909, one from Ethan.
January	4, 1910, two from Milltown.
January	13, 1910, one from Milltown.
January	13, 1910, one from Wessington Springs.
November	13, 1910, one from Scotland.
January	21, 1911, one from Zeeland.
January	21, 1911, one from Aberdeen.
November	21, 1914, one from Zeeland.
December	11, 1914, one from Centerville.
February	1, 1915, one from Centerville.
November	25, 1917, one from Meckling (not mounted).
December	4, 1917, one from Ethan (male, No. 2252).
December	5, 1917, one from Altamont (female, No. 2256).
December	26, 1917, one from Beresford (male, No. 2271).
January	3, 1918, one from Burbank (female, No. 2279).
March	5, 1918, one from Bridgewater (male, No. 3063).

15. Purple Finch. *Carpodacus purpureus.* On October 20, 1903, Mr. Anderson received a male of this species from Parkston. Another specimen was received from the same place on March 5, 1904. An effort was recently made to secure some information as to these specimens from the party sending them, but without success. Mr. Anderson says, however, that the birds had been shot, indicating that they probably had not been caged birds.

PART II.

Below is given the annotated list of birds for Union county. Only the "point," or southeastern corner of the county, has been under observation. This region includes two large "cut-off" lakes, or old Missouri river beds, several patches of rather dense timber and the timber bordering Big Sioux river, and considerable flat bottom land.

1. Eared Grebe. *Colymbus nigricollis californicus.* Noted on McCook lake on April 22, 1911 (Stephens).

2. Pied-billed Grebe. *Podilymbus podiceps.* It is very commonly seen on McCook and Goodenough lakes, and, no doubt, breeds locally.

3. Loon. *Gavia immer.* Noted on April 9, 1916, in back water of the Missouri near McCook lake (Allen, Ludeke).

4. Ring-billed Gull. *Larus delawarensis.* A tolerably common migrant; numerous records in spring of 1918 (Allen, Stephens).

5. Herring Gull. *Larus argentatus.* No positive records, though listed in the field notes of various observers.

6. Franklin's Gull. *Larus franklini.* A common migrant.

7. Forster's Tern. *Sterna forsteri.* This is the species believed to occur with regularity in the spring. Specimens have not been taken, so that we cannot positively eliminate *S. hirundo.* Mr. Allen found this species around McCook lake throughout the summers of 1915 and 1916, and in 1915 it was even more numerous than the Black Tern.

8. Least Tern. *Sterna antillarum.* This is a late migrant. On June 2, 1918, twenty-one were counted about McCook and Goodenough lakes. This tern hovers and plunges into the

water for its food, as do other members of the genus. It is not known to breed here, though it has been reported as breeding along Vermillion river in the adjoining county.

9. Black Tern. *Hydrochelidon nigra surinamensis.* A common summer rèsident (Allen, Ludeke); but certainly rather scarce in 1918 (Stephens).

10. Double-crested Cormorant. *Phalacrocorax auritus.* Seven were noted on Goodenough lake on April 14, 1918 (Allen, Ludeke. Hayward, Stephens); five again noted in same locality May 1, 1918 (Anderson, Stephens); four again noted in same place on May 5, 1918 (Allen); all probably of the same flock.

11. White Pelican. *Pelecanus erythrorhynchos.* A very common migrant. On April 15, 1917, two immense flocks were seen in flight over Goodenough lake, and were variously estimated to contain from 300 to 500 individuals each (Allen Ludeke, Stephens). They were very numerous in the spring of 1918, and four flocks aggregating seventy-five individuals were seen as late as June 2.

12. American Merganser. *Mergus americanus.* Mr. Anderson has mounted two specimens on the following dates, both shot at McCook lake; one on October 2, 1912, and the other on the following day. Mr. Ludeke also saw a flock of about a dozen on Goodenough lake on March 24, 1918.

13. Mallard. *Anas platyrhynchos.* A very common species, and has apparently increased some in the last three years.

14. Black Duck. *Anas rubripes.* An uncommon species. On March 2, 1904, Mr. Anderson mounted one for Dr. Rich. Upon inquiry the following statement was elicited from Dr. Rich concerning this specimen: "The Black Duck was shot by Chas. Sangster on the Missouri river near the mouth of the Big Sioux, but probably off the banks of South Dakota. He had a camp a few miles above the mouth of the Big Sioux, and hunted along the Missouri and also about McCook lake. The sex was not given in my records."

15. Gadwall. *Chaulelasmus streparus.* The writer has seen this species at McCook lake both dead and alive. It is only a tolerably common migrant, known by the hunters as the Gray Duck.

16. Baldpate. *Mareca americana.* A common migrant.

17. Green-winged Teal. *Nettion carolinensis.* A tolerably common migrant.

18. Blue-winged Teal. *Querquedula discors.* An abundant migrant and occasional breeder.

19. Cinnamon Teal. *Querquedula cyanoptera.* A rare migrant. On April 2, 1911, a male of this species was shot at McCook lake and taken to Mr. Anderson, who mounted it; it remains in his collection.

20. Shoveller. *Spatula clypeata.* An abundant migrant.

21. Pintail. *Dafila acuta.* An abundant and early migrant.

22. Wood Duck. *Aix sponsa.* One was taken on McCook lake on October 12, 1904, and mounted by Mr. Anderson. The writer learned indirectly that several were seen (probably shot) by hunters at McCook and Goodenough lakes in the fall of 1916. Though seen or taken nearly every year by hunters, this species is no longer among the common ducks; it is uncommon, if not rare. It is because of its rarity that an instance of capture is made the subject of comment among those interested.

23. Redhead. *Marila americana.* Noted by A. F. Allen at McCook lake on April 11, 1915, and has been taken by Mr. Ludeke at the same place. It was very abundant on Goodenough lake in the spring of 1918. (Stephens.)

24. Canvas-back. *Marila valisineria.* Mr. Ludeke has taken this species on McCook lake, and he says with reference to the fall season that "Canvas-backs and Redheads are occasionally bagged but are not plentiful." The Canvas-back is uncommon also even in the spring. We visited Goodenough almost weekly in the spring of 1918, and saw only one flock of eight Canvas-backs. This was on April 14.

25. Lesser Scaup. *Marila affinis.* A very abundant migrant. It may possibly breed.

26. Ring-necked Duck. *Marila collaris.* A specimen which had been shot at McCook lake was received for mounting by Mr. Anderson on April 2, 1911.

27. Golden-eye. *Clangula clangula americana.* On November 22, 1911, Mr. Anderson mounted two which had been killed

at McCook lake. Mr. Allen noted the same species at the same place on April 1 and 8, 1917. Not a common species.

28. Bufflehead. *Charitonetta albeola.* On April 2, 1911, Mr. Anderson mounted a male which had been shot at McCook lake. Very uncommon species.

29. White-winged Scoter. *Oidemia deglandi.* Mr. Ludeke is authority for the statement that three of these Scoters were shot at the Loblolly (on Lake Goodenough) in the fall of 1914.

30. Ruddy Duck. *Erismatura jamaicensis.* The writer has seen it at various times on the smaller sloughs around McCook lake, and Mr. Ludeke also reports it. The writer has never seen it in flocks, but always alone or mixed with other ducks.

31. Snow Goose. *Chen hyperboreus.* A regular migrant in limited numbers. One taken at McCook lake and mounted by Mr. Anderson on March 19, 1911. Also noted by Mr. Allen on the dates of April 11, 1915, and April 1 and 8, 1917. The reader's attention is called to the report of Dr. R. M. Anderson on a large series of Snow Geese (see *The Birds of Iowa*) in which the conclusion is fairly drawn that there is no justification for the separation of the Greater Snow Goose from the Snow Goose; that, at best, the distinction is very doubtful.

32. Blue Goose. *Chen caerulescens.* A regular migrant in limited numbers. A flock of twelve was noted on April 1, 1917, (Allen, Ludeke), and a single one on March 24, 1918, (Ludeke).

33. White-fronted Goose. *Anser albifrons gambeli.* One was shot at McCook lake on April 9, 1911, and sent to Mr. Anderson for mounting. A flock of three were noted while flying over McCook on April 9, 1914 (Stephens); and a flock of 150 or more were noted in flight on April 11, 1915 (Allen, Ludeke); another flock, perhaps a little larger, was observed to settle on Goodenough lake on April 14, 1918 (Allen, Ludeke, Stephens).

34. Canada Goose. *Branta c. canadensis.* It is still a tolerably common migrant.

35. Whistling Swan. *Olor columbianus.* Dr. G. C. Rich tells the writer that he saw six or seven shot at McCook lake one fall earlier than 1903. One which had been taken at McCook lake was mounted by Mr. Anderson on March 24, 1911. Another specimen taken on Goodenough was mounted also by him on

November 17, 1913. The latter specimen is now in the possession of Mr. Ludeke.

36. Bittern. *Botaurus lentiginosus.* A common summer resident.

37. Least Bittern. *Ixobrychus exilis.* A single bird was seen at the upper end of Goodenough lake, which is more or less marshy along the borders, on June 2, 1918. No doubt breeds.

38. Great Blue Heron. *Ardea herodias.* A common migrant, arriving at McCook lake as early as July 11 (1915), and then increasing in numbers, until on September 5, fifty were noted in one day (Allen).

39. Green Heron. *Butorides virescens.* Noted on August 22, 1915, and again three were seen on September 5, 1915 (Allen). Mr. Ludeke also reports this bird as common throughout the summer.

40. Black-crowned Night Heron. *Nycticorax naevius.* A flock in flight over Lake Goodenough were noted on April 15, 1917, by Messrs. Allen, Ludeke and Stephens. Noted once in 1918 by Mr. Allen.

41. Coot. *Fulica americana.* A common summer resident.

42. Red Phalarope. *Phalaropus fulicarius.* A specimen which had been taken in the vicinity of McCook lake was mounted by Mr. Anderson on November 28, 1912, and is now in his collection. This specimen was first reported by the writer as an Iowa record (see Wils. Bull., XXVI, p. 103, 1914), but was later corrected (see Wils. Bull., XXVIII, p. 92, 1916).

43. Wilson Phalarope. *Steganopus tricolor.* Noted at Lancaster slough (since drained) on May 20, 1911, by Rev. M. B. Townsend.

44. American Avocet. *Recurvirostra americana.* Dr. Guy C. Rich has kindly furnished a note of one "shot by Sangster from a bar in the Missouri river a few miles above Sioux City, near McCook lake, South Dakota." This specimen was mounted and is now in the Rich collection in the museum of the Sioux City Academy of Science.

45. Woodcock. *Philohela minor.* Mr. A. J. Anderson informs the writer that he shot a Woodcock at McCook lake in 1896 or 1897. This is a very rare species in this region.

46. Wilson's Snipe. *Gallinago delicata.* Mr. Ludcke gives the following note: "Wilson's Snipe arrive in Union county about April 1st—some have been shot at the Loblolly this early. They appear again in fair numbers about the end of August and remain until the ice forms in October. In spring and fall migrations they can be classed as plentiful."

47. Long-billed Dowitcher. *Macrorhamphus griseus scolopaceus.* Noted at Lancaster slough on May 20, 1911 (Townsend). Of course, of the two subspecies it is assumed that *scolopaceus* is more probable.

48. Stilt Sandpiper. *Micropalama himantopus.* Noted at Lancaster slough on May 20, 1911 (Townsend).

49. Pectoral Sandpiper. *Pisobia maculata.* A common migrant. On September 26, 1914, the writer saw two at McCook lake. On August 26, 1917, Messrs. Allen and Luckde saw a flock of twelve, amongst a large mixed flock of sandpipers, at the same place.

50. Least Sandpiper. *Pisobia minutilla.* A flock of considerable size was noted at McCook lake on August 26, 1917 (Allen and Ludcke). The writer also has one record for the same place on September 26, 1914.

51. Semipalmated Sandpiper. *Ereuntes pusillus.* A number were noted among the large flock of sandpipers on August 26, 1917 (Allen and Ludcke).

52. Hudsonian Godwit. *Limosa haematica.* One was shot at McCook lake by Chas. Sangster on May 14, 1896 (Rich). Doctor Rich and Rev. M. B. Townsend saw a flock of five at Lancaster slough on May 27, 1911. Mr. Townsend had noted them in the same place one week earlier.

53. Yellow-legs. *Totanus flavipes.* A common migrant.

54. Upland Plover. Bartramian Sandpiper. *Bartramia longicauda.* Mr. Allen reports seeing one on August 16, 1917, in the fields east of McCook lake. His son told him that there were others of the same kind farther over the fields.

55. Spotted Sandpiper. *Actitus macularius.* A common summer resident.

56. Long-billed Curlew. *Numenius americanus.* On October 25, 1914, Mr. A. J. Anderson was on a sandbar in Missouri river

opposite Union county. Two of these Curlews flew in from the north and alighted for a moment on the bar.

57. Black-bellied Plover. *Squatarola squatarola.* This species is still seen in small numbers on the sandbars in Missouri river opposite Union county. The writer has definite records of several being taken. They come through during the last week of October.

58. Killdeer. *Oxyechus vociferus.* A common summer resident.

59. Semipalmated Plover. *Aegialitis semipalmata.* Three were noted at McCook lake on August 26, 1917 (Allen and Ludeke). A flock of four were seen at Goodenough lake on May 1, 1918 (Anderson and Stephens).

60. Ruddy Turnstone. *Arenaria interpres morinella.* Several were noted at Lancaster slough on May 20, 1911, by Rev. M. B. Townsend.

61. Bobwhite. *Colinus virginianus.* This species is still present but in very limited numbers. On some of the timbered lands near Goodenough lake the farmers give it protection, and there it may be found. During the writer's own excursions into Union county within the last eight years he has come across it only four times.

62. Prairie Chicken. *Tympanuchus americanus.* The following note from Mr. Ludeke gives the status: "The Prairie Chicken strays into the district around the Loblolly and McCook lake occasionally, but can be slated as decidedly scarce." The writer flushed a single bird along the shore of McCook lake on March 24, 1918.

63. Mourning Dove. *Zenaidura macroura carolinensis.* A common summer resident.

64. Marsh Hawk. *Circus hudsonius.* A tolerably common migrant and summer resident.

65. Red-tailed Hawk. *Buteo borealis.* Noted on March 3, 1918, at McCook lake (Allen).

66. Sparrow Hawk. *Falco sparverius.* Noted as follows: On April 22, 1911 (Stephens); April 1, 1917 (Allen and Ludeke); and on April 14, 1918 (Allen, Ludeke, Stephens).

67. Osprey. *Pandion haliaetus carolinensis.* This species is a frequent visitor at McCook lake, where it was seen in the fall of 1914 (two by Ludeke), and on April 25, 1915 (Allen and Ludeke). In 1918 it was noted on April 21 (Allen) and on May 1 (Stephens). The following specimens have been mounted by Mr. Anderson:

April	19, 1897,	one from McCook lake.
September	14, 1904,	one from McCook lake.
September	27, 1905,	one from McCook lake.
October	5, 1914,	one from McCook lake.
May	6, 1915,	one from McCook lake.

68. Western Horned Owl. *Bubo virginianus occidentalis* Stone. Mr. Allen saw one of these light colored Horned Owls in the woods near McCook lake on March 3, 1918. Some facts on the abundance of this race during the winter of 1917-18 in the upper Missouri valley are recorded in another paper by the writer. There can be no doubt that two forms which are so different as the light and dark colored *Bubos* which occur here should be in some way distinctively designated. However, whether it should be done by means of binomialism or trinomialism is one of the difficult zoological problems not yet satisfactorily settled.

69. Snowy Owl. *Nyctea nyctea.* On December 21, 1917, a "white" owl was killed near McCook lake by farmers, because, they claimed, it had been taking chickens. The winter of 1917-18 marked a wonderful visitation of Snowy Owls in this general region. Some forty records were obtained during the winter and spring. A full report will be made in another paper.

70. Yellow-billed Cuckoo. *Coccyzus americanus.* A common summer resident.

71. Black-billed Cuckoo. *Coccyzus erythrophthalmus.* Not to be compared in abundance with the preceding. The only record is one seen on May 17, 1918 (Stephens).

72. Belted Kingfisher. *Ceryle alcyon.* A common summer resident.

73. Hairy Woodpecker. *Dryobates villosus.* Tolerably common in both summer and winter, and probably breeds.

74. Downy Woodpecker. *Dryobates pubescens.* A common resident. *Medianus* is the subspecies listed for this locality.

75. Red-headed Woodpecker. *Melanerpes erythrocephalus.* A common summer resident.

76. Northern Flicker. *Colaptes auratus luteus.* A common summer and occasional winter resident.

77. Whip-poor-will. *Antrostomus vociferus.* The only note the writer has is from Mr. Ludeke, who states that Dr. Gould has heard it calling in the vicinity of McCook lake. There seems no reason why they should not be there in abundance, for the writer has heard them calling on the Iowa side of the Big Sioux, and has estimated the presence of fifteen or twenty birds.

78. Nighthawk. *Chordeiles virginianus.* May 30, 1915 (Allen); June 2, 1918 (Stephens).

79. Chimney Swift. *Chaetura pelagica.* One individual, which had probably strayed over from the city, was noted near Big Sioux river on May 20, 1918 (Stephens).

80. Ruby-throated Hummingbird. *Archilochus colubris.* Noted on August 26, 1916 (Allen), and on August 28, 1916 (Stephens).

81. Kingbird. *Tyrannus tyrannus.* A common summer resident.

82. Arkansas Kingbird. *Tyrannus verticalis.* A common summer resident, though less numerous than the preceding species.

83. Crested Flycatcher. *Myiarchus erinitus.* July 11, 1915 (Allen). In 1918 found in McCook lake woods, and probably breeding (Allen and Stephens).

84. Phoebe. *Sayornis phoebe.* A common summer resident

85. Olive-sided Flycatcher. *Nuttallornis borealis.* This species was found just in time to be included in this list, viz., on June 2, 1918. The writer had previously doubted its occurrence here. On this occasion the bird, which was at once recognized as a strange flycatcher, was perched upon the topmost branch of a dead tree located in the dense portion of the woods bordering McCook lake. It made frequent sallies out over the treetops, returning to the same perch or to similar ones nearby. It was easy to eliminate *verticalis* and *crinitus* because of the absence of yellow on the underparts. *Tyrannus* was eliminated because of the absence of the white-tipped tail. This bird sat in

a very erect attitude, and was distinguished from other flycatchers of similar size by its relatively short tail and robust fore part of the body. The dark grayish sides were very distinct, and stood out in strong contrast to the median line of white, which, however, showed a noticeable tinge of yellow or straw color. This field record was made jointly by Dr. Rich, Messrs. Allen, Anderson, Ludcke, and the writer. Visher lists this species as a "rare migrant" for Clay county, and we grade it in the same terms for Union county.

86. Wood Pewee. *Myiochanes virens.* A common summer resident.

87. Acadian Flycatcher. Green-crested Flycatcher. *Empidonax virescens.* A specimen was taken on June 2, 1918, in the McCook lake woods.[3] We do not know much about the abundance of this species here, but it is believed to be rather uncommon.

88. Least Flycatcher. *Empidonax minimus.* Noted on May 12 and 15, 1918 (Allen), and on May 17 and 20, 1918 (Stephens). This is a tolerably common species here and, no doubt, breeds.

88. Prairie Horned Lark. *Otocoris alpestris praticola.* This is a common species throughout the year. Mr. Allen has seen it in March, in the plowed fields near McCook lake in numbers estimated at about seventy individuals. It is one of the earliest birds to breed.

89. Bluejay. *Cyanocitta cristata.* A common summer resident.

90. Crow. *Corvus brachyrhynchos.* A common resident.

91. Cowbird. *Molothrus ater.* A common summer resident.

92. Yellow-headed Blackbird. *Xanthocephalus xanthocephalus.* An abundant migrant, which also breeds in the upper end of Goodenough lake.

93. Red-winged Blackbird. *Agelaius phoenicius.* A common summer resident.

94. Western Meadow Lark. *Sturnella neglecta.* A common summer resident.

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[3]The determination of this specimen was verified by Dr. H. C. Oberholser.

95. Orchard Oriole. *Icterus spurius.* A common summer resident.

96. Baltimore Oriole. *Icterus galbula.* A common summer resident.

97. Bronzed Grackle. *Quiscalus quiscala aeneus.* A common summer resident.

98. Goldfinch. *Astragalinus tristis.* A common summer resident.

99. Pine Siskin. *Spinus pinus.* Noted April 18, 1915 (Allen).

100. Lapland Longspur. *Calcarius lapponicus.* Rare in this locality if one may judge from the lack of records. Rev. M. B. Townsend furnishes the only record, viz., April 1, 1911, in the fields near McCook lake.

101. Vesper Sparrow. *Pooecetes gramineus.* Five noted near McCook lake on April 22, 1911 (Stephens), and two on May 12, 1918 (Allen). Visher lists the subspecies *confinis* for Clay county, but a specimen from the Sioux City area was identified some years ago by Ridgway as *gramineus*, as indicated in the notes of Dr. Rich.

102. Savannah Sparrow. *Passerculus sandwichensis savanna.* Noted April 22, 1911 (Stephens), and several times during first week in May, 1918 (Allen, Stephens).

103. Lark Sparrow. *Chondestes grammacus.* Noted April 25, 1915 (Allen); numerous records in May, 1918 (Allen, Stephens).

104. Harris Sparrow. *Zonotrichia querula.* A common or abundant migrant from the middle of March to the middle of May (Allen, Ludeke, Stephens). Numerous October records by Allen.

105. White-throated Sparrow. *Zonotrichia albicollis:* Noted on April 11, 1915 (Allen), and on May 7, 1917 (Mrs. H. J. Taylor). Several spring records in 1918.

106. Tree Sparrow. *Spizella monticola.* A common winter visitor.

107. Chipping Sparrow. *Spizella passerina.* A tolerably common summer resident.

108. Clay-colored Sparrow. *Spizella pallida.* Noted on April 28, 1915 (Allen); numerous records in May, 1918 (Allen, Stephens).

109. Field Sparrow. *Spizella pusilla.* An abundant migrant and common summer resident.

110. Slate-colored Junco. *Junco hyemalis.* A common winter visitor.

111. Song Sparrow. *Melospiza melodia.* A common migrant, not known to breed.

112. Lincoln's Sparrow. *Melospiza lincolni.* A common migrant.

113. Fox Sparrow. *Passerella iliaca.* Noted on October 29, 1916, and April 8, 1917 (Allen); April 15, 1917 (Stephens); March 25, 1918 (Mrs. Bailey); and on April 8 and 14, 1918 (Stephens).

114. Towhee. *Pipilo erythropthalmus.* A common summer resident.

115. Cardinal. *Cardinal cardinalis.* The Cardinal has become very well established as a permanent resident in this county (Union). It will probably remain and increase so long as sufficient patches of timber with undergrowth exist to furnish shelter and breeding sites.

116. Rose-breasted Grosbeak. *Zamelodia ludoviciana.* A common summer resident.

117. Indigo Bunting. *Passerina cyanea.* "Breeds at McCook lake every year, but is hardly common." (Allen.)

118. Dickcissel. *Spiza americana.* A common summer resident.

119. Scarlet Tanager. *Piranga erythromelas.* A tolerably common migrant, which may also breed.

120. Purple Martin. *Progne subis.* A small colony has occupied a martin house at one of the cottages on McCook lake each summer since 1915.

121. Cliff Swallow. *Petrochelidon lunifrons.* Noted September 6, 1917 (Mrs. Bailey). No nests have been observed within the area.

122. Barn Swallow. *Hirundo erythrogaster.* A common summer resident (Allen).

123. Tree Swallow. *Iridoprocne bicolor.* Noted April 25, 1915 (Allen). Numerous records in April and May, 1918.

124. Bank Swallow. *Riparia riparia.* A common summer resident (Allen). Large migrating flocks observed in May, 1918. Breeds.

125. Rough-winged Swallow. *Stelgidopteryx serripennis.* Two noted on May 5, 1918 (Allen). Found apparently nesting in bank near McCook lake late in May, 1918. More common along Big Sioux river, where the banks afford nesting sites.

126. Bohemian Waxwing. *Bombycilla garrula.* Noted on April 18, 1915 (W. J. Hayward).

127. Cedar Waxwing. *Bombycilla cedrorum.* Large numbers were seen in the woods by McCook lake through March, April, and May, 1918 (Allen, Ludeke, Stephens).

128. Red-eyed Vireo. *Vireosylva olivacea.* A common summer resident (Allen). Perhaps less numerous than the next species (Stephens).

129. Warbling Vireo. *Vireo gilva.* A common summer resident.

130. Blue-headed Vireo. *Lanivireo solitarius.* Noted on September 6 and 17, 1917 (Mrs. Bailey); and on May 10, 1918 (Mrs. F. J. Hayden). Migrant only.

131. Bell's Vireo. *Vireo belli.* A common summer resident.

132. Black and White Warbler. *Mniotilta varia.* Noted on September 6, 1917 (Mrs. Bailey), and on May 12 and 15, 1918 (Allen).

133. Tennessee Warbler. *Vermivora peregrina.* Noted on May 16, 1915 (Allen). Common in May, 1918 (Allen, Stephens).

134. Yellow Warbler. *Dendroica aestiva.* A common summer resident.

135. Myrtle Warbler. *Dendroica coronata.* A common migrant.

136. Magnolia Warbler. *Dendroica magnolia.* A tolerably common migrant.

137. Black-poll Warbler. *Dendroica striata.* A tolerably common migrant in May, 1918 (Mrs. Bailey, Allen, Stephens).

138. Palm Warbler. *Dendroica palmarum.* Noted on May 7, 1917, by Mrs. F. J. Hayden. Several other records were obtained the same spring in adjacent counties.

139. Grinnell's Water Thrush. *Seiurus noveboracensis notabilis.* Noted on May 12, 1918, in vicinity of McCook lake (Allen).

140. Maryland Yellow-throat. *Geothlypis trichas.* A common summer resident.

141. Yellow-breasted Chat. *Icteria virens.* Noted in summer of 1916 in woods on west shore of Goodenough lake, and on May 15, 1918, in woods near McCook lake, by Mr. Allen.

142. Wilson's Warbler. *Wilsonia pusilla.* Noted by Mrs. Bailey on May 14, 1918, in woods along Big Sioux river.

143. Redstart. *Setophaga ruticilla.* A common migrant, and tolerably common summer resident according to Mr. Allen's notes.

144. Catbird. *Dumetella carolinensis.* A common summer resident.

145. Brown Thrasher. *Toxostoma rufum.* A common summer resident.

146. Western House Wren. *Troglodytes aedon parkmani.* A common summer resident.

147. Brown Creeper. *Certhia familiaris americana.* Noted on October 29, 1916, and on April 7, 1918 (Allen).

148. White-breasted Nuthatch. *Sitta carolinensis.* A common winter visitor, and may breed sparingly.

149. Black-capped Chickadee. *Penthestes atricapillus.* A common summer resident and winter visitor.

150. Golden-crowned Kinglet. *Regulus satrapa.* Noted on April 1, 1917 (Allen and Ludcke), and on April 7, 1918 (Allen).

151. Ruby-crowned Kinglet. *Regulus calendula.* Noted on May 7, 1917 (Mrs. Taylor); on October 14, 1917 (Allen); and on April 28, 1918 (Stephens).

152. Wood Thrush. *Hylocichla mustelina.* A common summer resident.

153. Olive-backed Thrush. *Hylocichla ustulata swainsoni.* An abundant migrant.

154. Robin. *Planesticus migratorius.* A common summer resident.

155. Bluebird. *Sialia sialis.* A common summer resident.

DEPARTMENT OF BIOLOGY,
MORNINGSIDE COLLEGE.

AN UNUSUAL EXAMPLE OF INCISOR GROWTH IN THE WESTERN FOX SQUIRREL.

DAYTON STONER.

A short time ago a partly broken skull of the Western Fox Squirrel, (*Sciurus niger rufiventer* (Geoffroy), bearing a curiously formed upper incisor was brought to me for examination by Mr. W. F. Kubichek, now of the Children's Museum, Brooklyn, New York. The animal was evidently an adult and was killed near Homestead, Iowa, November, 1917. The lower mandible as well as the posterior portion of the brain case is missing.

By referring to the accompanying figures, the points made in the following discussion may be followed more closely.

As is well known, the incisor teeth of this squirrel and, indeed of all rodents, grow from a persistent pulp; growth continues as rapidly as the tips of these teeth are worn away, and a sharp, chisel-like edge is constantly maintained. Apparently this animal had, through some accident or other, lost the exposed tip of the lower left incisor, thus leaving the upper incisor of that side unapposed; as a consequence, the latter tooth did not extend downward much farther than normally, but assumed the outline of an incomplete circle, growing backward and upward along the outer side of the superior maxillary. The apex of the tooth at the time the animal was killed, had covered over the anterior opening of the infraorbital foramen and a bony deposit had begun to take place behind the tubercle and just below and anterior to that foramen, as well as on the anterior face of the orbital plate of the superior maxillary. Both these osseous deposits were due, no doubt, to the continued and ever-increasing irritation set up by the growing incisor.

Conditions indicate that, after a time, the lower left incisor grew out again, but instead of meeting the cutting edge of the upper incisor of that side, it apposed the lower margin of the now almost completed circle into which the upper incisor had grown. The lower margin of this recurved upper incisor thus became worn into a thin edge at a point opposite the apex of the right upper incisor.

As the lower left incisor continued to grow longer, not being directly apposed by the cutting edge of a tooth in the upper jaw, it was pushed to one side so that the outer face of the *right* upper incisor became worn and very thin from side to side at the apex. Both lower incisors were thus pushed to the right of the normal alignment and continued to grow uninterruptedly. Not being directly apposed by a tooth in the upper jaw, the tips of these lower incisors penetrated the flesh covering the palatal surface of the premaxilla and had already worn a small irregular hole in the bony anterior palatal surface of the right premaxilla just anterior to the maxillo-premaxillary suture.

This state of affairs must have caused much inconvenience and even pain to the animal until its sufferings were ended by a shot from the hunter's gun.

The State University.

DESCRIPTION OF PLATE I.

FIG. 1. Skull of *Sciurus niger rufiventer*, showing normal incisor growth.

FIG. 2. Skull of *Sciurus niger rufiventer*, (left side) showing abnormal incisor growth.

FIG. 3. Skull of *Sciurus niger rufiventer*, (right side) showing abnormal incisor growth.

Fig. 1

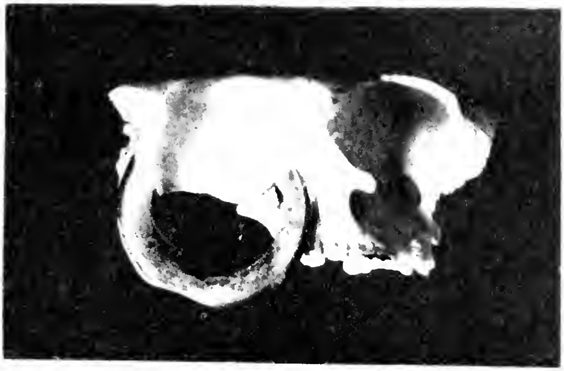

Fig. 2

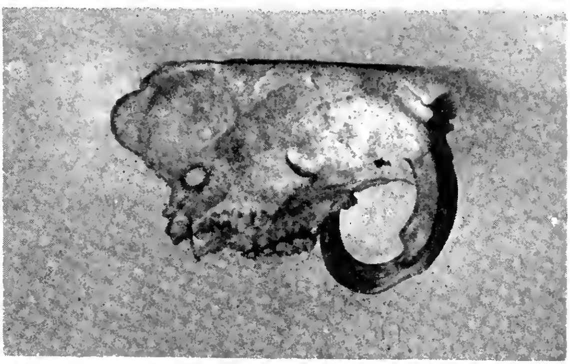

Fig. 3

PHARYNGEAL DERIVATIVES OF AMBLYSTOMA.

FRANCIS MARSH BALDWIN

The recognition, within recent years, of the parts played by certain structures arising from the walls of the human pharynx, in health and disease, renders these bodies of great interest, and hence all facts which throw light upon their morphology are of value. It was from such considerations that the writer undertook the study detailed in this paper, for, while a knowledge of their development in amphibia may have no immediate practical value, the close relations of that group to the ancestry of the mammals gives every addition to our knowledge an interest which would not be expected with such groups as the teleosts or the birds.

The literature of the subject, which it is not necessary to go into here, while not great, is rather difficult to follow, partly because of the lack of unanimity of opinion as to homologies, and partly because of the conflicting nomenclature of the subject, the same structures often having different names, even in the minor groups of vertebrate animals. In some groups on the other hand, pharyngeal derivatives are found which apparently do not occur in the amphibians or at least in the urodeles. These have not been considered in this study, and therefore this paper is restricted to the consideration of the thyreoid and thymus glands; the so-called postbranchial body; the so-called 'epithelial bodies' or 'gill-remnants,' and the carotid gland, although the latter is not a true pharyngeal derivative.

The study is based upon serial sections of larvæ of *Amblystoma punctatum*, beginning with larvæ 5mm. long (about the time of hatching), and including successive stages (8mm., 10mm., 12mm., 15mm., 19-20mm., 25mm., 35mm., 40mm.) through the 45mm., following these stages with the transformation period, and sections of young and old adult heads. Supplementing the slides, gross dissections were made in the adult. The young larvæ were fixed in Smith's fluid, stained in toto in Borax-carmine, dehydrated, embedded and mounted in the usual way. The older larvæ and adult heads were fixed in formaline (heads decalcified), dehydrated, embedded, sectioned and doubly stained on the slide with Borax-carmine and Lyon's blue. Wax reconstructions were made of the thyreoid gland in the 8, 9, 15, 19 and 40mm. larval stages; of the thymus gland in the 19 and 35mm. stage as well as the early, late and adult stages; of the postbranchial body in the 19, 40mm., and early transforming stages; of the epithelial bodies in the late transforming and adult stages (these appear only at the time of metamorphosis and persist in the adult); and of the carotid gland in the late transforming and adult stages, (this gland appears during the time of metamorphosis also, but as pointed out later is not a true pharyngeal derivative).

Since the entire results of my study have been published in the last issue of the Journal of Morphology (March, 1918), Vol. 30, No. 2, it is necessary here only to point out in a summary way some of the more important conclusions.

The anlagen of the thymus bodies are recognized in Amblystoma larvæ 8mm. long, as epithelial thickenings at the caudo-dorsal extremity of five pharyngeal pouches (counting the hyomandibular pouch as the first). These thickenings soon become solid epithelial bodies, which lose their early connection with the pharyngeal entoderm, and lie in the connective tissue, dorsal to their respective pouches. These bear certain relationships in position to the ganglia of the cranial nerves and the ear.

The darkly staining cells which are scattered or grouped about in the region close to the thymus bodies are regarded as mesenchymatous in origin and are not ectodermal contributions to the thymus bodies.

Of the five primitive epithelial thymus bodies, the first two degenerate early; this degeneration takes place with some irregularity in different individuals since in some larvæ, the second body had disappeared in the 11mm. stage, while the first still persisted as a very slender stalk of cells. Usually, however, both bodies had disappeared by the 15mm. stage.

The three remaining bodies are, at first, small, spherical or slightly oval structures, of about equal size (in 19mm. larvæ, measuring 90x75 micra, 75x60 micra and 90x120 micra respectively) but during the later larval stages they increase gradually in size and elongate somewhat so that in larvæ 45mm. long (the stage before transformation), they have the dimensions of 220x164, 180x240, and 285x350 micra respectively.

The three bodies during the larval stages, lie close behind one another and caudolateral to the posterior wall of the ear. The third and fourth bodies are usually close together, while between the fourth and fifth bodies there is a much larger interval.

In the adult, the thymus gland is a three-lobed flattened structure (probably formed by the union of the three larval thymus bodies) lying in the side of the neck, caudad and a little dorsal to the angle of the jaw. It is surrounded by loose connective tissue richly supplied with vascular vessels, and innervated by rami of the glossopharyngeal and vagus nerves.

The anlage of the thyreoid gland is recognized in larvæ 5mm. long, as a very shallow cuplike depression in the medial floor of the pharnyx in the region of the hyomandibular pouch (not the second branchial pouch as Maurer '88 states for Triton) between the thickened oral plate, and the anterior limits of the pericardium.

As development proceeds, this cup-shaped anlage proliferates cells from its ventral surface so that in 8mm. larvæ a solid elongated stalk cell reaches in a caudal direction toward the anterior wall of the pericardium a distance of about 100 micra, but it does not unite with the anterior wall in any way (differing in this respect from the similar formed structure described by Miss Platt in Necturus). A little later (9.5mm. larvæ) the distal end of the solid stalk begins to divide into right and left halves, and this continues with some rapidity so that in 10mm. larvæ it is completed, and in addition, the anterior connection with the pharynx is lost and the two halves lie lateral to the geniohyoideus muscle of either side.

I find no evidence that the cells which formed the connecting stalk of the two halves of the thyreoid, or those which formed the connecting stalk persist to form accessory thyreoids as was described by Maurer in Triton.

After becoming completely divided into right and left halves, each half loses its solid and compact condition. The epithelial cells scatter loosely into the connective tissue and arrange themselves irregularly about the dorsal wall of the inferior jugular vein of either side (larvæ 13mm. long) and from these loosely scattered epithelial cells the follicles of the gland arise by mitotic division.

Follicles first appear in larvæ 15mm. long; they are either globular or elliptical, with a well defined outer layer of cuboidal cells enclosing a conspicuous cavity, probably containing a fluid of some sort but no colloid. They vary greatly in size, but, as a rule, they enlarge as development proceeds, varying from 19 to 36 micra in diameter in the 19mm. larvæ, to 100 micra in length and between 50 and 75 micra in the late larval and early transforming stages.

A sort of membrana propria appears late in the larval life; it not only surrounds the follicles and the intervening lymph spaces, but also envelops the inferior jugular vein in the region of the gland.

A so-called rete mirabile of the inferior jugular vein fails to develop during the whole of the larval period, and so far as the writer is able to learn from careful study of the developmental stages, the external carotid artery has no direct connection with the gland.

Colloid appears rather late in the larval stages, the first evidence of it being seen in larvæ 39mm. long.

With the transformation of the ventral gill-region, the thyreoid gland is pushed a little laterally and caudally, so that it lies in the space just in front of the anterio-lateral wall of the pericardium, and, in the adult, it is flanked medially by the geniohyoideus, laterally by the hyoideus internus of the first branchial arch, and dorsally by the sternohyoideus muscles.

From the condition of the follicles in the late transforming and early adult gland, it is evident that new follicles of smaller size are being budded from the larger ones.

The blood supply of the adult gland is from small venous twigs from the sterno and genio-hyoideus muscles, which upon entering the gland break up into numerous smaller vessels (rete mirabile) and which join the jugular vein some distance caudad. Its connection with the external carotid artery is very doubtful.

The earliest stage in which the anlage of the postbranchial body is recognized in my material is in larvæ 8mm. long. It develops as a rule, on the left side (in a single individual 19mm. long on the right side as well). In its early condition, it is a thickening of a certain portion of the pharyngeal floor, lying between the anlage of the fourth branchial (fifth visceral) pouch and the anlage of the glottis, and protruding slightly ventrally toward the dorsal wall of the pericardium. It is thus 'postbranchial' as Maurer claimed for a similar structure in Triton, and appears in the relative position of a sixth pouch.

In 9.5mm. larvæ, the anlage makes a solid cylindrical stalk of cells (about 40 micra long, and between 25 and 30 micra thick) extending vertically downward from the floor of the pharynx. It soon elongates, loses its connection with the pharynx (11-13mm. larvæ), and as an irregular, poorly defined mass of cells lies medial to the aditus laryngeus muscle.

In one 19mm. larva, a postbranchial body was found on the right side as well as on the left; the left, however, was the larger. This is an unusual condition, since in none of the other specimens studied did the structure on the right side occur, but is of interest since it shows the possibility of some variability within a genus of urodeles. It is also important as bearing upon the question of homologies of these structures.

In the later larval stages, the postbranchial body becomes very irregular; in some regions it is solid, in other parts it shows follicular structure, with cuboidal cells forming a fairly definite layer enclosing a conspicuous lumen, but which in no case contains colloidal material.

During transformation, because of increase in the size of the surrounding structures (especially the laryngeus and sternohyoideus muscles), the postbranchial body is flattened laterally and reduced to a sheet of poorly defined cells which now contain no lumen. In the material studied by the writer the structure and anatomical position of the postbranchial body in the adult is variable. It could not be found by gross dissection. In sections of young adult heads, it is a fairly compact oval body composed of regular cuboidal cells enclosing a spacious lumen. In sections of old heads, the writer was not able to locate the structure.

The carotid gland and epithelial bodies in Amblystoma begin their development at the time of metamorphosis. There is no evidence to show that the carotid gland is concerned in its genesis with the epithelial cells of the degenerating gill-pouches.

The anlagen of the epithelial bodies (two on either side) are recognized as irregular longitudinal sheets of entodermal cells (remnants of the ventral portions of the fourth and fifth visceral pouches) extending caudad (caudal limits poorly defined) from points where the afferent branchial arteries enter their corresponding gills in the early transforming stage.

As transformation proceeds, the irregular longitudinal sheets of entodermal cells become resolved into compact oval bodies (two on a side) so that in the late transforming stage, these lie one behind the other, close behind the carotid gland, each being enveloped by connective tissue covering. They now take a position laterad to the second aortic arch.

The two epithelial bodies of either side are easily exposed in the adult by gross dissection. They lie embedded in the connective tissue on the side of the neck in the region just below the thymus just caudad to the carotid gland, although their position may vary slightly in different individuals.

The blood supply of these small epithelial bodies is from the small twigs from the second aortic arch and from the external carotid artery, and they are innervated by a small ramus from the vagus nerve.

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FOOD CONSERVATION AND ECONOMIC ENTOMOLOGY.

R. L. WEBSTER.

Damage by insects to crops is generally recognized to be of great importance. Not infrequently we see estimates of losses, but even these fail to impress most of us until some widespread insect depredation occurs, such as an outbreak of armyworms, or of white grubs. Several years ago, at the request of President Raymond A. Pearson, the writer made the following estimate of the annual losses caused by insects in Iowa.

ESTIMATES OF INJURY TO IOWA CROPS BY INSECTS.

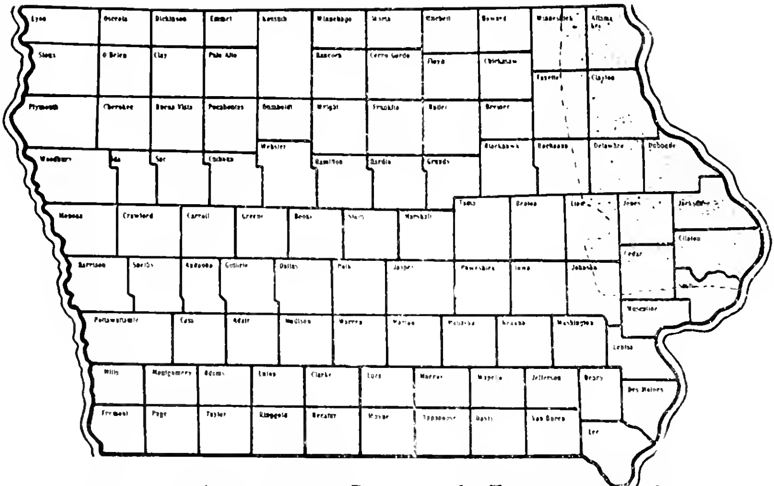
Corn	$20,000,000.00	10 per cent of crop
Oats	3,500,000.00	5 " " " "
Winter wheat	1,100,000.00	10 " " " "
Spring wheat	150,000.00	5 " " " "
Barley	240,000.00	5 " " " "
Rye	50,000.00	5 " " " "
Potatoes	550,000.00	10 " " " "
Hay (tame)	4,500.00	10 " " " "
Alfalfa	400,000.00	10 " " " "
Total	$25,994,500.00	

In a consideration of a set of figures of this kind it must be remembered that there is always a certain amount of damage that passes unnoticed. Not infrequently a crop may be injured sufficiently to cause a decrease of 10 per cent in the total yield. Naturally it is impossible to separate entirely losses due to certain other factors, such as unfavorable weather conditions, poor seed, different soil and plant diseases. Moreover, all possible combinations of these factors may exist.

It is the opinion of the writer that such an estimate is made on a basis eminently fair. When one considers that it is possible, under favorable conditions, to raise 100 bushels of corn to the acre, and that our average yield in Iowa is something considerably less than 40 bushels, one may realize that the state is losing greatly through one cause and another.

In this paper the writer wishes to point out a few of the destructive insects to crops in Iowa and to show how damage by these may be greatly reduced. In the work of an economic entomologist one meets an individual now and then who will throw up his hands when insects are devastating his fields.

Sometimes, it is true, the situation is so difficult that there is really not much that can be done. More often, however, the case is far from hopeless, and even if great damage has been done, specific recommendations may be given so that further damage may be avoided in the future.



Area Where White-grub Damage Is Expected 1918.

Figure 7.

Severe damage by white grubs in Iowa has occurred in 1912 and 1915. Injury to corn and grass lands (timothy and bluegrass) in extreme northeast Iowa has been especially severe. The area affected is shown in fig. 7. In 1912 the loss to the corn crop alone in the five counties of Allamakee, Clayton, Dubuque, Delaware and Jackson, amounted to more than three million bushels. At 39 cents a bushel, the value of corn at that time, this loss amounted to more than a million dollars.

Since loss to meadows and pasture was not taken into consideration, and since the damage by the grubs extended into adjoining counties, this figure falls considerably short of the whole amount. Again, in 1915, at least an equivalent loss occurred, although less noticed because of heavy precipitation which kept vegetation green above the surface although the grubs kept busy at their work all summer on the roots below ground.

Severe damage by white grubs is usually periodical in occurrence. In the Iowa outbreak, which also extends into Illinois and well into Wisconsin, it was early determined that every three years would bring about a recurrence of the trouble. This will not recur indefinitely, and even now the prospects for future damage seem to be decreasing in certain sections. Natural enemies of the grub will eventually put an end to the present abundance.

A generalized life cycle of these insects is better shown as given herewith. Later investigations may show that some species have a different life history, but that given applies generally to Iowa.

First Year. Beetles emerge from soil in May, feed and deposit eggs. Grubs hatch and begin to feed, wintering over in the soil, (1917 in northeastern Iowa).

Second Year. Grubs feed during the season. The most damage to crops is caused in the second year. The grubs winter over in the soil, practically full grown. (1918 in northeastern Iowa.)

Third Year. Grubs feed early in the season, pupate in June or July, changing to beetles a few weeks later, remaining in the soil over winter. (1919 in northeastern Iowa.)

Fourth Year. Same as the first.

In previous outbreaks of white grubs the worst damage occurred to corn when this was planted on sod ground. Studies have also well determined that the damage is always worst on the rougher land, in the vicinity of timber. The beetles feed on foliage in the woods, and deposit their eggs in uncultivated ground near at hand. In northeast Iowa little injury occurred on the prairie land.

When white grubs are expected in any particular year in localities where conditions seem to be favorable for the grubs farmers are advised to plow as little sod as possible. Again, corn should not be planted on sod ground in a "grub year."

Here in Iowa last year it was determined that conditions all pointed toward damage by white grubs in 1918. In May, 1917, the beetles were common in this area, and farmers reported the small white grubs abundant in the fall. These were plowed up in sod ground. Consequently a "white grub campaign" was begun in 1918.

Under the food production act the federal department of agriculture has stationed a man in Iowa whose time is devoted entirely to extension work on cereal and forage crop insects. With the help of the county agricultural agents meetings were held in all those counties where severe damage is expected. The county agent planned these gatherings and usually two or three days were spent in a county. This work is being carried on in cooperation with the Agricultural Extension Department at Ames.

Mr. E. V. Walter, the government extension entomologist, talked at 33 meetings in this campaign, with an average attendance of 65 persons to a meeting, and a total of 2,155. The meetings were held from March 19 to April 10, 1918.

In this instance the entomologist has been able to give specific recommendations in advance. By holding these meetings in small communities in the white grub district the essential information is put directly into the hands of those people to whom it is of most value. Working through the county agricultural agent he also becomes better informed on the subject and will be better equipped to fill his position as farm advisor.

In the summer of 1918 a second man, Professor H. E. Jaques, head of the Department of Biology, Iowa Wesleyan College, is also engaged in this work.

Grasshoppers in 1917 caused much injury in Iowa, especially in the southern portion of the state, where clover was badly damaged. In certain counties clover was practically a failure.

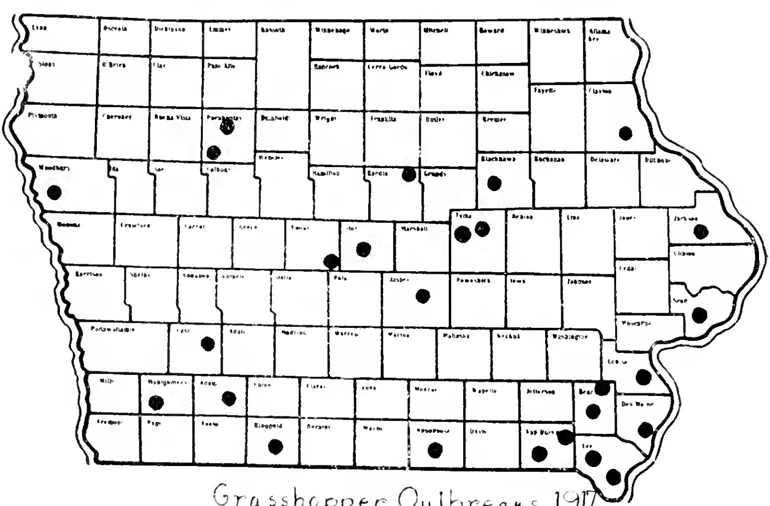


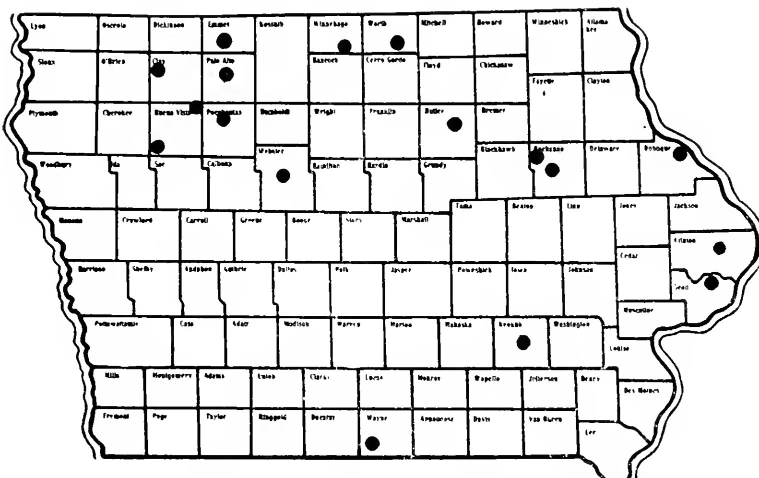
Figure 8.

Fig. 8 shows the localities where grasshoppers were reported to the experiment station in 1917.

While damage is likely to occur in Iowa in 1918, its extent is difficult to foretell. Several reports of "cabbage snakes" (Mermis) came in during the fall, and as these are parasitic on grasshoppers, it is probable that the abundance of the insect will be reduced to some extent.

Good success was obtained in Iowa in 1917 by the use of a poison bran mash. This has been widely used in Kansas and elsewhere recently and proved very successful in Iowa. Should grasshoppers become abundant in Iowa in 1918 it is planned to hold demonstrations in the counties where trouble may occur, working again with the county agricultural agents.

Probably the most puzzling questions the economic entomolo-



Wireworm Outbreaks 1917

Figure 9.

gist has to answer are those relating to wireworms. Figure 9 shows where these insects were reported in 1917.

Through the federal extension entomologist advice is being given on wireworms at small gatherings arranged for by the county agricultural agent. With a better understanding on the part of the farmer of the conditions under which wireworm damage is likely to occur there is no doubt that damage of this character may be measurably reduced.

Still another feature of the work is that in the nature of an entomological survey for destructive insects on field crops. Last year a survey of fall wheat was undertaken with the object of determining whether damage by the Hessian fly might be expected in 1918. This work is being continued this spring and is now in progress. In two counties some little damage by this insect is anticipated. In all other counties visited so far, however, there appears to be no possible chance for serious trouble.

In this paper the writer has attempted to show how the economic entomologist can determine, with a high degree of accuracy, the chance for the abundance of many of our common insects. With such information in hand he is far better able to aid the farmer in his efforts to increase food production. It is probably impossible to anticipate all insects, but with the aid of the machinery at hand, much may be done, and is being done, to raise more and better crops in this national emergency.

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A LIST OF THE BIRDS FOUND IN MARSHALL COUNTY, IOWA.

IRA N. GABRIELSON.

During a three years' residence at Marshalltown, Marshall county, Iowa, ending September 15, 1915, the writer spent most of his spare time in a study of the avifauna of the region. Nearly all parts of the county were visited, the area within which most of the work was done being indicated on the accompanying map (figure 10).

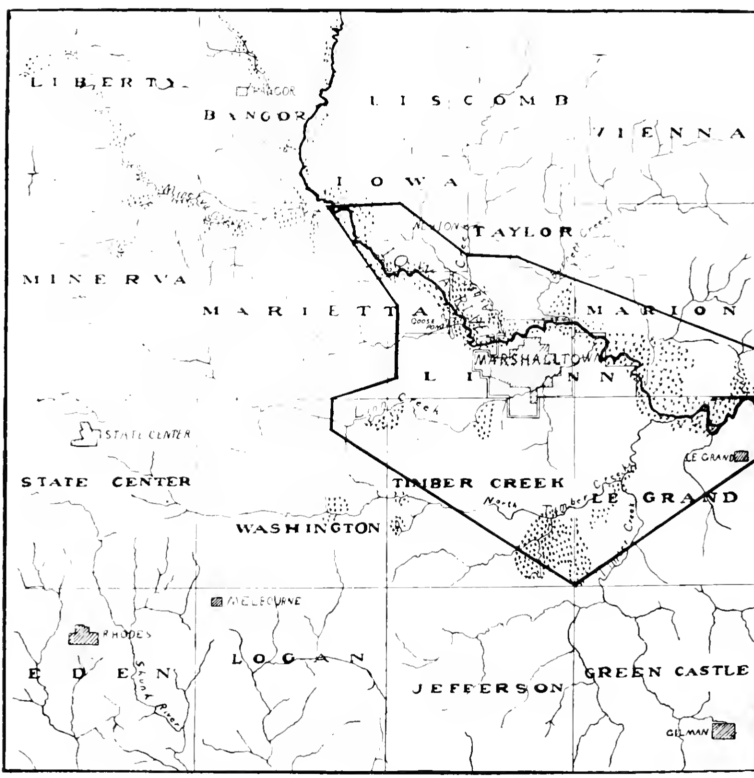

FIG. 10. Map of Marshall county, Iowa. The area inclosed by the heavy black line includes the territory within which most of the birds recorded in this paper were found.

Marshall county lies almost in the exact center of the state of Iowa. Its geology and topography have been fully described by

Beyer* and the following account is based partly on his report and partly on my own observations. As is the case with most counties of the state, it is approximately twenty-four miles square. For a description of its general topography I can do no better than quote Beyer's account, as follows:

* * * In order better to understand the more general configuration, conceive a more or less regular surface very slightly inclined to the southeast. Let there be a slight depression in the position of the Iowa river, flanked on either side with parallel

Fig. 11. Iowa river at Clay Bluffs. The open pasture in figure 13 is shown on the right.

ridges, the crest on one side bisecting Vienna township diagonally, while a line passing through State Center, Van Cleve, and Laurel marks approximately the position of the other. Spread over the surface a material which responds readily to water action, but holds with equal fidelity the vigorous carving of the spring freshet and the most delicate tracery of the summer shower; given these conditions, time and the erosive agents are the only requisites to account for the general physiography of the region.

*The Geology of Marshall County, by Samuel Walker Beyer. Annual Report for 1896 of Iowa Geological Survey, Vol. VII, pp. 199-262, with 2 maps, figs. 25-37, Pls. V-VI.

A small section of the northwestern corner of the county lies within the Wisconsin drift area. However, most of the marshes and "kettle holes" which characterize that formation have now been drained. The Iowan drift sheet extended over the northeastern corner and as its most characteristic work left scattered bowlders, some of which are of huge size. The remainder of the county is covered with a loess soil, which has eroded into rolling hills separated by narrow V-shaped valleys. The most important physiographic feature from an ornithological standpoint is Iowa river. It has a general northwest to southeast trend and serves

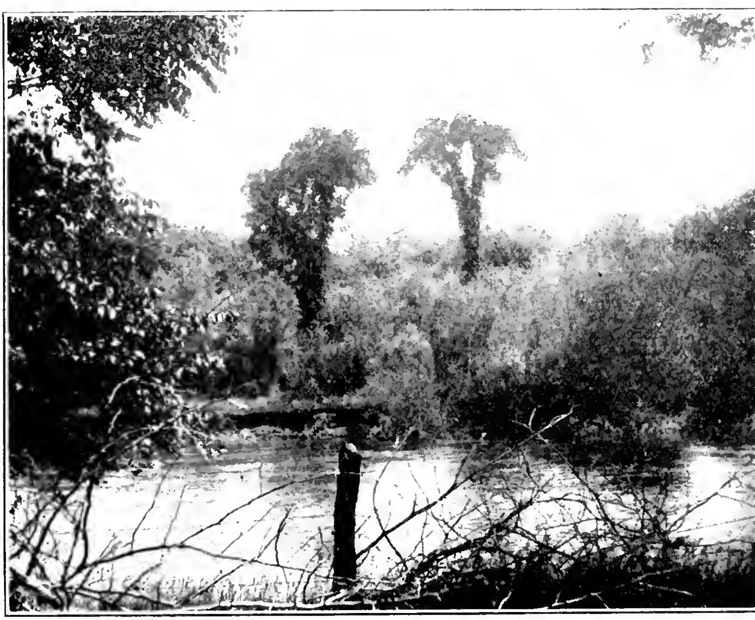

FIG. 12. Characteristic low timber of Iowa river valley. The two old elms represent the older timber growth which is now largely cut off.

as a bird-migration route to the interior of the state. The valley averages from one to two miles in width and contains more or less timber. At various places in the county cut-offs have been formed, some of which still contain permanent bodies of water, while others are filled by the spring freshets and then slowly disappear by evaporation during the summer months. The Goose Pond or Ponds, frequently mentioned in this paper, is the largest of these and lies northwest of Marshalltown. It consists of a pond or series of ponds, depending on the state of the river, which extend for considerably more than a mile in a general north and south direction. These ponds furnish the only resort of any size in the county for waterfowl, and the mud flats exposed by the summer evaporation attract thousands of sandpipers during the fall migration.

Practically the entire county outside the flood plain of the Iowa and its tributaries* is under cultivation, and consequently little of the original prairie flora and fauna can be found undisturbed. Much of the timber and underbrush has been cleared along the streams, leaving open wooded pasture land, and consequently here, too, it is difficult to find any large area in which original conditions are preserved.

Most of the timber is second growth and not of large size. Some beautiful specimens of oak of various species, elms, and one or two black cherries still stand in the Marshalltown cemetery, however, and at various places at the north end of the city. Frequent groves of giant cottonwoods can be found along the Iowa river and some other streams. Perhaps the largest area of wild land remaining within the limits of this county is along Mormons Ridge, which lies along Iowa river, northwest of the town of Albion. It is well wooded and somewhat rugged, and this probably accounts for its present condition.

The following list of trees and shrubs, while by no means complete, contains the more common forms growing along Iowa river and tributary streams (nomenclature from Gray's New Manual of Botany, 7th edition):

Red cedar. *Juniperus virginiana* Linnaeus. Occasional on the bluffs along the river. All small.

Green brier, *Smilax rotundifolia* Linnaeus. Common in the bottom land.

Black willow, *Salix nigra* Marshall. Common.

Sandbar willow, *Salix longifolia* Muhlenberg. Common.

Salix missouriensis Bebb. (?)

White poplar, *Populus alba* Linnaeus. Occasional as an escape; common in cultivation.

Aspen, *Populus tremuloides* Michaux. Tolerably common on the hillsides.

Cottonwood, *Populus deltoides* Marshall. Probably the dominant lowland form.

Butternut, *Juglans cinerea* Linnaeus. Common on the flood plain of Iowa river. Occasional on the upland.

Black walnut, *Juglans nigra* Linnaeus. Common with *J. cinerea*.

*For a full discussion of these tributaries see Beyer, op. cit., pp. 205-208.

Hickory, *Carya ovata* (Miller) K. Koch. Tolerably common upland form.

Pignut, *Carya glabra* (Miller) Spach. Common.

Hazelnut, *Corylus americana* Walter. Common.

Hop hornbeam, *Ostrya virginiana* (Miller) K. Koch. Common upland form.

River birch, *Betula nigra* Linnaeus. A few trees below Marshalltown along Iowa river. Other birches are frequently cultivated.

White oak, *Quercus alba* Linnaeus. Common.

Bur oak, *Quercus macrocarpa* Michaux. Most common oak.

Red oak, *Quercus rubra* Linnaeus. Common.

Scarlet oak, *Quercus coccinea* Muenchhausen. One or two trees supposed to be of this species are in the Soldiers' Home grounds.

Black oak, *Quercus velutina* Lamarck. Common.

Slippery elm, *Ulmus fulva* Michaux. Tolerably common.

Elm, *Ulmus americana* Linnaeus. Common.

Hackberry, *Celtis occidentalis* Linnaeus. Common on the lowlands.

Red mulberry, *Morus rubra* Linnaeus. Not common. An occasional native tree is found along the river.

Prickly gooseberry, *Ribes cynosbati* Linnaeus. Tolerably common.

Missouri gooseberry, *Ribes gracile* Michaux. Tolerably common.

Wild black currant, *Ribes floridum* L'Her. Not common.

Sycamore, *Platanus occidentalis* Linnaeus. Common bottomland form.

Wild crab, *Pyrus ioensis* (Wood) Bailey. Common on the Iowa river flood plains.

Hawthorne, *Crataegus* sp. Undoubtedly several forms of hawthorne are represented here. One or two dense thickets covering several acres each existed along the Iowa river and the open pastures are filled with them. These have been broken and deformed by cattle until no two are alike.

Black raspberry, *Rubus occidentalis* Linnaeus. Not common.

Dewberry, *Rubus villosus* Aiton. I found it only in the high, dry openings on the oak ridges along the Iowa river. It probably occurs in similar situations along other streams.

Wild rose, *Rosa blanda* Aiton. This was the common wild rose, although others undoubtedly occur.

Wild black cherry, *Prunus serotina* Ehrhart. Common.

Choke cherry, *Prunus virginiana* Linnaeus. Tolerably common.

Wild red cherry, *Prunus pennsylvanica* Linnaeus. Tolerably common in the upland timbers, particularly at Clay Bluffs.

Wild plum, *Prunus americana* Marshall. Common in small thickets in the bottom lands.

Kentucky coffee tree. *Gymnocladus dioica* Linnaeus. Common in the river bottom.

Honey locust, *Gleditsia tricanthos* Linnaeus. Common about Marshalltown along Iowa river.

False indigo, *Amorpha fruticosa* Linnaeus. Common roadside shrub.

Prickly ash, *Xanthoxylum americanum* Miller. Common.

Sumach, *Rhus glabra* Linnaeus. Common.

Poison ivy, *Rhus toxicodendron* Linnaeus. Common.

Wahoo, *Evonymus atropurpureus* Jacquin. Not common except at a few spots on Mormons Ridge.

Bittersweet, *Celastrus scandens* Linnaeus. Quite common.

Maple, *Acer saccharum* Marshall. Cultivated very commonly, especially along the streets of Marshalltown. A few found along the river may be native.

Soft, or white, maple, *Acer saccharinum* Linnaeus. One of the most common lowland trees.

Box elder, *Acer Negundo* Linnaeus. Also common along river.

Woodbine, *Psedera quinquefolea* Linnaeus. Common.

Frost grape, *Vitis vulpina* Linnaeus. This seems to be the common wild grape, although others may occur.

Red-osier dogwood, *Cornus stolonifera* Michaux. Common *Cornus*, but others probably are present.

Green ash, *Fraxinus pennsylvanica* var. *lanceolata* (Borkhausen) Sargent. Common.

Black ash, *Fraxinus nigra* Marshall. Not common.

Honeysuckle, *Lonicera dioica* Linnaeus. Not common.

Wolfberry, *Symphoricarpos occidentales* Hooker. Frequent.

Sheepberry, *Viburnum lentago* Linnaeus. Uncommon.

Elderberry, *Sambucus canadensis* Linnaeus. Common.

The timbered area is almost wholly confined to the valleys of the various streams and to the upland immediately adjacent. It is divided into two rather sharply differentiated groups: An upland form, in which oaks, hickories, ironwood, and wild cherries (particularly *P. pennsylvanica*) predominate; and the river bottom group, containing as the most conspicuous forms, willows, cottonwoods, elms, ash, maples, and hawthornes. Aside from this the country-side is dotted with groves about nearly every group of farm buildings. The trees in these groves vary greatly, but perhaps maples, willows, and the various conifers are more often planted than any others. Hedges of osage orange (*Maclura pamifera* (Raf.) Schneider) are found occasionally along the country roads. Several groves of catalpa also remain from a craze for catalpa planting which swept over the country a few years ago. They were planted as *C. speciosa* but as a matter of fact the majority of them proved to be *C. bignonioides* which winterkilled to some extent in this region.

Outside these wooded areas practically the entire surface of the county is under cultivation, the principal crops being corn, oats, and clover, although many others are cultivated to some extent. This condition of affairs has quite a marked influence on the distribution of breeding as well as migratory birds. The more noticeable effects on breeding birds are discussed here.

The pure or almost pure stands of oak found at frequent intervals on hills along the streams contain comparatively few breeding birds. In such timber there is little or no undergrowth and birds find little shelter. The oven-bird, whip-poor-will, wood pewee and various hawks and owls frequented this woodland and where such timber had been cut off enough to allow a growth of hazel and other shrubs, the red-eyed vireo, warbling vireo, redstart, chewink, oven-bird, and yellow warbler are common. The open wooded pastures, both upland and bottom land,

FIG. 13. Characteristic woodland pasture on the river bottom. The trees in the foreground are the Kentucky Coffee-tree. (*Gymnocladus dioica.*)

harbored the greatest variety of breeding birds, the most common being the crow, blue jay, chickadee, blue-bird, green heron, and song sparrow in the more densely wooded section; dickcissel, catbird, brown thrasher, indigo bunting, yellow-billed cuckoo, migrant shrike, and field sparrow in the shrub and open forest portions; while the open or nearly treeless pastures furnished acceptable nesting sites for the vesper sparrow, meadow lark and bobolink. The cultivated areas are not rich in breeding birds. The clover contains perhaps the greatest variety of nesting birds, and the writer has found the field sparrow, red-winged blackbird, grasshopper sparrow, dickcissel, meadowlark, bobolink, and Maryland yellow-throat nesting in it. Dickcissels frequently build in weeds growing in oat and wheat fields, and the writer has found goldfinch nests in thistles in similar situations in other parts of Iowa. The cornfields are practically devoid of bird life, the prairie horned lark and the killdeer being the only two species which the writer has found commonly there during the nesting season.

Fig. 14. Open lowland pasture with a scattered growth of Hawthorn (*Crataegus sp.*)

This leaves for consideration the towns and artificial groves, which contained the greatest concentration of bird life. The bronzed grackle was rarely found breeding except in the various groves of conifers scattered about the country. In Marshalltown the robin, Baltimore oriole, chipping sparrow, flicker, and red-headed woodpecker nested commonly in the trees and shrubs along the city streets. Every year the nighthawk nested on the roofs of buildings, although the writer never found it elsewhere.

The following birds were found to be breeding more frequently in the towns and country groves than in the natural nesting sites along the river, (Those marked with an asterisk were not found breeding in the native timber at all): *mourning dove, flicker, red-headed woodpecker, *kingbird, blue jay, *orchard oriole, *Baltimore oriole, *bronzed grackle, *chipping sparrow, rose-breasted grosbeak, yellow warbler, catbird, brown thrasher, western house wren, wood thrush and robin. Others frequenting these groves as freely as they do the native timber include the downy woodpecker, screech owl, goldfinch, cuckoos, and sparrow hawk.

It is evident that these groves have exerted in the past as they now do, an important influence on the local distribution of breeding bird population. Not even the increase of the English sparrow to a commanding position as far as numbers go seems to have any effect in driving other birds from their nesting sites. Around some farm yards these sparrows have filled with their nests every available nook about the buildings, and dozens of their unsightly structures appear in the near-by trees. Yet with them I have found large numbers of robins, mourning doves, chipping sparrows, and other birds nestling apparently undisturbed.

The only instance of actual destruction of other birds' nests by the English sparrow was one reported by Raymond Jarvis. In this case a robin's nest was entered by a sparrow which dropped out the eggs one at a time.

The absence of breeding marsh and aquatic birds was very noticeable. Only two small bits of marsh land came to my notice, although a few scattered "kettle holes" probably still exist in the northwestern part of the county. A small cat-tail swamp lying at the base of Mormons Ridge and an area near the Country Club which was marshy at some seasons furnished practically all of the breeding records for birds of this type. Of all the marsh-nesting species which are common a short distance to the north and west, the red-winged blackbird was the only common breeding species here.

MIGRATION DATA.

An area along Iowa river between the Country Club and the Marshalltown cemetery was chosen for a study of migration and as nearly as possible this area was covered each day. For two seasons the route used was covered by the same observer at the same hour almost daily during the spring migrations, but because of press of other duties less extensively during the third season. It would seem that with all factors as nearly equal during each trip as it was possible to make them the data secured should furnish a fairly reliable guide to the migratory movements of birds in this region. Once or twice a week trips were made over this territory and up the river to and including the Goose ponds. It was found that while more species would be seen on a single trip over the larger territory the number of new arrivals was not likely to be increased much over that obtained from the more limited area. Some interesting results were obtained from the more limited area. It was found that the number of species seen on a given day varied directly with the length of time spent in the field. On the other hand two or three hours in the early morning seemed to reveal as many new migrants as the longer trips. This probably was due entirely to local conditions. At this point the Iowa river valley is wide, but the timber fringe comparatively narrow. As it is used to the exclusion of any other migration line near Marshalltown, it follows that a careful working of two miles of this timber belt furnished almost as complete a list of the migrating forms as the more extended trip. The route followed each morning crossed and recrossed this timber and the adjacent pasture lands at frequent intervals, and to the best of my knowledge furnished a reasonably accurate list of the birds occupying the territory on that morning. On the other hand a trip covering ten miles of the river bottom offered opportunity to visit localities where other species which were known to be nesting or lingering from previous migration waves could be added to the day's list. One phase of these bird movements brought out repeatedly during the three season's observations was the tendency for a species to appear in large numbers on a certain date and after slowly decreasing for several days, suddenly to increase in numbers again. The goldfinch, a common and noisy species, well illustrates this point. These birds winter in small numbers but do not usually become common before the last of March. In 1913 they first appeared in numbers on March 31. On this date the species was marked common, on April 1 tolerably common, on April 3 several, and on April 5 and 6 three individuals were recorded for each day. They were not recorded again until April 12 and 13 when they were common on both dates. They were then absent until April 19, when a single bird was noted. These birds became common on April 20 and are marked common until April 27, but with explanatory notes. Thus on the 23d a note says "greatly increased." That is, they were common from April 20 to 23, but their numbers increased notably on the 23d. Again they are noted "greatly increased" on May 2, a date which marked the end of the noticeable fluctuations until the breeding season begins. The data for this species in 1914 and 1915 show the same fluctuations in numbers.

Many interesting things were noted during these migration studies, full discussion of which must be reserved, however, for a future paper, but a few of the more interesting are included here.

Late August and early September of both 1913 and 1914 were marked by enormous flocks of sandpipers which were feeding on exposed mud flats around the Goose ponds. These flocks were composed principally of pectoral, least, semipalmated, solitary, and spotted sandpipers, and yellowlegs. In addition many others, including the white-rumped and Baird's sandpipers, killdeer and semipalmated plover, appeared regularly and sometimes in considerable numbers. These flocks were tame and afforded an unusual opportunity for close comparative study. As far as possible the opportunity was used and many hours were spent watching the various activities of the different species.

In 1914 the usual spring flood of Iowa river failed to materialize and the migrating ducks instead of spreading out over hundreds of acres of flooded fields were compelled to remain in the river proper. The Federal migratory-bird law prohibiting spring shooting was in force for the first season and it was very generally observed. Whether or not this had any relation to the numbers of the ducks, the fact remains that more waterfowl were seen during this season than in several previous years spent in various parts of Iowa. As these ducks were practically unmolested they became very tame and remained until long after the usual time of departure for the north. Many species remained until May 1 or later and practically all the latest spring records given in the annotated list were obtained in this year.

In 1915 the country was again alive with ducks, and while more species were present, these did not linger so late as in the previous year. Large numbers remained about a week or more and during that time became quite tame. A muddy willow-grown point projecting into the Goose ponds formed a favorable observation point. On March 31 at this place I noted the following fourteen species of ducks and geese in a few hours, all within twenty to thirty yards: mallard, gadwall, baldpate, green-winged teal, blue-winged teal, pintail, red-head, canvas-back, scaup, lesser scaup, ring-necked duck, ruddy duck, white-fronted goose, and Canada goose. This place of concealment looked out over a favorite feeding spot, and ducks of different species kept drifting in throughout the day. The numbers present varied from a few dozen to many hundreds and furnished an interesting study.

LOCALITIES.

It may be best to define the location of some of the places most frequently referred to in the following annotated list:

Mormons Ridge.—A rough, wooded ridge extending several miles north from the mouth of Minerva creek along the west bank of Iowa river.

Goose Ponds.—An abandoned channel of Iowa river which may be one or a series of ponds according to the stage of the water in the river. Northwest of Marshalltown on the west side of the river.

Cemetery.—Between Marshalltown and Iowa river.

Soldiers' Home.—Between the western part of Marshalltown and Iowa river.

City Park.—A tract of forty acres along the river just east of the cemetery.

Country Club.—On the Iowa river bottom one and one-half miles east of Marshalltown.

ANNOTATED LIST.

The annotated list following contains a total of 201 species, all but two of which are from personal records made between September 1, 1912, and September 7, 1915. A large percentage of these records is based on specimens actually collected, all of which are now in the Public Library at Marshalltown. An additional list of five species given in the hypothetical list includes those forms on which my data were not positive enough to warrant definite records. In addition to these the range of a number of species indicates that they should be found here, but the writer failed to discover them. Some of those which sooner or later are almost certain to be found are the loon *(Gavia immer)*, Hutchin's goose *(Branta canadensis hutchinsi)*, Virginia rail *(Rallus virginianus)*, Henslows sparrow *(Passerherbulus henslowi henslowi)*, and several species of longspurs *(Calcarius* spp.).

1. *Podilymbus podiceps.* Pied-billed Grebe. A tolerably common migrant from March 26 to May 22 and from August 22 to November 4.

A large flight of these grebes alighted on Iowa river on April 24, 1914. Over 100 were counted in a tramp of about three miles along the river. They continued unusually abundant until May 4, when ten birds were seen. In fall they were not as abundant as in spring, single birds being the rule. One bird remained on the pond in the cemetery from October 7 to November 4.

One was caught alive on the morning of April 24, 1914. It was on the ground in a large pasture and seemingly unable to rise. A specimen was collected August 27, 1913, on the Goose ponds.

2. *Larus argentatus.* Herring Gull. A rather rare migrant. On March 25, 1913, a flock of seven large gulls over the pond were rather doubtfully referred to this species. However, they were a considerable distance away and the identification was not absolutely certain. One was positively identified on March 30 of the same year and March 30, 1914, the writer secured a specimen in immature plumage at the Goose ponds. The writer has three other spring records, April 4, 1913, April 4, 1914, and March 20, 1915, and one fall record October 16, 1913, when one was seen eating a partly decayed fish.

3. *Larus delawarensis.* Ring-billed Gull. This species seemed to be more uncommon than the Herring Gull. While on several occasions there have been noted larger gulls which were supposed to be ring-billed gulls the writer has only one positive record, that of May 11, 1914, when a gull of this species in full plumage and with the black ring on the bill distinctly visible, was seen at close range.

4. *Sterna forsteri.* Forester's Tern. A flock of ten Forester's Terns was seen over the Goose ponds on May 11, 1914. This flock and a single bird noted in the same locality May 22, 1915, constitute all the records the writer has for the county. It was probably a regular migrant which was missed because of lack of time to visit suitable localities.

5. *Hydrochelidon nigra surinamensis.* Black Tern. A common migrant from May 11 to May 25 and an uncommon fall migrant. On April 12, 1914, a flock of six were seen over Iowa river below Marshalltown, but no more were found until May 11, when forty were counted over the Goose ponds.

In the fall it was seen on August 22, 1913; July 25, 1914; August 5, 10, 19, and 22, and September 7, 1914.

6. *Phalacrocorax auritus auritus.* Double-crested Cormorant. On October 15, 1912, a cormorant of this species struck the court house tower in Marshalltown and was picked up the next morning. The bird was apparently uninjured and was kept alive for some time in the city park.

One was collected out of a flock of eighteen on May 11, 1914, and a second specimen secured out of a large flock was given to me by Mr. Henry Friese on October 14, 1914. A third was found along the shore of the Goose ponds on the same day. All three records were made in the same locality. The species was undoubtedly a regular migrant through this region.

7. *Pelecanus erythrorhynchos.* White Pelican. A migrant which rarely stopped in this locality. Mr. Henry Friese brought the writer an immature write pelican killed over the Goose ponds on September 28, 1913. The writer later learned of three others which were killed on the same day but failed to secure any of them. This bird was recorded in the Auk. (Vol. XXXI, p. 255, April, 1914).

The only other record is one of a single bird killed south of Marshalltown on May 4, 1914, and brought into the Public Library to be mounted.

8. *Mergus americanus.* Merganser. A rather rare migrant. On April 1, 1913, the writer saw the head of an adult male of this species in a farm yard, and on inquiry learned that it had been shot the day before on the Goose ponds. A pair was watched at the Goose ponds for some time on March 29, 1914.

9. *Lophodytes cucullatus.* Hooded Merganser. A tolerably common migrant from March 27 to April 24 and October 17 to November 15. It was usually found on the sluggish bayous of Iowa river and never appeared in great numbers. On April 4, 1913, Mr. R. Clay sent the writer a beautiful male to be mounted. On April 10, 1913, a male was secured by Mr. Friese and sent to the writer. Both of these specimens were taken on the Goose ponds. Three fall specimens were secured. Harold Buchwald brought one on October 29, 1913, and Mr. Friese two on October 27, 1914.

The hooded merganser was also a rare summer resident, three being flushed from a small pond on June 7, 1913.

10. *Anas platyrhynchos.* Mallard. An abundant spring and fall migrant from February 22 to May 11 and August 22 to December 13. In 1914 numbers of ducks remained until the second week in May and some mallards were in this flock. In 1913 and 1914 the first ducks of this species were noted on March 11 and 12 respectively. In 1915 the ice went out of the river February 12 and the first mallards were seen February 22. This species was usually the second duck to arrive in the spring, being preceded only by the pintail. Their favorite feeding grounds in spring were the flooded bottom land corn fields, where they picked up the waste grain. One female taken April 4, 1914, had a large handful of softened corn in the gullet and was barely able to fly. In the fall the large majority of the migrating birds were seen between October 16 and 27. The earliest fall record was a flock of twenty noted on August 22, 1913, and the latest, a single pair which remained about a little spring on the river bank until December 13, 1913. Single birds were taken on March 22 and 31, and April 4, 1914, and March 20, 1915.

The mallard was also a rare summer resident and probably bred occasionally. The following summer records are at hand: June 7, 1913, a single bird; May 25, 1914, one female; June 4, 1915, one male; and July 31, 1915, a flock of four on a small pond. Mr. Henry Friese informed the writer that he had noted these two pair of birds several times during July.

11. *Chaulelasmus streperus.* Gadwall. In the writer's experience the gadwall was an uncommon migrant and he has only the following records of its occurrence. March 25, 1913, one shot out of a flock of four; and March 29, 1913, a lone female

collected; September 2, 1913, four birds were seen in a flock of blue-winged teal and one secured; a flock of six was noted April 11, 1914; three were seen September 22, 1914; a female was found in possession of a hunter at the Goose ponds October 24, 1914; a flock of ten was observed at the Goose ponds on March 29, 1915; and a pair at the same place on March 31, 1915. All of these birds were found on the Goose ponds, except the one recorded March 29, 1913, which was taken about four miles below Marshalltown on Iowa river.

12. *Mareca americana.* Baldpate. A rare migrant. On March 21, 1914, a flock of four was flushed from a small stream running into Iowa river and a fine male secured. On March 29, 1915, three were seen on the Goose ponds and four more on March 31. These are the only records of the species that the writer has for the region. Most hunters did not seem to know the duck.

13. *Nettion carolinense.* Green-winged Teal. An abundant spring migrant from March 14 to May 9. The species was unusually abundant in 1914, large numbers remaining along the river until April 11 and a few lingering until May 9. It was much less common in the fall from September 1 to October 24. March 24, 1913, Harold Buckwald brought in a female which was shot the previous day along Iowa river. A male was secured on April 4, 1914, at the Goose ponds. An injured female was found at the same place on September 1, 1913, and one was taken September 5, 1914. Three were secured on October 4, 1913,

14. *Querquedula discors.* Blue-winged Teal. The blue-winged teal was the most abundant duck of the section. In the spring migration it appeared from March 15 to May 25, although it was most common in late March and early April. In the fall migration from August 22 to November 3, it was much less common.

During the spring migration of 1914, these birds remained in numbers until May 16. As they were undisturbed they became very unsuspicious, and it was possible to walk slowly within twenty yards of a feeding flock before they flew. A few were reported by Mr. Friese to have remained throughout the summer of 1915, about the Goose ponds. Specimens were collected at various times.

15. *Spatula clypeata.* Shoveller. A tolerably common spring migrant from March 14 to May 11. This was one of the later migrants and was most common from April 25 to May 4. In the fall only scattered individuals or pairs were noted from September 5 to November 1. Mr. Clay gave the writer a female shoveller which was taken on Iowa river above Marshalltown, April 4, 1913. Others were collected May 3 and October 4, 1913.

16. *Dafila acuta.* Pintail. The pintail was the earliest and one of the most abundant spring migrants. It appeared from February 14 to April 4. In 1914 a few individuals remained until May 11 when a single bird was noted. This duck regularly arrived immediately after the breaking up of ice in the river. A heavy freshet on February 12, 1915, drove the ice out of the river and two days later the first pintails arrived. They were seen until February 27 when cold weather set in, and they were not noted again until March 28, when they appeared in great numbers. They were common until April 1, and no more were seen after that date. This was about two weeks later than the height of the migration in 1913 and 1914. The writer has no fall records for this region. Pintails were taken March 15, 1913, and March 21, 1914.

17. *Aix sponsa.* Wood Duck. The writer's only record is of a flock of six seen September 5, 1915, at the Goose ponds. He walked up behind a clump of willows within twenty yards of this flock and watched them for some time before they flew. This duck undoubtedly nested in the county in the past and Mr. Metcalf of Albion stated that he frequently saw them below Tama on Iowa river.

18. *Marila americana.* Redhead. On March 21, 1914, three redheads were flushed from Iowa river and one was wing-tipped. This bird fell on the opposite bank of the river, ran off into the weeds and was lost. On March 29, 1915, a flock of thirty redheads was observed on the Goose ponds, and later in the day four were seen with a flock of scaups. On March 31, two more were noted on the ponds. These are the only records the writer has for the region. It was probably a regular and not uncommon migrant in the spring.

19. *Marila valisineria.* Canvas-back. This duck was reported occasionally by hunters, but the writer's only record is

of a flock of six noted on the Goose ponds March 31, 1915 It was probably a more or less regular migrant through the county but did not appear in any numbers.

20. *Marila marila.* Scaup Duck. The writer has only spring records for this duck and few of them, although it undoubtedly occurred more frequently than these records show. One male was collected April 4, 1914, on the Goose ponds and a number were observed there on March 29 and 31, 1915. Except under favorable conditions it is not easy to distinguish this duck from the lesser scaup, and as a consequence this bird probably escaped notice many times.

21. *Marila affinis.* Lesser Scaup. The lesser scaup was found commonly as a spring migrant from March 13 to May 11. In the fall it appeared in smaller numbers from October 22 to November 14. On March 13, 1913, a female was secured from the roof of the Court House in Marshalltown. This bird had struck the tower the previous night and had been killed. Two others were collected on the Goose ponds April 19, 1913. As a spring migrant the lesser scaup was most abundant during the last week in March.

22. *Marila collaris.* Ring-necked Duck. The ring-necked duck or "Black Jack" was a regular spring migrant, but did not appear in any numbers except in 1915, when it was common from March 27 to March 31. The earliest date for the spring migration was March 21, 1913, when several were secured by hunters, and the latest was May 1, 1914, when a single male was seen on the river near the Country Club.

On April 25, 1915, a male was observed on the Goose ponds. When this bird saw the writer it submerged and swam with only the bill and eyes visible until out of gunshot when it rose from the water and flew away. My only fall records are of a pair which were seen on the Cemetery pond October 23, 1913, and a single bird seen October 31 in the same place. A female was secured March 31, 1914, and a pair March 31, 1915. All three were taken on the Goose ponds.

23. *Clangula clangula americana.* Golden-eye. The only record for this species is of seven birds secured out of a flock by hunters on December 6, 1913.

24. *Charitonetta albeola.* Bufflehead. A male bufflehead was noted on the river near the Country Club on March 31, 1913.

A crippled bird (female) was found just above the Soldiers' Home on May 9, 1914. These are the only records the writer has for the species in this territory. It was probably a fairly regular migrant.

25. *Erismatura jamaicensis.* Ruddy Duck. The ruddy duck was noted only twice, both times in the spring. On May 2, 1914, a pair were seen swimming about in the Goose ponds and on March 31, 1915, another pair were seen at close range in the same pond. It was probably not an uncommon duck.

26. *Chen hyperboreus hyperboreus.* Snow Goose. A large flock of snow geese probably of this subspecies were noted in a pasture near the Goose ponds on March 15, 1913, but none were secured. Very few geese alighted in this territory unless forced to do so by stormy weather and no other snow geese were seen.

27. *Anser albifrons gambeli.* White-fronted Goose. A flock of about twenty-five of these geese were noted in the lower end of the Goose ponds on March 30, 1913. A convenient dike allowed approach within sixty yards to watch them for some time through the glasses. On March 31, 1915, three were seen in

28. *Branta canadensis canadensis.* Canada Goose. The Canada goose was a common spring migrant from March 7 to April 4. It was also common in the fall from October 12 to December 1. Most of them passed high over head without stopping, but occasionally they were driven down in numbers by unfavorable weather.

Although *B. c. hutchinsii* undoubtedly occurs, the writer never handled specimens. Two killed by Mr. Henry Friese October 12, 1913, and presented to the writer were typical *canadensis.*

A terrific wind and rainstorm the night of March 23, 1913, drove great numbers of these geese to the ground. They were heard passing back and forth over town and the next morning they were found to be common over the entire river bottom. By eight o'clock they had all disappeared.

In the spring of 1915 a flock of about twenty birds remained in a large corn field for nearly two weeks. They wandered about the field feeding on waste corn and left a perfect network of tracks, in the mud and snow. The little knoll where they roosted at night was covered with dung and feathers and gave the impression of a great number of birds. This flock was last seen on March 31.

29. *Botaurus lentiginosus.* Bittern. A tolerably common migrant from April 5 to May 19. Less common migrant from August 27 to October 24.

A rare summer resident. A pair was seen about a small pond near Mormons Ridge through June and July of 1915, and undoubtedly nested. This species would be more plentiful if it were not used as a target by many gunners. Lack of suitable nesting sites also prevented its breeding in any numbers.

30. *Ixobrychus exilis.* Least Bittern. The least bittern was a rare migrant and also a rare breeding species. Two birds seen at the Goose pond on May 22, 1915, were the only migrating birds to come under observation.

On June 28, 1915, a nest was found in a small swamp near Mormons Ridge. At this time it contained four eggs. When the nest was again visited on July 23, it contained four downy young which were not over four or five days old.

31. *Ardea herodias herodias.* Great Blue Heron. A common spring migrant from March 28 to May 12. Much more common in the fall from July 25 to November 22. A male secured November 8, 1913, along Iowa river had his feet frost bitten but was otherwise in good condition. On April 8, 1913, Mr. Henry Friese brought in a male in fine plumage which had been shot at the Goose ponds. These herons became quite numerous during August and as they were unmolested got tame and unsuspicious. After September 1 they became rare as those which were not killed left the territory after the opening of the hunting season.

32. *Butorides virescens virescens.* Green Heron. A very common summer resident from April 24 to September 26. A single belated individual was found November 6, 1914, on Minerva creek. A female was seen flying from a nest in a tall elm on June 28, 1915, at Mormons Ridge. No attempt was made to reach this nest but one egg could be seen with the aid of the glasses.

33. *Nycticorax nycticorax naevius.* Black-crowned Night Heron. The black-crowned night heron was an uncommon spring migrant from May 3 to May 29 and a common fall migrant from July 27 to October 3. A single immature bird was taken on No-

vember 3, 1913, along Iowa river. During the first two weeks in September of 1913 and 1914 a small flock of these birds formed a roost in a clump of trees between the Goose ponds and Iowa river. They remained until September 12, 1913, and to September 22, 1914.

34. *Grus mexicana.* Sandhill Crane. According to the older hunters this bird was formerly common in this region. It is now rare and the only definite record that the writer has is of a flock of thirty-five seen April 1, 1913.

35. *Rallus elegans.* King Rail. Owing to the scarcity of suitable nesting sites this bird was a rare summer resident. An adult followed by a single downy young crossed the road in front of the writer near Mormons Ridge on July 13, 1915. A hunter told of seeing an adult and young in a bit of swampy land near the Country Club on July 25, 1915. On July 27 this spot was visited and an adult and eight downy young were found. These are the only records the writer has for the county.

36. *Porzana carolina.* Sora Rail. The sora is tolerably common as a spring migrant from May 3 to May 24. On May 22, 1915, ten birds were seen, which was the greatest number observed on one day. One was collected on May 17, 1913, at the Goose ponds and one was brought in which had been picked up along Linn creek on May 12. In the fall it was seen twice, a single bird September 18, 1914, and three September 22, 1914.

37. *Gallinula galeata.* Florida Gallinule. A rare migrant in both spring and fall. One was collected out of a flock of coots on May 4, 1914, at the Goose ponds. One was seen in the same place October 17, 1914. This bird probably occurred more frequently, but escaped notice.

38. *Fulica americana.* Coot. A common spring migrant from March 25 to May 24 and less common in the fall from September 22 to November 1. Coots were regularly shot by gunners and left lying along the banks of the river. Consequently they were seldom seen in any numbers except in 1914, when flocks of from ten to fifty were seen between April 11 and May 16. One taken October 12, 1913, is in the collection.

39. *Steganopus tricolor.* Wilson Phalarope. A pair was noted feeding on the mud flats at the Goose ponds May 2, 1914, and the male was collected. They were feeding in company with

a flock of yellowlegs when found. This is the writer's only record for the county.

40. *Gallinago delicata.* Wilson's Snipe. The Wilson Snipe or "Jack Snipe" was tolerably common in spring from April 15 to May 4 and a much more common migrant in fall from September 26 to November 18. A single bird remained about the sewer outlet at Marshalltown until November 18, 1913. One taken November 7, 1913, is in the collection.

41. *Macrorhamphus griseus griseus.* Dowitcher. A rare spring and fall migrant. One was secured from among a flock of sandpipers on August 10, 1914, and two others were seen on May 22, 1915. On both occasions the birds were found in a small swampy spot near the Goose ponds.

42. *Pisobia maculata.* Pectoral Sandpiper. This was the most common sandpiper of the region in both spring and fall migrations though far more abundant during the latter season. The spring migration extended from April 4 to May 22, and the fall from July 8 to November 18. The waters in the Goose ponds became low during July and August and great flocks of sandpipers fed over the mud flats thus exposed during the latter month. Though the fall migration was extended over a long period by straggling individuals or small flocks the sandpipers were most abundant from about August 10 to September 7. Some notes on this and succeeding species were published in the Wilson Bulletin, Vol. XXVI, p. 45.

43. *Pisobia fuscicollis.* White-rumped Sandpiper. Only two records are at hand for this species in spring; namely, May 4 and 8, 1914. Two birds were seen on each occasion. In the fall it was noted regularly from August 19 to 27, but between those dates was very common. One taken on August 19, 1914, was too badly shot to make a skin. A single straggler was collected November 7, 1913, at the Goose ponds. It was so fat that the skin broke open on the breast when it fell. This bird was recorded in the Wilson Bulletin, Vol. XXVI, p. 45.

44. *Pisobia bairdi.* Baird's Sandpiper. Noted as a spring migrant only in 1914 when a few were seen on several dates from April 25 to May 11. In the fall they were a tolerably common migrant from August 15 to September 7. They could readily be picked out in the great mixed flocks of sandpipers that fre-

quented the mud flats of the Goose ponds. One was taken September 7, 1914. For 1913 records see Wilson Bul. Vol. XXVI, p. 45.

45. *Pisobia minutilla.* Least Sandpiper. A common spring migrant from April 25 to May 22 and abundant in fall migration from July 8 to October 12. Next to the pectoral this species was the most numerous sandpiper, in the fall flocks. They were so common and tame that it was difficult to collect shore birds without getting them. They were most abundant during August and early September.

46. *Pelidna alpina sakhalina.* Red-backed Sandpiper. On October 6, 1913, after the bulk of the sandpipers had departed, four of this species were found feeding on the deserted mud flats around the ponds. One was taken at this time. On the 10th on again visiting the ponds the writer was surprised to find a flock of fifty-two in one place and eight in another. These flocks were very tame and allowed a close approach and were actually counted. Four specimens were taken from this flock. These birds have been recorded in Wilson Bul., Vol. XXVI, page 45.

47. *Ereunetes pusillus.* Semipalmated Sandpiper. The semipalmated sandpiper was observed in spring from May 4 to 8, 1914. In the fall it was common from August 3 to September 7 and a single belated bird was seen October 12, 1913. (Wilson Bul., Vol. XXVI, p. 45.)

48. *Totanus melanoleucus.* Greater Yellowlegs. The writer has only three records of the greater yellowlegs in Marshall county. A single bird was taken at the sewer outlet on April 23, 1913. Another bird was seen but not taken on the Goose ponds on October 6, 1913, (Wilson Bul., Vol. XXVI, p. 45), and a third seen near the same place August 10, 1914.

49. *Totanus flavipes.* Yellowlegs. A common migrant from April 11 to May 24 and abundant in the fall from August 3 to September 20. On October 20, 1913, one of this species was secured and another was seen on November 1. (Wilson Bul., Vol. XXVI, p. 45.) These two latter were probably late stragglers as no others had been seen later than September 20.

50. *Helodromas solitarius solitarius.* Solitary Sandpiper. A very common migrant from April 23 to May 31 and July 8 to October 7. (Wilson Bul., Vol. XXVI, p. 45.) The solitary sandpiper did not frequent the mud flats as constantly as the other sandpipers but was more often found along Iowa river and the smaller streams.

51. *Catoptrophorus semipalmatus inornatus.* Western Willet. A rare migrant, the only record being a bird secured at the Goose ponds on May 2, 1914. This bird was sent to Mr. H. C. Oberholser who identified it as the western form.

52. *Bartramia longicauda.* Upland Plover. The only two spring records that the writer has for this species are of single birds seen on June 7, 1913, and May 2, 1914. In the fall it was not an uncommon migrant from July 27 to September 1. These fall birds fed by preference on cut over clover or alfalfa lands, a fact which was accidentally discovered. The birds were wild and shy while in this locality which was in decided contrast to their rather unsuspicious ways in northwestern Iowa where they bred in considerable numbers a few years ago.

53. *Actites macularia.* Spotted Sandpiper. A very abundant migrant from April 23 to May 24 and from August 10 to October 8. (Wilson Bul., Vol. XXVI, p. 45.) Also a common summer resident and breeding species. Young birds partly grown were common along the river in July. The only nest of this species found was one reported by a grade school boy on June 2, 1914. This nest containing four eggs was destroyed by a sudden freshet in the river on June 8. A pair with three downy young were seen on July 8, 1914.

54. *Charadrius dominicus dominicus.* Golden Plover. A rare fall migrant. A female was taken on October 4, 1913. The bird was alone feeding on a mud flat and took wing at my approach. As it flew it was seen to be a new form and it was collected. (Auk. XXVI, p. 255, April, 1914.) A hunter stated that the day before he had taken four out of a flock of five at that point and this one may have been the survivor. A flock of twenty-five was noted on October 3, 1914, in almost the same place. This flock was feeding in the wheat stubble and was very wary and suspicious.

55. *Oxyechus vociferus.* Killdeer. A common summer resident from March 14 to November 1. In the spring migration numbers of killdeer passed through this locality until about May 1, after which date only the breeding birds remained. Small flocks probably of breeding birds began to appear in late July. Gradually the flocks grew larger, the maximum number being present during the first ten days in October.

A pair with four downy young were seen along the Goose ponds on July 8, 1914. In June of 1915 Mr. Henry Friese sent two young killdeers just a few hours old which he had captured in his corn field.

56. *Aegialites semipalmata.* Semipalmated Plover. An uncommon migrant. One out of a flock of nine was taken September 1, 1913, while they were feeding on an extensive mud flat. It was also recorded on August 22 and 27 and September 20 of that fall. In the spring of 1914 two were noted along the shores of a small pond on May 3. These remained until the 8th when they were joined by another, and the three were last noted on May 10. Between August 10 and 22 from one to three birds were noted at the Goose ponds on various dates. The species was not found at all in 1915.

57. *Colinus virginianus virginianus.* Bob White. This species was local. On several farms that were visited where the birds were carefully protected small coveys could always be found but outside of these places the records are few. Three downy young were seen June 14, 1915, but no nests were found. Further down Iowa river it is reported to be more common.

58. *Tympanuchus americanus americanus.* Prairie Chicken. An uncommon permanent resident. Their numbers were somewhat increased during the winter by birds from farther north but in nearly three years of field work in this region the writer saw only seven flocks of these birds. The largest of these contained twenty-five birds and the smallest three. A nest was reported from north of Marshalltown in 1914, but by the time the place was visited the birds had either hatched or the eggs had been destroyed. It undoubtedly bred in small numbers throughout the country.

59. *Zenaidura macroura carolinensis.* Mourning Dove. An abundant migrant and summer resident from April 2 to Octo-

ber 10 and a rare winter resident. In the fall of 1912 three mourning doves remained about an open pasture until December 4. A bird reported by Mr. Henry Friese spent the winter of 1914-1915 about the barn yard of his place (the writer saw the bird February 21).

The mourning dove nested commonly throughout the region under discussion. The favored site seemed to be in the coniferous trees or fruit trees about farm buildings. On May 30, 1915, twelve nests containing eggs or young were found in a small grove of spruce containing possibly a hundred trees. On June 4, 1915, fourteen occupied nests were found in another little grove of conifers less than two miles distant from the one visited on May 30. Little attention was paid to the nesting of this species except in 1915. The earliest date noted on which eggs were found was May 23, 1915. The eggs hatched May 30. The latest date is July 16, 1915, when a nest containing two eggs was found. One nest discovered June 5, 1915, contained one egg. The second one was laid on June 6 and the eggs hatched on June 21. This gives an incubation period of fifteen days.

Most of the nests seen in this locality were of the usual type—that is flimsy, loosely woven platforms built in conifers, fruit trees, etc. Three unusual ones were noted. A nest found on June 6, 1913, was built in the hand of a stone figure on a monument in the Marshalltown cemetery. A very few sticks had been placed in the hand before the eggs were laid. This nest was about ten feet from the ground. Two pairs found in 1915 (May 30 and June 4) were using old robins' nests.

60. *Cathartes aura septentrionales.* Turkey Vulture On October 4, 1913, the writer collected a juvenal female turkey buzzard at Clay Bluffs. (Auk, Vol. XXVI, p. 255, April, 1914.) The bird was resting on a willow stub near the water's edge and took wing as we approached. Another bird was seen the same day and again on October 12. On May 12, 1915, Mr. Charles Metcalf reported that he had found a nest (two eggs) of this species in a hollow stump near Mormons Ridge. June 24 the writer visited this nest with him and found a single downy young. The nest was visited at intervals till July 14 at which time the nestling was nearly full grown. The wing quills were developing rapidly and the body feathers were beginning to show through the down. A number of unsuccessful efforts were

made to watch the bird from a blind. A regular umbrella blind was used and when this failed a nearby pile of cord wood was converted into a hiding place with no better success.

61. *Circus hudsonicus.* Marsh Hawk. The marsh hawk was recorded every month in the year except January but was most common as a migrant in March and October. A single male secured by Hartley Vogt November 7, 1913, is the only one from this region in the collection. It is an uncommon summer resident and breeding species. During July of 1915, Mr. Friese found a nest of this species containing young.

62. *Accipiter velox.* Sharp-shinned Hawk. Hawks of all kinds were comparatively uncommon in this region, owing to the prevailing custom among the gunners of shooting every one that comes within range. The sharp-shin was found as a spring migrant from April 27 to May 22 and in fall from September 12 to October 21. Three specimens were taken as follows: An adult female, April 27, 1913; a male, October 12, 1913; and a female, September 12, 1914.

63. *Accipiter cooperi.* Cooper's Hawk. Recorded from April 3 to November 15 but never abundant. This species occasionally bred, as several eggs of "hen hawks" in the collections of boys in Marshalltown belonged to it. A young bird evidently not long out of the nest was seen at Mormons Ridge on July 1, 1915. One pair started to build in a tall willow along Iowa river in April, 1914, but disappeared before completing the nest.

64. *Buteo borealis krideri.* Red-tailed Hawk. Except the sparrow hawk, the red-tail was the most common hawk of the region. It was found in all months except January, being most abundant as a migrant in March and April and October and November. On April 29, 1914, a pair were noted about a nest in a tall cottonwood but they disappeared in a few days. A pair nested in 1914 in a little clump of giant cottonwoods on Iowa river about five miles above Marshalltown. No details as to this nest were secured. Mr. Friese gave the writer an immature red-tail which was shot October 19, 1913, just after it had boldly killed a chicken in his yard. A second specimen was secured on October 25, 1913. Mr. H. C. Oberholser has identified these two specimens as *B. b. krideri.*

65. *Buteo lineatus lineatus.* Red-shouldered Hawk. On October 25, 1913, an immature bird of this species was secured from a dense patch of timber along Iowa river. It is the only record of this hawk for the county. (Auk, Vol. XXXI. p. 255, April, 1914.)

66. *Buteo platypterus.* Broad-winged Hawk. A tolerably common migrant from April 1 to May 22 and August 21 to September 30. A single straggler was noted November 27, 1914. More broad-wings are shot by gunners than any of the other *Buteos* because of their habit of allowing a person to walk within easy gunshot before taking wing.

67. *Haliaeetus leucocephalus leucocephalus.* Bald Eagle. Harold Merryman brought in an adult male bald eagle on May 13. 1913. The bird had been killed with a twenty-two caliber rifle the previous day. It was found in an open pasture six or seven miles north of Marshalltown.

68. *Falco columbarius columbarius.* Pigeon Hawk. One noted September 21, 1913, by Mr. Howard Graham and the writer. We were looking at a flock of mourning doves sitting on a telephone wire when our attention was drawn to a bird much nearer to us. At first it was taken for another dove, but when the glasses were turned on it, it proved to be a hawk of this species. We walked slowly to within twenty feet of it and walked all around it. The bird paid little attention to us but made a dash at a mourning dove which flew by. It chased the dove around a little willow thicket and then started after another one which flew by, both birds passing quickly out of sight among the trees.

69. *Falco sparverius sparverius.* Sparrow Hawk. This was the most common hawk of the county. It was a common spring migrant and uncommon summer resident from March 15 to October 12. It was found in the greatest numbers in March, April and September. An adult male was taken September 12, 1913.

It was occasionally noted during the summer and on July 13. 1915, an adult female was seen accompanied by a barely fledged young bird. They were sitting on fence posts along a country road north of Albion. A nest was reported in 1914, but could not be visited until it was too late.

70. *Pandion haliaetus carolinensis.* Osprey. The Osprey was a rare migrant through Marshall county. The only spring record is of one seen April 29, 1914. It is rather more common in the fall and the writer has four records as follows: September 19, 1913, two were noted along Iowa river and one was taken (Auk, Vol. XXXI, p. 255, April, 1914). Another was seen September 26, 1913, and single birds were noted September 5 and 18, 1914.

71. *Asio wilsonianus.* Long-eared Owl. An uncommon breeding species. On April 3, 1913, four of these birds were found roosting in a small hawthorne tree overgrown by grape vines. About 226 pellets were collected under this tree. These have been examined by the Biological Survey and the following mammals and birds have been identified from them:

4 Song Sparrows *(Melospiza melodia)*;
1 Robin *(Planesticus migratorius)*;
1 Least Shrew *(Cryptotis parva)*:
5 Short tailed Shrews *(Blarina brevicauda)*;
3 House Mice *(Mus musculus)*;
89 White footed Mice *(Peromyscus c. noveboracensis)*;
70 *Meadow Mice (Microtus pennsylvanicus)*;
18 *Meadow Mice (Microtus ochrogaster)*.

On May 10, 1913, a nest of this species containing four eggs was found near the roost tree. The nest was about twenty feet from the ground in a vine covered tree. It was visited on May 12, 17, 24, 30, 31 and June 7, for the purpose of photographing the young. The parent birds invariably went through the same performance while the writer was about. The one on the nest remained until I actually started to climb the tree. Then it would swoop down at me, swerve to one side and land on a branch about thirty feet from the nest. This bird then commenced to make a curious moaning sound, roll its eyes and snap the mandibles together. About this time the other parent would appear on the scene and a duet of these sounds, interspersed with two other notes which might be described as a hoarsely uttered "wah-wah-wah—" and "wuk, wuk, wuk," followed. The feathers were ruffled, the wings partly spread and occasionally they made short flights from one tree to another while this concert was going on. On May 17 one young one and two eggs were found—the fourth egg having disappeared. A meadow mouse (*Microtus sp.*) was found in the nest. On May 24, there were three young. The oldest one had grown considerably and was beginning to show traces of pin feathers. A second *Microtus* was found on this visit. On May 30 the oldest one had distinct feathers on the wings and showed faint black bars on the breast. On the last visit, on June 7, the oldest bird was found on a branch beside the nest. The wing quills were about two inches long. The others were in about the same state of development as this bird was on May 30. The difference in the size of these birds would seem to indicate that the parents begin incubation as soon as the first egg is laid.

Outside of this nesting pair and the four found roosting there are only two records. These were of single birds seen on August 27, 1913, and March 14, 1914.

72. *Asio flammeus.* Short-eared Owl. A regular winter visitor from October 7 to March 21. There is only one summer record for the county though it breeds regularly a little farther north. On August 19, 1914, a single bird of this species was seen near the Goose ponds. On August 21 one (presumably the same bird) was collected at this place.

73. *Strix varia varia.* Barred Owl. On November 15, 1913. Mr. Howard Graham and the writer were attracted by the noise made by a large flock of crows and found an owl of this species surrounded by them. We followed the bird for some time but finally lost it when it crossed the river. This is the writer's only record for the county.

74. *Otus asio asio.* Screech Owl. A common permanent resident and the most abundant owl of the county. On June 6, 1913, a nest of this species was found containing two young just able to fly. July 20, 1915, while walking along the street in Marshalltown about 8:00 p. m. the writer was viciously attacked by a screech owl. Investigation disclosed two barely fledged young in the tree under which he was passing. People who resided in the neighborhood said that these owls had made a regular practice of flying at people in the evening or even clutching at their hats as they did at mine.

75. *Bubo virginianus virginianus.* Great Horned Owl. On the evening of June 25, 1915, a great horned owl alighted in the top of a broken aspen tree in front of a camp at Mormons Ridge

and proceeded to give a serenade. He was heard again on June 29 and July 1. This is the only bird of this species which the writer saw in the region.

76. *Nyctea nyctea.* Snowy Owl. This species was an irregular winter visitor. The writer saw no living birds during his stay, but was informed by Mr. Charles Metcalf that several had been seen during the month of January, 1914. There are a number of mounted specimens in the public library of Marshalltown without labels, but doubtless these are local birds.

The remainder of this paper will appear in Volume XXVI of these Proceedings.

U. S. Department of Agriculture
Bureau of Biological Survey.

THE INFLUENCE OF FLOODS UPON ANIMALS

D. M. BRUMFIEL.

TABLE OF CONTENTS

INTRODUCTION.

The attention of the writer was first called directly to this problem by certain observations made along the White Water river, in southeastern Indiana, at the time of the great flood which swept that section of the country in the spring of 1913—generally known as the Dayton Flood. The writer was attempting to make collections of insects in the bottom lands of this small tributary of the Ohio river between the downpours of rain on Monday, March 24, 1913, at the time when that particular stream overflowed its banks. The observation that certain forms of animal life were destroyed outright, and others were forced to flee before the rising water, while still others were carried along on floating driftwood and other debris by which they might be introduced into new regions led to analysis of the influence of such floods upon animal life.

This analysis is based upon the study of the limited portion of the White Water valley with which the writer is the most familiar, in occasional visits to the region in the two years following March, 1913, together with a careful review of the changing conditions which have been noticed since the largest previous flood, that of 1898. Having analyzed these changes and their underlying causes the writer had hoped to follow this with a careful survey, verified by actual collections to substantiate the conclusions and illustrate the statements made. Having not been able to spend sufficient time in the region at times when extensive collections were possible, and for the same reason being unable to follow the intermediate and successional changes between floods, it has been considered advisable to present this brief paper in order to record the observations made and also in order to call the attention of other workers to this interesting problem in the hope that some one, more favorably located, may care to continue the work by more intensive studies.

The photographs were all taken by the author, April, 1915, unless otherwise stated.

GENERAL DISCUSSION OF THE REGION STUDIED.

The limited region under observation consisted of a small por-

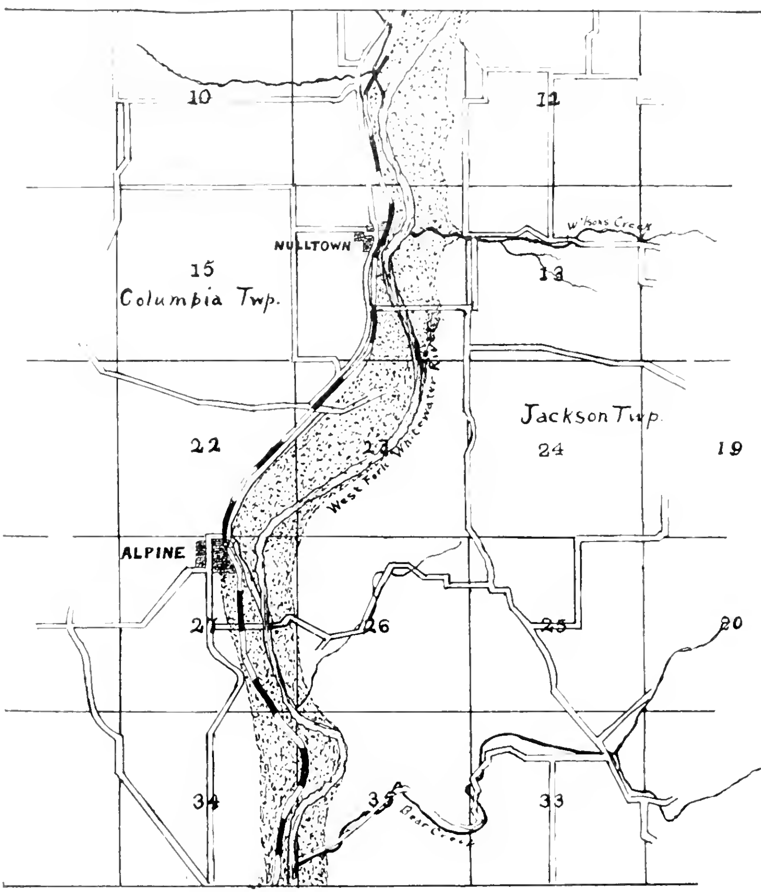

FIG. 15—A portion of Jackson and Columbia townships, Fayette county, Indiana. The course of the West Fork White Water river with stippling to indicate the area covered at high water. Map by H. M. Trusler and the author.

tion of the extreme western edge of Jackson and the extreme eastern edge of Columbia township, Fayette county, Indiana, about five miles south of the county seat, Connersville. The West Fork of the White Water river forms the boundary line between these two townships, claiming a narrow portion of each for its flood plain. The stream itself, when normal, varies from perhaps fifty to a few hundred feet in width and from eighteen inches to a maximum depth of about twelve feet. As

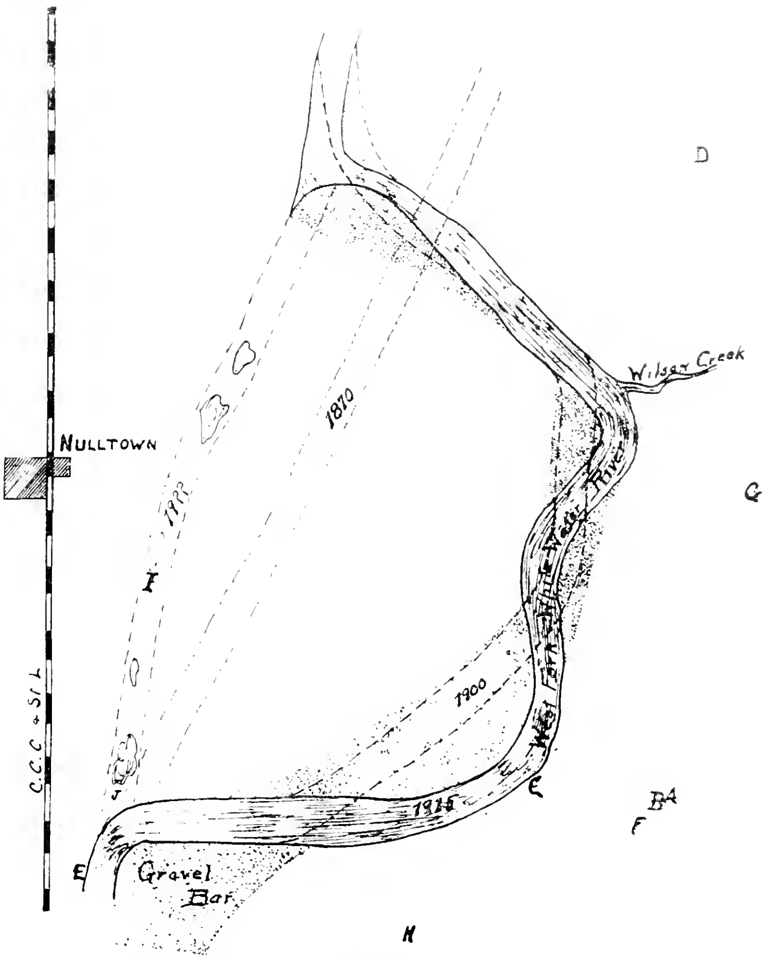

FIG. 16.—Small portion of the region shown in figure 15 on a larger scale, showing changes in the course of the stream and the location of the most prominent gravel bars. The separate letters correspond to the letters of certain of the following figures and mark the locations from which the photographs were made. Map by H. M. Trusler and the author.

with all streams of this size in this region, it flows rapidly, has well defined alternating pools and rapids, and has for the most part a gravelly bottom. It is subject to annual freshets and usually overflows its banks at least yearly. In such a flood as that of 1913 it attains a width of nearly a half mile, altering its course, sculpturing its flood-plain, and sweeping away fences, crops and even buildings during its brief period of devastation. Figure 15 shows a mapping of its course for five miles with the area covered at high water indicated in shading.

The most careful study was given to that portion near the mouth of Wilson's creek and this has been given in an enlarged mapping (figure 16) to show greater detail and a careful approximation of the changes in the course of the stream over this area. The separate letters indicate the places from which were taken the photographs that serve to illustrate the physiographical and vegetational features.

WAYS IN WHICH THE FLOODS INFLUENCE ANIMAL ASSOCIATIONS.

In analyzing the ways in which floods affect the local distribution of animals, that is, animal associations, it is at once recognizable that all of the efforts are carried out in one of two general ways: viz., first, by abruptly changing the habitats of the animals topographically; and second, by directly changing the composition of the associations themselves without necessarily affecting the physical habitat.

Of the foregoing, topographical changes may be brought about in several ways: (1) the course of the stream may be directly altered, (2) the character of the stream may be altered, that is the local habitats within the stream itself may be subject to physical disarrangement, and (3) changes may be brought about in the physiography of the flood-plain.

It is too obvious to need elaboration that in the alteration of the course of a stream areas which were once the abode of wholly terrestrial forms come to harbor only those which are aquatic, and likewise aquatic habitats are transformed into those which can support only terrestrial forms of life. The map comprising figure 16 is an enlarged sketch of the aforementioned portion of the stream near the mouth of Wilson's creek, on which an attempt has been made to show the changes in the course of the river in recent years. Dotted lines indicate the approximate bed of the river in 1870 (from data gathered from men who have spent upwards of fifty years in the immediate vicinity), in 1900 and a new channel which the stream is cutting for itself and in

FIG. 17.—The rising water in the flood-plain, March, 1913. It was at this point that the writer took the caterpillars from the grass blades and weed stems. Location A, figure 16.

FIG. 18.—Permanent pool in the bottom of a large washout. The ground upon which the writer stood in taking the photograph for figure 17 was taken away in the formation of this washout. The same line of fence posts shows in both figures. Location B, figure 16.

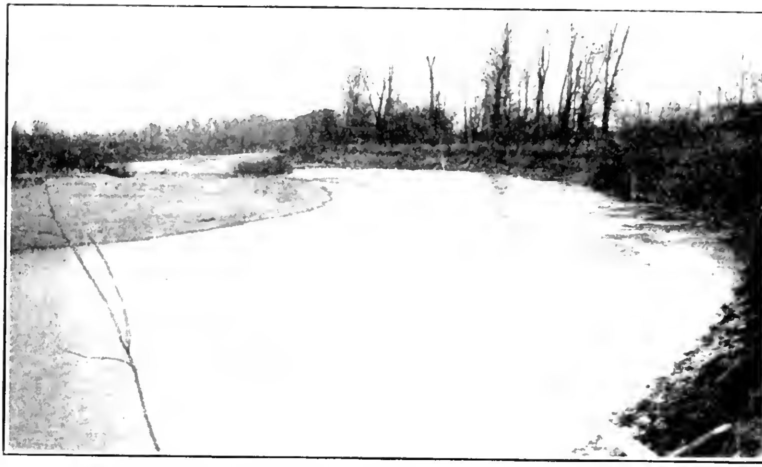

FIG. 19.—Looking up White Water river. The low gravel bar opposite the steep soil bank into which the stream is cutting is shown. In 1900 the right hand bank of the stream at this place was several rods to the left of the edge of the photograph. Location C, figure 16.

FIG. 20.—The flood assisting to protect against itself. The young forest, mostly elm, has been planted in the last few years on the flood-plain by seeds carried by the high water and the wind. Location D, figure 16.

which it promises to be established within a very few years. The actual course of the stream in 1915 is represented by continuous lines. The cutting of the new channel and the permanent pools established there (shown also on the map) come properly under the discussion of the flood-plain and will be considered there. The stippled sections represent gravel bars and directly opposite each the stream flows against a relatively high soil bank into which it is rapidly cutting at these points.

In the changing of the course of a stream there are other effects which incidently influence the animal life beside the important one noted. Of these the features perhaps the most deserving of notice are the oxbow lakes or ponds which are left isolated from the stream, except in the flood season, as cut-off depressions in the old channel. Many of these contain water throughout the year, their bottoms being below the level of the water in the stream, and may persist for a number of years before they are finally filled by the deposition of material and the growth and decay of aquatic and amphibious plants. In such formations are found persisting those forms of animal life from the original stream which are adapted to existence in quiet water. Later purely pond forms may be introduced and become established.

Changes within the stream itself may be many. Deep, quiet pools may be created where there were none by the scooping out of material from the bottom or by partial damming by the piling up of stones and gravel to form a new rapids, increasing the depth of water above that point. Sand bars, shoals, or mud flats may be built up. Rapids may be cut down through the action of successive floods. The sorting of the soil materials may decidedly alter the character of the bottom leaving sand where there was mud or flat stones where there was formerly sand, etc. Each of these changes results in a change in the kinds of animals which are to be found there. The deep, quiet pools will provide a home for larger fish and different species of fish than could exist permanently in the shallow water or in the rapids. The stony bottom and stony rapids provide shelter for many crustaceans and insect larvæ such as May flies (Ephemerida) and Stone flies (Plecoptera) while the mud bottoms abound in worms and molluscs, e. g. the common species of fresh water mussel, all being forms that do not thrive in other conditions. The stony rapids, shown in figure 21, have been a favored habitat for the last several years of numbers of the small yellow catfish, (no specimens were secured but they possess strong similarity to the stone cat *Noturus flavus* Rafinesque, in habits and appearance except that they seldom attain more than eight inches in length) and Neuropterous larvæ (*Corydalis cornuta* Linneus). *Necturus maculosus* Rafinesque has also been taken here occasionally. Needham and Lloyd (Needham, J. G., and Lloyd, J. T., 1916) record similar data from their observations on Fall creek, Ithaca, New York.

Hand in hand with the above mentioned changes in the bottom of the stream occur changes in the nature of its banks which may be abrupt and cut in clay (see figure 19) or rock, or gradual and consist of sand (see figure 19), gravel or mud, crowded with vegetation or swept bare, depending upon the action of the stream at flood time. Each of these conditions brings about corresponding variations in the character of the animal life that is in predominance. In portions of the Ohio river valley the presence of muskrats (*Fiber zibethicus* Linneus) and the location of their burrows along the banks bears evidence to this fact. Figures 29 and 30 show the above-water entrance to one of these burrows in a soil bank.

In general the topography of the flood-plain is altered in two ways—by the removal of material and by the deposition of material. The removal of material most commonly results in what are known as "wash-outs." These may be of varying size and depth from mere cuplike excavations where the water has swept about some obstruction to great holes many feet deep and in some cases of acres in extent. The smaller of these are permanently dry, containing water for only a few hours or days after the recession of the flood, while many of the larger ones are of sufficient depth that they mark the location of permanent pools and contain associations of animals adapted to quiet aquatic life. Such washouts are shown in figures 18, 23, 24, 25 and 26. The pool shown in figure 18 is at the bottom of a washout of more than an acre and the water persists with a depth of four to five feet throughout the year although it is several hundred yards from the stream. From such pools the writer has taken crayfish, water beetles, turtles (*Chelydra* and *Chrysemys*) and several species of fish, including *Cyprinus carpio* Linneus of two and three pounds in weight, common sucker *Catostomus commersonii* Lacepede, hogsucker *Catostomus nigri-*

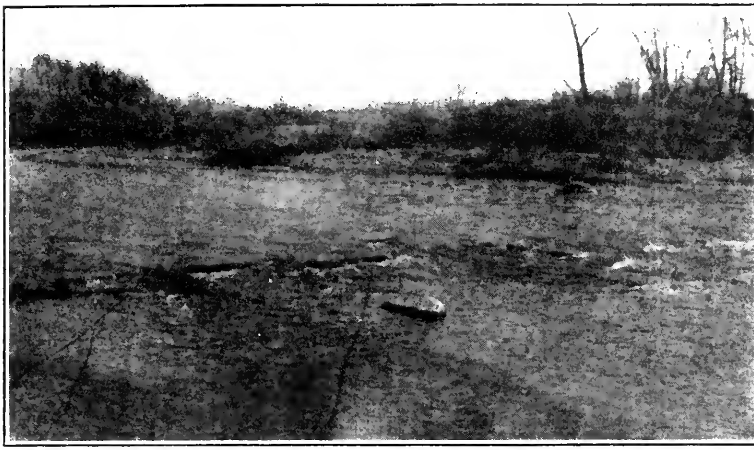

FIG. 21.—Shallow, stony rapids. The home of *Corydalis cornutus* larvæ, etc. Location E, figure 16.

FIG. 22.—Dried plants of *Melilotus alba*, having become established upon the gravel bar during the previous year. This is one of the most important pioneers in revegetation of such areas. Location F, figure 16.

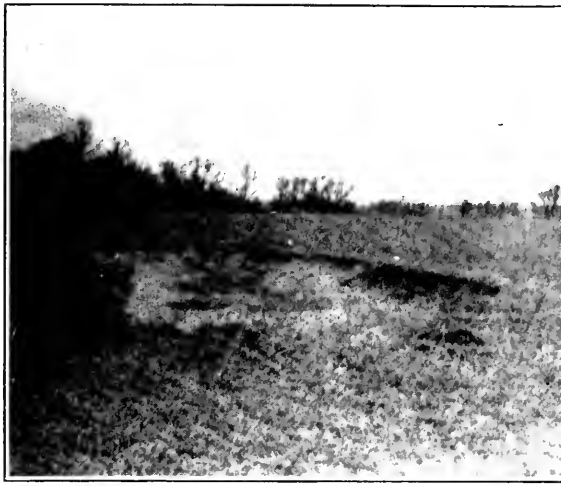

Fig. 23.—A washout made by the flood of 1913 in a cultivated field. The dark areas in the bottom of the excavation mark the extent to which revegetation had been carried on in two years. Location C, figure 16.

Fig. 24.—A washout made by the flood of 1898. It has not only become completely resodded but trees are thriving in what was once the soilless gravel bottom. Location H, figure 16.

cans Le Sueur, red-horse *Moxostoma* sp. (?), and bullheads *Ameiurus natalis* Le Sueur, several weeks and even months after the recession of the flood. Coker (1915) calls attention to the fact that the number of fish is diminished by young fish being carrier away from the stream during overflow.

The cutting of new channels is to be considered under the sculpturing of the flood-plain at least until such are claimed by the stream when in its normal condition. The cutting of one such channel is indicated on the map, figure 16. Figures 25 and 26 show scenes viewed from the bottom of the cut.

The deposition of material upon the flood-plain is almost invariably the direct result of the washouts just mentioned. The soil materials scooped out to form these holes in the flooded plain are capable of being carried in inverse proportion to their coarseness, the gravel and sand usually being deposited immediately below the washout while the soil proper, loam, clay, etc., is often carried in suspension by the water for a much longer distance. This has its most important effect upon animal life indirectly through its alterations made in the character of the vegetation. All animal life, we know, depends either directly or indirectly upon plant life, and many animals are limited to a small number of plant species for food. Even certain of the predaceous animals are limited to a relatively small number of animal species for prey and the parasitic forms naturally depend upon one particular host. The flood-plain is especially rich in mesophytic plants with a corresponding wealth of animal species. In the case of cultivated fields the animal life is more or less distinct, depending upon the nature of the plants under cultivation. The materials deposited by the floods may be roughly classified in this relation as (1) sterile, i. e., sand and gravel, and (2) fertile, i. e., silt. Gravel bars built up in the midst of the fertile flood-plain (figures 27 and 28) are in some cases for years practically barren of both plant and animal life. A deposition of silt may have either of two effects. It may be laid upon a stretch of gravel rendering, in the course of a few months, an area, sterile and waste, into a tangle of grasses and herbaceous plants with most complex animal associations being developed and maintained. On the other hand, cultivated fields, blue grass pasture lands or waste places in which a great wealth of native plants have become established may receive this layer of silt and the area will be obliged to undergo a complete succession of plant changes before the original condition is again reached. In the region under observation one of the first plants to invade a new area, either fertile or sterile, is the common sweet clover, *Melilotus alba* Desr., which is shown in figure 22 as having become established during the previous year on a gravel bar. Clements (1907) gives a brief statement concerning plant succession on flooded soils. Each stage in this series of plant changes must present a related change in the character of animal life present.

It is of no little importance that floods influence animal associations directly without actually affecting either the physiographical or vegetational environment. This is in turn, upon analysis, seen to be capable of accomplishment in two ways: (1) by destroying or removing forms already in existence and (2) by providing a means of dispersal, i. e., carrying forms into new regions.

While the writer was collecting at the edge of the advancing water he observed great numbers of subterranean caterpillars, many of which do much damage to agriculture. These larvæ were seen to climb grass blades and weed stems to keep out of the water which forced them from beneath the soil or from their places of refuge at the surface of the soil, only to be overtaken at the uppermost tip of the plant and eventually drowned. Of thirty-nine specimens taken, twenty-five were the common army worms, *Heliophila unipuncta* Haworth, two were *Noctua c-nigrum* Linneus, one *Prodenia ornithogalli* Guenee, ten *Apantesis virgo* Linneus, and one *Apantesis phyllira* Drury.

Higher forms of animal life were affected by the floods in being forced to flee. Woodchucks, (*Marmota monax* Linneus) were driven from their burrows to take to trees, etc., for temporary safety and numbers of field mice (*Microtus sp. (?)* were seen swimming for refuge to higher points of land. Wood (1910) records having seen voles clinging to stumps above water and Shelford (1913) speaks of mammals as climbing trees under such circumstances. It is most probable that great numbers of these and other mammalian forms also perished during the period of inundation. Wood (1910) thinks that in spite of the fact that they can swim readily, many of these small mammals perish with each flood. Russell (1898) tells of seeing the dead bodies of drowned rabbits hanging in the willows on the delta of Mackenzie river.

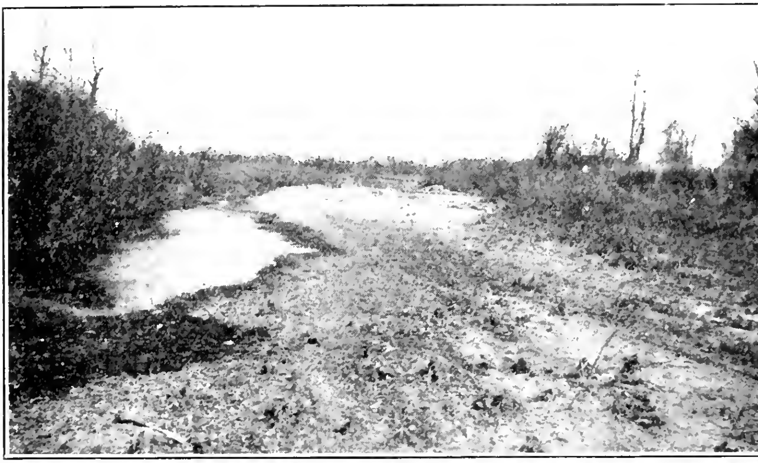

FIG. 25.—This photograph, taken from the bottom of the new channel which is being cut, shows the depth of the channel and one of the permanent pools which lie in it. From this pool were taken three of the species of fish mentioned on page 162. Location I, figure 16.

FIG. 26.—This pool lies only a short distance above the outlet of the new channel. Beside certain of the other fish mentioned small specimens of the small mouth black bass, *Micropterus dolomieu*, were found to be able to maintain themselves. Location J, figure 16.

FIG. 27.—Blue grass pasture land on the flood-plain of White Water river. This and the succeeding figure serve to illustrate change in the nature of the flood-plain by the deposition of gravel upon fertile areas.

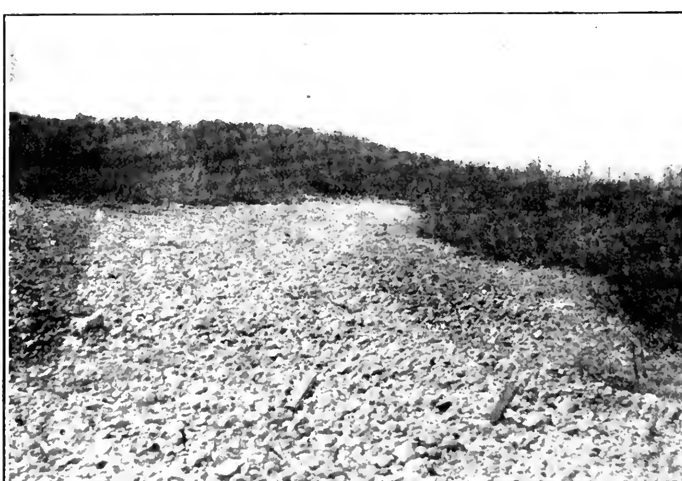

FIG. 28.—Gravel bar thrown down upon blue grass pasture land. This and the preceding photograph were taken from the same spot by merely facing the camera in another direction.

Of these higher forms, the field mice, and even a specimen of the common cottontail rabbit, (*Lepus nutalli mallurus* Thomas) were seen riding upon the floating driftwood. From such rafts as the writer was able to reach were taken Rhyncophorid, Carabid and Chrysomelid beetles, among other insect forms, and spiders. Shelford (1913) has also recorded having observed insects upon nettles and driftwood. This part, played by the flood, in dispersal of animal life is of considerable possibility and may account, in part at least, for the wide distribution of many of our common forms.

ACKNOWLEDGMENTS AND LITERATURE.

For determination of the lepidopterous larvæ listed in this paper I am indebted to Dr. Stanley B. Fracker, of the University of Wisconsin. I am under especial obligation to Dr. Chas. C. Adams, of Syracuse University, Syracuse, New York, and Professor Gilbert L. Houser, of this institution, for many aids to me in the preparation of this paper and for criticism of the manuscript. I wish, also, to particularly acknowledge my indebtedness to Mr. H. M. Trusler, of Indianapolis, Indiana, for his assistance to me in the preparation of the maps.

As this particular field has practically remained untouched up to the present, there is little available literature on the subject as such. To be sure, there are, no doubt, hundreds of individual references pertinent to the subject, not only in zoological, but botanical and physiographical publications as well. However, to the best of my knowledge, this is the first attempt to bring any of these together in an American publication. I realize that the following list contains but few of the many possible references but it is my intention to give only those titles which I personally consulted in connection with this paper. Inasmuch as many of these are but incidental references, I have included an explanatory paragraph with each title.

Antipa, Gregor, 1912.

Die Biologie des Inundationsgebietes der unteren Donau und des Donaudeltas. Verhand VIII. Inter. Zöol. Kongresses zu Gras, 1910. pp. 163-208.

This article consists of a description of the biological conditions on the flooded lower Danube and its delta. He includes in his discussion, for example, observations concerning the modified nesting habits of birds in response to the flooded conditions of the region. This is the most pertinent article on the subject that has come under my notice.

Garman, H., 1890.

A Preliminary Report on the Animals of the Mississippi Bottoms near Quincy, Illinois, in August 1888, Part I.

Bulletin of the State Laboratory of Natural History; Vol. III, Article IX, pp. 123-184.

He treats of the topography of the flood-plain with a detailed discussion of the forms of animal life taken, the emphasis being laid upon the normal fish fauna.

Alvord, J. W., and Burdick, C. B., 1915.

Report of the Rivers and Lakes Commission on the Illinois River and Its Bottom Lands with Reference to the Conservation of Agriculture and Fisheries and the Control of Floods. 139pp.

While this article contains no direct reference to the subject proper, the comparative treatment of the agriculture and fisheries of the region, data of past floods, and estimates of future inundations, together with the discussion of remedies, serve to make it a paper of importance.

Clements, F. E., 1907.

Plant Physiology and Ecology. 315 pp. Holt & Co., New York.

Paragraph 300 on page 280 gives a brief statement concerning plant succession on flooded soils.

Needham, J. G., and Lloyd, J. T., 1916.

The Life of Inland Waters. 438 pp. Comstock Publishing Company.

On page 42, in the chapter on the Nature of the Aquatic Environment, "The rate of settling (of silt) is dependent upon the rate of movement of the water and on the size of the particles," as illustrated by certain features of Fall creek, Ithaca, New York.

In the chapter on Types of Aquatic Environment the authors discuss the formation of flood-plain lakes and ponds, page 67. On pages 84 to 85 the effect of silt upon organisms is brought out.

In the same chapter, pages 87 to 88, in the discussion of high and low waters, high waters and the inconstancy of water level are recorded as disturbing the adjustment of the vegetation and causing migration of the larger animals.

In the chapter of Aquatic Societies the authors treat of the varieties of bottom formation and the consequent faunal variations, pages 356 to 367.

Shelford, V. E., 1913.

Animal Communities in Temperate America. The Geographical Society of Chicago, Bulletin 5. Univ. of Chicago Press.

On page 105, under the discussion of special stream problems, the author gives a list of species taken at the side of the bank at high water. He makes the statement that in times of flood the fresh and quiet water forms become mixed. On page 106 he advances the idea that large floods crush swift water forms beneath moving stones. The migration of Mollusca upstream during floods is recorded, pages 106 to 107.

On page 202 the author records having observed insects on nettles above the rising water and upon driftwood. In this same connection, mammals are spoken of as climbing trees, page 203.

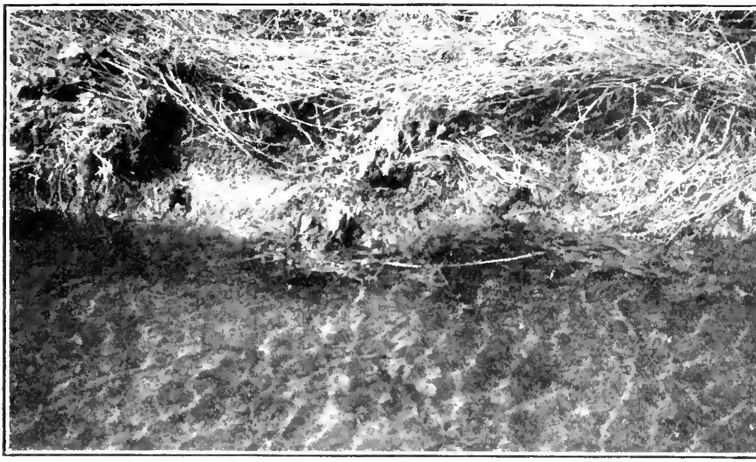

Fig. 29.—The above-water entrance to burrow of muskrat, *Fiber zibethicus*, in soil bank of White Water river.

Fig. 30.—A nearer view of the entrance to the burrow shown in figure 29.

Coker, Robert E., 1915.

Water conservation, Fisheries, and Food Supply. Popular Science Monthly, July, 1915.

Under the heading "Floods and Fishes," pages 93 to 94, the author speaks of the diminution of the number of fish by floods as taking place in the following ways: (1) young fish being left away from the stream by the overflow, (2) recently laid eggs prevented from hatching, (3) the deoxygenation of the water for the young fish by turbidity.

Reynolds, R. V. R., 1911.

Grazing and Floods. A study of conditions in the Manti National Forest, Utah.

Bulletin 91. Forest Service, United States Department of Agriculture, 16 pp. map and 5 pl.

Under the heading "Damage from Floods" the statement is made that floods have resulted in the destruction of many fish. All of the streams or this region were formerly of cold, clear water, which never became turbid, and were well stocked with trount. These fish have been killed in the thick mud brought down by floods and are now very few in numbers.

Cameron, A. E., 1913.

General Survey the insect fauna of the soil within a limited area near Manchester (England); a consideration of the relationship between soil insects and the physical conditions of their habitat.

Journal Economic Biology, Vol. VIII, 159-204.

On page 190, under the topic of "Soil Insects and Soil Moisture" the author discusses the practice of artificially flooding fields as a means of combatting insect pests, and states that certain wire worms can live six days in water.

Chittenden, F. H., 1904.

Insects Injurious to the Basket Willow. Bureau of Forestry Bulletin No. 46, pp. 63-80.

On pages 63 to 64 the writer emphasizes the desirability of planting basket willows in land that is subject to complete inundation for several days at a time as the injurious insects rise to the surface and are swept away.

Webster, F. M., 1904.

The Suppression and Control of the Plague of the Buffalo Gnats in the Valley of the Lower Mississippi River, and the Relations thereto of the Present Levee System, Irrigation in the West, and Tile Drainage in the Middle West.

Proceedings of the Twenty-fifth Annual Meeting for the Promotion of Agricultural Science, 1904, pp. 53-72.

The author shows how the extensive flooding of the lower Mississippi flood plain makes it possible for these insects, *Simulium venustum* Walker, to develop in large numbers over wide areas attached to drift wood, floating logs, growing bushes, etc., in the flood water.

Wood, F. E., 1910.

A Study of the Mammals of Champaign County, Illinois. Bulletin of the Illinois State Laboratory of Natural History, Vol. VIII. Article V.

On page 512 the author records having seen voles clinging to stumps above the water, and having been told that in high water of the Illinois river white footed wood mice take to the trees above the water. He thinks that in spite of the fact that they can swim readily, many of these small mammals drown with each flood.

McIlhenny, E. A., 1914.

The Wild Turkey and Its Hunting. 245 p, 19 pl.

Doubleday, Page and Company.

In the chapter on Enemies and Food the author tells of the turkeys resorting to tree tops during the overflow of the extensive bottom land forest and feeding almost exclusively upon the buds of the trees at such times. He records one instance of two months' duration, pages 143 to 149.

Russell, Frank, 1898.

Explorations in the Far North. State University of Iowa, 1898.

The author observed the dead bodies of rabbits suspended from the willows on the delta of the Mackenzie river. These had been drowned during the overflow of the stream. Page 139.

The State University.

A LONG-LIFED WOODBORING BEETLE.

H. E. JAQUES

Early in April of 1917, Mrs. C. B. Doe, living in Mt. Pleasant, Iowa, called the writer to her home to see what proved to be a matured larva of a Cerambycid. This white larval form about an inch in length, together with about 50 cc. of wood chewings, had been shaken from a round hole just discovered in one of the pieces of an imitation mahogany book case.

The "monster" had already been viewed by others of the community and the suggestions that had been made to preserve the piece of furniture from ruin were as amusing as they were unscientific. The larva was placed in a box. In about two weeks it had pupated and in a few days more had emerged as a normal specimen of *Eburia quadrigeminata* Say.

It is interesting to note that while the food plants of this species are given by Blatchley as Hickory, Ash, and Honey Locust, the piece of the book case in which it had spent its growing days was birch. While the piece was less than an inch in thickness, there was no indication of the borer reaching either surface during its migrations except at the place of its final exit.

The bookcase has been in the possession of Mrs. Doe and in continued use for nineteen years. It came to its present owner from the household effects of the mother-in-law. The original owner, Mrs. Doe insists, owned the piece of furniture for about twenty-five years. There seems to be no doubt that the figures given for the age of the infested piece of wood are reliable. If the egg was laid before the wood was worked up, as is believed, the beetle in question must have been more than forty years developing.

Mr. J. McNeil writing in the American Naturalist, Volume XX, p. 1055, tells of two long horns, which strangely enough were of this same species, emerging from an ash door-sill that had been in place nineteen years. In that case the relation of the tunnels to the solid brick wall on which the door-sill rested, seems to have made it certain that the eggs must have been laid in the wood before the house was built.

DEPARTMENT OF BIOLOGY,
IOWA WESLEYAN COLLEGE.

THE LIFE AND BEHAVIOR OF THE HOUSE SPIDER

H. E. EWING.

Few species of invertebrates come under our every day observation more than the common house spider, *Theridion tepidariorum* K. It is a familiar object in attics and in basements, in cellars and in outhouses of all kinds, in fact it will be found in almost any of the situations where there is shelter and moisture, and where insects may be found in sufficient numbers for food. In looking up the literature relating to this spider the writer was surprised to find that no one, apparently, had worked out its life history or made systematic observations on its habits.

In a casual way people have long observed some of the interesting habits of the house spider, while its feats of bravery or skill have occasionally attracted such attention as to elicit comment from the press. Those who are interested in nature study will find in this species a subject for observation fully as worthy as the honey bee, the field mouse or the robin.

It is believed that the house spider is an American species, because on this continent it is frequently found out of doors away from the habitations of man, while in Europe it is found almost exclusively under artificial conditions. If this is true, the semi-domestication of this species must be of recent origin. Because of the close relationship of this spider to man Professor Comstock calls it the domestic spider, although it is probably more frequently known as the house spider.

LIFE ON THE WEB.

This spider is domestic in two senses of the word, it lives in close relation with man, and on its web we find all individuals of a home—male, female and offspring. The male, however, may be only temporarily on the web, for he is more or less of a wanderer, and if driven from his home by his domineering spouse, he may hunt a more congenial mate elsewhere, or obtain solace from a wandering life of adventure. The young spiders stay on the web of the parent for many days. Here most of them either die of starvation, or become dainty morsels for the mouths of hungry bird nestlings.

Duties and Habits of the Female. The female spider (figure 31) is much larger than the male and is usually about one-third of an inch long, although individuals vary much in size. The abdomen is highly arched, and somewhat conical behind. Above it is marked by several irregular transverse bands. The legs have the distal ends of the segments darkened giving them at times a banded appearance. The general appearance of the female is grayish, although some specimens may be of a tawny or brownish hue. There is considerable variation in the abdominal marking, hence it may be said to be variously mottled.

The female is at all times complete master of the home. Not only does the male assent to this condition, but he lives for much of his life in great fear of his mate. If for any reason or for no reason the ire of the female is aroused she assaults him viciously. The one period that is most dangerous for the male is

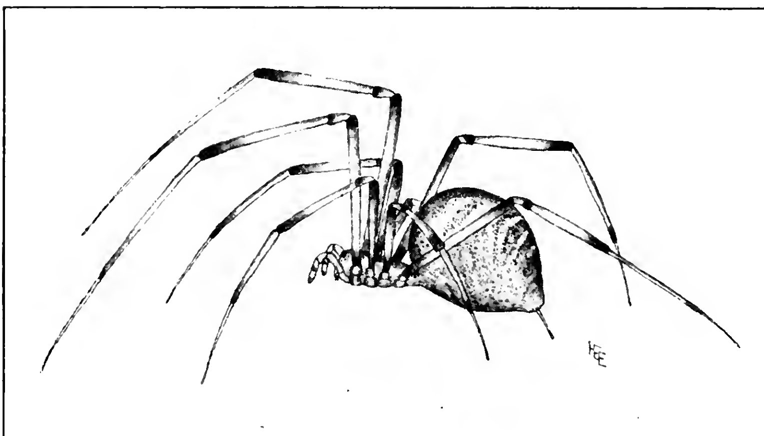

Fig. 31.—Mature female, X4.

immediately after mating. The female, apparently recognizing his weakness at this time, seizes the opportunity to make her assault, and it is only through cunning and discretion that the male will make good his escape.

That the female spins no cocoon and lays no eggs unless fertilized by the male appears to be shown experimentally. An immature female was confined in a cage on May 31. This female was kept until August 24, almost three months. She spun no cocoon and was released. Another immature female was taken on June 2. In captivity she reached maturity July 14, but did not cocoon by August 24, when she was released. Another immature female was captured on June 2, and confined in a cage by herself. By June 14 she was mature. She was dead on July 14. No cocoons were left. Again an immature female which had been isolated and had reached maturity before June 16 lived in her cage without cocooning until August 24, when she was released. When we consider that the female will cocoon several times during a season, it appears from these observations that fertilization is necessary before oviposition and cocooning begin.

Is the female fertilized once for her life time, like the queen bee, or is she fertilized before depositing every egg mass and spinning her cocoon? An experiment performed last summer throws some light upon this subject. On May 4 a male and female found in the college greenhouse on the same snare were confined in a breeding cage. Here they lived together until May 21 when the male was found dead. Soon after this, on June 2 the female spun her first cocoon which yielded 117 eggs. These eggs were fertilized, for 17 out of 31 which I placed in separate vials hatched. Following the death of the male the female spun a second cocoon on June 22; a third, on July 9; a fourth, on Sept. 3. The fourth was the last cocoon spun. The eggs from each of these cocoons were isolated, and kept under observation for many days. Not one of them hatched. It appears then that the female is fertilized several times during her life, also that a single fertilization is effective only for the succeeding batch of eggs.

Nourishment appears to affect the cocooning in a fundamental way. Where female spiders were fed an abundance of their favorite food, house flies, they cocooned more frequently and spun much better cocoons than when they were more poorly fed. After experience with many individuals it was found that frequently a female that had gone for some time without cocooning could be induced to cocoon by feeding her a liberal supply of flies. Improperly nourished females or old females would sometimes spin cocoons so thin that the egg masses showed clearly through the walls.

The House Spider as a Huntsman.—As a huntsman the house spider is both bold and skillful. Victims several times its size are snared and killed with precision. In order to capture the prey snaring is first resorted to. The web spun for this purpose consists of many lines of silk brought back and forth in a perfectly irregular fashion in some obscure corner or out-of-the-way place where there is an abundance of moisture and plenty of flies to catch. They make no attempt at symmetry, as is done by most spiders, yet from a position usually near the top there radiate out to the other parts of the web a few lines that will

Fig. 32.- Her most common catch. Female snaring a house fly; X4.

enable the female to perceive even slight vibrations in most parts of the web.

When a victim, usually a fly, gets tangled in the web the female rushes at once to it, and turning rapidly about literally throws the sticky silk against the victim with her hind legs. (figure 32.) Strands of silk pulled from the spinnerets by the tips of these legs are wrapped about the body of the fly several times. If the struggling victim so tears the web as to threaten escape the female ties it fast with the new strands of silk which after being wound about the body of the fly are fastened to the web. When securely "wrapped" the victim is calmly approached by the female and bitten, apparently at the most available spot. This may suffice to bring about a speedy death. If not, the female repeats her dose of venom several times, until eventually the prey succumbs. After the victim is killed the female snips all the strands of silk adhering to it, and carries her prey to the top of the web. Here she feeds on it at her leisure.

This is the normal way of snaring the prey. It is the same method as is employed by the males and also by the spiderlings. Occasionally a spider will drop from her web on her line of silk, and throw a few sticky loops about a victim and draw it into her web, where it is killed. This is not very commonly done, however, and in no case do either male, or female or spiderlings leave the web to search for prey as is done by some of the other species of spiders.

The prey of the house spider consists of a great variety of invertebrates and according to some accounts even vertebrates are not exempt from attack. Dipterous insects are the most common, and of these the house fly is pre-eminently the species most preyed upon. Carefully kept records of many snares show this species to be by far the most common one caught. The spiders do not seem to be averse to any of the common arthropods. Phalangids and other species of spiders constitute a considerable item of their diet.

McCook in one of his interesting volumes on "American Spiders and their Spinning Work" relates the capture of a mouse by a spider which was observed by several persons in the state of Kentucky. The mouse when first observed had a strong line of silk spun around its tail which was carried up to the spider's web on the underside of a table. This line was strengthened by many strands of silk, and the spider kept shortening it continually until finally the mouse swung free from the floor. In this position it was finally killed after many hours. McCook authenticated this case by obtaining written statements from eye-witnesses, and by determining specimens, said to be the same as the spider heroine, as *T. tepidariorum* K.

Dr. Fitch relates an equally wonderful feat of a house spider that snared a snake a foot long which did not die until six days later. This was done by the spider throwing a loop around the snake's neck, and pulling the victim higher and higher until it was almost free from the ground. Such feats as these are unusual, yet the house spider is a vicious huntsman when she is driven by hunger. The writer has several times seen females drop from their webs, and snare with their silk victims much larger than themselves. It appears plausible that the mouse might have been snared in this way by a female driven by great hunger.

The feeding habits of the male and of the spiderlings are similar to those of the female. The male has not the strength or spinning ability of the female hence confines his attack to smaller prey. The spiderlings feed chiefly upon gnats and other minute insects which they snare in a manner similar to that of the adult.

Thirst of Spiders.—It has been the observation of all who have studied the spiders that they become quite thirsty. The house spider is no exception to this general rule. They demand water almost daily during hot weather, and when a small spray is turned upon their web they will hurry to sip many of the small droplets adhering to the silken threads.

If an individual is supplied with an abundance of fresh flies, one a day at least, it can live for several days, probably weeks, without water, but if water is at hand it will drink as if quite thirsty. House spiders will never be found in abundance in dry places where water is not available for drink. It is in damp basements, damp cellars, or in greenhouses where much water is used in spraying that they are found in considerable numbers.

If a spider has gone for a long while without water, and is then allowed to drink its fill, the abdomen is noticed to swell out very perceptibly. Frequently the writer has observed a female drink several good sized drops of water before her thirst was quenched.

The Cocoon—How Made—Its Contents.—The cocoon is almost oval in shape, but is considerably drawn out at the upper end where it is suspended to the web, so as to make it somewhat flaskshaped. It varies from about one-fourth to a third of an inch in length, and is usually about two-thirds as broad as long. The cocoon is formed out of the silk, drawn from the spinnerets and wound about and around many times, and finally packed closely together during and after the process of spinning. It is

FIG. 33.—The first stage in the cocooning process, spinning the cone-shaped foundation previous to egg laying. Drawing X4.

not parchment-like as are some of our common insect cocoons, and there appears to be no admixture of any sticky substance with the silk. When first spun the cocoon is a shiny light tawny color, but as it ages it becomes darker. Old cocoons lose their shiny appearance.

The method by which the female spins her cocoon and lays therein her eggs is of considerable interest and does not appear to have been reported, although McCook gives some notes on the process which are believed to be considerably in error. The writer had the good fortune to witness the complete cocooning

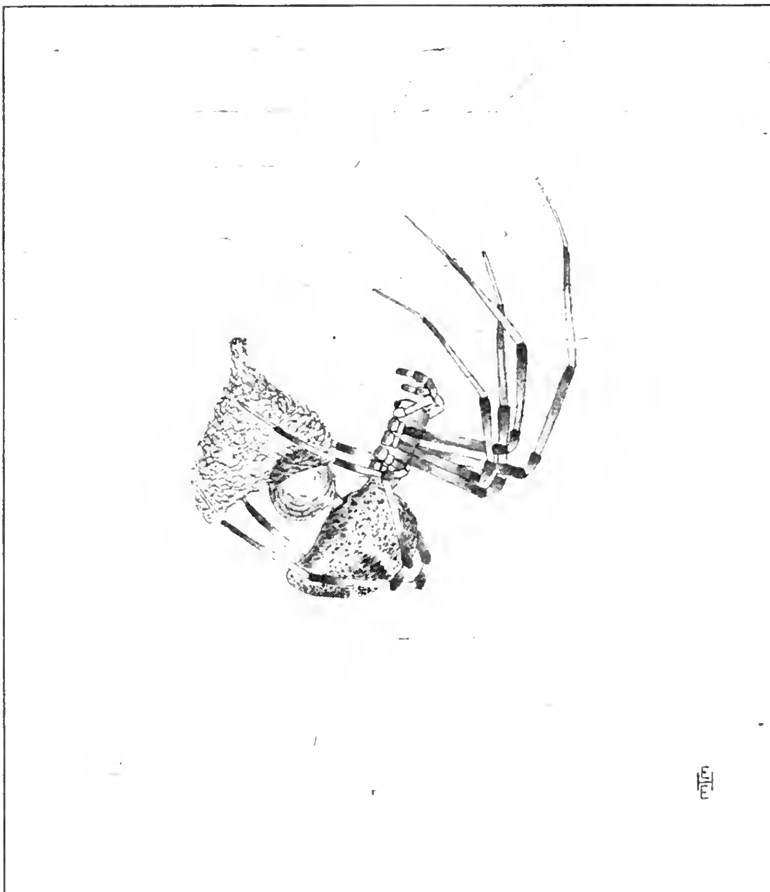

Fig. 34.—The second stage of the cocooning process, placing the egg mass in the cone-shaped foundation. Drawing X4.

process by one of the females kept in captivity. Previous to this time he had on a few occasions noticed a part of the process. The cocooning is done usually late in the day, in the evening or at night, and as far as was observed was never done during the heat of the day. This accounts for the difficulty experienced in obtaining observations of the process.

To begin with she spins a cone-shaped base which hangs cap-like suspended by several threads of silk from the web (see figure 33). After this is done the female, hanging by her front legs and grasping the sides of this cone-shaped base with the third and fourth pairs of legs, slowly forces out of the vulva the egg mass. The eggs emerge ensheathed by a filmy membrane and slightly stuck together. When they are all out they make a mass globular in shape, which is pressed into the cone-shaped base (figure 34). As this is being done the edges of this caplike base of silk are pulled around the egg mass so as to hold the latter temporarily in position. Now the sheath of the egg mass is snipped off, and the female rapidly spins new strands of silk so as to complete the oval of the cocoon. At this stage the cocoon is very flimsy, and the egg mass shows plainly through its walls. Next the female spins silk back and forth around the cocoon to give it thickness. While she does this she hangs from the web by the first pair of legs, rotates the cocoon with the second and third pairs of legs, and applies the silk, as all spiders do, with the hind legs; or she may modify this process somewhat by hanging by the first and second pairs of legs, rotating the cocoon with the third pair and applying the silk with the last pair. Never has the writer found the female hanging by one leg while spinning her cocoon as described and figured by McCook. When the cocoon is rotated it is not turned continually one way, but the movement is frequently reversed. While laying on the silk and after it is laid on the female works it down making it more compact (see figure 35). This is done chiefly by the aid of the cheliceræ according to the writer's observations, although McCook states that the tip of the abdomen is used for this purpose.

During the process of building the cocoon the female works very rapidly. The cone-shaped base is laid down in a few minutes. The eggs were deposited in three and one-third minutes according to the observer's watch. The thickening of the cocoon walls takes the most time. The whole cocooning process as it was observed from beginning to end took approximately one hour.

The contents of the cocoon after it is spun vary according to its age, and other conditions. One of the cocoons was opened by the writer just as the young spiders began to emerge and the following were found: Cast spiderling skins, 195; dead spiderlings, 17; live spiderlings, 13; quiescent spiderlings, 32; developing eggs, 18; unfertilized eggs, 15. At the time the cocoon was examined 5 spiderlings had emerged. Such an examination throws much light upon what must take place in this

Fig. 35.—Third stage of cocooning process, finishing the cocoon. In this drawing the female is working together the strands of silk with her jaws, or chelicerae. Drawing X4.

closed bassinet. The presence of 195 cast skins shows that the first molt takes place inside of the cocoon. This is also shown by the presence of the quiescent nymphs which are known to be the first instar. The presence of 17 dead spiderlings and of so few live ones in proportion to the large number of cast skins found would indicate that some of the spiderlings had slain their brothers. Cannibalism is known to exist among the young of other species, and it certainly exists to a limited extent in *T. tepidariorum*. The writer is of the opinion that those individuals that first reach the second nymphal stage (the first active stage) habitually feed upon the other spiderlings in the cocoon that are in the first nymphal, or quiescent stage. The presence of 15 unfertilized eggs is not to be wondered at. The percentage of unfertilized eggs in many cases will amount to 50 per cent.

Some counts were made to find out the number of spiderlings emerging from a cocoon. Twelve days after the first spiderlings had emerged from a cocoon a count was made of them and there were 115. Not a single dead one was found in the breeding cage, and since 12 days had been allowed for their emergence probably all were out that would come out. In another case a count was made, at least 8 days after the beginning of the emergence of the spiderlings. This time 254 individuals were found. All of these were alive except probably two or three individuals.

Number of Cocoons Spun in a Season.—McCook states in regard to the number of cocoons spun by *T. tepidariorum*, "It spins during the season from three to five ovoid cocoons......" In another place he mentions finding a dozen cocoons in the meshes of a single snare. Undoubtedly the number of cocoons spun during the year depends largely upon the food supply. If the female is properly fertilized and amply fed she will spin more than five cocoons in a season. A female which was captured by the writer April 12, and kept in captivity spun nine cocoons before her death, which occurred between October 9 and November 27. Another female which was captured May 4, probably a few days before she was mature, did not do so well. She spun four cocoons during the season, dying before November 25.

That the female spins several cocoons has been known for a long while, for three or four or even more will frequently be found on a single snare. Of course it is not always known that the cocoons found on a single snare are those made by a single female, but usually they are. Mature females as a rule do not desert their snares, but immature females have been observed by the writer to adopt old snares. This they frequently do, especially where the spiders are so numerous as to cause some crowding.

Can Spiderlings Emerge from their Cocoons by Themselves? It has been frequently debated as to whether spiderlings can emerge by themselves from the silken cocoon which encloses them. The chief reason for the debate apparently lies in the fact that the female of several species is known to help in the

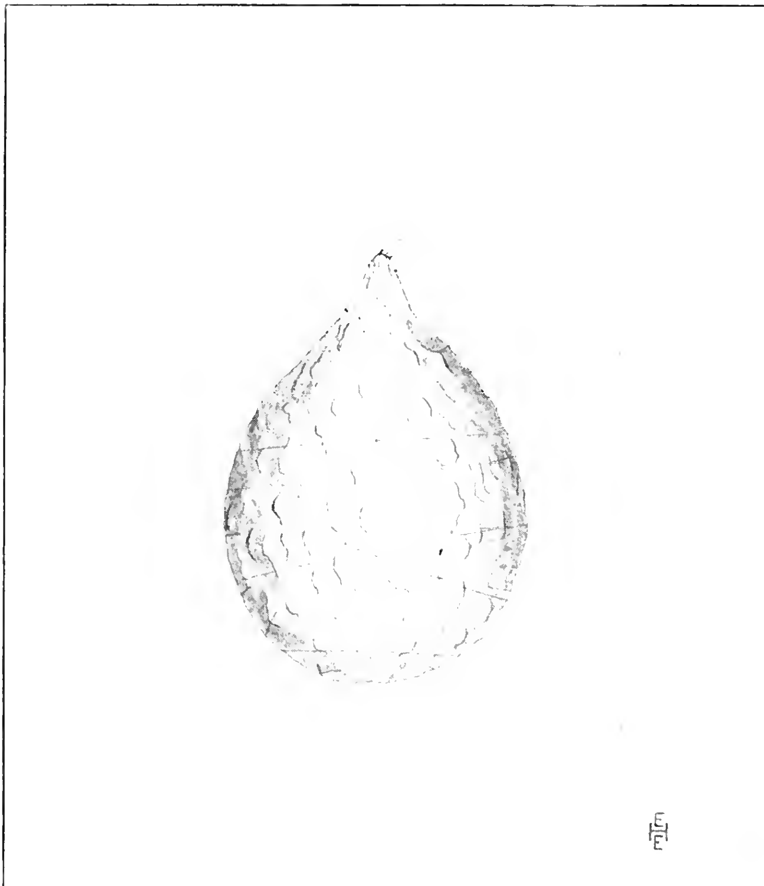

Fig. 36.—The finished cocoon. The silk is so well packed together as to suggest parchment. Apparently no gluey substance is used in this packing process. Drawing X1.

liberation of her young by making a hole through the wall of the cocoon for their exit. In the case of the house spider, it appears that normally the female helps in the liberation of her offspring from the enclosing cocoon, but can they gnaw their way out without her aid?

The writer has settled this question to his own satisfaction. Spiderlings will gnaw their way out without any aid from the female, if for any reason she is not present to help. In support of this statement the following recorded observations are given. A female that had cocooned in captivity was removed from her breeding cage to see if the spiderlings would emerge by themselves. Nine days later the brood of spiderlings had emerged. The male had died in this case before the female was removed. Again a cocoon which had been spun in a breeding cage was removed, and placed by itself in a large bottle. Five days later three spiderlings had emerged. There was so much moisture in this bottle that soon the cocoon was covered with mold. No more spiderlings were observed to emerge, but an exit hole had been made for them.

In the writer's recorded daily observations on webs in their natural environment several records were made of the emergence of spiderlings from cocoons that were unaccompanied by the adult spider. On June 15, 1910, a brood of spiderlings was observed to emerge from a cocoon in a web on which no adult had been observed since June 6 previous. Again on June 29, 1910, a brood of spiderlings emerged from a cocoon on a web that had been inhabited for two days previous only by a spiderling about 3 mm. long. On this same snare on July 7 a second brood of spiderlings emerged from a second cocoon. No adult had been recorded since the emergence of the spiderlings from the first cocoon. On another snare observed in the College Greenhouse a female spun her first cocoon on either June 5 or June 6. On June 7 the snare was deserted, the cocoon only being left. It remained in this condition until June 23, when the spiderlings emerged by themselves. Several other records were made of spiderlings emerging by themselves, but they will not be quoted here, since enough have been given, it is believed, to establish the fact that they are capable of doing so.

Cannibalism.—Cannibalism is known to exist among some spiders, as it does among some insects, but it is probable that there has been much exaggeration in many of the reports of cannibalism among spiders. Again many species may prove to be cannibalistic when kept under unnatural conditions; especially is this true where they are crowded or are not sufficiently fed. That the first active nymphs that appear inside the cocoon in the case of the house spider may be cannibalistic appears very probable, yet in regard to this point we have no direct evidence.

The female of the house spider, especially when kept in captivity, is liable to slay her mate. In nature this apparently seldom happens, due, as the writer's observations appear to show, to the elusiveness of the male. It is seldom indeed that, in natural conditions, the male is found slain in the snare of the female. The writer has records of several males being slain by their mates in captivity. Having no chance of escape they were caught by the angry females and in all such cases were eaten as prey.

The death rate among the little spiderlings after they have emerged is surprisingly great. From a brood of a hundred or more rarely more than two or three will reach maturity. In nature this would probably be explained on account of natural enemies, of which there are many. Yet even when they are carefully guarded in breeding cages it is found impossible to rear to maturity more than a very small percentage of the spiderlings coming from the cocoons. Even the separation of the young into individual cages appeared to lessen the difficulties but little.

Never has the writer observed one of these free living spiderlings to snare or kill another, although he has very strong evidence of one spiderling killing two others. This spiderling was found feeding on one of its brothers, and the next day the body of the other brother was found sucked. It may be that both of the individuals fed upon had died of natural causes, hence we have no convincing evidence of cannibalism in this case. Cannibalism, if it does exist among the emerged spiderlings, is so rare that it should not be considered as a part of the normal behavior of the species.

HABITS OF THE MALE.

The male is not nearly so often observed as the female. Three reasons may be given for this; he is much smaller, for much of his life he is a wanderer, and lastly he is much shorter lived than the female.

The male (figure 37), although varying considerably in coloration, is much darker than the female. The prevailing color is a light chestnut brown. The legs do not as a rule appear banded as in the female, and the abdomen is not so mottled. As is true of all adult male spiders, the palpi are modified so as to be used in fertilization. In this species the bulb of the palpus is quite large, almost black, and is hooked and pointed at its tip.

Wandering Habits.—Continuous daily observation made during one season on fifteen snares revealed much in regard to the wandering habits of the male. Webs that had been without male occupants were found to be suddenly occupied, only to be deserted again a few days following. Frequently a male was found for several days on the snare of an immature female, waiting for her to reach maturity after which mating would take place.

After mating with the female the male is frequently driven

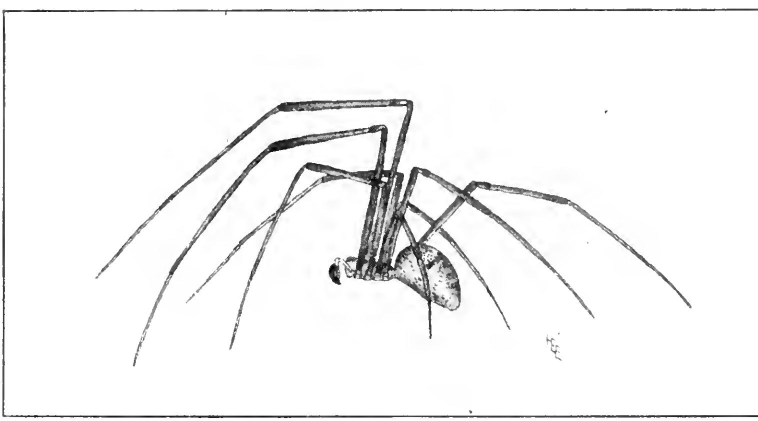

FIG. 37.—Mature male. X5½.

from her snare, whereupon he may wander for a long distance until another snare is found. If the snare be vacant the male may remain upon it for a few days until he has rested and fed. His stay is usually short unless a female occupies the web.

Courtship.—The life of the mature male is taken up largely in courting females. It is very interesting to watch a male approach the snare of the female and make his advance. The flirtation that ensues takes place over the silken web, and by means of it. First the female starts as if alarmed, not knowing whether friend or foe is at hand. She jerks sharply on the lines of the silk running from her resting place. The male answers by similar short jerks. He approaches nearer. The female signals again, and again the male returns the signal. The male continues to approach the female and all the while the two keep up their signaling. If the female is pleased with the male she frequently meets him half way, if not she will suddenly assault him, whereupon he flees hurriedly.

Following this initial rebuff the male may, after a few minutes, return to the bottom of the snare, and wait until the female is in a more receptive mood (figure 38), or he may renew his advances. If this is done it is usually at the peril of his life, for the female is dangerous to her mate even when she is to all

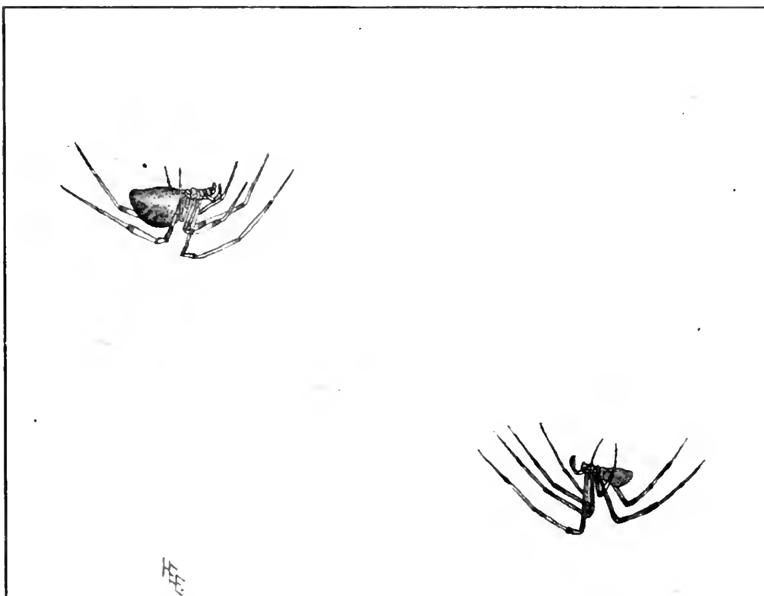

Fig. 38.—A house spider home in a lidless cigar box. Male and female in their usual positions. Four-fifths natural size.

appearances desirous of him, but many times more so when she is not in a receptive mood toward him.

Copulation in the case of the house spider takes place on the snare. The male after the usual preliminaries of courtship rushes toward the female as she hangs with her back downward and applies one of his sperm-filled palpi to the vulva (figure 39). This the male does while he is in a reverse position from that which he usually has in the web, i. e., his back is upward. After one of the palpi is applied to the vulva the other may be applied. However, the males do not alternate regularly in applying the palpi, neither do they repeat many times with a single palpus. At one mating copulation usually takes place several times and rapidly. One male which was kept in captivity copulated with a female four times in three minutes. The mating process is very fatiguing to the male and frequently leaves him exhausted. It is at this time that the female assaults the male, and occasionally in nature and frequently in captivity succeeds in capturing and killing him. The venom of the female is fatal when applied to the male, and probably would be fatal to the female herself if she should by accident inflict self injury.

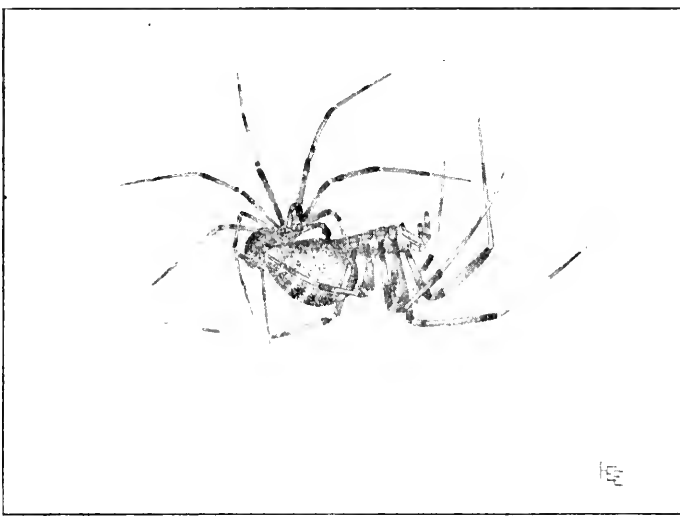

FIG. 39.—Method of mating in *T. tepidariorum.* Drawing X2⅔.

Polyandry.—In mating habits the house spider is more or less promiscuous. One male may mate with several females, but if he does it is by wandering from one web to another. Never does more than one mature female occupy a web, but upon this web occasionally two or even more males may be found. The writer kept two males with a female in captivity. Among them there was no jealousy or enmity. Two males have been observed mating with a single female at one time, each taking his turn, without any commotion.

The female is, then, irregularly polyandrous. The males are promiscuous. Yet while both of these statements are true there appears to be a tendency toward normal monogamy. Many of the males doubtless mate with a single female, then are either killed by her or die of starvation. Before this mating takes place the male may be found for several days on the snare of the female, hence one might infer that the species was strictly monogamous, but careful observations show it to be otherwise.

Food Habits.—Young males spin their snares like the young and adult females. They appear to be as proficient in the art as the female spiderlings. But this is not true of the adult male. He spins very little. What prey he snares is caught generally on a web built by the female. Frequently males will inhabit temporarily deserted snares, making use of them to the best of their advantage.

When inhabiting the web of the female the male will frequently snare victims by himself. If he does, however, he never shares directly in the spoils, for no sooner will he catch his prey than the female will drive him away and appropriate it for herself. Upon the web of the female the male subsists almost entirely from the discarded morsels of his mate. He literally lives upon the crumbs that fall from her table, being for the time being economically dependent on her.

LIFE HISTORY.

In the araneids very little has been done in working out the details of the life history for any of the species, and nothing upon *T. tepidariorum.* In the writer's work with the house spider no less than forty-seven individual life history experiments were carried on so that the number of individuals that were followed through any stage was sufficiently great to give good averages except for possibly the last two stages.

The Egg.—The egg is almost pure white, but appears somewhat translucent. The shell is smooth, slightly shiny, but reflecting little light. When freshly laid the egg is almost a perfect sphere, but as the embryo develops it becomes somewhat molded to suit the shape of the latter. The interior of the egg is minutely granular. The egg shell is membraneous and not more than one-twentieth the total thickness of the egg.

The incubation period was determined for 14 eggs. None of the eggs hatched in less than 7 days, and all were hatched in 8 days. The average obtained for the length of the incubation period was 7.8 days.

The number of eggs laid in a single cocoon varies greatly, and since there is a great variation in the number of cocoons spun by a single female there will be a great variation in the total number of eggs laid by her. The egg laying record of one female is here given:

Time of Cocooning	Eggs in Cocoon	Fertilized or Not
June 2	117	Fertilized
June 22	74	Not Fertilized
July 9	27	Not Fertilized
Sept. 3	41	Not Fertilized
Total	261	

According to these records the average number of eggs laid in the cocoon is 65+, but the writer is of the opinion that this is considerably less than the average that would have been obtained if many counts had been made. Likewise the total of 261 eggs for a single female is probably low. This particular female was fertilized only once during her life—before the first egg mass was deposited. If she had been fertilized before each oviposition it is probable that the number of eggs would have been greater. This point has not been ascertained, however. A single count made of the eggs in a cocoon of another female gave 213. That the number of eggs laid in a single cocoon may even exceed this latter number is clearly shown in the counts of the spiderlings emerging from a single cocoon. One of these counts gave no less than 254 spiderlings coming from a single cocoon.

First, or Quiescent Nymph.—There is one thing in the life history of this spider, as well as others, that is very unusual in arthropods and its significance from the standpoint of racial advantage is hard to understand. The reference is to the occurrence immediately following the egg of a quiescent instar. In the case of insects with a complete metamorphosis, there is a quiescent instar, but it follows the feeding, growing instar, the larva, and its advantage is clearly evident. The larval or caterpillar stage, which is a later development in the phylogeny of insects, is an adaptation which permits the individual to feed voraciously for a short time, make its growth, and store up energy in the form of fat. Now it can seek a hidden protected place, where it would be probably impossible to obtain food, but where it is concealed from most of its enemies, and here it slowly transforms into the adult. The occurrence of the pupal stage in insects follows the development of a specialized larval stage.

In fact it is an adaptation, the racial benefit of which clearly depends upon another adaptation, the development of the larval stage. But why should we have in spiders a quiescent stage following the egg stage? This point the writer is not ready to answer, but it is interesting to note that the quiescent instar is here protected, as in insects, from most natural enemies. Many insect larvæ spin a protecting cocoon before they pass into the quiescent stage. In the house spider the mother has already spun the cocoon to protect her young from enemies during their quiescent period.

The first, or quiescent nymph (figure 40) differs from all of the following nymphal instars in being absolutely unarmed.

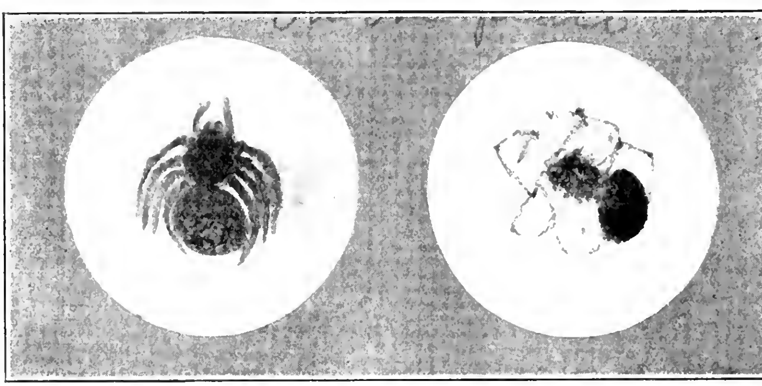

Fig. 40.—First or quiescent, nymph to the left; to the right the second, or first active nymphal instar.

There are no spines or hairs of any kind on the body or legs, and the tarsi are without claws. The quiescent nymph is stouter than the other spiderlings. The legs, instead of being longer than the body, are somewhat shorter than the body. They are not used during this stage.

The molting process of the quiescent nymph was observed. It was the same as in the other stages. First the skin of the cephalothorax splits around the sides of the body just above the coxæ of the legs. Then the legs and palpi are slowly extracted from their old coverings, and finally the skin splitting along the sides of the pedicel onto the abdomen releases the latter, which is drawn out. Presumably there is a molting fluid poured out between the old and new skins which aids in the molting process.

The length of the first, or quiescent nymphal stage was obtained for fourteen individuals. In no case was it less than 2 days or more than 3 days. The average for the 14 individuals was 2.3 days.

The Second Nymph.—When the second nymph (figure 40) emerges from the old skin of the quiescent nymph it is fully armed and prepared for an active life. One of its first duties is to cut its way out of the cocoon. This it can do, as we have shown, by working with other individuals without aid from the mother. When free the first nymph can spin and snare prey as the adult does. True it is that the snare is not extensive or strong, yet it is sufficient for the snaring of the most minute insects.

For a long while after emerging from the cocoon the spiderlings of the first active nymphal stage will remain near together (see figure 41). By so doing they frequently invite disaster for the whole brood at the hands of some hungry bird. Yet, there is an evident advantage to the species in this communalism, as it enables the individuals to unite their snares, which are quite small and of little importance when existing separately, into one large snare, which is much more efficient in holding an entangled victim. Again if a single individual would die of starvation its body would be at hand for the others to consume, as they are accustomed to do. Thus if no food is obtained for a long period by way of ensnared prey, the bodies of the starved ones will keep alive a few of their brothers and sisters.

The writer has reared these second nymph spiderlings by feeding them exclusively upon white flies and plant lice. When they are confined in individual cells or cages the amount of web spun is so small that even such small insects as plant lice or white flies are snared with difficulty. Undoubtedly the second nymphs obtain many of their "catches" on account of the victim being snared by silk spun by the mother spider, on whose webs this instar lives.

Data were obtained upon the length of the second nymphal stage for four individuals. The minimum obtained was 19 days; the maximum 26 days. Some individuals of this stage lived longer than 26 days and died without molting, indicating a greater maximum for this period. The average obtained for the

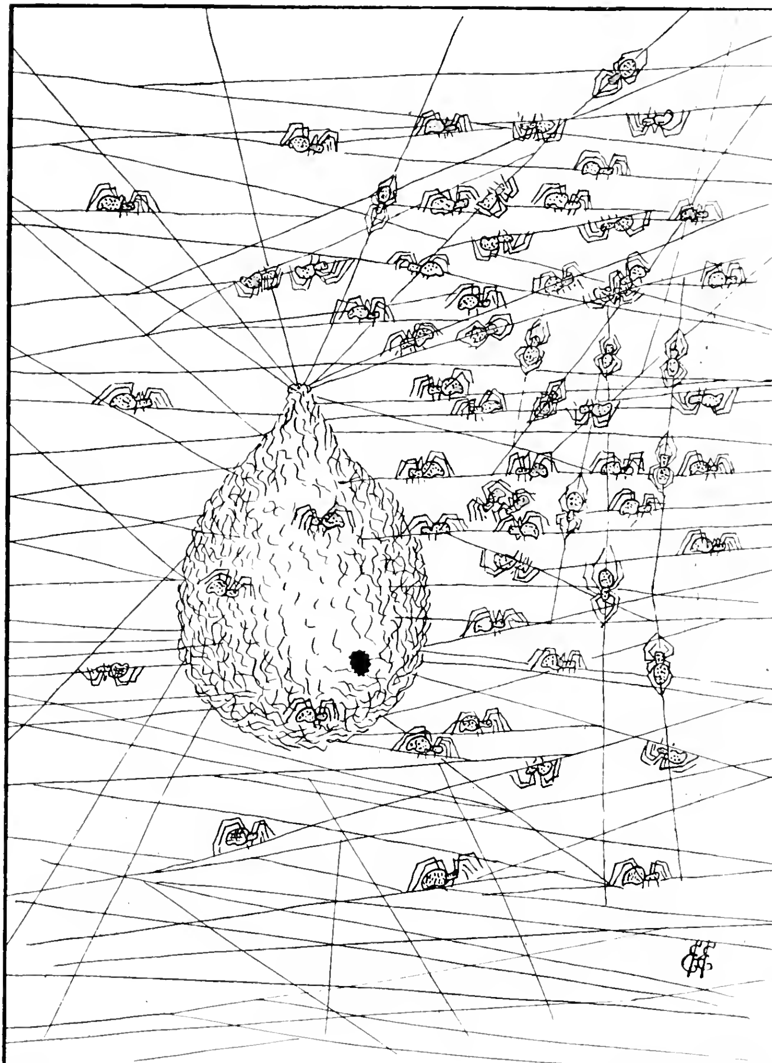

Fig. 41.—Spiderlings emerging from cocoon; X6.

second nymphal stage was 23.3 days. The second nymphal stage is therefore over ten times as long as the first nymphal stage.

The second nymph is of about the same size as the first, or quiescent nymph. When it first emerges the body is slightly smaller, but as feeding takes place the body becomes larger.

The body of the second nymph is an obscure yellowish green, with dark markings above similar to those of the adult. The cephalothorax is lighter than the abdomen. The eyes are black and conspicuous. The legs are white marked with dark bands.

The Third Nymph.—The third nymphal instar is similar in practically all respects except size to the second instar. It is quite active, and spins better and snares better than the second nymph.

Data were obtained on the length of the third nymphal stage for eight individuals. The minimum time for this stage was 6 days, the maximum 20 days. The average for the eight individuals was 12 days. This is almost exactly one-half the time consumed in the second stage, and this difference can probably be partly explained by the fact that prey can be much better snared in this stage, hence the nymphs are better nourished.

The Fourth Nymph.—The fourth nymph is like the third only that it is larger and stronger. The average length of the fourth nymphal stage was found to be 10.2 days. Five individuals were used in obtaining this average. The shortest time observed was 6 days, the longest 21 days.

That there is considerable danger attendant to the molting process of the spiderlings as well as of adults is evidenced by the fact that one of these fourth nymphs was observed to die during the process of casting off the third nymphal skin. The skin of the cephalothorax came free above, but the spiderling was unable to withdraw its legs from their old skins.

The Fifth Nymph.—The fifth instar has no special distinguishing characteristics. The length of this stage was noted in the case of two individuals. One passed through this stage in 5 days, the other in 9 days.

One day the writer dropped a fly upon the web of a fifth nymph. The nymph immediately dropped to the bottom of the cage feigning death. Here it remained motionless for a long time. This is a habit frequently noticed in adults. Only fear appears to bring about the response.

It sometimes happens that there is no fifth nymphal stage in the case of female individuals. At least the writer has one record of a female reaching maturity with the fifth molt. In another case it was found that the specialized sexual structures of the palpi of the male appeared during the fifth stage.

The Sixth Nymph.—A sixth nymphal stage usually occurs in this species, but not always. One of the male individuals reached maturity in the sixth stage. The length of this stage when it does occur was determined for two individuals. One passed the stage in 14 days, the other in 29 days.

Number of Nymphal Instars.—Data were obtained in regard to the number of molts and nymphal instars for seven different individuals. They are here given:

Number of Individual	Number Nymphal Instars	Sex	Notes
1	4	Female	Mated with 2 males after 4th molt.
2	8	?	Died after 8th molt.
3	5	Male	Showed characters of male in last nymphal instar.
4	8	Female	Kept through season following her maturity. Mated and spun cocoons. No more molts.
6	8	Female	Kept through season following maturity. Did not molt after becoming mature.
5	6	Female	Died at end of season.
7	7	Female	Died at end of season.

From these data it appears that the number of molts for each individual varies considerably. In the case of females it was found to vary from four to eight. No data were obtained in regard to the variation of the number of molts in the case of the male. It was feared that this apparent variation in the number of nymphal instars was due to individuals molting after reaching maturity. In regard to this point, though, it was later shown that molting does not take place after reaching maturity. Two of the individuals reared in one season, were kept through the next, and neither of them molted during the second season. Again, observations of mature males and females kept in captivity did not reveal molting after maturity was reached.

Longevity of Adults.—The house spider is probably not long-lived. Individuals which hatch out in the spring, if properly fed, will reach maturity by the following winter. These over-wintering individuals, if females, normally live through the coming season as the writer's experiments plainly show. In the case of the males it is different. Males even when well fed do not appear to live through the second season, and many of them meet disaster or starvation early in the second season.

A female which hatched from an egg deposited on July 12, 1910, reached maturity by November 27 of the same year. She lived until August 20, 1911, when she was removed from her cage on account of the writer leaving Ames. Another female reared the same season at Ames, reached maturity before January 26 of the following year. She lived until August 20, when she was removed from her cage.

In regard to the longevity of the males but few data were obtained. One male collected with a female on a web in a basement on April 12 died May 30. It was not ascertained whether he died a natural death or was killed by the female. A male captured on May 31 and kept by himself was yet alive on August 16 when the experiment closed.

BEHAVIOR.

No opportunity was afforded for special studies on the behavior of this species, but some of the observations are here recorded.

Tropisms.—The most evident response of the species to chemical or physical elements of its environment is noticed in the response of the spiderlings to light. They are positively phototropic. When the spiderlings were allowed to emerge from their cocoons in glass cages they invariably worked their way to the side next the light. This is not true with mature individuals. In captivity the mature spiders chose places in all parts of the cages irrespective of the light. Out in nature the webs of the mature spider will be frequently found in a dark basement and also in the bright light of the greenhouse.

Instincts.—That the house spider is guided and ruled in her more purposive responses chiefly by instinct appears evident.

The little spiderling, when it first reaches the active stage, the second instar, spins its web in the same manner as the adult. It does this regardless of the nature of its surroundings. The small confines of a homeopathic vial are as suitable for this response, as the more natural environment on the mother's web. If a small insect is caught in this spiderling's web the latter rushes at it, and upon reaching the insect reverses its position,

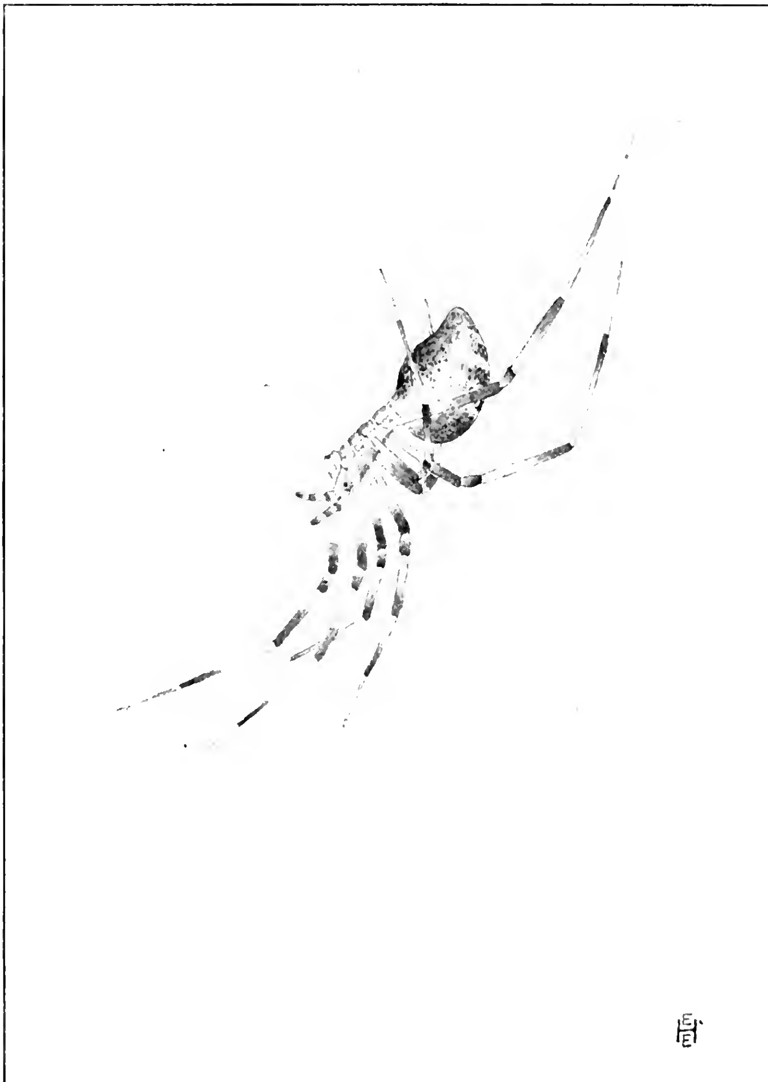

Fig. 12.—Female in attitude of alarm; X 4

and wraps up the victim in a manner almost exactly the same as the mother does. This whole process is done without prevision, experience, or parental direction, hence we call it instinctive.

The writer has never observed a female go through her cocooning process for the first time, but if we examine these first cocoons we find they are apparently as well built as the later ones. The cocooning process is quite complicated, and undoubtedly it is instinctive. If instincts are built up from reflex acts, certainly many such acts have contributed to this adaptive performance. It is interesting to note that in this case more than simply reaching maturity is necessary to start the chain of reflex performances. Fertilization is also necessary.

Memory does not appear to be well developed in the house spider. A cocoon kept from the female a few days was not accepted by her when returned to her cage. It has been shown that the females of some species will not accept a cocoon after being separated from it for more than 48 hours.

Reason.—That spiders lack prevision, as well as the ability to profit by experience is indicated by the following experiment. A male and female were captured and placed in a common glass battery jar which had perpendicular sides. They could not climb the smooth glass sides of this jar so a wooden approach was placed leading up on the sides of the jar from near the middle. Although the male passed several times by this approach he never attempted to climb it. Both male and female continued to try to climb the sides of the jar for twenty minutes, when I placed the foot of the approach against the bottom of the wall. In this position the female walked over the base of the approach several times, but made no attempt to crawl up it. Finally the male came across the base of the approach. He at once climbed to the top of the same, and dropped down spinning a thread as he came which he fastened at the bottom of the cage. Now he showed no signs of prospering from his experience, but continued to try the smooth glass again many times in succession. Finally he came across the wooden approach, but, poor spider, he passed right over it to try the smooth perpendicular glass walls and continued in this manner for some time. This reaction certainly suggests a lack of reason, at least in its higher form.

The blindness of the spider's instinct to snare victims, showing no accompanying judgment was shown in the following way. The web of the female was gently shaken by the end of a small wire so as to imitate the jerking on the web by an ensnared fly. At once the female rushed down to the end of the wire, and turning rapidly about she proceeded forthwith to wrap up the end of the wire with her sticky silk which she pulled out with her hind legs. More than this she passed drag lines to other parts of the web, so as to make sure the victim should not escape. As the wire was vibrated again, again she repeated these performances just as if she were snaring a victim.

The type of reason in this spider, if it does exist, is certainly different from that shown in higher animals.

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A PRELIMINARY LIST OF THE ACARINA OF IOWA

ALBERT HARTZELL.

In 1886, Professor Herbert Osborn and Professor L. M. Underwood published, in the "Canadian Entomologist," a preliminary list of the Acarina of North America. This list included 99 species in 28 genera. In 1907, Nathan Banks published his "Catalog of the Acarina, or Mites, of the United States," which includes about 450 species in 133 genera. This number probably represents less than one-third of our mite population.

The mites of New York, Ontario, Virginia and Illinois have been studied to a considerable extent, but large areas still remain to be covered and very few local lists have been published. In fact so little is known of the distribution of the various species that Banks omits all locality reference in his catalog. The mite population in the vicinity of Ames has been quite well covered by Dr. H. E. Ewing, but records from other places in the state are few and scattered.

In the preparation of this paper complete data have been given wherever obtainable. This includes a reference to the original description, locality, date, habitat and name of the collector. Collections made by Dr. H. E. Ewing and Professor J. E. Guthrie are accredited H. E. E. and J. E. G. respectively. The Zoological Record has been used as a standard for abbreviation of publications.

Dr. H. E. Ewing has kindly placed at the writer's disposal his private collection, which has been invaluable in the preparation of this paper. Dr. W. W. Dimock of the Veterinary Division, Iowa State College, also has contributed much in making this paper more useful by furnishing several important records of parasitic species.

Family **EUPODIDÆ.**

RHAGIDIA Thorell.

R. pallida Banks, Tr. Amer. ent. Soc., vol. XXI, p. 222, (1894). From Ames, March 3, 1910; under bark of log; by H. E. E.

LINOPODES Koch.

L. antennaepes Banks, Tr. Amer. ent. Soc., vol. XXI, p. 221, (1894). From Ames, September 30, 1909; under a log; by H. E. E.

EUPODES Koch.

E. variabilis Banks, Tr. Amer. ent. Soc., vol. XXI, p. 221, (1894). From Ames, September 18, 1909; under an old piece of wood; by H. E. E. From Grinnell, April 30, 1910; under a board in damp place; by J. E. G.

TYDEUS Koch.

T. coccophagus Ewing, Psyche, vol. XVIII, p. 38, (1911). From Ames, August, 1910. (Species found in abundance attacking oyster-shell scale.) August 17, 1910; from linden leaf; by H. E. E.

Family **BDELLIDÆ.**

BDELLA Latreille.

B. cardinalis Banks, Tr. Amer. ent. Soc., XXI, p. 219, (1894). From Ames, September 10, 1909; under rotten bark; by H. E. E.

B. peregrina Banks, var. *iowaensis* Ewing, Bull. Amer. Mus. Nat. Hist., vol. XXXVII, p. 150, (1917). From Ames; rare; under stick in woods; by J. E. G.

B. virgata Ewing, Univ. Ill. Bull., vol. VII, p. 70, (1909). From Ames, September 14, 1909; under bark of European elm; by H. E. E.

SCIRUS Hermann.

S. quadripilis Banks, Tr. Amer. ent. Soc., vol. XXI, p. 220, (1894). From Ames, October 26, 1909; under old piece of wood; by H. E. E.

EUPALUS Koch.

E. parvus Ewing, Bull. Amer. Mus. Nat. Hist., vol. XXXVII, p. 151, (1917). From Ames. Mentioned by R. L. Webster and H. E. Ewing in Psyche, vol. XIX, pp. 121-134. Found on *Lepidosaphes ulmi* Linn. An enemy of oyster shell scale, but not numerous at Ames; by T. M. McCall.

Family **CHEYLETIDÆ.**

MYOBIA Heyden.

M. musculi Schrank, Enum. Ins. Austr., p. 301, (1781). Mégnin. J. Anat. Physiol., vol. XIV, p. 432, (1878). From Ames; common on mice; by H. Osborn.

Family **ANYSTIDÆ.**

ANYSTIS Heyden.

A. agilis Banks, Tr. Amer. ent. Soc., vol. XXI, p. 211, (1894). From Ames, September 14, 1909; under bark of wild cherry; by H. E. E.

Family **TETRANYCHIDÆ.**

TETRANYCHUS Dufour.

T. erythreus Ewing, Bull. Amer. Mus. Nat. Hist., vol. XXXVII, p. 152, (1917). From Ames, September 27, 1909; by H. E. E.

T. telarius Linn., Fauna Suecia, p. 481. (1761). The common red spider or spider mite. From Ames and Des Moines. Reported from Iowa on the following plants: tomato, potato, apple, alfalfa, evergreens, chrysanthemum.

Family **ERYTHRÆIDÆ.**

ACHOROLOPHUS Berlese.

A. ignotus (Oudemans), Ent. Ber., vol. I, p. 92, (1903). From Ames, July 22, 1910; on a larva of *Melanoplus bivittatus;* by H. E. E.

ERYTHRÆUS Latreille.

E. gracilipes (Banks), P. ent. Soc. Washington. From Ames, October 5, 1909; under old piece of wood; by H. E. E.

E. gracilipes (Banks), P. ent. Soc. Washington. From Ames, October

From Ames, August 12, 1912; by R. L. Webster. October 8, 1909; on the collector's clothing; by H. E. E.

FESSONIA Heyden.

F. longilinealis (Ewing.), Tr. Acad. Sci., St. Louis, vol. XVIII, p. 61, (1909). From Ames, June 25, 19—; on *Oribata latincisa* Ewing; under board; by J. E. G.

Family **TROMBIDIIDÆ.**

EUTROMBIDIUM Verdun.

E. corticis Ewing, Bull. Amer. Mus. Nat. Hist., vol. XXXVII, pp. 155-156, (1917). From Ames, October 14, 1909; under bark; rare; by H. E. E.

E. trigonum Hermann, Mém. Apt., p. 26, (1804). The locust mite. From Ames, October 9, 1917; commonly found on *Melanoplus femur-rubrum*, *M. differentialis* and also on *Spharagеon boili* Scud; by the writer. Also the following: Ames, August 21, 24, 26 and 30, 1910; on *M. differentialis*; by H. E. E.

MICROTROMBIDIUM Haller.

M. muscarum Riley, First Rept. U. S. Ent. Com., p. 306, (1878). The house fly chigger. From Ames, August 30, 1910; by H. E. E. Common on house fly.

ENEMOTHROMBIDIUM Berlese.

E. ovalis Ewing, Bull. Amer. Nat. Hist., vol. XXXVII, p. 156, (1917). From Ames; running over ground; by H. E. E.

ALLOTHROMBIDIUM Berlese.

A. pulvinus Ewing, Bull. Amer. Nat. Hist., vol. XXXVII, p. 157, (1917). From Dallas Center, April, 1917; on apple tree; by W. F. Chaney.

Family **GAMASIDÆ.**

DERMANYSSUS Dugès.

D. gallinae (Redi), Esper. Int. Insetti, pl. II, (1688). Mégnin, Parasit., p. 115, (1880). The chicken mite. From Ames, summer, 1910. The Auk, vol. XXVII, No. 3, July, p. 337, (1911); August 20, 1910; on chicken, originally from English sparrow nest; by H. E. E.

SEIUS Koch.

S. hirsutus Koch, Crust. Myr. Arach, (1835). From Ames, October 3, 1909; under old piece of wood; by H. E. E.

GAMASUS Latreille.

G. predator Banks, P. Ent. Soc. Washington, vol. XII, p. 5, (1910). From Ames, October 14, 1909; under old piece of wood; by H. E. E.

LIROASPIS Banks.

L. americana Banks, Can. Ent., p. 174, (1902). From Ames, October 26, 1909, and September 11, 1910; under old piece of wood; by H. E. E.

Family **ARGASIDÆ.**

ARGAS Latreille.

A. miniatus Koch, Arch. Naturg., vol. X, p. 219, (1844). The chicken tick. Reported from Iowa; no locality given; in U. S. Dept. Agr. Bur. Ent. Bull. 106, p. 47.

ORNITHODOROS Koch.

O. megnini Dugès, La Naturaleza Mexicana, vol. VI. p. 197, (1885). The spinose ear tick. Reported from Iowa in U. S. Dept. Agr. Year Book for 1910, p. 222; from Davenport and Ames in U. S. Dept. Agr. Bur. Ent. Tech. Ser. No. 15, p. 17; from Iowa in U. S. Dept. Agr. Bur. Ent. Bull. 106, p. 62.

Family IXODIDÆ.

IXODES Latreille.

I. cookei Packard, 1st Rept. Peabody Acad. Science, p. 67, (1869). Reported from Iowa by Banks in U. S. Dept. Agr. Bur. Ent. Tech. Ser. No. 15, p. 29, (1908).

I. scapularis Say, J. Ac. Philad., vol. II, p. 78, (1821). The black legged tick. Reported from Iowa in U. S. Dept. Agr. Bur. Ent. Bull. 106, p. 77.

Family ORIBATIDÆ.

PELOPS Koch.

P. laticuspidatus Ewing, Jour. New York Ent. Soc., vol. XVII, p. 117. (1909). From Ames, September 14, 1909; under bark of European elm; by H. E. E.

ORIBATA Latreille.

O. emarginata Banks, Tr. Amer. ent. Soc., vol. XXII, p. 7, (1895). From Ames, September 14, 1909; under old piece of wood; September 16, 1909; under bark of *Acer saccharinum*; by H. E. E.

O. depressa Banks, Tr. Amer. ent. Soc., vol. XXII, p. 6, (1895). From Ames, Sept. 14, 1909; under bark of wild cherry; by H. E. E.

O. nigra Ewing, Jour. New. York Ent. Soc., vol. XVII, p. 119, (1909). From Ames, May 3, 1910; under stone; by J. E. G.

O. texana Banks, Jour. Acad. Philad., p. 494, (1906). From Ames, October 14, 1909; under old piece of wood; by H. E. E.

SPHÆROZETES Berlese.

S. latincisa, (Ewing), Jour. New York Ent. Soc., vol. XVII, p. 121., (1909). From Ames, January 25, under board; host of *Samaris longilinealis* Ewing; by J. E. G.

PROTORIBATES Berlese.

P. maximus Ewing, Psyche, vol. XV, p. 107, (1908). From Ames, October 14, 1909; under bark; by H. E. E.

CERATOZETES Berlese.

C. virginica (Banks), Jour. Acad. Philad., p. 493, (1906). From Ames, September 19, 1909; under old piece of wood; by H. E. E.

PELORIBATES Berlese.

P. banksi (Ewing), Bull. Illinois Lab., vol. VII, p. 361, (1909). From Ames, September 23, 1909; under bark of *Quercus* sp.; by H. E. E.

P. iowaensis Ewing, Bull. Amer. Mus. Nat. Hist., vol. XXXVII, p. 160, (1917). From Ames; an old piece of wood; by H. E. E.

P. serratoseta Ewing, Psyche, vol. XIV, p. 114, (1907). From Ames, September 18, 1909; under old piece of wood; by H. E. E.

ORIBATELLA Banks.

O. achipteroides Ewing. var. *australis* Ewing, Bull. Amer. Mus. Nat. Hist., vol. XXXVII, p. 160, (1917). From Ames; under stone; by H. E. E. Type collected by J. E. Guthrie at Red Wing, Minnesota.

O. quadridentata Banks, Tr. Amer. ent. Soc., vol. XXII, p. 8,(1895). From Ames. September 11, 1909; under old piece of wood; by H. E. E.

LUCCOPPIA Berlese.

L. pilosus (Banks), Tr. Amer. ent. Soc., vol. XXII, p. 11, (1895). From Ames, September 23, 1909; under bark of shell-bark hickory; by H. E. E.

TEGEOCRANUS Nicolet.

T. subniger Ewing, Bull. Amer. Mus. Nat. Hist., vol. XXXVII, p. 163, (1917). From Ames, October 7, 1909; under old piece of wood on the ground; by H. E. E.

DAMÆUS Koch.

D. brevitarsus Ewing, Bull. Amer. Mus. Nat. Hist., vol. XXXVII, p. 164, (1917). From Ames; under old piece of wood; by H. E. E.

D. sufflexus Michael, Jour. Royal Micr. Soc., vol. V, p. 394, (1885). From Ames, September 11, 1909; under old piece of wood; by H. E. E.

DAMEOSOMA Berlese.

D. sculptilis Warb. and Pear., Proc. zool. Soc. London, vol. II, p. 564, (1905). From Ames, October 14, 1909; under old piece of wood; by H. E. E

DAMEOLOS Paole.

D. apicolis Banks, Tr. Amer. ent. Soc., vol. XXII, p. 13, (1895). From Ames, October 26, 1909; under old piece of wood; by H. E. E.

ORIPODA Pergande and Banks.

O. elongata Pergande and Banks, Ann. entom. Soc. Amer., vol. III, p. 209, (1910). From Ames. April 16, 1894; in gall on elm twig.

Family **HYPOCHTHONIDÆ.**

HYPOCHTHONIUS Koch.

H. rufus Koch, Crust. Myr. Arach., fasc. 3, fig. 19, (1835). From Ames, June 17, 1913; under a log in moist place; by J. E. G.

Family **HAPLODERMATIDÆ.**

GINGLYMACARUS Ewing.

G. sphaerula (Banks), Tr. Amer. ent. Soc., vol. XXII, p. 16, (1895). From Ames, September 17, 1909; under old piece of wood; by H. E. E.

Family **TARSONEMIDÆ.**

TARSONEMUS Canestrini and Fanzago.

T. chionaspivorus Ewing, Psyche, vol. XVIII, p. 40, (1911). From Ames. Specimen collected while studying oyster-shell scale from *Chionaspis* sp. on poplar; by H. E. E.

Family **TYROGLYPHIDÆ.**

GLYCIPHAGUS Hering.

G. spinipes Koch, Crust. Myr. Arach., fasc. 23. fig. 1, (1841). From Des Moines; on the skin of *Xanthocephalus xanthocephalus* Bonap; Keyes' collection, Iowa State College Museum.

TYROGLYPHUS Latreille.

T. lintneri Osborn, Science, vol. XXII, p. 360, (1893). From Manchester, September 20, 1915; on floor of barn; by G. W. Dunham.

T. siro Linn., Syst. Nat., ed. X, p. 616, (1758). Common cheese mite. From Ames, 1893; by H. Osborn.

RHIZOGLYPHUS Claparède.

R. phylloxerae Riley, 6th Missouri Rept., p. 52, (1874). From Eldora, May, 1916; on roots of alfalfa; by Ben Walker.

MONIEZIELLA Berlese.

M. angusta Banks, U. S. Dept. Agr. Bur. Ent. Tec. Ser. No. 13, p. 23, (1906). From Ames, July 25, 1910; on *Chionaspis* sp; by H. E. E.

M. entomophagus (Loboulbene), Bull. Soc. ent. France, p. 54, (1852). From Ames, July 23, 1910; feeding on egg shells and dead oyster-shell scale; by H. E. E.

Family **ANALGESIDAE.**

MEGNINIA Berlese.

M. tyrrelli Haller, Arch, Naturg., p. 55, (1882). Taken from bird skins in Keyes' collection, Iowa State College Museum, Ames; *Agelianus phoeniceus* Linn. Des Moines; *A. phoeniceus* Linn., *Piranga rubra* Linn., and *Spiza americana* Gmel. Iowa City; on *Hesperiphona vespertina vespertina* Coop.

M. pici-majoris Buckholtz, Bemerk. Gatt. Dermalechus, p. 43, (1869). Des Moines; taken from skin of *Dryobates pubescens* Linn., Keyes' collection, Iowa State College Museum.

PTERODECTES Robin.

P. muticus Banks, Proc. ent. Soc. Washington, vol. XI, p. 141, (1909). Des Moines; taken from skin of *Pooecetes gramineus* Gmel., Keyes' collection, Iowa State College Museum.

ANALGES Nitzsch.

A. cemidonotus Trouessart, Bull. Soc. Angers, vol. XXVIII, p. 29, (1899). Polk county, taken from the skin of *Euphagus carolinus* Müll, Keyes' collection, Iowa State College Museum.

A. passerinus Linn., Syst. Nat., ed. X, p. 616, (1758). Ames; taken from skin of *Agelianus phoeniceus* Linn., Keyes' collection, Iowa State College Museum.

Family **SARCOPTIDÆ.**

NOTOEDRES Railliet.

N. notoedres Mégnin, Paras., pp. 172-174, (1880). From Ames; summer of 1910; on rats; by H. E. E.

SARCOPTES Latreille.

S. suis Gerlach, Kratze und Raube, p. 137, (1857). The mange mite of swine. From Ames; by Dr. W. W. Dimock. According to Dr. Dimock found at other places in the state.

CNEMIDOCOPTES Fürstenberg.

C. mutans Robin, Bull. Soc. Moscow, vol. XXXIII, p. 184, (1860). Scaley leg of chicken. From Ames and other parts of the state; by Dr. W. W. Dimock.

PSOROPTES Gervais.

P. bovis (Gerlach), Kratze und Raube, p. 114, (1857). Psoroptes of cattle. From Storm Lake, June 21, 1913; on cattle; by Dr. W. W. Dimock.

P. equi (Herring), N. Acta. Ac. Leop., XVIII, p. 585, (1838). Psoroptes of the horse. From Northwood; April 18, 1912; on horse; by Sabin Reese.

Family CYTOLEICHIDÆ.

LAMINOSIOPTES Megnin.

L. cysticola Vizioli, Giorn. Anat. Fisiol., vol. I, p. 257, (1870). From Seymore; January 27, 1912; on pigeon; by Dr. W. W. Dimock. From Des Moines; August 30, December 7, 1912; on chicken; by Dr. W. W. Dimock. From Ames; January 30, 1913; on chicken; by Dr. W. W. Dimock. From Morehead; by Dr. W. W. Dimock.

CYTOLEICHUS Mégnin.

C. nudus Vizioli, Giorn. Anat. Fisiol., vol. I, p. 257, (1870). On chicken; by Dr. W. W. Dimock.

Family ERIOPHYDÆ.

ERIOPHYES Siebold.

E. pyri (Pagen.), Berh. Ver. Heidelberg, vol. I, p. 48, (1857). The pear leaf blister mite. From Ames; on Russian pear trees; by H. Osborn.

E. quadripes (Shimer), Tr. Amer. ent. Soc., vol. II, p. 319, (1869). The maple leaf gall mite. Generally distributed throughout the state. June and July, 1884; by H. Osborn.

The following unidentified species observed by Prof. H. Osborn are mentioned in Iowa Agr. Coll. Bull. 2, pp. 58-61, (1884). The ash gall mite. College grounds, Ames, June 16, 1884; the elm bud deformer, Ames, January, 1883; under bark of elm. The box elder mite; no locality given.

Family DEMODECIDÆ.

DEMODEX Owen.

D. canis Leydig, Ann. Nat. Hist., vol. XIII, p. 75, (1844). The hair folicle mite of the dog. From Ames; January 17, 1917, on dog; by Dr. W. W. Dimock.

D. phylloides Csokor, Oesterr. Vierteljahrschrift. fur Veternärkunde, vol. LI, p. 133, (1879). The hair folicle mite of swine. From Iowa on pigs shipped to Ames; fall of 1916; by Dr. W. W. Dimock.

CONCLUSION.

1. The American Acarina are quite distinct from those of Europe. The most important exceptions are among the ticks and itch mites.

2. The mite fauna of Iowa is in general very similar to that of Illinois, yet it is interesting to note that in the vicinity of Ames we find several of the northern forms. This is a little unusual because Ames is located fully a hundred miles south of the lower limit of the Transitional Life Zone.

3. No records of sheep scab or human scabies have been noted in recent years. Sheep scab at one time occurred in this state but due

to the efficient work of the United States Bureau of Animal Industry it apparently has been eradicated.

4. This list is a preliminary one and is in no case complete. It includes 74 species in 55 genera.

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NOTES ON THE FOOD OF THE YELLOW PERCH IN CAYUGA LAKE.

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The intention of the writer at the time this study was begun, was to make a careful examination of the stomach contents of the yellow perch, *Perca flavescens* (Mitchill), in its various ages and during the different seasons of the year. For various reasons this program could not be carried out at the time, and no opportunity has been found since.

Most of the work was done during the summer of 1915, in the limnological laboratory of the Department of Entomology at Cornell University. The fish, twenty-one in number, were seined in the southern end of Lake Cayuga, a narrow glaciated body of water approximately forty miles in length, situated in the central portion of New York state. Hauls were made on two days, June 25, and July 14, the majority of the specimens having been taken on the latter date.

As soon as the perch were killed, a slit was made anterior of the anal fin. Then further action of the digestive juices upon the food was prevented by placing the fish in an 8 per cent solution of formaldehyde. Following this the stomach contents were removed into a watch glass, and the various elements then sorted into similar containers. In most cases the food which had reached the small intestine was too decomposed to permit accurate identification.

After these preliminary steps the contents were examined under the binocular or compound microscope for identification. The length of all fish examined was from the tip of the snout to the base of the caudal fin.

Nematodes, Cestodes, Trematodes and Acanthocephala were found among the stomach contents but were not included in the count since they are parasitic and can not be regarded as food. In a few cases some small Crustacea were found that were probably taken in accidentally, or were obtained secondarily from prey the fish had caught. The following indicates the stomach contents in detail:

STOMACH CONTENTS IN DETAIL.

Numbers 1 to 5 inclusive caught June 27.

1. $3\frac{1}{4}$ inches long.
   - 2 Mayfly (Ephemeridæ), nymphs.
   - 1 caddis-fly (Trichoptera), nymphs.
   - 1 *Ablabesmyia* pupa.
   - 1 *Tanytarsus* pupa. } Chironomidæ
   - 1 fish, $\frac{3}{4}$ inch in length.
2. 3 7-16 inches long.
   - 3 fish, each about 1 inch in length.
3. $2\frac{3}{4}$ inches long.
   - 2 fish, one $1\frac{1}{4}$ inches in length, the other $\frac{3}{4}$ inch in length.
4. 3 1-16 inches long.
   - 4 *Cambarus propinqus* (Crustacea)
5. $2\frac{3}{4}$ inches long.
   - 2 small fish.
   - 1 *Chironomus* larva (Chironomidæ).

Numbers 6 to 21, caught July 14. West shore of the lake about one mile from its southern end.

6. 6 inches long.
   - 5 *Gammarus fasciatus* (Crustacea), with parts of another.
   - 25 *Hyalella knickerbockeri* (Crustacea).
   - 4 *Chironomus* larvæ.
   - 2 *Ischnura verticallis* nymphs (Odonata).
   - 1 *Chironomus* pupa.
   - 1 *Lepticellus larva* (Trichoptera).
7. 6 inches long.
   - 423 eyed eggs, probably those of carp or of the golden shiner, *Abramis chrysoleucus*.
   - 1 minnow very well digested.
   - 1 *Cambarus propinqus*.
   - 2 shells of *Planorbis exactus*. (Gastropoda)
   - 1 shell of *Gammarus*.
8. 6 7-16 inches long.
   - 1000 eggs, similar to those found in 7.
   - 3 *Chironomus* pupæ.
   - 1 Chironomid pupa, genus unknown.
9. $6\frac{1}{4}$ inches long.
   - 1 *Planorbis parvus*.
   - 1 *Physa* (Gastropoda).
   - 1 larva of *Leptocerus ancylus*. (Trichoptera).
   - Remains of one fish.
10. 6 1-16 inches long.
    - 125 eggs similar to those found in 7 and 8.
    - 1 *Cambarus propinqus* $1\frac{1}{4}$ inches long without shell, probably eaten while molting.
11. $5\frac{1}{4}$ inches long.
    - 50 *Gammarus fasciatus*.
    - 1 *Cambarus propinqus*.

1 Trichopterous larva.
1 stickleback (*Eucalia inconstans*), 1 1-16 inches long.

12. 6⅛ inches long.
Contents very well digested. Parts of at least 3 small fish.
A few Crustacean appendages.
9 small eggs.

13. 6⅝ inches long.
A minnow wound doubled up which was almost as long as the perch itself.
1 egg.

14. 6 inches long.
1 *Cambarus propinquus.*
20 to 25 Leptocerid, (Trichoptera), larvæ. These were fairly well digested so that no accurate count could be made. Their cases of vegetable matter were also present.

15. 5⅞ inches long.
1 *Orthocladius* larva, (Chironomidæ).
2 *Chironomus* larvæ, (Chironomidæ).
2 *Chironomus* pupæ, (Chironomidæ).
Part of an insect larva.
10 Leptocerid larvæ similar to those found in the preceding stomach.
2 young perch, each about 1 inch long, very well digested.
2 Cyprididæ (Ostracoda).
2 Minnow? eggs.
Seed of an aquatic plant, (accidental).

16. 6⅛ inches long.
2 *Cambarus propinquus*, one 1¼ inches long, the other slightly less.
At least 6 *Hyalella knickerbockeri*, (Crustacea allied to *Gammarus*).
1 *Chironomus* larva, the head of another.
12 fish eggs.

17. 6 inches long.
10 *Cyclops.*
3 *Daphnia.*
1 *Eucrangonyx*, (Crustacea closely related to *Gammarus*).
28 fish eggs.
12 *Eucalia inconstans*, (brook stickleback).
4 Leptocerid larvæ, (Similar to preceding ones).
Numerous Crustacean fragments and appendages.

18. 6 inches long.
1 *Cambarus propinquus.*
75 *Gammarus fasciatus.*
4 *Hyalella knickerbockeri.*
2 *Chironomus* larvæ.
1 Chironomid larva.
1 Chironomid pupa.

28 Trichopterous larvæ.
23 eggs, probably fish eggs.

19. 6 7-16 inches long.
2 *Cambarus propinqus.*
6 *Gammarus fasciatus.*
1 *Campeloma* (Gastropoda).
52 fish eggs.
1 Trichopterous larva.

20. 5 5-16 inches long.
6 Crustacean? eggs.
297 *Hyalella knickerbockeri*
3 *Gammarus fasciatus.*
1 Trichopterous larva.
1 *Basiaeschna* nymph } Odonata
4 *Ischnura verticallis* nymphs } Odonata
6 water mites (Hydrachnida).
3 fish eggs.
2 *Chironomus* larvæ.
4 *Chironomus* pupæ.

21. $4\frac{1}{4}$ inches long.
142 *Chironomus* larvæ.
1 *Chironomus* pupa.
2 Hydrachnids.
1 *Enallegma* nymph (Odonata).
1 *Ischnura verticallis* numph.
Remains of several Tricnopterous larvæ, their number impossible to ascertain.
30 *Hyalella knickerbockeri.*

Of the fish examined two ages predominated, one and two year olds. The larger fish seemed to feed on smaller organisms such as Chironomidæ, Trichoptera and Gammaridœ as much as on prey of greater size.

The presence of twelve sticklebacks, (*Eucalia inconstans*), in the stomach of one perch was somewhat of a surprise as previous investigators have not mentioned this fish as food of the perch. Since Forbes (1878-80), and Baker (1916), reported Corixidœ as occurring rather commonly in the stomach of the perch it seems strange that none was found in this lot, while the fact that only parts of two mayflies (Ephemeridæ), were found was also quite unlooked for, inasmuch as perch have been observed feeding almost entirely upon mayflies during the June transformations of these insects. Crustacea were present in thirteen stomachs with evidence of their having been in another. Of these Decapods represented by *Cambarus* were in eight while Amphipods were found in ten, these being mostly *Gammarus* and

Hyalella. There were also a few members of other groups of the Crustacea. Hydrachnids were found in two. From the above we may conclude that in both volume and number, fish, fish eggs, and Crustacea play an important part in the food of the perch in Cayuga lake during the first half of the summer.

I am greatly obliged to Dr. Needham, Dr. Johannsen and Mr. Lloyd of the Department of Entomology, Cornell University, for assistance in identifying material in which they are specialists, and to Dr. Embody, under whose direction the work was undertaken, I am especially indebted for kind assistance in the preparation of this paper.

The contents are summarized in the following table:

STOMACH CONTENTS OF YELLOW PERCH.

No.	Length in inches	Crustacea	Mollusca	Fish Eggs	Odon-ota	Trichoptera	Diptera	Acarina	Fish	Miscellaneous
1	3 1/4					1	2		1	Remains of 2 Ephemerid nymphs
2	3 7/16								3	
3	2 3/4								2	
4	3 1/16	4								
5	2 3/4						1		2	
6	6	30			2	1	5			
7	6	2	2	423					1	
8	6 7/16			1000			4			
9	6 1/4		2			1			1	
10	6 1/16	1		105						
11	5 1/4	51				1			1	
12	6 1/8			9					3	Few Crustacean appendages
13	6 5/8			1					1	
14	6	1				25				
15	5 7/8	11		9		10	5		2	Part of larva of an insect; seed of an aquatic plant
16	6 1/8	17		12			2			
17	6	14		28		4			12	Numerous Crustacean appendages
18	6	80		23		28	4			
19	6 7/16	8	1	52		1				
20	5 5/16	300		3	5	1	6	6		Six Crustacean eggs
21	4 1/2	30			2	several	143	2		Remains of several Trichopterous larvæ
	Total	549	5	2165	9	77?	172	8	29	

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DEPARTMENT OF ZOOLOGY,
IOWA STATE COLLEGE.

SPIDERS OF THE FAMILY ATTIDAE COLLECTED IN THE VICINITY OF AMES, IOWA.

I. L. RESSLER.

In this work with the Attidæ collected in the vicinity of Ames the writer used Banks' arrangement in the separation of genera and species. A few of the specimens were collected by Prof. C. P. Gillette in 1888-90 and identified by Banks in 1891; some were collected during the summer of 1916 by L. S. Wells while others were collected during the fall of 1916 and spring of 1917 by the writer, who has identified all except those that were collected by Prof. Gillette.

The bright colors of a number of the specimens have been lost due to their long preservation in alcohol. Recently there has been adopted a preserving medium which will preserve without destroying the colors. This medium is composed as follows:

Glycerine	40 parts
Formalin (4 per cent)	40 parts
Alcohol (95 per cent)	20 parts

It has been found that by allowing spiders to become thoroughly saturated with the above solution they can be pinned and kept in the same manner as insects. A number of brightly colored *Epeiridae* and *Thomisidae* have been mounted in this manner for over a year and a half and they have retained all of their brilliant colors and characteristic markings.

Spiders of the family Attidae are commonly known as jumping spiders because of their quick jumping movements. They are of small or of medium size, have a short body and stout legs, the tarsi of which are furnished with two claws. Spiders of this group can always be recognized by the arrangement of the eyes, which are in three rows. The anterior row is on the vertical side of the face, and the median eyes are at least twice as large as the lateral eyes. The posterior median eyes are very small, and are situated just back of the anterior lateral eyes. The posterior lateral eyes are from two to five times as large as the posterior median eyes and are situated back of the posterior median eyes. They constitute the posterior limits of the ocular quadrangle. The ocular quadrangle is the area defined by the eyespace and occupies the entire head region.

Unlike most families the length of the legs is variable. Emerton, who has done very extensive work with the new England

Attidae says: "The relative length of the legs is very variable. The fourth pair is usually the longest, but often the first, and even in some species the third pair. The legs of the first pair are usually thickened, and often those of the second pair. Most species can jump a considerable distance and this seems to be done from all the legs at once and does not depend on their relative length or size. The feet have two claws, generally long and with many small teeth, and, under the claws, a bunch of long hairs."

Many of the spiders of this group are very brightly colored. "As much so as are humming birds or beetles," says Peckham in his "Attidae of North America." Unfortunately most of those in the collection at Ames have lost much of their brilliancy due to their early preservation in alcohol. The coloration is due to a thick covering of hairs and irridescent scales which may easily be rubbed off thus destroying some distinctive characteristics.

The males of this family, unlike those of many other families, differ very little in size from the females. At mating time the males display a curious habit, one which perhaps makes the study of this group extremely interesting. At this time the males will dance before the female, and assume various attitudes in order to display their ornaments to best advantage. It has been observed in the genus *Salticus* that two males will frequently try to win the favor of the same female. Each male becomes extremely jealous of the other, and waits for opportunities to attack his rival. The fight between the two jealous lovers lasts until one of them is defeated when the other, minus most of his beautiful ornaments and bright scales becomes the proud possessor of his mate won by conquest.

The following account of the feeding and nesting habits of the Attida, has been taken from "The Spider Book" by J. H. Comstock:

"The jumping spiders are hunters, pursuing their prey or springing upon it when it comes near them. They move sidewise or backward with great ease, and can jump a long distance. They spin a drag line. I have seen them jump away from the side of a building, to catch an insect, flying near, and quickly regain their position by means of the dragline. They make no webs except nests in which they hide in winter or when moulting or laying eggs. These nests are sac-like in form, composed of several envelopes and usually furnished with two openings.

"The egg-sacs are frail. As they are made within the sac-like nest, there is not the necessity for a dense cocoon that there is with most other spiders. The cocoon is usually lens-shaped and suspended, like a hammock, from the walls of the nest. There may be several cocoons within a single nest; but usually there is only one. With the species that we have observed, the eggs are laid early in the season, and the young soon hatch. They are guarded by the parent female until they disperse. On the approach of winter the young make the sac-like nests in which to pass the winter."

ATTIDAE IN THE AMES COLLECTION.

PHIDIPPUS

P. audax Hentz. *P. castrensis* Koch. *P. electus* Koch. *P. insolens* Hentz. *P. podogrosus* Hentz. *P. rufus* Hentz.

DENDRYPHANTES

D. militaris Hentz. *D. octavus* Hentz.

HABROCESTUM

H. pulex Hentz.

THIODINA

T. sylvanus Hentz.

ICIUS

I. elegans Keyserling.

WALA

W. palmarum Hentz.

MARPISSA

M. undata DeGeer.

SALTICUS.

S. scenicus Clerck.

ZYGOBALLUS

Z. nervosus Peckham. *Z. sexpunctatus* Hentz.

NEON.

N. nelli Peckham.

SYNEMOSYNA

S. formica Hentz.

DESCRIPTIONS OF GENERA AND SPECIES.

PHIDIPPUS Koch 1846.

The representatives of this genus are large and usually very hairy. The cephalothorax is high and widened across the middle. The first legs are very stout, and are thickly covered with hairs. The ocular quadrangle is a little wider than long and is confined to the anterior two-fifths of the cephalothorax. The anterior row of eyes is curved and the eyes are but little separated. The small median eyes are closer to the anterior lateral eyes than to the posterior. Most of the species of this genus can be identified by their characteristic markings.

Phidippus audax Hentz, 1845.

This is a large spider. The ten specimens in the collection at Ames range from nine to fourteen millimetres in length. The cephalothorax is black, covered with short black and white hairs. The clypeus is thickly covered with white hairs. The mandibles are a bright irridescent green, and the claws are reddish brown. The abdomen is black and is covered with short black hairs and longer white ones. On the dorsal side of the abdomen at about the middle is a large somewhat triangular white spot; a little further caudad and on each side is a pair of white spots. Directly back of these near the apex is another very minute pair of white spots. Some of the specimens have a faint white basal band on the abdomen. In some immature specimens the markings are a delicate orange yellow.

P. audax is perhaps one of the most common of our Attids. It ranges throughout the United States, chiefly from the Eastern coast as far west as Colorado. It has been described under at least a dozen names. Koch in his Die Arachniden, published in 1846 is responsible for nine synonyms.

Phidippus castrensis Koch 1846.

This is a medium sized spider of which there is in the collection but a single male. The colors have been very much dulled due to long preservation in alcohol. The cephalothorax still retains some of its brilliant orange colored scales. The sternum and mouth parts are black. The abdomen is orange brown with a dorsal white basal band. The legs are uniformly brown with whitish bands at the joints. The coxa are all darker than the rest of the legs.

This spider has previously been reported from the eastern states by Emerton and from Pennsylvania by Peckham.

Phidippus electus Koch 1846.

The cephalothorax is dark brown, covered with white hairs, with some longer black hairs in the eye region. The dorsal side of the abdomen has a light longitudinal central stripe on which is a faint white stripe and two pairs of white dots. The sternum and ventral side of the abdomen are brown and are covered with short white hairs. The legs are a uniform light brown and are covered with long white hairs.

There is a single female of this species in the collection. It was collected by Professor Gillette and identified by Banks in 1891. The distribution is given as the United States.

Phidippus insolens Hentz 1845.

The collection contains but a single female of this species. It is 10.5 millimetres in length. The cephalothorax is dark brown, almost black in the eye region, when in alcohol. The fresh specimen has a thick covering of golden hairs over the entire ocular quadrangle. There is also a sparse scattering of long whitish hairs covering the entire cephalothorax. The sternum and mouth parts are dark brown. The abdomen has a narrow white basal band on the dorsal side. About midway along its length there is an indistinct, oblique white bar on each side. On the posterior end are several pairs of indistinct white spots. The entire dorsal aspect of the abdomen is covered with short golden hairs among which there is a scattering of long white and brown ones. The ventral side of the abdomen is snow-white and covered with short, bristly hairs. A pair of parallel dark lines run the length of the ventral side. The legs are a dark reddish brown and are thickly covered with long white hairs. On the upper side of the femur of the first pair of legs there is a fringe of black hairs.

This species is given by Comstock as a southern species and was reported in 1889 by Peckham from Georgia, Florida and Colorado, and in 1900 from Long Island. A specimen collected at Ames and identified (1891) by Banks as *P. mystaceous* the writer has been unable to associate with other than *P. insolens*.

Phidippus podagrosus Hentz 1846.

There is but a single female of this species in the collection. It measures ten millimeters in length. The markings are somewhat faded. The general color is light brown with black and white markings. The cephalothorax is covered with reddish brown hairs and the clypeus has a rather dense covering of white hairs. The margin of the cephalothorax is black. Dorsally the abdomen has a white basal band, and on the posterior half there are two longitudinal black bands on which are four pairs of white spots. The ventral side of the abdomen has a pair of parallel dark stripes running its length. There is a covering of variously colored hairs over the entire abdomen. The legs are light brown, darker towards the joints, and covered thickly with gray hairs. The palpi are straw colored.

This spider is found on plants throughout the summer and early fall. It has previously been reported from the New England states by Emerton and from Alabama, Georgia and Florida by the Peckhams.

Phidippus rufus Hentz 1846.

This species is represented by two females in our collection. The cephalothorax is covered with reddish yellow hairs except in the eye region, which is black. The clypeus has a thick covering of long white hairs. The sternum is black with a covering of white hairs.

The abdomen is brick-red and has a white basal band on the dorsal side. There is a pair of black longitudinal stripes on the posterior end. On these stripes there are two pairs of white spots. The legs are brown with darker rings at the joints.

This spider is very widely distributed throughout the United States.

DENDRYPHANTES Koch 1837.

The spiders of this genus are all of medium size and very hairy. The anterior row of eyes corresponds to that of *Phidippus;* the middle eyes are midway between the anterior lateral and the posterior eyes. The ocular quadrangle occupies two-fifths of the cephalothorax. While this is a large group, the writer has been able to collect only the two following species.

Dendryphantes militaris Hentz 1845.

These spiders are six to ten millimetres in length. The general color is brown with a covering of gray and black hairs. The abdomen of the female is marked with four pairs of white spots dorsally, while on each side there are four oblique white spots. At the basal end of the abdomen there is a white band. The male is a lighter brown than the female with a white stripe beneath the eyes and extending almost the length of the cephalothorax. A white band around the sides of the abdomen extends to the caudal end, with four pairs of white spots on the dorsal side.

Comstock says that this spider ranges over a large part of our territory. Emerton has reported it from the New England states and Peckham from Pennsylvania and Alabama.

Dendryphantes octavis Hentz 1846.

This is a very beautiful and prominently marked spider.

The writer has never seen any other than the alcohol preserved specimens. These are all dull red in color. There are only females in our collection all of them about six millimetres in length. Following is Peckham's description of color and markings: "Cephalothorax brown with short white hairs. Abdomen very variable; sometimes pinkish with white bands at base and on the sides, and four pairs of white spots; sometimes brown with many pale spots and curved bands; sometimes brown with four pairs of black spots; sometimes bronze with white hairs at the base and on the sides, and two longitudinal black bands upon which are three or four pairs of white dots. The clypeus is white with other parts varying between light and dark brown."

This species is distributed over a large part of the United States and Mexico. It is commonly found on small trees and bushes.

HABROCESTUM Simon 1876.

In this genus the cephalothorax is short and slightly bulging on the sides. The ocular quadrangle is a little wider than long, with the second row of eyes about midway between the anterior lateral and the posterior eyes. The posterior eyes are separated the width of the cephalothorax. The third pair of legs is longest. The abdomen is oval-shaped.

Habrocestum pulex Hentz 1846.

One female collected by Osborn and identified by Banks (1891) is in the collection. The markings have been destroyed by their many years in alcohol. The following is Comstock's description:

"This is a small species, the male measuring only one-sixth inch in length, the female a little more. In the male the cephalothorax is reddish, dark in the eye-region, with a narrow white triangle pointing forward, and lighter behind the eyes; the abdomen is dark brown, with two longitudinal, nearly parallel, light lines on the basal half and a broad transverse white mark just behind the middle. In the female the cephalothorax is dark, with a large triangular spot reaching from the eyes to the hind end. The abdomen is dark, with either two light longitudinal lines on the basal half, as in the male, or with several irregular light spots in this region, and with a transverse light band just behind the middle. Around and behind the band are other irregular light markings."

This species has previously been reported by Peckham from New York, Pennsylvania, Wisconsin, Iowa, Tennessee and Alabama, and by Emerton from the New England states.

THIODINE Simon 1900.

This genus can readily be identified by four setæ, arranged in pairs, with bulblike swellings near the bases, on the under side of the tibiæ of the first legs. The function of these setæ is not known although some authors claim they are used as sense organs. Otherwise the characteristics of this genus are the same as those of Dendryphantes with which it has frequently been confused.

Thiodina sylvanus Hentz 1846.

The cephalothorax is yellow with brown markings. The eyes are located on dark brown spots, and between the eyes there are also brown spots. The pointed abdomen is a light brownish yellow with three lighter stripes running longitudinally on the dorsal side. A row of dark brown spots runs along the dorsal stripe. A single female measuring seven millimetres in length is in our collection. It was collected by Professor Gillette and identified by Banks. Professor Comstock states that this is a southern species, and distributed from the Atlantic to the Pacific.

ICIUS Simon 1876.

The cephalothorax is low with the sides nearly parallel. The ocular quadrangle takes up less than one-half the length of the cephalothorax. The single species with which the writer has worked has the middle row of eyes nearer to the anterior lateral than to the posterior eyes, although Comstock says that the position may vary.

Icius elegans Keyserling 1893.

This is a small irridescent bronze-green spider measuring about six millimetres in length. The cephalothorax is marked along the lower margin with a white stripe. The only marking on the abdomen is a white basal band. The legs are straw colored with the femur of the first pair almost entirely black. All of the legs are marked above with a narrow black longitudinal stripe.

This species has been reported throughout the eastern half of the United States. There is but a single specmen in the Ames collection.

WALA Keyserling 1884.

The cephalothorax is flat with the sides rounded. The ocular quadrangle occupies about two-fifths of the cephalothorax. The abdomen is nearly twice as long as the cephalothorax. The first pair of legs is longer than the others.

Wala palmarum Hentz 1846.

A single female identified by Banks in 1891 is in the collection. The cephalothorax is brown with a narrow white stripe extending its length on each side. The eyes are on dark spots. The clypeus is thinly covered with white hairs. Dorsally the abdomen has two white stripes on each side and a central notched dark stripe extending lengthwise. The sternum and mouth parts are brown and the ventral surface of the abdomen is white. The first pair of legs is dark brown and the others are white.

This spider ranges throughout the eastern and southern half of the United States and is found during the summer on trees and bushes.

MARPISSA Koch 1846.

This genus is one of the most common which has been observed around Ames. These spiders have been active until early November. During the early part of March several were observed moving about and many adult males and females which wintered under the bark of trees were collected. The distinguishing characteristics of this genus are that the tibiae of the first pair of legs are armed with three pairs of spines beneath. and a large gray, angular central band on the abdomen. It is a very small genus represented by but three species in our fauna. Large numbers of one of these have been collected at Ames by the writer.

Marpissa undata DeGeer 1778.

This species is very easily recognized by the uniform gray cephalothorax and the angular gray central stripe on the abdomen bordered with black. Its length is from ten to thirteen millimetres. It ranges from the east coast as far west as Utah.

SALTICUS Latreille 1804.

The cephalothorax is about one and a half times as long as wide and slightly wider in the middle than at either end. The anterior eyes are very unequal in size. The middle eyes are located about halfway between the anterior lateral and the posterior eyes.

Salticus scenicus Clerck 1757.

This spider has at least twenty-nine synonyms. It is a very beautiful little fellow about six millimetres long, and is found on the sides of houses and fences. The writer has observed it in the greenhouse throughout the entire winter. The front of the head above the anterior row of eyes is white. Just behind the posterior row of eyes is a pair of white spots. The rest of the cephalothorax is brown. The abdomen is dark brown with a white basal band and two pairs of oblique white spots at the sides. The legs are banded alternately white and brown.

This spider is very widely distributed throughout the United States.

ZYGOBALLUS Peckham 1885.

The cephalothorax is very high and slopes abruptly just behind the posterior row of eyes. The anterior median eyes are more than twice as large as the anterior lateral eyes. The middle row of eyes is nearer to the anterior lateral eyes than to the posterior eyes. The ocular quadrangle occupies more than one-half the length of the cephalothorax.

Zygoballus nervosos Peckham 1888.

The collection contains only a single female of this species. The following is Peckham's description of both sexes: "In both sexes the cephalothorax is brown thinly covered with whitish scales. The narrow clypeus is white. In the male the abdomen is brown, slightly metallic, with a very bright white basal band extending two-thirds of the way along the sides, a nearly longitudinal white bar edged with black, on each side at the posterior end, and a white spot at the spinnerets. The female abdomen, of a lighter brown, is marked .... with two short curved bands just back of the basal band, followed by two short white spots with black spots behind them, and farther back a series of indistinct whitish chevrons, with a second pair of black spots a little in front of the spinnerets."

This species has previously been taken from Maine to Illinois and south to Virginia.

Zygoballus sexpunctatus Hentz 1845.

The cephalothorax is black and bears a small tuft of white hairs in front of each posterior eye. The clypeus is covered with white hairs. The abdomen is dark with a dorsal whitish basal band and three pairs of white spots. The legs are reddish brown with the femora of the first two darkest. A single female about three millimetres in length is in the collection. This has been reported by the Peckhams and Comstock as having been collected only in the southern states.

NEON Simon 1876.

These are very small spiders. The ocular quadrangle occupies more than one-half the length of the cephalothorax. The cephalothorax is moderately high and flat, sloping very sharply just back of the posterior eyes.

Neon nelli Peckham 1888.

There are two females measuring three millimeters in length in the collection. The cephalothorax with the ocular quadrangle darkest. The abdomen is brown and has lighter spots and faint chevrons on the posterior half. The legs are light with dark brown rings.

SYNEMOSYNA Hentz 1832.

This is one of three genera of antlike spiders which occur in our fauna. There is but a single representative of this genus in the United States. The cephalothorax is long and narrow, tapering at the posterior end. There is a very sharp constriction just behind the posterior eyes. The ocular quadrangle occupies about one-third of the cephalothorax. The abdomen is long and narrow with a deep, dorsal depression about midway along its length.

Synemosyna formica Hentz.

A single female measuring eight millimetres in length is in the collection. It was collected by Prof. C. P. Gillette and identified by Banks in 1891. The cephalothorax is brown with black markings at the sides, and a few white hairs in the region of the eyes. The anterior median eyes are fully three times as large as the anterior lateral eyes. The abdomen is brown, and has a white stripe which extends downward, just behind the dorsal depression and unites in a white spot on the ventral side. The first pair of legs is light with a brown stripe extending their length above and below. The second pair is all light and the third pair is light except the femur which is brown. The fourth pair has the femur and tibia brown, the rest all light.

This species is distributed throughout the United States. It lives on plants and runs like an ant. The mimicry is so perfect that it is often mistaken for an ant.

The following table will show the distribution, throughout the United States of the Attidæ in the Ames collection. The eastern half of the United States would include all of the territory east of the Rocky Mountains except the arid prairie country.

Entire U. S.	Eastern Half U. S.	Southern States
Phidippus	*Phidippus*	*Phidippus*
P. audax	*P. castrensis*	*P. insolens*
P. electus	*Habrocestum*	*Thiodina*
P. podogrosus	*H. pulex*	*T. sylvanus*
P. rufus	*Icius*	*Zygoballus*
Dendryphantes	*I. elegans*	*Z. sexpunctatus*
D. militaris	*Marpissa*	
D. octavus	*M. undata*	
Wala	*Zygoballus*	
W. palmarum	*Z. nervosus*	
Salticus	*Neon*	
S. scenicus	*N. nelli*	
Synemosyna		
S. formica		

Iowa lies in the Austral life zone which is composed of three trans-continental belts, the Transitional, Upper Austral and the Lower Austral. The Transitional belt dips down into northern Iowa, extending as far south as Charles City. The fauna of this belt is both Boreal (northern forms) and Austral. Ames lies but one hundred miles south of this zone, yet not a single northern species has been collected, although all of the forms in the first two columns of the table are found throughout the entire transitional belt.

On the other hand consider the Lower Austral belt, which cuts through Arkansas and extends north along Mississippi and Missouri rivers a short distance. Ames is situated more than two hundred miles from the northern limits of this zone and yet there are present three species which are stictly southern in their range.

This would seem to be an unusual state of affairs were it not a well known fact that animal and insect migrations tend to follow water courses. Our southern species could have followed the Mississippi until they struck the Des Moines at the junction of these two rivers and from there found their way up into this country.

The writer has done considerable work on the spiders of all families collected in the vicinity of Ames and this paper is but preliminary to a work on the entire spider fauna of Iowa.

Although this is not the first work on spiders which has been undertaken in Iowa, it is the first that has been published. In 1896 Banks described a new Drassid, which had been collected at Ames by Professor C. P. Gillette. A number of years previous Professor Gillette collected eighty species at Ames which were identified by Banks in 1891. A number of these were Attidæ and have been included in this article. On account of the peculiar habits of the Attidæ they are, in comparison with other families, poorly represented in collections.

The most important contributions to our knowledge of North American species of Attidæ are those of Hentz; of George W. and Elizabeth G. Peckham; and of J. H. Emerton. The papers of Hentz were published originally in the Journal of the Boston Society of Natural History, from 1842 to 1845. Those of the Peckhams were published in the Transactions of the Wisconsin Academy of Sciences, Arts, and Letters, 1883 to 1889, and later, in 1901, a "Revision of the Attidæ of North America," was published in the Transactions of the Wisconsin Academy. Emerton's works, which dealt entirely with the New England Attidæ, were published in the Transactions of the Connecticut Academy of Arts and Sciences 1888 to 1892.

The works of Baron Walkenauer, 1837 to 1847, and that part of Die Arachniden, by C. Koch published in 1846, contain descriptions of many American Attidæ, but owing to the vagueness of the descriptions comparatively few have been identified with certainty, Baron Walkenauer described sixty-four species, but upon comparing them with nearly all of Hentz's species and with many others from different sources, the Peckhams were able to identify only four.

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THE WHITE WATERLILY OF McGREGOR, IOWA.

HENRY S. CONARD

At the meeting of this Academy held in Grinnell one year ago I reported some observations upon the white waterlily of Clear Lake, Iowa[1]. The present notes are made possible through the kindness of Mr. H. C. Daubenberger of McGregor, Iowa, who sent specimens to Grinnell from his home in the first week of August, 1917. The package contained four flowers, three leaves and a rhizome twenty-one inches long.

The McGregor plant appears to be identical with that of Clear Lake. The flowers are large, with an unusually large number of peals; stamens less numerous than at Clear Lake; carpels the same as at Clear Lake. The outermost petal is in some cases oblanceolate, in others broadly spatulate. The peduncle is dull brownish or faintly striped with brown. The leaf has 12 or 13 veins, with a very long principal area. The petiole was brown striped in all three of the specimens sent to me. The rhizome was ¾ to 1½ inches in diameter, with two buds that gave evidence of being incipient tubers. The stipules are nearly twice as broad as long.

There is therefore in Iowa a type of waterlily of fairly wide distribution, combining characteristics of *Nymphaea odorata* and *N. tuberosa*, and variable in respect to certain of these characteristics. Further records from these and other localities are greatly to be desired.

[1]Proc. Iowa Acad. Sci., Vol. 24, p. 449, 1917.

	Sepals	Petals	Stam.	Carp.	Outer Petal	Peduncle Diam.	Color
Flower 1	4	46	81	15	oblanceolate	7mm.	dull brownish
2	4	45	67	14	oblanceolate	6	faintly striped
3	4	47	85	16	spatulate	6	not striped
4	4	38	79	16	spatulate	7	striped
Average	4	44	75	15			
Av. Clear Lake	4	32	92	15			

	PETIOLE		Veins	Radius. Princ. Area
	Diameter	Color		
Leaf 1	7mm.	striped	12	3¾ : 3
2	6	striped	13	
3	6	striped		5½ : 4¾

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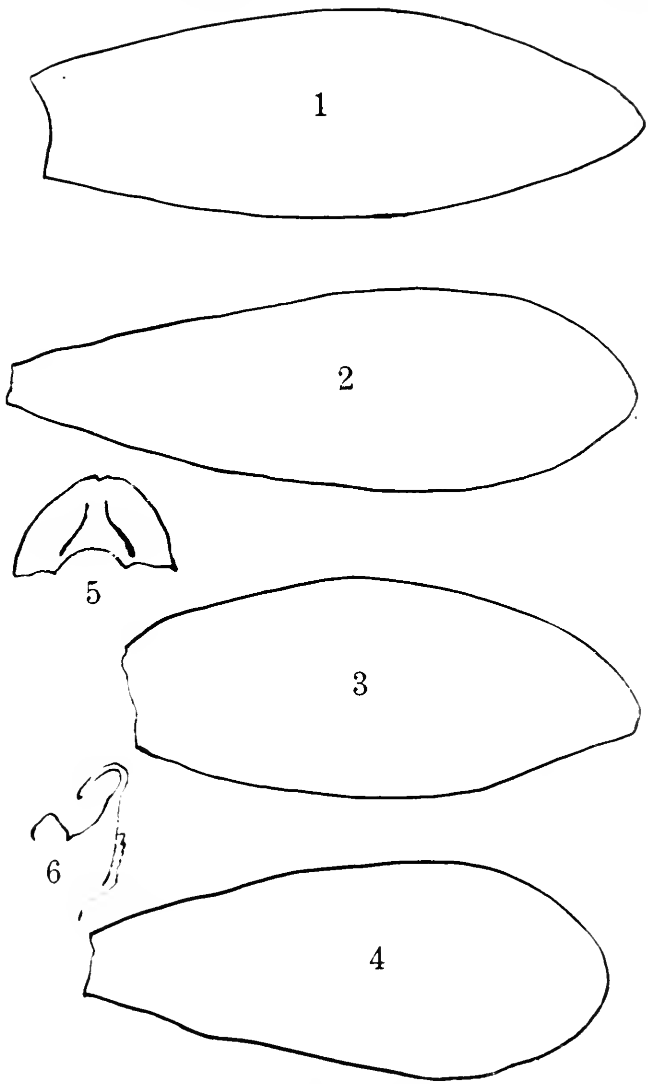

Nymphaea tuberosa of McGregor, Iowa. 1, sepal; 2, petal of second row, Fl. 1; 3, sepal; 4, petal of second row, Fl. 3; 5, stipule; 6, section of ovary. All natural size.

THE GENERAL CLASSIFICATION OF HIGHER PLANTS.

HENRY S. CONARD.

A large part of our thinking about living things is bound up with some system of classification. This system is at once the product of the best thought, and a guide to further thinking. The function of classification as a guide is peculiarly important to beginners. It is therefore extremely desirable that classification should represent correctly the most approved conclusions of the science in question. At the present time current usage in botanical classification is not in harmony with the most approved conclusions. The following tabulation and discussion is an attempt to express recent morphological thought in its bearing on the broader lines of taxonomy. According to this view, the Vegetable Kingdom may be outlined thus:

- Thallophyta
- Embryophyta (Archegoniatae)
  - Atracheata (Bryophyta)
  - Tracheata (Vasculares)
    - Lycopsida (Lycopodiales and Equisetales)
    - Pteropsida
      - Aspermae (Filices)
      - Gymnospermæ
      - Angiospermæ

In defense of this scheme, the best of authority can be cited, and it appears to the writer that the evidence is overwhelmingly favorable. That the Thallophyta is a miscellaneous group, united only by negative characters, is freely admitted. The term has, however, proven so useful as to deserve permanent acceptance. It serves to gather up all those elementary forms of plant life which are clearly lower than the fairly coherent archegoniate or embryophytic series. This twofold arrangement, Thallophyta and higher plants, has long been familiar in the taxonomic portion of the Strasburger text-book.

By including all of the mosses, ferns and flowering plants in the single group Embryophyta, we call attention to the embryo as the feature of their life history which has doubtless been of prime importance in bringing about the very obvious supremacy of this group on the face of the earth. The careful sheltering of an embryo plant within parental tissues is a distinct advantage to the new generation. It is precisely paralleled in the development of the higher animals. It is well worth while, therefore, to point out this characteristic as basic in the evolution of land plants.

In the lectures of Professor E. C. Jeffrey at Harvard University—I am not aware of any publication of the point—the Embryophyta are next divided into those without tracheary or vascular tissue (Mosses) and those with such tissues. This again is a distinction of the highest biological significance. It is the absence of water conducting apparatus that keeps the mosses of small stature. It was the development of effective water conducting tissues which made it possible for land plants to attain to sizes exceeding those of the humble mosses. These tissues were also necessary for a plant which should continue to vegetate and reach upward in a dry atmosphere, provided only its roots have access to a water supply. Since, therefore, the size, habit and habitat of the principal vegetation of the earth are dependent on the possession of tracheary tissues, it is well to name the higher plant group Tracheata. Owing to these same biological conditions, the evolution of these plants has been largely recorded in the structure of their vascular parts. Progress has been made possible by means of ever increasing perfection and specialization of the water and food conducting organs. Finally, in fossil plants the water conducting cells and vessels have retained their characteristics better than any other tissues, and therefore these cells and vessels offer the fullest chronological record of the changes in plant structure throughout geological time.

The Tracheata were recognized by Jeffrey in 1897 as constituting two well marked groups which he named at that time Lycopsida and Pteropsida, on account of their resemblances in certain important features to the lycopods and ferns respectively. Although we may agree with Bower that Lycopodium is the most suggestive plant to consider as ancestral to the entire tracheate phylum, all the facts point to the conclusion that the fern series is much larger, that it includes the seed plants, and that it was separated from the lycopsidan stock in early or mid Palaeozoic times.

The fundamental anatomical difference between the lycopods and equiseta on the one hand, and the pteropsida on the other is this. In Lycopsida the leaf trace is small, and the water conducting cells of the leaf trace, coming into the stem from the leaf, end abruptly in contact with the water cells and vessels of the stem. The leaf gets only what water these trace cells can catch from the side of the cells of the stem. There is no direct water passage from stem to leaf. Correlated with this we find that in all Lycopsidans—Lycopodium, Selaginella, Psilotum, Equisetum, Lepidodendron, etc.—the leaf is small and individually of little consequence. Such leaves may be numerous, or may be greatly reduced. In the first case—Lycopodiales—the number makes up for size. In the latter—Psilotum, Equisetum—the stem takes over the function of photosynthesis. These small leaves when fertile, are further limited to one or a few sporangia. And the sporangia are axillary or nearly so, and associated with the upper side of the leaf.

Now in the Pteropsida there are for every leaf few or several water conducting cells, or vessels which bend out bodily from the stem into the leaf, carrying an uninterrupted flow of water directly out into every veinlet of the foliar structure. This at once removes the limitation of size in leaves. The giant leaves of tree ferns, palms, bananas and the like now become possible. On such a leaf also, with its great assimilating capacity, spore formation may go on *ad libitum*, as actually occurs in ferns. In stems whose primary vascular tissues take a tubular form, the vessels which curve out into the leaf leave an actual break or gap in the continuity of vascular tissues in the stem. Above every leaf trace there is an area where medullary cells come more or less directly into contact with cortical cells. Such a break in the cylindrical stele Jeffrey calls a leaf gap. And he calls such stems phyllosiphonic. The Pteropsida are therefore primarily phyllosiphonic and megaphyllous. In Lycopsida gaps in the stem stele occur only in relation to branches. This group is therefore called cladosiphonic and microphyllous.[1] It cannot be doubted that this distinction marks the profoundest biological and evolutionary cleavage in the vascular plants.

Among Pteropsidans, recent studies of fossil plants have shown remarkably close affinities. The fern alliance merges insensibly into the gymnosperms, and these, anatomically at least, grade off very strikingly into the angiosperms. In fact, the gap above the gymnosperms is as yet more serious and difficult to bridge than that between the gymnosperms and ferns. One cannot tell at present whether a given fossil stem or leaf is fern or gymno-

[1]Cf. Jeffrey: Anatomy of Woody Plants, 1917.

sperm unless the manner of its fructification can be established in considerable detail. The Pteropsida therefore represents a highly unified, natural series. The series is divided wholly on the question of seeds. Since, then, there is at present no term to designate the fern section of this great phylum, I have proposed for this lower seedless group the name Aspermæ, suggested by my colleague Miss M. L. Sawyer. The term corresponds aptly with the accepted names of the two higher groups, Gymnospermæ and Angiospermæ.

Up to the last step this classification has the advantage of dichotomy. This is an assurance of simplicity. It follows strictly those great biological characters which have influenced the trend of evolution, and which have themselves appeared in response to world-phenomena of cosmic origin. Its general acceptance would certainly help the student to tabulate our present thought regarding plants, and to think correctly in pursuit of further knowledge.

Department of Botany,
Grinnell College.

A VARIATION IN THE BLACK WALNUT.

L. H. PAMMEL AND CHARLOTTE M. KING.

Several years ago Professor A. B. Noble of the English Department of Iowa State College called my attention to a peculiar walnut which he thought might be hybrid between the butternut (*Juglans cinerea*) and the black walnut (*Juglans nigra*). He again called my attention to the same tree last fall, in October, 1917.

The history of the tree, as given to me by Professor Noble, is as follows: The tree came up from some walnuts gathered and discarded. It has borne a crop of walnuts for a number of years. All fruits on this tree have been essentially the same. Other seedlings from the same batch had normal walnuts. The trunk of the variating walnut tree appears to be of the black walnut type, a straight trunk with upright branches. The bark of the young stems and branches is light brown, covered with thin scales; the bark of the main trunk is of the same general color, with scales more deeply divided, more roughened and darker in color than the butternut. The leaves look like those of the common black walnut, the leaflets are ovate lanceolate and taper pointed, smooth above, lower surface and petioles downy. The fruit is somewhat pyriform, contracted near the base, light yellowish green, somewhat roughened by small hairs and is about the same size as the common black walnut. The nut resembles the nut of the common black walnut in that it is dark brown, corrugated, not ribbed as the butternut. The odor of the tree as well as the taste of the nut was that of the walnut.

In cutting off some of the branches some five inches of the stub were allowed to remain on the tree and a part of the bark was removed from the body of the tree, leaving this exposed to the weather. When the stub was proprely cut close to the trunk of the tree it was found that this portion of the wood was dark in color, showing the regular character of the heart wood. The remaining wood was light in color, the color of the sap wood of the walnut. This led those who trimmed the tree to believe that it must be a hybrid between the black walnut and butternut. We have not scanned the literature on hybrids. The *Juglans nigra* has been hybridized with several species of *Juglans*, notably the California walnut, *Juglans californica*.

Seeds have been planted, and what they will develop into will be watched with interest.

A somewhat similar case was found by one of us near Hamilton, Illinois, in 1918.

It is possible that some one has recorded this variation before. Dr. C. S. Sargent in describing *Juglans nigra* says "oblong or slightly pyriform"[1].

At the meeting of the Iowa Academy in Ames, Mr. Paul Rowe of Indianola called attention to a variation in the black walnut. The two examples of variation show some deviation from the usual type. In one case the greatest dimension is from stem to blossom, giving a form approaching the mutant described in this paper; the second nut has greatest dimension "at right angles to the plane of division of the nut." This is another interesting variation.

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[1]Manual of the Trees of North America, 128.

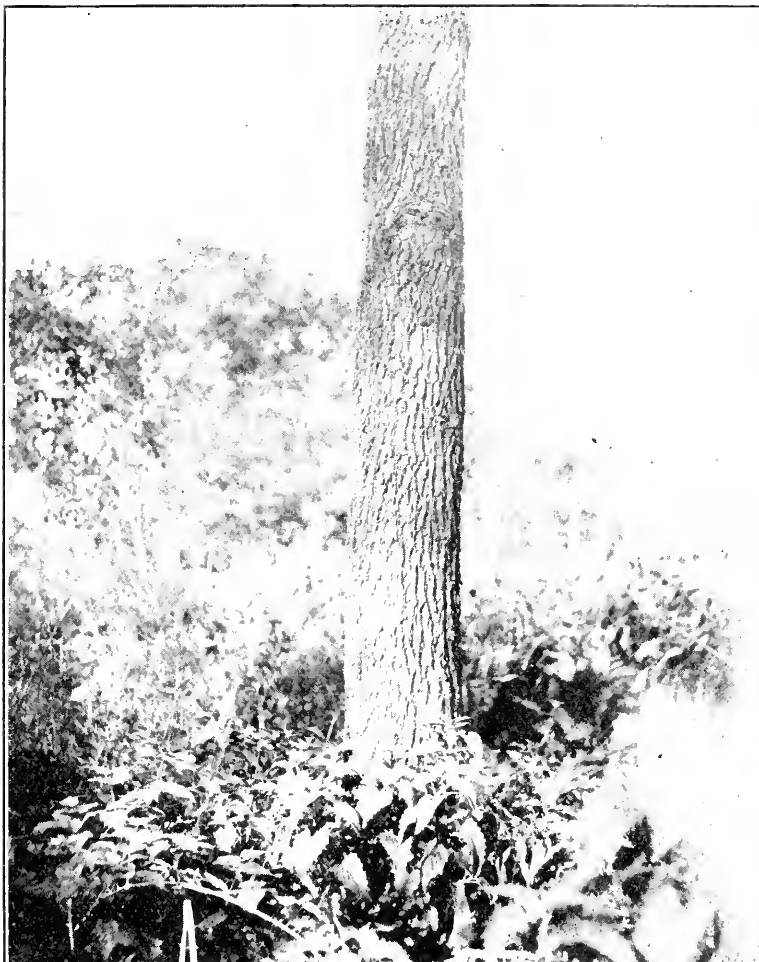


Fig. 43.—Trunk of mutant walnut tree. Photographed by C. M. King.

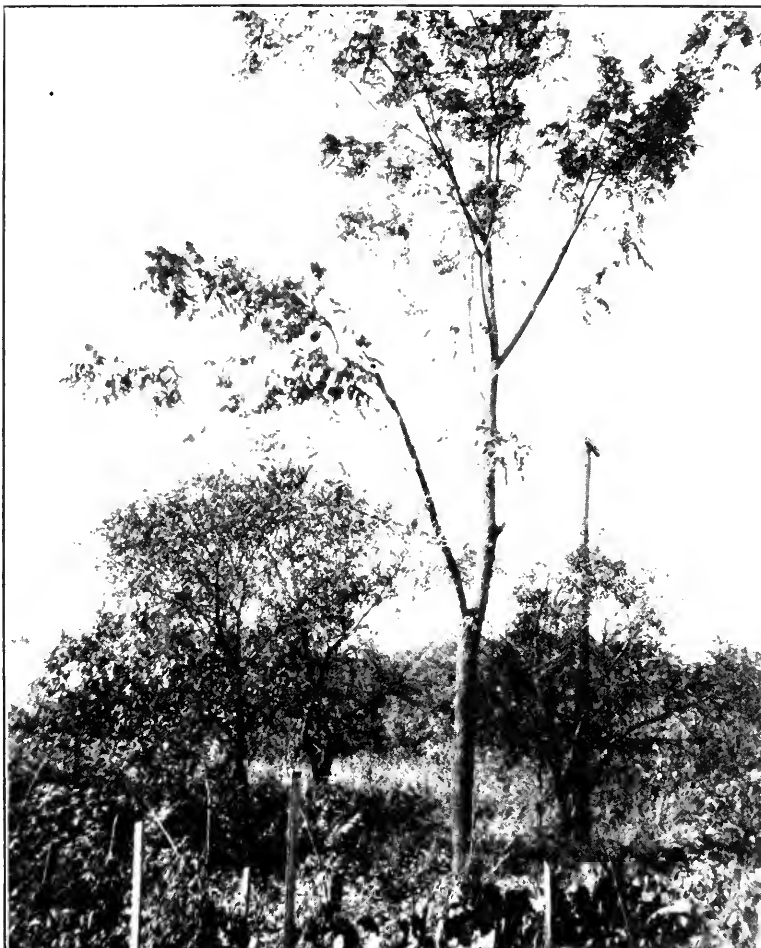
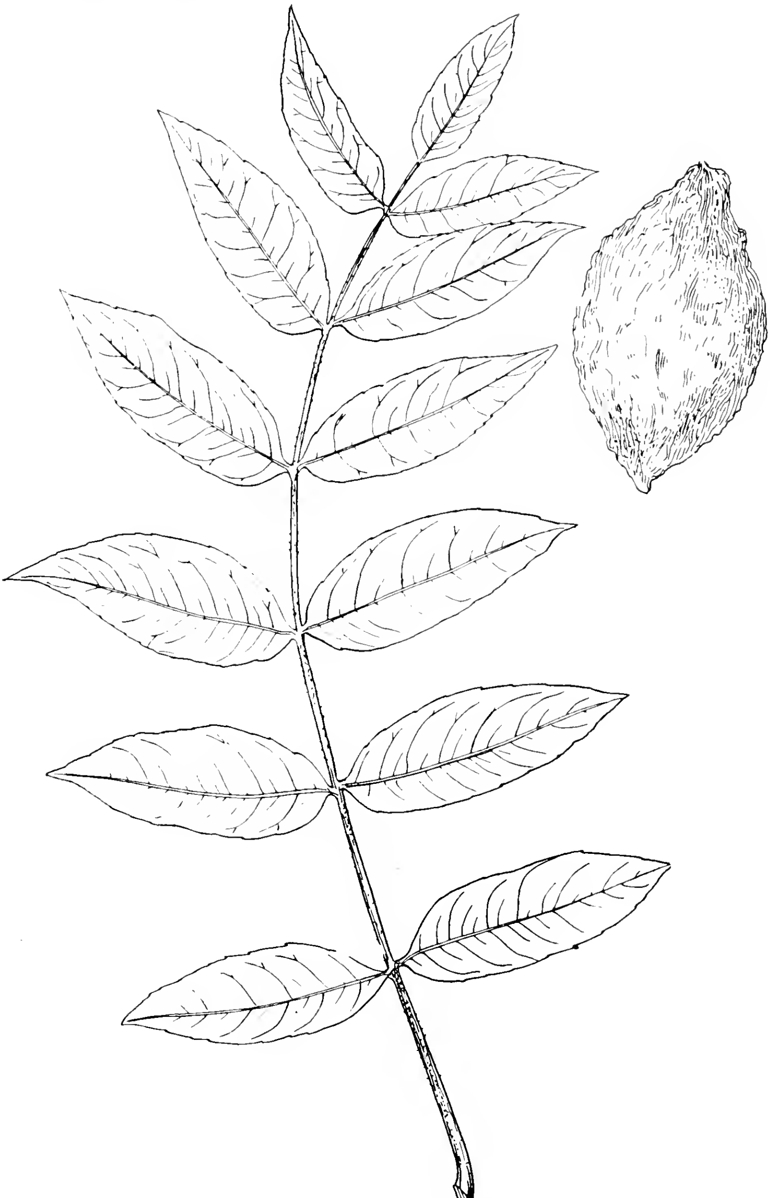


Fig. 44.—Tree of the mutant walnut, in fruit. Photographed by C. M. King.



Leaf and fruit of mutant walnut. From drawing by C. M. King.

AN ANNUAL WHITE SWEET CLOVER.

L. H. PAMMEL AND C. M. KING.

Sometime previous to the spring of 1916 Professor Hughes of the Farm Crops Department of the Iowa State College found in the experimental plots of the common white sweet clover (*Melilotus alba* (L) Lam), a form which produced an annual root and died at the clcse of the season.

During the spring of 1917 Mr. H. S. Coe of the U. S. Department of Agriculture, in a conversation about the white sweet clover said he had found an annual form, and asked whether I had ever observed one and whether I knew of one. In an examination of available literature, I was able to find but a single description of such a clover. The Manuals of Gray[1] and Britton[2] describe only the biennial type of white sweet clover. The genus *Melilotus* is described as annual and biennial in Gray's Manual, in Britton and Brown's[3] Illustrated Flora, Bentham and Hooker,[4] and Engler and Prantl[5] and in botanical works in general.

Engler and Prantl list *M. ruthenica* Bieb. as annual, a white sweet clover, marked in the description given in DeCandolle's Prodromus[6] as "annual with question." This sweet clover found in southern Russia is described as having a "testaceous seed" which is not true of *M. alba* or its strains. The *M. alba* var. is the most common type cultivated in the United States generally. Compared with the biennial species it is less valuable as a forage plant.

The fact that a plant of the type of the biennial white sweet clover (*Melilotus alba*) is an annual will be a distinct gain to agriculture. By scarifying the seed it may be sown in with corn when this is "laid by", and thus help to fertilize the soil, as well as producing forage in the fall.

Professor H. D. Hughes[7] has called attention to this annual white sweet clover, in several published notes[8]

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[1]Robinson, B. L., and Fernald, M. L., Gray's New Manual of Botany, 7 ed., 510.

[2]Britton, L., Manual of the Flora of the Northern States and Canada. 3 ed., 538-539.

[3]Britton, N. L., and Brown, A., Illustrated Flora of Northern United States and Canada, 2-273.

[4]Bentham, G., and Hooker, J. D., 1, 487, 1862.

[5]Engler, A., and Prantl, K., Die Natürlichen Pflanzen Familien. Teil 3, Abteilung 3, 247, 1894.

[6]De Candolle, P., Prodromus Systematis Naturalis, 2, 186.

[7]Hughes, H. D., Discover New White Sweet Clover. The Alumnus of Iowa State College, Nov., 1917, 77. Better Iowa, Oct. 8, 1917.

[8]Field's Seed Sense, November, 1917, 14 [letter].

H. S. Coe[9] described the plant in the American Journal of Agronomy as follows: "*Melilotus alba* Desr. var. *annua* n var. (Annual white sweet clover) erect or ascending, branching, glabrous or young branches and leaves slightly pubescent; leaves petioled, leaflets mostly oblanceolate, some narrowly ovate to oblong, serrated, obtuse to truncate, corolla white, 4 to 5 mm. long, the standard longer than the other petals, racemes numerous, slender 4 to 15 cm. long; pods rectangular 3 to 4 mm. long; root becoming 15 to 30 inches in length and enlarged very slightly if at all at the crown. Crown buds are not formed." Coe states in this article that he observed this annual sweet clover in 1916 grown from seed received from Alabama the previous winter.

In Farmers' Bulletin 797 Mr. Coe[10] states "Fields of an exceptionally early blooming strain were found in Illinois, Iowa and North Dakota, in the summer of 1916. An annual white flowered sweet clover was found in several localities in the fall of 1916. The seeds which produced these plants were grown in Alabama."

The interesting point arises as to whether this clover is a recent mutant or whether it has been in existence for a long time. It is of interest to note that Professor Hopkins observed this clover about 1913.

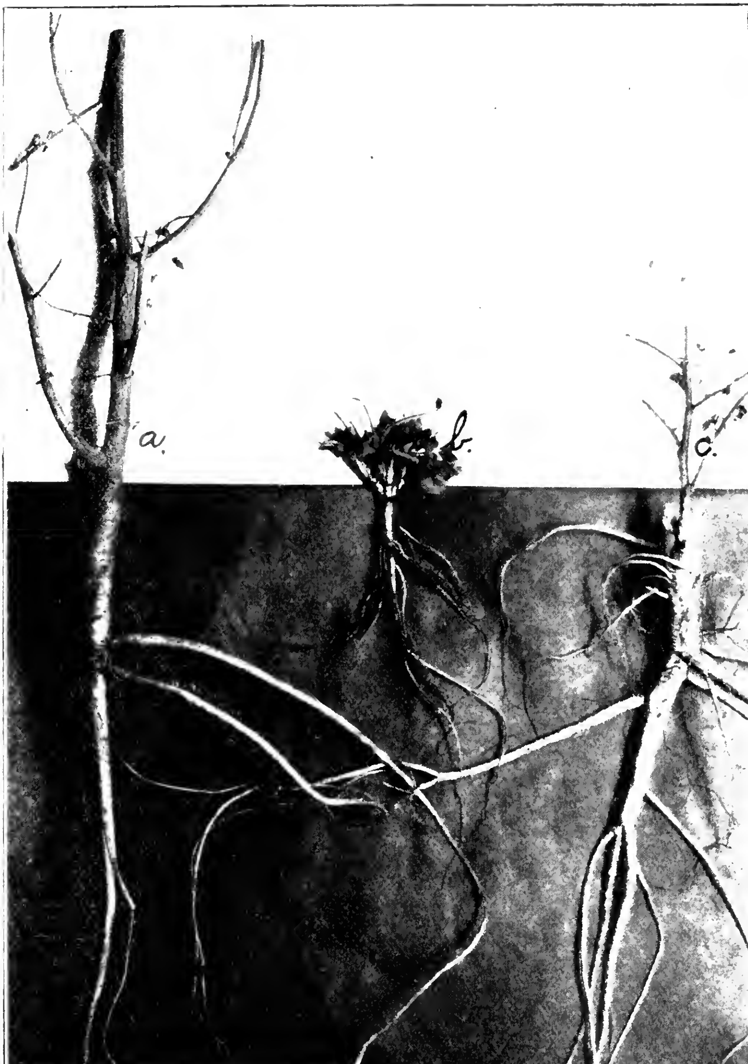
L. H. Bailey[11] makes an interesting statement with regard to the Dwarf Lima Bean. He says "now a most curious thing about these dwarf lima beans which have appeared so suddenly in the past few years, is that they have come from each of these three types—Henderson from the Sieva type, Thorburn and Dreer from the Potato Lima type and Burpee from the Large Lima type—thus showing that each of these types or races is developing along independent or parallel lines."

Nothing is known about where the seed of this annual white sweet clover observed by Professor Hughes, came from. He states that he scarified a lot of sweet clover seed from various places. Samples from many sources were planted; but where the seed came from was not taken account of because he was studying the germination of the scarified seeds.

In the biennial sweet clover the upper portion of the underground organ is a stem and produces numerous buds which

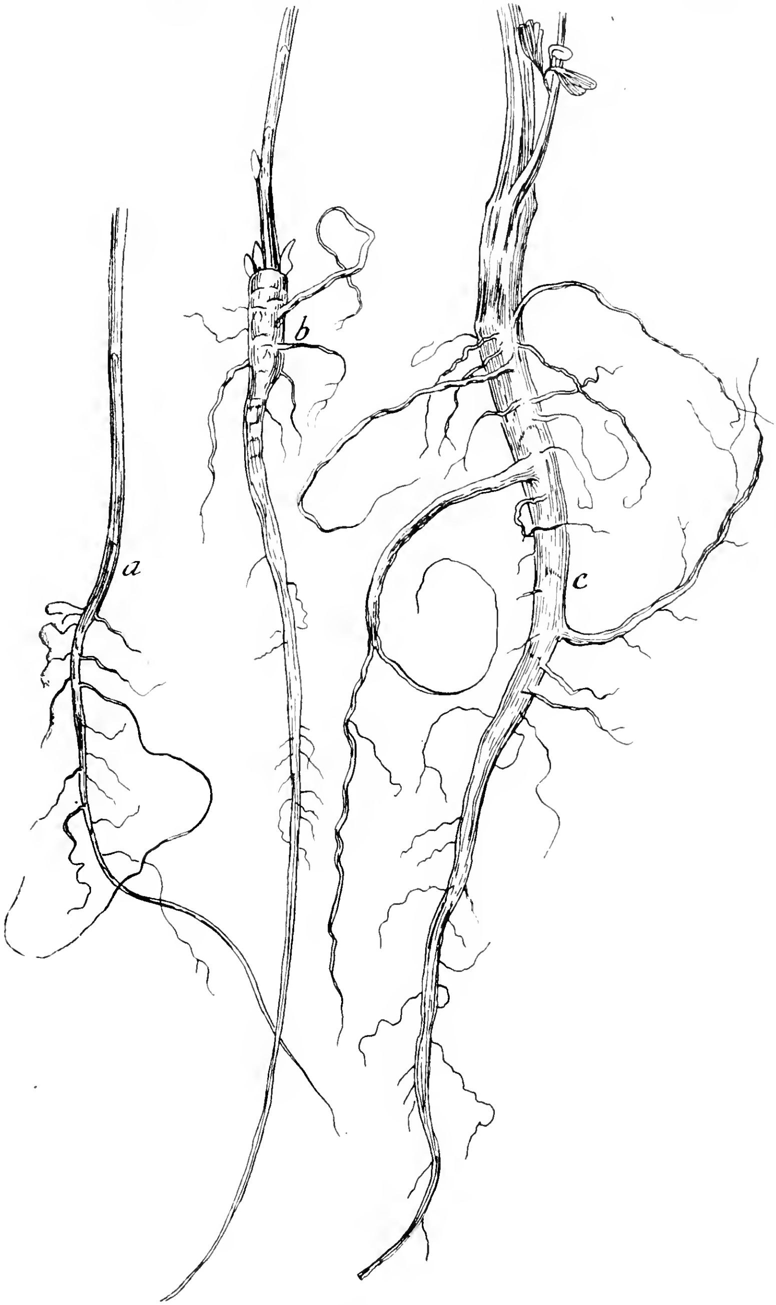
[10]Coe, H. S., Farmers' Bulletin 797, p. 78.
[11]Bailey, L. H., Survival of the Unlike, 131-132.
[9]Coe, H. S., An Annual Variety of *Melilotus alba*, Journal of the American Society of Agronomy, 9, 380-382.

give rise to the stem. These are entirely absent on the annual white sweet clover; there is little or nothing to distinguish the annual from the biennial in the leaf and flower characters. The figures of the root and the photographs of the plant show the differences between the two types of white sweet clover.



The roots of three types of clovers: a. *Melilotus alba*, the biennial; b. the medium red clover (*Trifolium pratense*); c. the annual white sweet clover (*Melilotus alba* Desr. var. *annua* H. S. Coe). From a photograph.

a. The white annual sweet clover (M[illegible]) [illegible] typical plant in the field, from a photograph. [illegible] Plants of [illegible] annual [illegible] sweet clover three and one-half months from seeding.



The roots of three sweet clovers: a. the annual *Melilotus indica;* b. the biennial *Melilotus alba;* c. the *Melilotus alba* var. *annua.* Drawings by C. M. King.

PERENNIAL MYCELIUM OF PARASITIC FUNGI.

L. H. PAMMEL.*

In an interesting and valuable article on the perennial mycelium of some of the species of Peronosporeæ Dr. I. E. Melhus[1] calls attention to the perennial mycelium of the following species: *Phytophthora infestans*, *Phytophthora cactorum*, *Cystopus candidus*, *Plasmopara viticola*, *Plasmopara pygmaea*, *Plasmopara halstedii*, *Peronospora dipsaci*, *Peronospora schachtii*, *Peronospora alsinearum*, *Peronospora grisea*, *Peronospora effusa*, *Peronospora ficariae*, *Peronospora parasitica*, *Peronospora viciae*, *Peronospora rumicis*. In a review of this paper by the writer, attention was called to the perennial character of *Plasmopara viticola* in our *Vitis vulpina*.[2]

I have observed water sprouts on *Vitis vulpina*, not only in Iowa, but in La Crosse, Wisconsin, and Sandusky, Ohio, which, in some cases, were five feet long and completely covered with the conidiophores and spores of the fungus. This state of affairs on the *Vitis vulpina* is a very common occurrence. Infected water sprouts are not so common in Iowa, but the percentage of infection is rather large when compared with plants under other conditions. Probably many other species of the family have a perennial mycelium. These will no doubt be brought to light in a study of this interesting group of fungi. It is to be hoped that Dr. Melhus will continue his investigations. I might mention in this connection that the mycelium of the *Peronospora obducens* on *Impatiens fulva* in Wisconsin commonly occurs in the cotyledons of the plant. The *Sclerospora graminicola*, so common at times on *Setaria viridis* and *S. italica* and *S. germanica*, is undoubtedly seed borne.[3] Clinton[4] has shown that infected lima beans readily transmit the downy mildew of the lima bean (*Phytophthora phaseoli* Thaxter.) In a recent excellent paper by George A. Osner of Cornell University,[5] attention is called to the manner of infection of timothy smut. *Ustilago striaeformis* (West) (Niessl) a fungus well named because of the characteristic lead colored sori distributed

[1]Jour. Agrl. Research, 5, 67.
[2]Rep. Iowa State Hort. Soc., 50, 151, 1915.
*From time to time the writer has made a few notes on parasitic fungi. Since the subject of fungi is not especially engaging his attention just now, it seemed best that these notes should be brought together.
[3]Bull. Iowa Agrl. Exp. Sta., 104, 241. L. H. Pammel, J. B. Weems and F. Lamson-Scribner. Bull. Iowa Geol. Survey 1, 88: This paper gives the earlier references to Farlow, Webber, Halsted and Trelease.
[4]Rep. Conn. Agrl. Exp. Sta., 1905, 278-303, *pl. 20-22*.
[5]Bull. Cornell Univ. Agrl. Exp. Sta. 381, 189-230, *pl. 17 f. 45-58*.

in lines on the leaves of grasses it infects. This was well shown in the figures by Osner, Trelease[6] and by the writer.[7]

Attention is called to the dwarfing of the blue grass, from the same cause, which has been found quite common in Iowa for a great many years The purpose of this note is to call attention to the fact that the same stool of timothy will produce the smut for years. The writer thought for many years that this smut is a perennial. He has noticed it in Iowa, Wisconsin and Missouri. The following is a good illustration of its occurrence. The plant noted was in the Missouri Botanical Garden during the spring of 1886. It was found on the same stool of grass the following season, 1887. When the writer came to Ames in 1889 he naturally looked for timothy smut on the walk leading from the laboratory to the drive way, and found an abundance of timothy and many other plants diseased as mentioned in two publications.[8] Its perennial nature was mentioned in the publications; also that it was found on quack grass. The disease was found to be abundant in 1890 and 1891. Timothy smut could always be found on blue grass where it occurred on timothy, but it was somewhat harder to detect.

In one of the early papers on the subject of the Wild Rye Smut[9] (*Urocystis agropyri* (Preuss) Schorr) the writer noted its perennial character. It has always been found in abundance on isolated stools where the dried leaf was found; the majority of the culms and leaves show the fungus. It is more or less common in Iowa. It does not fluctuate with the season. The diseased plants are somewhat dwarfed and the leaves torn into shreds. On the specimens the fungus makes its appearance somewhat earlier in June than wild rye blooms, but it may continue to produce spores during the entire summer. Last summer the writer removed some plants of *Elymus* sp. from Graceville, Minnesota, (cutting off the leaves), to the college green house, and during the fall and winter an abundance of *Urocystis* appeared on the greenhouse plants.

It may also be noted that it occurs on quack grass in some sections of the United States, as reported in the papers referred to. In Iowa, at least, it has not been found on quack grass. The

[6]Rep. U. S. Dept. Agrl., 1885, 87-88, *pl. 18*.

[7]L. H. Pammel, J. B. Weems and F. Lamson-Scribner, in Grasses of Iowa. Bull. Iowa Geol. Survey 1, 251-256, *pl. 2, f. 122*. In this paper the fungus was referred to Tilletia as had previously been done.

[8]Bull. Iowa Geol. Survey 1, 251-256, *f. 122*. Also Some Fungus Diseases of Iowa Forage Plants. Separate from Bull. Iowa Crop Service.

[9]Pammel, Weems and Scribner, Bull. Iowa Geol. Survey 1, 257, *f. 120*, *pl. 3*

smut of quack grass and the wild rye smut may prove very distinct species. Experiments can only determine whether the infection occurs at blossoming time or whether the seed becomes infected.

We have a large number of fungi which are perennial. For a number of years the writer has observed the sycamore blight Fungus (*Gnomonia veneta* (Sacc & Speg) Kleb) on a single tree on the college farm. The mycelium is perennial in the buds. This fungus produces the well known hexenbesen. Early in the season, this year, there was not a single sound leaf on the tree, the young leaves were all blighted with the Gloeosporium stage of the fungus. Later, however, new leaves appeared. In some seasons the fungus is much more abundant than others. The writer has, however, never failed to see some of the fungus. Later in the season many of the leaves may be merely spotted. Duggar[10] states: "Upon Sycamore it is in one stage primarily a disease of the leaf veins, although commonly the death of considerable portions of the lamina adjacent soon follows. In another stage the fungus is notably fatal to shoots, young trees and seedlings. Edgerton[11] has noted that this fungus may produce in the early spring an effect similar to frost injury." J. P. Anderson[12] made the same observations on sycamore blight in Ames and E. A. Southworth[13] mentions the same kind of spots and diseased twigs from Washington, D. C. F. Lamson-Scribner[14] also describes the sudden wilting of the twigs due to the fungus from Washington, D. C., where he studied it.

During the season of 1916 there was a great deal of buckeye blight (*Phyllosticta paviae* Desm) on the Ohio buckeye (*Aesculus glabra* var. *octandra*). During the next season (1917) the same groves were visited in July. The trees looked unusually healthy. Not a single diseased leaf could be found. The evidence indicates that the fungus is not perennial. Infection depends on the time and character of the weather.

The white oak blight (*Gloeosporium* sp.) was abundant during the season of 1915 in many parts of Iowa. In some places the trees looked as though they had been sprayed with an arsenical spray. There was comparatively little in 1916, but in 1917 there was a great deal in some trees. It does not seem as if the

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[10] Fungus Diseases of Plants, 180.
[11] Bot. Gazette, *45*, 367-408, *pl. 11. f. 17*.
[12] Proc. Iowa Acad. of Science, *21*, 109.
[13] Jour. Mycl., 5, 51-52.
[14] Rep. U. S. Dept. Agrl., 1888: 388.

mycelium of this is perennial, but infection depends upon meteorological conditions.

The blackberry and black cap raspberry rust (*Caeoma nitens* Burrill)[15] is common in Iowa and recurs on the same plant year after year, as has been observed for many years. This fact has, of course, been observed by other investigators, like Clinton[16] and Newcombe[17]. Clinton[18] found the mycelium, especially in the pith, in a more or less zonal area. Newcombe found the mycelium from the stem down to the roots.

In black knot of plum (*Plowrightia morbosa* (Schw. Farl) the perennial character of the fungus is well known. Where it occurs the disease spreads centrifugally from infected trees. The fungus spreads along the diseased stem killing it. Farlow[19] long ago called attention to the perennial nature of the mycelium. Halsted[20] and Humphrey[21] and nearly every writer on the subject of black knot has called attention to the perennial character of the mycelium. One of the most effective ways of destroying the fungus is to remove the infected tree. In a domestic plum orchard under observation some years ago one variety highly susceptible was cut out. Since then the disease has not occurred in the orchard. The writer has recently noticed in Osceola and Clarke counties some large trees of *Prunus serotina* badly infected. Many of the old branches were dead. Sometimes rather large burls are found on the tree, as has been previously noticed in Wisconsin; whether these are connected with this fungus has not been determined. In some cases perhaps they are.

Gymnosporangium globosum Farlow. The perennial character of the mycelium of this fungus was described by Farlow[22], Pammel[23], Thaxter[24], Kern[25] and others. It was observed only once in central Iowa, at Ames. The gall and the part of the branch was removed. The fungus has not been observed since. This fungus is fairly common in southeastern Iowa on *Juniperus virginiana*.

[15]This name is used because the writer has not seen the *Puccinia peckiana* in Iowa, though he has found it in Wisconsin. Kunkel, Bull. Torrey Bot. Club, *48*, 559-569, has discovered the short and long cycle forms of *Caeoma*.

[16]Bull. Ill. Agrl. Exp. Sta. 29 273-296 *pl. 1-4*. Proc Am. Acad. Arts & Sci., B. S. 1865-85. See the account of Farlow also.

[17]Jour. Mycology, *6*, 106-107, *pl. 75-76*.

[18]Bull. Ill. Agrl. Exp. Sta. 29, p. 277.

[19]Bull. Bussey Institute, *1876*, 440-453, *pl. 4-6*.

[20]New Jersey Agrl. Exp. Sta., 78, 1-11.

[21]Mass. Agrl. Exp. Sta., *8*, 200-210, *pl. 1*.

[22]Amer. Mem. Boston Soc. Nat. Hist., 38, *2 pl.* 1880.

[23]Bull. Iowa Agrl. Exp. Sta. 84, 10.

[24]Bull. Conn. Agrl. Exp. Sta. 107, 1-6.

[25]The Nature and Classification of Plant Rusts. Transactions of the American Microscopical Society, *32*, 59.

The *Gymnosporangium clavariforme* occurs occasionally in northeastern Iowa. The fungus mycelium is found in the cortex, breaking out in elongated patches. The perennial character of this fungus is well known. The *G. nidus-avis* also occurs in northeastern Iowa. The mycelium of this is certainly perennial.

The rust of Canada thistle *(Puccinia suaveolens)* (Pers) is undoubtedly perennial. I do not recall its ever having been recorded for this state, but in sections of the country where the host plant is abundant the rust is frequent. I am inclined to think that *Uromyces Glycyrrhizae* is also perennial.

The mycelium of *Exoascus communis* on *Prunus hortulana* is described as perennial. This species is commonly found on the young branches of this variety of plum. So far as the writer has observed, where this branch dies the fungus does not infect new branches. The infection always comes from the spores of the fungus. In some species at least in *Exoasus deformans* the infection is said to take place at the time of the opening of the buds. Duggar[26] says; "but it may also result (occasionally) by the growth of a perennial mycelium from the old wood, in which it has rested over winter into the expanding peach buds." He quotes Sadebeck as stating "the mycelium winters over in the primary cortex and medullary tissues of the one-year-old branches." This fungus is common in some seasons in Iowa. In the case of *E. communis* the branches have always been found dead, the fungus appearing only on new shoots.

The cases of perennial mycelium of parasitic fungi are much more common than plant pathologists at first thought. The perennial mycelium of parasitic fungi is an important matter with reference to the treatment of plant diseases. In some cases weeds harbor the perennial mycelium of certain fungi and by destroying these weeds the injury from the fungus may be greatly lessened.

DEPARTMENT OF BOTANY,
THE STATE COLLEGE.

[26]Fungus Diseases of Plants, 279.

A STUDY OF THE FORMATION AND DEVELOPMENT OF THE FLOWER BUDS OF JONATHAN AND GRIMES GOLDEN IN RELATION TO DIFFERENT TYPES (CLOVER SOD, BLUE GRASS SOD, COVER CROP, AND CLEAN TILLAGE) OF SOIL MANAGEMENT.

R. S. KIRBY UNDER THE DIRECTION OF J. N. MARTIN.

SUMMARY.

The data so far obtained are insufficient to warrant conclusions as to what is true as a rule. This summary simply states briefly what was found during 1916 and 1917 concerning the formation and development of flower buds in these two varieties of apples, growing on plots representing four types of soil management in the Council Bluffs orchard humus Experiments of the Sections of Pomology and Soils of the Iowa Experiment Station.

1. Flower buds were formed, that is, differentiated from leaf buds, earlier on sod plots than on plots receiving some cultivation each year.

2. The earliest time at which flower buds were formed occurred on clover sod, with a low percentage of soil moisture. Flower buds formed earlier on a clover sod than on a blue grass sod having slightly less soil moisture. On the other hand, flower buds formed earlier on a blue grass sod than on a clover sod having about 2½ per cent more soil moisture. These facts indicate two things: *first,* that the addition of nitrates in the clover sod causes the flower buds to form earlier; and *second,* that the amount of soil moisture is a very important if not the chief external factor in determining the time at which flower buds form.

3. The formation of flower buds began about the first of July on the plots where it occurred earliest and extended until the middle of September on the plots where it occurred latest, thus occupying a period of about two and one-half months. The time occupied by each tree in forming flower buds was about four weeks.

4. Trees in sod produced the largest proportion of flower buds and those in clover sod, which supposedly contained the most nitrates, produced a much larger proportion of flower buds than those in blue grass sod.

5. The period covering the time during which the different trees formed and developed their flowers extended from about the first of July, 1916, to May 17, 1917, thus being about ten months in length.

6. Apple flowers have two periods of rapid growth. The first one immediately follows the differentiation of the flower bud from the leaf bud, and during this period, which is about six weeks in length, the floral organs are differentiated. During the second period, which begins about six weeks previous to the opening and ends with the full expansion of the flower, the floral organs increase their size many times. During the time intervening between the two periods of rapid growth, growth continues but is slow.

INTRODUCTION.

This series of apple fruit bud investigations was started as graduate work under the direction of the senior author by F. M. Harrington of the Horticultural staff at the suggestion of S. A. Beach, Chief in Horticulture of the Iowa Experiment Station. The collection of material for this purpose was begun by T. J. Maney, now Chief of Pomology of the Station. Later the work passed into the hands of the junior author, R. S. Kirby, as a fellow in horticulture.

These investigations were inaugurated as a phase of the orchard humus project which is being carried on by the Pomology Section with the co-operation of the Soils Section of the station. This project was inaugurated in 1910 in an orchard near Council Bluffs which has been leased till 1925 for this purpose. It was initiated by and has remained under the general supervision of Professor Beach with the immediate management in charge of Chief Laurenz Greene for the horticultural staff. In 1917 Chief Maney succeeded Professor Greene in this work.

This orchard humus investigation is a modified continuation of the orchard humus project initiated by Professor Beach at the State Experiment Station, Geneva, New York, in 1903 and carried forward by him for three years before coming to Iowa. The results of that work have been reported by Hedrick (17) in New York Station bulletins 314 (1909), 375 (1914), and 376, (1914), and in other publications.

Owing to the close relation between the formation of flowers and the production of fruits, a good knowledge of the factors affecting the development of fruit buds is essential to a scientific determination of the best methods of orchard management to secure regular and abundant crops. To add to our scientific knowledge of such factors has been the purpose of these investigations.

The Pomology Section is keeping very careful records of the soil moisture in the different plots of the orchard humus experiment and of the annual yield of each individual tree. These records have been open to the use of the authors in their interpretative study of the results of the different methods of soil management in the experiment plots on the development of fruit buds in the varieties of apple trees under observation.

REVIEW OF LITERATURE.

Of the many publications on bud formation only those most closely related to the work reported in this bulletin are reviewed.

Vincent (33) in 1884 studied the development and formation of flower buds of a number of common orchard fruits. He reported the relative development of flower buds as shown by measurements of floral organs, at different times from March 6 to July 24.

Goff (10, 11, 12, 13), one of the first to make a systematic study of the formation and development of apple flowers, reports as a result of his work in 1898 that in case of the Hoadley Apple flower and leaf buds were differentiated as early as June.

As a result of the second investigation, Goff found that flower buds may form in September as well as in July and suggests that flowers are formed as a result of a check in growth which may be caused by drought in summer or the cool nights of autumn. He further states that the flower buds are not structurally different from leaf buds but that they probably never revert back to leaf buds.

The results of his third series of investigations are summarized by the statement that embryo flowers may form on any tree from the time vegetative growth ceases till the middle of September.

In his fourth report which summarizes the results of his previous investigations on bud formation, the following conclusion should be noted: *First*, that the sap that goes to the undifferentiated buds must contain a certain amount of nutriment before it can form flowers; *second*, that the sap may become rich in nutriment by girdling below the bud or by the concentration

Most of the work here reported was done by the junior author while a fellow in the Department of Horticulture. Its success must be attributed to the immense amount of time and energy which he gave to the problem and to his cytological skill and excellent technique.—J. N. M.

of the sap due to the evaporation of the water through dry weather; and *third*, that, since every bud of the apple tree is a potential flower bud, the weather must have much to do in determining the number of flowers formed.

Drinkard (8), in 1909 to 1910, working in Virginia, studied in detail the development of the flower buds of three varieties of apples. He notes the following facts concerning the Oldenburg (Duchess) apple. The date of leaf and flower bud differentiation was as early as June 20. This was immediately followed by a period of active growth in which all floral organs except the pistil were formed by July 7 and all of the flower parts were formed by the first of November. In the following spring pollen grains were completely formed and the flowers were ready to open by April first. In conclusion the following statement is made: "The proper development of the fruit bud would therefore be influenced by factors which are brought to bear upon the tree prior to and during the period at which fruit-bud formation takes place. In the practice of such orchard operations as are designed to influence or control fruit-bud formation, it appears that such operations should be more effective in the spring and early summer than at other stages of development."

The truth of the last statement was verified by later experiments. In 1913 and 1915 Drinkard (9) conducted experiments to determine the effects of pruning, ringing, and stripping on the formation of fruit buds on the dwarf apple trees. The results indicated that spring pruning at the time of the resumption of growth retards the formation of fruit buds, while summer pruning the last of June greatly stimulated the formation of fruit buds. Fall pruning in November had little effect on bud formation. Stripping in June acted the same as pruning at that time. Ringing also stimulated bud formation when done after the leaves matured.

Remy (29) in 1911 studied relations existing between the fertilizers applied to the soil and the amount of nutritive substances in the various organs of the tree. One row of trees received a fertilizer containing all of the necessary elements while in the other rows nitrogen, potash, phosphoric acid, and lime, respectively, were withheld.

It was observed that a certain amount of nitrogen is necessary for the abundant development of fruit buds and that the ratios between the various nutritive elements appear to exert some influence on fruit bud development.

Pickett investigated the effect of soil management on formation of fruit buds of the Baldwin apple. The results of the first paper (27) which were largely drawn from macroscopic study indicate that clean tillage induces the formation of many more fruit buds than sod culture. The two most important factors stimulating fruit bud production were, moisture and nitrogen, the nitrogen being added to the soil in the form of a cover crop.

Kraus (20) in his investigations on the morphology of the apple, in 1913 carefully worked out the development of the flower parts. In the summary he states that "All parts of the flower are cyclic in arrangement and that the succession of cycles is acropetal."

Kraus (21 and 22) describes the manner in which flower buds may be borne, in regard to the type of branch or spur. He further explains the injury to the fruit-bearing power of a tree caused by heading back in winter or thinning out and advocates summer pruning to increase the number of fruit buds. Considering the factors causing fruit bud formation he states, "Fruit bud formation is directly induced and the buds are dependent upon the conditions existing within the tree, and not by any system that may be hotly agitated today and abandoned tomorrow."

Bradford (4) in 1914 conducted investigations to determine the relation between the development and the position of buds on the tree of Yellow Newton. He found that fruit buds were differentiated earlier on spurs than on sprigs. The buds of old spurs that produced no flowers the spring of the current year showed the most uniformity in development. On those spurs which produced flowers the current year the buds showed much variation in development, but most variation in cases where the flowers failed to produce fruit.

A short consideration of the variation in the varieties was undertaken with the result that a wide range in the development of fruit buds was discovered, and attributed to varietal and individual factors.

Gourley (14) after his investigation to determine the response of the Baldwin apple tree to cultural treatments, states that the plots in the experiment where the moisture ran the lowest during the period of fruit bud formation, coupled with good growing conditions earlier in the season, produced the largest number of buds and also that the yield in the "off" years of Baldwin apple trees can be materially improved by good cultural methods.

Magness (24) in 1916 conducted an extensive series of experiments to determine the influence of summer pruning upon the development of fruit buds in Oregon. He found that heading back in early summer had no influence on the number of fruit buds on spurs, but reduced the number of fruit buds formed on the one year wood. Also axillary leaf and fruit buds differentiated one month later than spur buds on the same tree.

Black (3) investigated the development of the Baldwin apple from the incipient shoot to the subsequent formation of the fruit. It was found that fruit buds may be anticipated by their position on the fruit spur, but are identified with certainty only by dissection.

Butler (5) has recently published a paper in which he divides branches on which fruit is developed into four classes, fruit branches, sprigs, darts, and spurs. A fruit branch is a leader in which the terminal and axillary buds in the upper two-thirds or thereabouts of its length become flower buds during the season of its development. The sprig is a shoot about a foot in length developing from two year old wood. The sprig not infrequently produced a flower bud the year of its formation. The dart is a very short spinelike branch with smooth bark. In some cases it may produce a terminal flower bud the first year but normally it does not produce flowers till the end of three years. The spur is a short, thick, brittle branch with much wrinkled bark and breaking readily with a smooth fracture. The spur usually develops from a bud formed during the previous season, that is, from two year old wood, and requires two season's growth to form a flower bud.

THE PURPOSE OF THE WORK AND METHODS EMPLOYED.

A microscopical study of buds from apple trees subject to different types of soil management should, if extended over a number of years and including a number of varieties, afford some data helpful in judging the influence of different types of soil management on the formation and development of fruit buds and thereby be of service in determining the merits of the different types of soil management in relation to the production of fruit.

The immediate purpose of the work reported in this bulletin, was to discover the ways in which different trees of the Jonathan and Grimes Golden growing on plots representing four types of soil management, (clover sod, blue grass sod, tillage and cover crop and clean tillage) differed in the time of forming flower buds, in the number of flower buds formed and in the rate of the development of flowers. In addition to the difference in the management of the soil, also such factors as the amount of soil moisture of the different plots and the growth and production of the different trees during previous years were considered in relation to the differences in the formation and development of flower buds.

At the time the orchard was leased it was eighteen or nineteen years old. It was perhaps in a little better condition than the ordinary neglected orchard of similar size and age. The soil of this orchard is known as Missouri loess. It has a texture almost as fine as clay but is very porous and affords excellent drainage and aeration. This soil is very deep and since it holds moisture well, it is an ideal orchard soil.

The part of the orchard included in the experiment was divided into six plots. These plots have received the following treatment since 1910.

Plot One (clover sod) has an east slope. Beginning with 1910 it was seeded to red clover but a poor stand resulted then and in the three next years; in the spring of 1914 it was seeded to white sweet clover. A very heavy stand was obtained in 1915 but the clover failed to reseed itself and in 1916 the plot was well covered with a good growth of weeds.

Plot Two (cover crop) is situated above plot one on the same east slope. Each year it receives weekly cultivations between May first and the last of July. Between July 25 and August 3 a leguminous or nonleguminous cover crop is sown. The leguminous crop is sown on even years. In 1915 rape and buckwheat were sown while in 1916 vetch was substituted for the buckwheat.

Plot Three (clean tillage) receives a weekly cultivation from early spring till late in July. The part of the plot on which the trees included in the experiment were located was near the top of the ridge on a southwest slope.

Plot Four (blue grass) was plowed in 1910 and seeded to blue grass. It required two or three years to get a blue grass sod established. The grass is mowed and allowed to remain on the soil as a mulch. The trees in this plot from which the buds were studied are located on a southwest slope.

Plot Five (cover crop) receives same treatment as plot two. It has a southwest slope.

Plot Six (clover sod) receives the same treatment as plot one

This work was a continuation of the bud study inaugurated by F. M. Harrington. The same trees which he had selected were chosen with the idea that his work could be used as a check on our results. These trees, consisting of one tree of the Jonathan and one of the Grimes Golden from each of the six plots, were carefully selected as representing the average growth and production of the trees of the respective plots.

In order to eliminate as much error as possible, due to a lack of uniformity in buds, all buds were collected from old spurs which bore no flowers in the spring of the current year. Also since the flowers of a cluster differ in development according to position in the cluster, only the terminal flower of the cluster was used in making comparisons.

Despite these precautions there still remains much chance for error. Buds on different spurs vary in time of formation and in rate of development. Hence the buds studied at successive collections, unless a large number of buds are included, vary so much in the proportion of backward and forward buds, that their average time of formation and rate of development may be far from the average of all the buds of a tree. Then there are a number of factors other than soil conditions, such as the health of trees, exhaustion from previously bearing a heavy crop, and individual characteristics that cause variation and make it impossible to draw conclusions except from a large amount of data.

At each collection ten buds were chosen from each of the twelve trees. The first collection was made on July 6, 1916, and during the following forty-two weeks, nineteen similar collections were made at intervals of approximately two weeks during active growth of summer, fall, and spring and at intervals of two to four weeks during winter when growth was inactive.

As soon as the buds were removed from the trees they were placed in labeled vials and immediately sent to the laboratory where all of the cutinized scales were removed, leaving only the vital parts of the bud and a very short peduncle to be killed.

Of the various reagents tried a modification of Drinkard's (8) formula for Gilson's mixture gave the best results in killing and fixing the material and was used throughout. The modification consisted of increasing the percentage of alcohol from ten to twenty-five to facilitate penetration through the pubescence of the buds. The material was left in the killing fluid from ten to twenty hours, the length of the period depending upon the size of the buds.

Dehydrating or the removing of all traces of water from the tissues was accomplished by means of increasing strengths of alcoholic solutions. Two hours was taken as the minimum time allowed for the material to remain in each solution.

In the 50 per cent, 60 per cent, and 75 per cent alcohols iodine was added to remove the mercury from the tissues, while the 85 per cent and 95 per cent alcohols contained 10 per cent of glycerine in which the buds were left for twenty-four hours to toughen the tissues and prevent brittleness, after which they were removed to absolute alcohol. The material was removed from absolute alcohol and run two hours in each of six solutions of different percentages of xylol which cleared the tissues and also prepared them for infiltration with paraffin.

The last two sets of buds were run through 25 per cent, 50 per cent, 75 per cent, and 100 per cent solutions of cedar oil for clearing, with the result that the material handled in this way was not nearly so brittle as the material cleared in xylol and could therefore be sectioned much thinner. This point was observed in running up material where thin sections were desired for the study of heterotypic mitosis.

It was found best to very gradually infiltrate the flower tissue with soft paraffin which was later replaced with medium and then hard paraffin (56°—58°C). The best results were obtained by imbedding the material in blocks of paraffin which were composed of four parts Leitz best grade of hard paraffin and one part Parowax. This mixture gave a grade of paraffin with a melting point of about 55°C. and with a toughness that the hard paraffin alone did not afford.

During the eight to ten hours that the material was in the paraffin oven the temperature of the oven was not allowed to rise over three degrees above the melting point of the paraffin used. This was very important because if the temperature was allowed to go higher than three degrees above the melting point of the paraffin, the tissues of the buds became hardened and brittle and could not be sectioned.

By being very careful in running up the material, it was found possible to get good sections in paraffin from buds taken at any time during the year. By using cedar oil in clearing and dehydrating, the material was more easily sectioned and by the use of cedar oil it is probable that all could have been sectioned on the rotary microtome, whereas without the use of the cedar oil it was necessary to cut some of the buds during the winter with the slide microtome. In tracing the differentiation of flower buds from leaf buds and in studying the development of the floral organs the sections were cut from 10μ to 25μ. In studying the formation of sporogenous tissues the material was sectioned as thin as 8μ.

In general all but the last two sets were stained with Delafield's haematoxylin according to the procedure recommended by Chamberlin (6). It was found that ten minutes staining gave the tissues a heavy overstain which gave excellent differentiation to the different flower tissues when destained in 70 per cent acid alcohol. In the last two sets the iron alum haematoxylon facilitated the study of mitosis which was taking place at that time.

In order to make a detailed comparative study of the various stages of development shown by the slides, at first it was thought best to make camera lucida drawings (x60) of the various stages. After about two hundred different stages had been drawn and studied, it was found that measurements could be used quite well in comparing the relative development of buds. The floral organs develop acropetally and their primordia appear when the primordia of organs preceding them have reached a certain length. The width of the crown of leaf buds was found to be less than .14 mm. during the period that flower buds were being differentiated. When the crown of a flower bud attained a width of practically .27 mm., then the differentiation of the individual flowers began. From the time of its differentiation until the primordium of the calyx appeared, the terminal flower increased in width from .16 mm. to .24 mm. When the calyx primordium attained a height of .11 mm. and the receptacle a width of .34 mm. then appeared the primordium of the corolla closely followed by that of the stamens. The primordia of the carpels appeared when the corolla and stamens had attained a height of about .10 mm. and the sporogenous tissue was differentiated in the upper anthers when the carpels were from .19 mm. to .24 mm. in height above the center of the torus. These measurements were found to be practically the same in both varieties of apples and no noticeable variations due to the different types of soil managements were observed. Since these measurements were found quite reliable, they were chosen in preference to drawings as a means of comparison. More than a thousand slides containing median longitudinal sections of as many flower buds were made and the measurements of each bud recorded.

RESULTS.

The results obtained from the microscopical study of the buds are given in tables I to IV inclusive. In these tables are recorded the measurements of the least and most advanced flowers found in the collections from July 20, 1916, to November 13, 1916. The number in the upper part of the square is the measurement of the least advanced bud in the collection made on the date designated at the left of the table, while the number at the bottom of the square is the measurement of the most advanced bud in that collection. The measurement of the floral organ last formed is the one recorded. For example, in the column under plot 1 of clover sod the terminal flower in the bud showing the least development had a width of only .16 mm., which is much less than the width of the flower at the time the calyx appears, while in the bud most advanced not only the calyx had appeared but the corolla was .02 mm. in height. In all of the flower buds collected on November 13, the carpels had appeared, and the sets of floral organs were thus complete. The empty squares at the top of Tables I and III, excepting the column under plot 5 of Table III, indicate that flower buds were not sufficiently advanced to be told from leaf buds. In a few squares there is only one number in which case only one flower bud was found among the ten collected or all were in practically the same stage of development. The measurements in table I show that on plot 1 of clover sod, the flower buds formed earlier and were more advanced on November 13 than were those on either of the other plots. In all of the other plots, including plot 6 of clover sod, the measurements show that flower buds were not formed until August and hence nearly a month later than on

TABLE I.

FORMATION AND DEVELOPMENT OF FLOWER BUDS IN THE JONATHAN.

Method of Management	Clover Sod								Cover Crop								Clean Tillage				Blue Grass			
Plot	1				6				2				5				3				4			
Date	I	K	C	O	I	K	C	O	I	K	C	O	I	K	C	O	I	K	C	O	I	K	C	O
July 20 1916	16		2																					
Aug. 2 1916	16	9																						
Aug. 18 1916		8	3		16 21								15 16				17				18	3		
Aug. 30 1916			6		18		1						19		6				6			2		
Sept. 15 1916			5 6			7 11			16 18					5 6			19	4				4 5		
Oct. 3 1916				11 16				2 4		4 6					1	5			4 5			5		2
Nov. 13 1916				16 22				3 16				2 6				10 16				2 13				3 19

The unit of measurement is .01 mm.
I—Width of the terminal flower.
K—Height of the calyx primordia.
C—Height of the corolla.
O—Height of the carpel primordia above the center of the torus.

TABLE II.

FORMATION AND DEVELOPMENT OF FLOWER BUDS IN THE JONATHAN.

Method of Management	Clover Sod		Cover Crop		Clean Tillage	Blue Grass
Plot	1	6	2	5	3	4
Date	0	0	0	0	0	0
December 9 1916	22 26	13 14	10 11	14 16	11	13 21
January 11 1917	14 24	16 21	12	12 14	12 13	17 24
January 30 1917	21 28	29		11 21	17 21	24
February 19 1917	12 27	16 24	11 21	12 22	6 20	13 22
March 23 1917	40 53	24 30	21 29	34 38	19 24	36 38
April 10 1917	86 Mother Cells Lose	80 Mother Cells		134 Tetrad	72 Synapsis	77 Mother Cells
Date of Blooming	May 9–17	May 9–17	May 10–17	May 9–17	May 10–17	May 10–17

The unit of measurement is .01 mm.
O—Height of the carpel primordia above the center of the torus.

TABLE III.

FORMATION AND DEVELOPMENT OF FLOWER BUDS IN THE GRIMES GOLDEN.

Method of Management	Clover Sod								Cover Crop								Clean Tillage				Blue Grass			
Plot	1				6				2				5				3				4			
Date	I	K	C	O	I	K	C	O	I	K	C	O	I	K	C	O	I	K	C	O	I	K	C	O
July 20 1916					16																			
Aug. 2 1916					22	3																		
Aug. 18 1916	24				17		1		22													1 9		
Aug. 30 1916		6			23		10			7	5						21				23	10		
Sept. 15 1916			4			4	10			4	6						16		6				6	
Oct. 3 1916				5			6	6												4				5
Nov. 13 1916				10 19				13 19												18				19

The unit of measurement is .01 mm.
I—Width of the terminal flower.
K—Height of the calyx primordia.
C—Height of the corolla.
O—Height of the carpel primordia.

TABLE IV.

FORMATION AND DEVELOPMENT OF FLOWER BUDS IN THE GRIMES GOLDEN.

Method of Management	Clover Sod		Cover Crop		Clean Tillage	Blue Grass
Plot	1	6	2	5	3	4
Date	O	O	O	O	O	O
December 9 1916	18 19	22 27	19		13 19	19 27
January 11 1917	18 22	18 20	13 19		19 21	16 20
January 30 1917	22	20 21	14		16 18	19 21
February 19 1917	16 22	24 30	21		20	24
March 23 1917	21 24	21 29	30			27 30
April 10 1917	80 Mother Cells	152 Tetrad			85 Mother Cells	63 Synapsis
Date of Blooming	May 9–16	May 9–18	May 9–18		May 9–18	May 9–18

The unit of measurement was .01 mm.
O—Height of the carpel primordia above the center of the torus.

Plot 1. According to the measurements the flower buds were slightly more advanced on blue grass sod than on other plots excepting Plot 1 of clover sod.

In Table II, the relative development of the flower buds of the Jonathans from December 9 to April 10 of 1917, is shown by the relative lengths of the carpels of the terminal flowers. When the different plots are compared as to the shortest and longest carpels recorded on the different dates, it will be noted that with two exceptions this table is in accord with what is shown in Table I in reference to the relative development of buds on the different plots. The exceptions referred to occurred on April 10 on plat 5 cover crop, and plot 3 clean tillage. The bud containing a flower with some stamens in synapsis and recorded under clean tillage was an exceptional bud, for the bud least advanced was less developed than the buds least advanced on the other plots and the buds on the average were less developed than the buds on the other plots. But on plot 5 cover crop the buds collected on April 10 were on the average more developed than buds collected from other plots. Either the buds on this plot developed more rapidly than buds on other plots, during the latter part of March and early part of April, or the buds of this collection happened to be exceptional. Unfortunately no flower buds, which would have served as a check on plot 5, were found in the collection from plot 2, cover crop, on April 10. The dates of blooming were practically the same on all plots. The cool spring which retarded blooming and thereby afforded an opportunity for the flowers least advanced to catch up may account for this. It may be that there is a difference in the rate of development just preceding the blooming period due to different methods of soil management, and it is also possible that buds backward in development surpass other buds in rate of development just preceding the blooming period. From the two tables it is seen that the flower buds of the Jonathan developed most rapidly from the time of their formation to November, and from February till time of blooming. During the remainder of the season development was slow.

In tables III and IV are given the measurements of the least and most advanced buds of the Grimes Golden on the different plots. The trees of the Grimes Golden formed fewer flower buds than the Jonathan on the plots where there was cultivation and the measurements are less complete. The tree on plot

5, cover crop, formed no flower buds at all, and in two collections from plot 2 cover crop and in one collection from clean tillage all buds were leaf buds. According to the measurements flower buds formed earliest and led in development on sod the blooming period on plot 6 clover sod. On the remaining plots the flower buds formed slightly earlier and were slightly more advanced up till April 10 on the blue grass sod. These tables are in accord with those of the Jonathan showing that the flower buds formed earliest and lead in development on sod and also that there are two periods at which growth is more rapid. It should be noted, however, that in contrast to the Jonathan which formed flowers earliest on plot 1, the Grimes Golden on plot 6 formed flowers earliest. This shows that there is some other factor which is as potent as soil management in its effects on the time of the formation of flower buds.

The formation of sporogenous tissue began about November 13 and continued until February 19. The mother cells of the anthers began to form about April first. The order of the formation of sporogenous tissue in the different trees was as follows:

Grimes Golden, blue grass sod.
Jonathan, blue grass sod.
Grimes Golden, clover sod, plot six.
Jonathan, clover sod, plot one.
Grimes Golden, clover sod, plot one.
Grimes Golden, clean tillage.
Grimes Golden, cover crop, plot two.
Jonathan, clover sod, plot six.
Jonathan, cover crop, plot five.
Jonathan, clean tillage, plot three.
Jonathan, cover crop, plot two.

With the exception of the Jonathan on clover sod, plot 6, the sporogenous tissue appeared earliest on the sod plots.

From a study of the slides it was ascertained that the formation of flowers for the two varieties of trees took place in the various plots in the order as shown below.

Jonathan	Grimes Golden
1. Clover sod. Plot one.	1. Clover sod. Plot six.
2. Blue grass sod.	2. Blue grass sod.
3. Clover sod. Plot six.	3. Clover sod. Plot one.
4. Cover crop. Plot five.	4. Cover crop. Plot two.
5. Clean tillage.	5. Clean tillage.
6. Cover crop. Plot two.	6. Cover crop. Plot five (no flowers)

The number of flower buds in each collection was recorded and from these data the percentages of flower buds formed by the two varieties on plots in sod and in cultivation were determined. The percentages are recorded in Table V and show with some exceptions that the percentages of flower buds were higher on sod.

TABLE V. PERCENTAGES OF FRUIT BUDS.

Kind of Soil Management	Clover Sod	Blue Grass Sod	Clover Sod	Cover Crop	Clean Tillage	Cover Crop
Number of plot........	1	4	6	5	3	2
Percentage of flowers formed by the Jonathans	81	51	95	92	41	26
Percentage of flowers formed by the Grimes Goldens	100	72	92	0	20	38

SOIL MOISTURE CONSIDERED IN REFERENCE TO THE FORMATION AND DEVELOPMENT OF FRUIT BUDS IN THE JONATHANS.

Determinations of soil moisture made at different places show that there is considerable difference in the amount of soil moisture in different regions of the same plot. It so happened, however, that determinations were made within a few feet of the Jonathans during the summer of 1916. The results of these determinations are given in Table VI and are interesting when considered in connection with the formation and development of flower buds. It will be observed that the sod plots, 1 and 4, which are the plots where flower buds formed earliest and most abundantly, had the lowest percentage of soil moisture. Also on plot 6 where flower buds formed later than on plot 1 the percentage of soil moisture was relatively high. Thus on the plots where the soil moisture was low, the flower buds formed earliest and also most abundantly with the exception of the Jonathan on plot 5.

TABLE VI. PERCENTAGE OF SOIL MOISTURE ON THE DIFFERENT PLOTS IN THE REGION OF THE JONATHAN.

Method of Management	Clover Sod		Cover Crop		Clean Tillage		Blue Grass		Cover Crop		Clover Sod	
Plot	1		2		3		4		5		6	
Date	S	SS	S	SS	S	SS	S	SS	S	SS	S	SS
June 25, 1916	10.8	10.7	15.6	14.0	13.5	13.2	10.6	9.6	16.1	15.1	15.7	14.7
July 14, 1916	8.0	8.3	16.9	16.5	15.4	16.9	7.6	8.4	15.4	13.2	13.3	12.9
July 31, 1916	6.7	7.0	16.5	15.4	14.3	9.3	5.6	7.0	11.9	11.5	9.5	8.7
August 15, 1916	11.1	7.3	14.0	10.8	14.5	10.6	10.5	6.5	16.1	14.8	9.4	7.2
Average per cent	9.1	8.3	15.0	14.2	14.4	12.8	8.5	7.8	14.8	13.4	11.9	10.8

S—Surface soil.
SS—Suosoil.

GROWTH OF THE TREES AS RELATED TO THE SOIL MOISTURE AND FORMATION OF FRUIT BUDS.

In Table VII is recorded the growth of the trees in diameter and the average percentage of soil moisture for the different plots. It will be noted from a study of this table that growth

TABLE VII. RELATION OF SOIL MOISTURE TO GROWTH.

Method of Soil Management	Circumference Increase of the trees in inches 1916	Average Soil water content June 18 to Aug. 22 Per cent
Blue Grass Sod	.63	8.1
Clover Sod, Plot 1	.68	8.7
Clover Sod, Plot 6	.88	11.3
Clean Tillage	1.	13.6
Cover Crop, Plot 5	1.25	14.1
Cover crop, Plot 2	1.63	14.6

was directly related to the percentage of soil moisture. With the exception of the Grimes Golden on plot 6 as shown by Table III, the trees making the least growth were ahead in the formation and the development of fruit buds. It will be noted that although the flower buds formed earliest on clover sod, the blue grass sod had less moisture. This fact suggests that the amount of nitrates in the soil may affect the time of bud formation.

THE FRUIT CROP OF PREVIOUS YEARS AS RELATED TO THE GROWTH OF THE TREES AND THE FORMATION OF FRUIT BUDS.

In Tables VIII and IX are recorded the growth and crop of the individual trees on the different plots during the years of 1915 and 1916, the percentage of fruit buds which each tree produced in 1916 and the order in time of forming fruit buds.

TABLE VIII. RECORDS OF THE JONATHAN.

Method of Management	Clover Sod		Blue Grass		Clover Sod		Cover Crop		Clean Tillage		Cover Crop	
Plot	1		4		6		5		3		2	
	G	P	G	P	G	P	G	P	G	P	G	P
1916	.68	292	.63	13	.88	109	1.25	340	1.00	65	1.63	109
1915	1.41	848	1.44	252	.94	178	2.33	786	2.25	1058	2.50	614
Percentage of Flower Buds	81.		51.		95.		92.		41.		26.	
Order of Forming Buds	1		2		3		4		5		6	

G—Circumference increase of the tree in inches.
P—Production of the tree in pounds.

TABLE IX. RECORDS OF THE GRIMES GOLDEN.

Method of Management	Clover Sod		Blue Grass		Cover Crop		Clover Sod		Clean Tillage		Cover Crop	
Plot	6		4		2		1		3		5	
	G	P	G	P	G	P	G	P	G	P	G	P
1916	.50	84	.81	324	1.50	793	.81	374	.75	579	1.25	451
1915	.44		.50	483	.69	590		270	1.13	592	.75	29
Percentage of Flower Buds	100		72		38		92		20		0	
Order of Forming Buds	1		2		4		3		5			

G—Circumference increase of tree in inches.
P—Production of the tree in pounds.

It will be noted from Tables VIII and IX, that in most cases the trees forming flower buds earliest and most abundantly were those which grew slowly and bore a comparatively small fruit crop during the year 1916. One of the trees which was in part an exception was the Jonathan on plot 5. It formed flower buds late but abundantly, made considerable growth but bore a comparatively small crop of fruit. On the other hand the Jonathan on clean tillage produced a small percentage of flower buds although neither growth nor crop was large. But it will be noted that during 1915 the growth and production of this tree were remarkably high and the tree was probably in a state of exhaustion in 1916.

DISCUSSION.

The data given in the preceding pages show that the formation and development of flower buds in the two varieties of apples subject to four types of soil management were associated with a number of factors. Early formation and high percentage of flower buds were associated with a low percentage of soil moisture, small growth and the production of a small crop. Also the fact that buds formed earlier on clover where the soil moisture was greater than in blue grass suggests that the amount of nitrates may be a factor of considerable importance. It is likely, however, that the most important factor was the amount of soil moisture, which also affects the growth of the tree and probably the size of the crop at the same time it affects the formation and development of flower buds.

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DEPARTMENT OF BOTANY,
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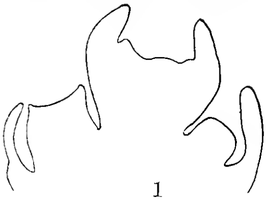
Description of Plate VII.

Camera lucida drawings showing the greatest development found on August 18, 1916.

Buds were in each case taken from,

1. Jonathan tree growing in plot one. Clover Sod.
2. Grimes Golden tree growing in plot one. Clover Sod.
3. Jonathan tree growing in plot six. Clover Sod.
4. Grimes Golden tree growing in plot six. Clover Sod.
5. Jonathan tree growing in plot four. Blue Grass Sod.
6. Grimes Golden tree growing in plot four. Blue Grass Sod.
7. Jonathan tree growing in plot two. Cover Crop.
8. Grimes Golden tree growing in plot two. Cover Crop.
9. Jonathan tree growing in plot three. Clean Tillage.
10. Grimes Golden tree growing in plot three. Clean Tillage.
11. Jonathan tree growing in plot five. Cover Crop.
12. Grimes Golden tree growing in plot five. Cover Crop.



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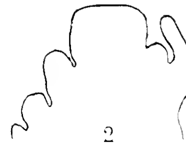

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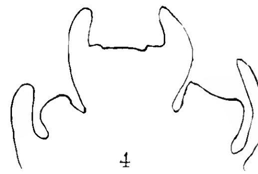

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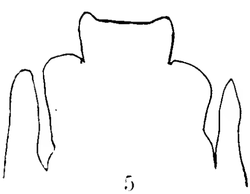

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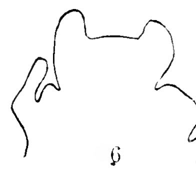

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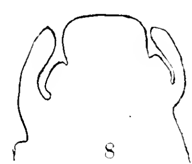

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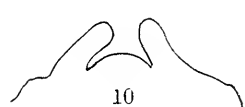

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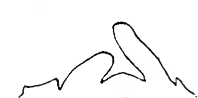
11



12

1 M.M.

THE GERMINATION OF SOME TREES AND SHRUBS AND THEIR JUVENILE FORMS.

L. H. PAMMEL AND C. M. KING.

(Contribution No. 2 on Germination of the Woody Plants.)

In the proceedings of the Iowa Academy of Science, 1917, we published a paper on the germination and the juvenile forms of some oaks, mostly species native to Iowa. In this paper some of the literature on the subject was given. C. S. Sargent[1] has touched on the germination of many of the species of North America, in some cases in detail. Germination of exotic species is described by Tubeuf.[2] It seemed well, therefore, to continue observations on the germination of Iowa species, and a few not native to the state are included. Little specific seems to be known about the vitality of tree and shrub seeds. The statements made are usually quite general. The species here studied were treated as to seed bed conditions in two ways. One lot of seeds was placed in good greenhouse soil in the fall (1917) and stratified in a cold frame, from which they were removed to the greenhouse in March, 1918. The second lot was planted in an open place covered with two inches of soil and leaves. Air temperature records were kept throughout the season, soil temperature records were kept in the fall until the ground was frozen, and again during the opening of the growing period of 1918.

Show[3] calls attention to the need of testing every lot of seed, these tests to be co-ordinated with actual germination in the nursery. His paper describes a series of tests of seeds of yellow pine, Jeffrey pine and incense cedar. He considers five factors influencing germination; 1. temperature of soil; 2. character of soil; 3. amount of light; 4. amount of water, and 5. depth of cover. The last three factors can be quite well standardized; character of soil is predetermined; temperature is consequently the variable. The germination of the three conifers is more rapid and complete in fertilized soils and slowest in clay. He finds that mean temperature does not apply strictly to germination. An examination of greenhouse germination shows that after two days with the same mean the germination increases

[1]Silva of North America, various volumes.
[2]Tubeuf, K. Samen, Früchte u. Keimlinge, Berlin, 1891.
[3]Show, S. B., The Relation of Germination in the Greenhouse and Nursery; Jour. of Forestry, *16*, pp. 319-328.

with increase between extremes. Thus if the temperature is constant at 60° F. on one day and varies from 50° to 70° F. with a mean of 60° on another, germination is highest following the latter.

The practice in testing seed in greenhouses is to hold air temperature to a minimum of 50° F. An examination of thermograph sheets and germination records indicates that minimum air temperatures down to 32° F., the freezing point, do not retard germination and in fact appear to accelerate it unless they are prolonged. Seed in the nurseries is of course subjected to a wider variation in temperature than in the greenhouse, but it is difficult to say that this results in slower germination. It is probable, though not proved, that the accumulated temperatures above 40° F. control germination. The author discusses the vitality of seeds of the three conifers. He finds that in the case of Jeffrey pine, seed several years old may be used. In case of yellow pine the germination percentage falls off after two years. Seeds of incense cedar fall to 33 per cent the second year, and have practically no germination after the third year. Three years tests on over forty lots of seed of sugar pine gave no consistent or reliable results. The author finds it important to know the average rapidity of germination so that enough young plants be produced before the necessary time for transplanting.

He finds in his tests that northern seed is more rapid and shows less variation than southern seed. He believes that for planting the percentage of effective germination should be determined for each species; as for instance, he has found it in the case of yellow and Jeffrey pines to be about 50.

Gifford[4] discusses germination distributed over a period of time; as in white pine, some grow the first year, many the second year, a few the third year. With regard to geographical conditions; the farther north and the higher the altitude, the smaller the seed and the smaller the percentage of germination, although the quantity produced is often immense. The author quotes from Rafn determination of germination percentage of many species, which indicate how variable is the value of seeds on the market.

Of the general statements which we find the following may serve the purpose of this paper. John Nisbet[5] quotes from Ney

[4] Gifford, J., Practical Forestry, pp. 102, 106, 111, 112.
[5] British Forest Trees and Their Silvicultural Characteristics and Treatment, 18.

on the germination in percentage of seeds as sold by seedsmen: birch 10; alder 15; elm 20; hornbeam 50; oak 60; chestnut 60; maple 50; beech 60.

K. Gayer and H. Mayr[6] state that in spite of care there is some loss in the vitality of seeds. Robinia was found to germinate 75 per cent; oak 69; beech 27; elm 26; birch 25.

Barrington Moore finds "In fir there are indications of a periodicity of reproduction which is of considerably more importance than that due to the seed supply. * * * and that these conditions are largely controlled by the forest itself."[7]

STANTON HILLSIDE SEED PLOT, OCTOBER, 1917.
SOIL TEMPERATURES OCTOBER 15 TO NOVEMBER 24.
Precipitation during this period, 1.39 inch.

Day	8:00 A. M. Deg. C.	12:00 M. Deg. C.	5:00 P. M. Deg. C.
Oct. 15	....	....	....
16	11.	14.	20.
17	14.	14.	14.5
18	12.5	10.5	....
19	6.	7.	7.5
20	7.5	7.5	....
21	4.	....	....
22	4.5	7.	15.
23	5.	6.	9.
24	3.5	7.	8.
25	6.	7.	9.
26	6.5	6.5	6.5
27	5.5	6.	6.
28	....	....	....
29	3.5	3.	3.
30	0.	3.	3.25
31	2.5	3.	3.5
Nov. 1	2.5	3.	5.
2	3.	4.	7.
3	5.	7.5	10.
4	....	....	....
5	6.5	8.5	10.
6	6.5	10.	11.
7	10.5	7	12
8	8.5	9.5	11
9	8	10	10.5
10	9	10	....
11	..	....	....
12	8	9.5	9.5
13	8	9.5	10
14	7	8.5	10
15	8	8.5	11.5
16	7	10.5	....
17	..	....	....
18	..	....	....
19	5	5.5	8

[6] Die Forstbenutzung 545 See Zürich Samenkontroll Station, 1876-1894.
[7] Reproduction in the coniferous forests of northern New England. Bot. Gazette 64, pp. 149-158.

Day	8:00 A. M. Deg. C.	12:00 M. Deg. C.	5:00 P. M. Deg. C.
Nov. 20	7	8	10
21	8	9.5	9
22	..	....	....
23	3.5	....	....
24	3.5	4.00	snow storm

C. M. King,
Observer

SOIL TEMPERATURE IN STRATIFIED BED SOUTH OF GREENHOUSE. NOVEMBER 14 TO NOVEMBER 30, 1917.

Day	8:30 A. M. Deg. C.	3:30 P. M. Deg. C.
Nov. 14	....	
" 15	1	15
" 16	3	14
" 17	4	13
" 18	....	....
" 19	....	8
" 20	6	14
" 21	8	11
" 22	1	2
" 23	9	1
" 24	9	7
" 25	....	....
" 26	....	....
" 27	1	4
" 28	1	3
" 29	1	2
" 30	1	....

W. Jeffrey,
Observer

TEMPERATURE AND MOISTURE RECORDS, AMES.

F. S. Wilkins, Observer.

Day		Temp Deg F Max.	Min.	Mean	Precip	Day		Temp. Deg. F. Max.	Min.	Mean	Precip
October, 1917	1	73	32			November, 1917	1	40	29	...	...
	2	80	43				2	56	21	...	...
	3	62	49				3	66	29	...	...
	4	73	49				4	63	35	...	...
	5	56	40				5	65	34	...	...
	6	64	25				6	68	30	...	...
	7	57	40				7	69	30	...	...
	8	49	23				8	45	36	...	...
	9	66	36				9	57	35	...	...
	10	55	34				10	55	40	...	.22
	11	51	31				11	59	40	...	...
	12	47	27				12	44	37	...	...
	13	61	12				13	42	34	...	...
	14	76	46				14	46	28	...	...
	15	71	40				15	58	26	...	...
	16	65	37				16	67	32	...	...
	17	72	48				17	61	31	...	...

	Temp. Deg. F					Temp. Deg. F			
Day	Max.	Min.	Mean	Precip	Day	Max	Min.	Mean	Precip
18	56	36		.75	18	46	30	...	...
19	45	27			19	51	20	...	...
20	43	32			20	64	32	...	...
21	48	22			21	66	40	...	...
22	44	24		.05	22	53	29	...	.06
23	46	23			23	34	17	...	...
24	50	23			24	34	12	...	...
25	48	31		.55	25	38	22	...	...
26	51	36			26	33	25	...	.30
27	47	21			27	36	31	...	...
28	45	29		.03	28	42	28	...	...
29	31	24		.01	29	33	22	...	...
30	36	14			30	43	26	...	...
31	39	19			..	...	...	...	...
Average	55.1	31.4	43.2		..	51.1	29.4	40.2	...
Total precipitation				1.39					.58

	Day	Max.	Min.	Mean	Precip		Day	Max	Min.	Mean	Precip
December, 1917	1	...	...	...	...	January, 1918	1	42	0	...	...
	2	37	32	...	...		2	41	11	...	...
	3	37	28	...	...		3	27	11	...	...
	4	32	12	...	...		4	40	14	...	...
	5	17	9	...	...		5	36	23	...	.01
	6	10	-10	...	.07		6	27	13	...	.01
	7	16	0	...	...		7	17	5	...	...
	8	1	-18	...	.05		8	17	1	...	...
	9	2	-8	...	...		9	21	4	...	...
	10	5	-13	...	...		10	11	-2	...	.05
	11	13	-12	...	...		11	-2	-17	...	.05
	12	14	3	...	.01		12	-3	-20	...	...
	13	5	-18	...	...		13	16	-8	...	...
	14	1	-10	...	.13		14	17	-6	...	...
	15	7	-13	...	.17		15	22	-7	...	...
	16	25	3	...	...		16	18	4	...	...
	17	40	15	...	...		17	15	4	...	...
	18	40	33	...	...		18	12	-5	...	...
	19	43	30	...	...		19	15	5	...	...
	20	49	34	...	...		20	23	8	...	...
	21	36	22	...	...		21	29	12	...	...
	22	35	19	...	...		22	18	5	...	...
	23	40	33	...	...		23	40	6	...	...
	24	40	9	...	...		24	39	19	...	...
	25	20	4	...	...		25	39	9	...	...
	26	31	11	...	...		26	10	-1	...	.20
	27	30	-2	...	...		27	12	3	...	.07
	28	3	-9	...	.10		28	8	-1	...	.12
	29	-1	-24	...	...		29	9	-25	...	...
	30	21	-12	...	.04		30	8	-14	...	...
	31	18	7	...	...		31	6	-26	...	...
Average	..	55.1	29.4	13.6	...		..	20.1	6	10.4	...
Total precipitation					.57						.51

Day		Temp. Deg. F. Max.	Min.	Mean	Precip	Day		Temp. Deg. F. Max.	Min.	Mean	Precip
February, 1918	1	7	-27	...	...	March, 1918	1	44	16-	...	...
	2	23	-9	...	...		2	53	30	...	...
	3	6	-3	...	...		3	49	26	...	...
	4	6	-20	...	...		4	55	38	...	..
	5	29	-9	...	...		5	45	27	...	. .
	6	41	23	...	...		6	28	16	...	...
	7	43	19	...	...		7	50	17	...	...
	8	38	22	...	.34		8	53	26	...	...
	9	27	9	...	...		9	39	18	...	.19
	10	52	23	...	...		10	38	8	...	...
	11	55	35	...	.11		11	57	27	...	...
	12	45	31	...	.06		12	60	37	...	...
	13	50	30	...	...		13	47	35	...	...
	14	43	19	...	.01		14	41	27	...	.26
	15	23	10	...	...		15	42	26	...	...
	16	23	0	...	.27		16	61	24	...	...
	17	25	-18	...	...		17	68	27	...	...
	18	39	11	...	...		18	79	34	...	...
	19	34	5	...	...		19	73	35	...	...
	20	-2	-6	...	...		20	76	37	...	...
	21	15	-10	...	...		21	66	48	...	...
	22	37	8	...	...		22	56	33	...	...
	23	56	25	...	...		23	58	26	...	...
	24	50	36	...	...		24	66	23	...	...
	25	50	25	...	...		25	72	27	...	...
	26	45	20	...	...		26	62	39	...	...
	27	43	31	...	.09		27	59	29	...	...
	28	36	22	...	...		28	63	29	...	...
							29	66	32	...	...
							30	71	31	...	...
							31	66	48	...	...
Average	..	34.7	10.8	22.8	...						
Total precipitation					.88						.45

April, 1918	1	74	25	....	16	67	47	.10
	2	65	36½	.09	17	65	44	.36
	3	49	29	....	18	58	38	....
	4	56	23	....	19	48	33	....
	5	54	27	....	20	41	30	.32
	6	55	39	.32	21	53	31	.20
	7	52	38	....	22	58	40	....
	8	51	25	....	23	54	37	....
	9	54	21	....	24	54	28	....
	10	58	22	....	25	58	51	....
	11	61	20	....	26	62	37	....
	12	61	20	....	27	64	38	.10
	13	66	25	....	28	54	36	.12
	14	68	28	....	29	48	38	.02
	15	64	46	.18	30	58	34	....
Total precipitation								1.91

AIR TEMPERATURES IN THE GREENHOUSE DURING THE PERIOD THAT THE TREES' SEEDS WERE GERMINATING THERE.

A. L. Bakke, Observer

	Temp. Deg. F.				Temp. Deg. F.		
Day	Max.	Min.	Mean	Day	Max.	Min.	Mean
March 10	94°	70°	82	April, 1	104	50	77
1918 11	96	78	87	1918 2	84	48	66
12	95	78	86	3	85	34	60
13	75	65	70	4	95	50	73
14	98	60	79	5	78	60	69
15	105	42	74	6	86	55	72
16	80	37	59	7	78	35	56
17	97	62	83	8	95	40	68
18	94	44	69	9	82	58	70
19	96	47	72	10	84	63	74
20	98	50	74	11	84	65	73
21	94	50	72	12	88	62	75
22	94	46	70	13	88	66	77
23	88	37	62	14	88	64	76
24	100	37	68	15	85	68	77
25	90	50	70	16	75	68	72
26	88	45	67	17	85	65	75
27	86	40	62	18	80	52	66
28	90	44	67	19	80	55	68
29	98	45	72	20	90	50	70
30	90	50	70	21	75	65	70
31	90	46	68	22	65	55	60
				23	95	52	76
				24	85	50	68
				25	90	60	75
				26	100	58	79
				27	105	62	84
				28	112	68	90
				29	104	65	85
				30	95	46	72
Aver.	92.5	51	71.9	Avg.	88	56.3	72.4

The air was constantly moist and the plants were watered daily.

TEMPERATURE IN THE FIELD.

	Temp. Deg. F.					Temp. Deg. F.			
Day	Max.	Min.	Mean	Precip	Day	Max.	Min.	Mean	Precip
May, 1918 1	70	28	49	....	June, 1918 1	71	58	64.5	3.3
2	82	46	64	....	2	72	57	64.5	....
3	88	54	71	....	3	73	56	64.5	2.17
4	92	61	76.5	....	4	80	58	69	2.93
5	83	60	71.5	....	5	75	62	69	2.56
6	73	60	66.5	.13	6	78	63	70.5	.01
7	78	52	65	....	7	73	47	60.0	....
8	87	53	66.5	.23	8	78	57	67.5	....
9	90	54	72	.06	9	85	61	73	....
10	60	40	50	....	10	92	65	78.5	....
11	65	39	57	....	11	92	71	81.5	....
12	65	44	54.5	....	12	82	61	71.5	....
13	61	37	49	....	13	89	60	74.5	....
14	78	37	57.5	....	14	90	67	....	....
15	88	61	74.5	....	15	89	63	....	....
16	84	63	73.5	....	16	98	70	....	....
17	81	62	71.5	.78	17	85	72	....	....
18	79	64	71.5	.20					
19	82	67	74.5	.04					
20	70	47	56.5	....					
21	77	56	66.5	.05					
22	68	52	60	.03					
23	64	46	55	.02					
24	80	57	66.5	2.89					
25	82	65	73.5	.02					
26	81	65	73	.03					
27	70	62	66	.90					
28	80	62	71	.10					
29	76	62	67	.17					
30	85	66	75.5	.07					
31	75	63	69	.43					
Aver.	80.45	54.35	67.4						
Total precipitation				6.15					

JUGLANDACEÆ.

Lubbock[7] has described and figured seedlings of *Juglans regia*, and of *Pterocarya caucasica*. M. Fleche[8] has pointed out the

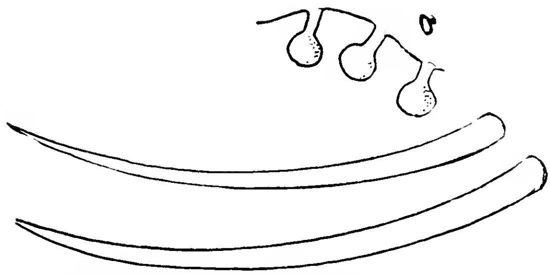


Fig. 45.—Trichomes of *Juglans cinerea*, from stem and leaf of seedling. a, Glandular hairs from leaf. Drawn by C. M. King.

characters of the leaves of the seedlings of the English walnut. Kronfeld[9] also has added to the literature on the Juglandaceæ. Lubbock[10] has further published on Juglandaceæ.

Fig. 46.—Black walnut (*Juglans nigra*), earlier and later stages of germination, pinnately compound leaves from the beginning. Photographed by Photo. Section, Experiment Station, F. E. Colburn.

Juglans cinerea L. Butternut. Collected September 28, 1917, at Cedar creek, Henry county, Iowa, by L. H. Pammel and G. B. MacDonald; placed in bed for stratifying, out of doors October

[7] A Contribution to our Knowledge of Seedlings, 513-515.

[8] l. c., 518.

[9] Beiträge zur Kenntniss des Walnuss Engler; Bot. Jahrbücher, 9, p. 280.

[10] On the Fruit and Seed of the Juglandaceæ: Jour. Linn. Soc. (Bot.) 28, p. 247.

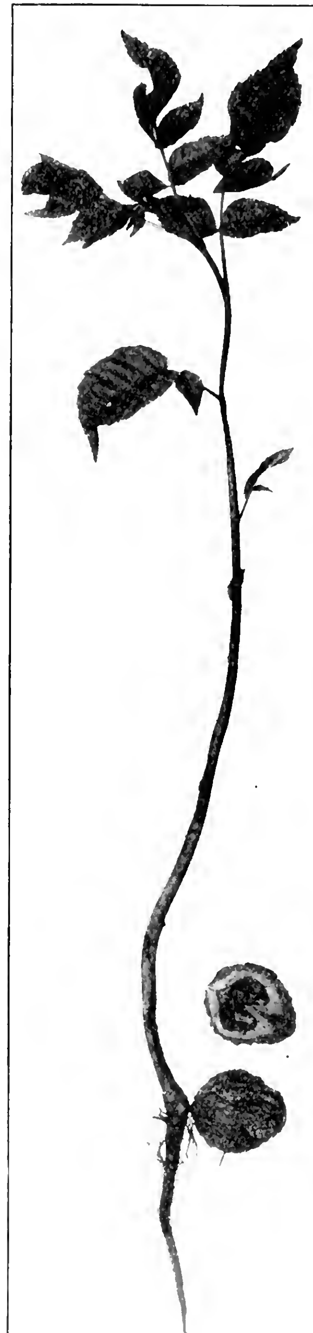


Fig. 47.—Seedling of *Juglans nigra*. Photographed by Photo. Section. F. E. Colburn.

10, 1917. Removed to greenhouse March 29, 1918. Germinated May 9, 1918, 75 per cent, germination hypogæous. Stem reddish. first leaves scalelike, glandular-pubescent above and below; small bud in axil of the scale. Fifth leaf of two, three or four leaflets, bud in axil of the leaf. Petiole glandular-pubescent. Upper surface of the leaves slightly glandular-pubescent; prominently reticulately veined, dentate, teeth glandular, petioles glandular-pubescent. Hairs upon the leaf, simple, slender, curved, sharp pointed. Colorless glandular hairs abundant, short stalked. Seeds planted in the fall of 1917 germinated out of doors, about 10 per cent by June 1.

Juglans nigra L. Black Walnut. Seedling examined from La

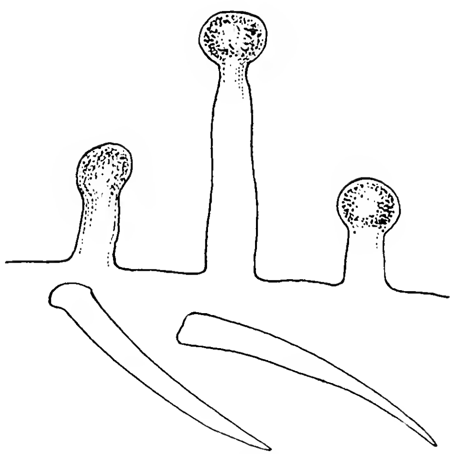


Fig. 48.—Trichome of *Juglans nigra*, and glandular hairs, from leaf. Drawn by C. M. King.

Crosse, Wisconsin, June 3, 1918. Germination hypogæous. Lubbock[11] states as follows: "Cotyledons bilobed and the lobes again bifid with the secondary segments entire or emarginate (in the immature state) slightly auricled at the base; radicle short, stout, triangular pointed." Root long, tapering, numerous rootlets, lower portion of stem smooth, bearing occasional alternate scales, upper part of stem purple, early leaves alternate, petiolate, small, simple, dentate, serrate, leaf, stem and petioles glandular, hairy, no stipules, buds in axils of leaf; three simple leaves occur on the stem alternate in arrangement, followed by the first compound leaf, which is 3-parted, having two lateral leaflets and

[11]A contribution to our knowledge of seedlings, 2, pp. 517-518.

a very much larger terminal leaflet; leaflets similar in form, ovate, acuminate, serrate, slightly lighter green below; leaflets and petiole glandular-pubescent; strongly veined; early leaves 5 to 7 leaflets. Margins of lower surface of leaf with glandular multicellular 3 to several celled trichomes; the trichomes some-

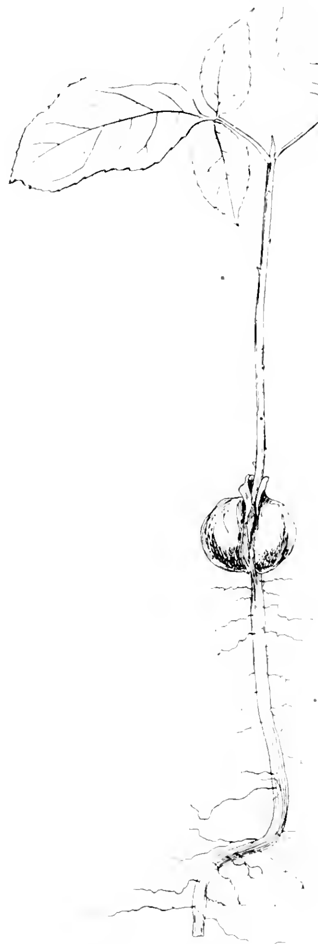


Fig. 19.—Seedling of *Carya ovata*. Drawn by C. M. King.

what constricted below the gland. Cells decidedly granular. Second kind of trichome, simple, straight or curved, rather thick-walled. Teeth also glandular tipped. Seeds planted in seed-bed out doors fall of 1917, 80 per cent germinated by June 1, 1918.

Carya ovata (Mill) K. Koch. Hickory-nut. Seed planted in greenhouse in the fall, seedling appeared above surface, April

12, 1917. Germination hypogæous. Radicle long, woody, brownish; lateral roots numerous, seedling described May 22, lower leaves scalelike, from seventh to ninth expanded into leaves Fully formed leaves have three leaflets, penni-nerved. Lower surface slightly pubescent, hairs on midrib. Upper surface of leaf smooth. Terminal leaflet larger than others, generally broadly oval, serrate. Lateral leaflets lanceolate. The young unfolding leaves pubescent on veins; young buds glandular; also base of petioles; young stem glandular.

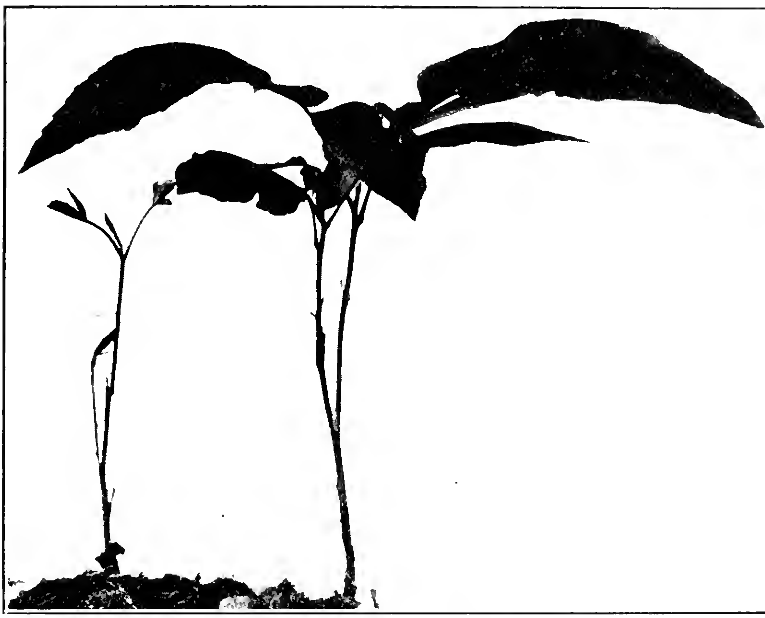


Fig. 50.—Missouri hickory nut (*Carya laciniosa*), early and later stages of germination. Photographed by Photo. Section, Experiment Station, F. E. Colburn.

Carya laciniosa (Michx. f.) Loud. Kingnut or Big Shell-bark. Seed collected on Chariton bottoms, September 28, 1917, by L. H. Pammel and G. B. MacDonald. Wintered out of doors; planted in greenhouse March 19; germinated May 1, 1918, 50 per cent. Germination hypogæous. Part of the stem above the ground reddish green, slightly roughened. Lower scales drop easily leaving a small bud in the axil. First leaf with long petiole, reddish, with resinous granules, leaflets folded toward the inside. In the first leaf lower portions scalelike, with ciliate margins, reddish. Trichomes long, slender, colorless, pointed.

slightly curved. Cell-wall thin, contents granular. Trichomes occur singly, very numerous.

Carya alba (L.) K. Koch. Mocker nut. Clemson College, December 7, 1917. Wintered in the greenhouse, germinated March

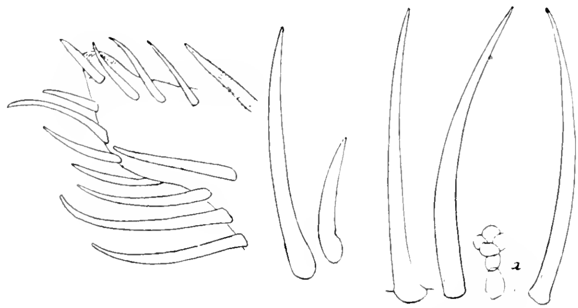


Fig. 51 Fig. 52

Fig. 51.—Trichomes on leaf of *Carya laciniosa* seedling, showing glandular tip of serration. Drawn by C. M. King.

Fig. 52.—Trichomes of *Carya alba* from stem and leaves of seedling. a, glandular trichome. Drawn by C. M. King.

28, 1918. Germination hypogæous; first leaves scalelike, alternate. Stem resinous and slightly pubescent, globules yellow. Scales five. First, second and third leaflets somewhat pubescent and covered with resinous globules on both surfaces. Petiole

Fig. 53.—Germination of hickory nut (*Carya alba*), various stages; early leaves of three leaflets, penninerved. Photogrphead by Photo. Section, F. E. Colburn.

slightly pubescent, also with resinous globules. Stalks of leaflet slightly pubescent and resinous. Margins serrate, terminal leaf serrate only beyond the middle. Trichomes occur singly, slightly curved, base enlarged; 1-celled cell wall of medium thickness, longitudinal markings. Resinous bodies nearly sessile, several cells, 5-7, some slightly stalked.

Carya glabra (Mill) Spach. Pignut. South Carolina, December 7, 1917, wintered in the greenhouse, germinated March 28, 1918, stem smoothish, reddish, slightly pubescent; with resinous globules. First, second and third leaves each with thin leaflets, terminal leaf largest, petioles and stalklets of leaf slightly pubescent. Margins serrate, lower and upper surfaces of the leaf with

Fig. 55

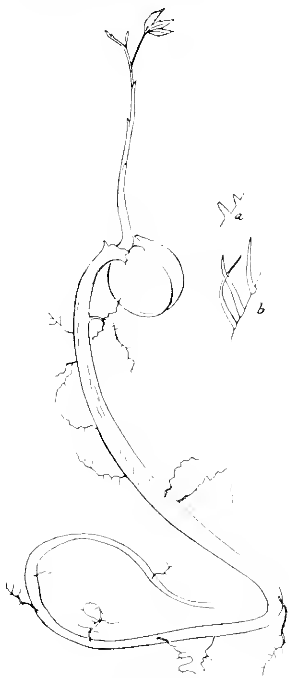


Fig. 54

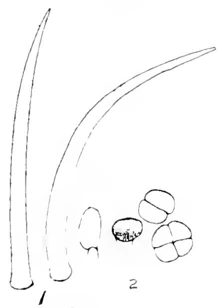


Fig. 56

Fig. 54.—Seedling of *Carya glabra*, showing early scales in stem. a, trichimes from stem; b, trichomes from leaf. Drawn by C. M. King.

Fig. 55.—*Carya glabra*. Group 1, trichomes from stem of seedling. Group 2, resinous glands, side and top views. Drawn by C. M. King.

Fig. 56.—Germinating nut of *Carya cordiformis*, showing radicle and young stem. Drawn by C. M. King.

resinous globules. Trichomes occurring singly, straight or slightly curved, 1-celled, with enlarged bulblike base. Tip curved, crooklike, or straight, walls with longitudinal roughening. Resinous glands freely present on stem and leaves of the young plant, consist of a glandular structure of about four cells, with short stalk.

Carya cordiformis (Wang) K Koch. Bitternut. Seed planted in greenhouse in fall of 1917, seedling described May 7, 1918. Valves of shell spread slightly at the apex, germination hypogæous, hypocotyl appears first, at its base the caulicle develops. Stem and young leaves reddish. First leaves scalelike, stem closely pubescent. At height of three inches the petioled leaf develops, with three leaflets, pinnate, ovate, serrate. The plant generally pubescent. At this stage of development the radicle is about twelve inches long, and one-third inch in diameter. Seeds planted in out door seed-bed, germinated by June 5, about 5 per cent.

Fig. 57

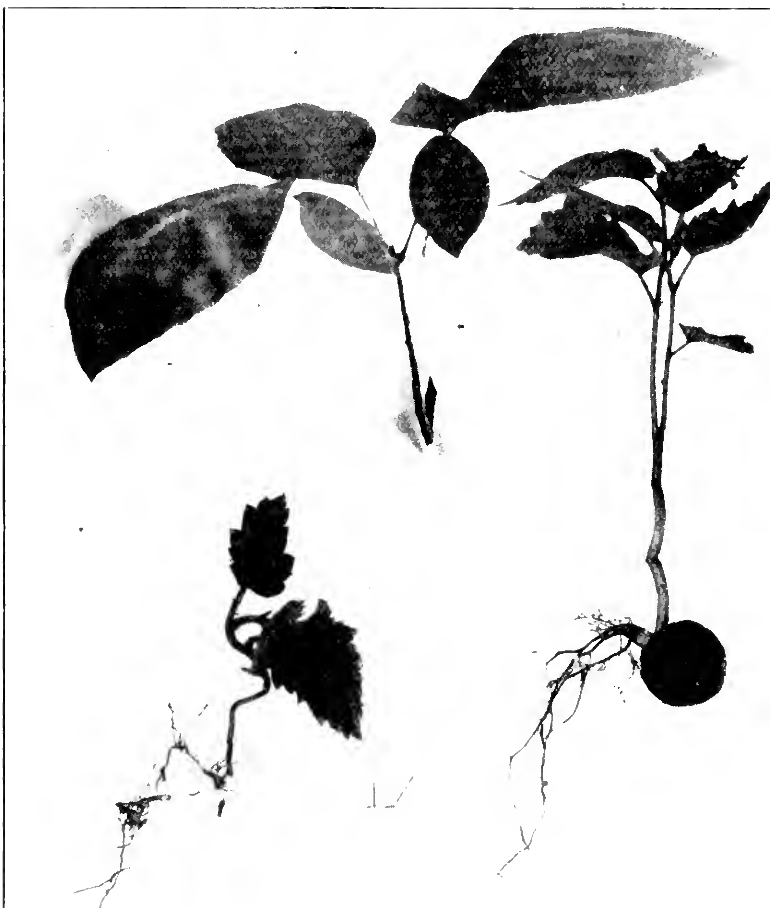


Fig. 59 Fig. 58

Fig. 57.—Germination of pig nut (*Carya cordiformis*), scales below the first compound leaf. Photographed by Photo. Section, F. E. Colburn.

Fig. 58.—Germination of common hazel nut (*Corylus americana*), showing nut caulicle and two branches. Photographed by Photo. Section, F. E. Colburn.

Fig. 59.—Young seedling of gray or cherry birch (*Betula lutea*), small cotyledons, alternate coarsely toothed leaves. Photographed by Photo. Section, F. E. Colburn.

FAGALES

BETULACEÆ.

The literature of the order was cited by us last year.[12]

Corylus americana Walt. Hazelnut. Seeds collected along Cedar river, Henry county, September 28, 1917. Stratified out of doors. Placed March 19, in greenhouse, germinated May 1, 25 per cent. Germination hypogæous, several brown roots, a few small scales on the stem, leaving scars. Seedling studied has multiple stems, green in color, stem glandular-pubescent. Lower leaves small, ovate, lanceolate, bright green above, pale beneath, conspicuously reticulately-veined, slightly pubescent on both surfaces, margins dentate; teeth glandular tipped. Stipules small, pointed, pale in color, soon falling. Trichomes long, occurring singly, slender, colorless, acute-pointed. Each dentation of leaf tipped with a reddish gland.

Lubbock[13] describes germination of *Corylus Avellana.*

Ostrya virginana (Mill) K. Koch. Hornbeam or Ironwood. Lubbock[14] describes the germination of the related genus *Carpinus.*

Seeds collected on Cedar river, Henry county, Iowa, fall of 1917. Wintered out of doors, planted in greenhouse, March 14, 1918, germinated April 10, 1918. Germination is not uncommon in the field, especially in leaf mould under trees. Germination epigæous. Hypocotyl (the stem below the cotyledons) terete, reddish, glandular-pubescent, the roots delicate brownish, giving off numerous roots. Cotyledons oval, auricled at the base, shortly petiolate, fleshy, yellowish below. Leaves alternate. First leaf oval, coarsely dentate, nearly smooth above, a few hairs along the midrib, scattered hairs elsewhere, on both surfaces. Stipules green, pointed, bearing trichomes. Stem above the cotyledons with scattered hairs. Trichomes simple, slender, varying from short to long, straight or slightly curved, pointed. The walls thin, smooth. Basal portion somewhat enlarged.

Betula lutea Michx f. Yellow or Gray Birch. Stratified outside for wintering. Removed to greenhouse March 14, 1918, germinated April 13, 1918. Hypocotyl smooth, cotyledons small, about 3 mm. by 4 mm., oval, entire, fleshy, surface granular in appearance. Under surface pale. First leaves not distinguishable in appearance from those of *B. papyrifera.* Leaves alternate, broad

[12]Pammel, L. H., and King, C. M., the germination and juvenile forms of some oaks: Proc. Iowa Acad. Science, 24, pp. 367-391.

[13]A contribution to our knowledge of seedlings, 2, pp. 533-539.

[14]A contribution to our knowledge of seedlings, 2, pp. 532, f. 667.

at the base, margin with coarse serrations, a few scattered hairs on the under surface of the leaf. Midrib prominent, petiole slightly hairy, stipules small, lanceolate, green. Hairs simple, varying in length, occasionally bent above the middle, frequently enlarged at the base, cell-walls thin.

Fig. 60

Fig. 61

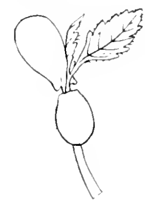
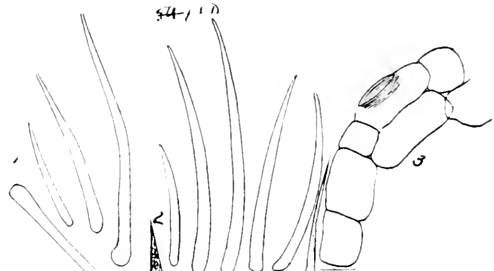


Fig. 62



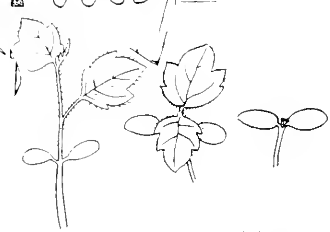


Fig. 63 Fig. 64 Fig. 65

Fig. 60.—Trichomes of leaf of *Corylus americana*, showing also glandular tip of serration. Drawn by C. M. King.

Fig. 61.—*Ostrya virginiana*, seedling. Drawn by C. M. King.

Fig. 62.—Group 1, trichomes of *Ostrya virginiana*. Group 2 trichomes of *Betula papyrifera*. Group 3, gland, from leaf. Drawn by C. M. King.

Fig. 63.—*Betula lutea*, seedling. Drawn by C. M. King.

Fig. 64.—*Betula papyrifera*, seedling. Drawn by C. M. King.

Fig. 65—*Betula alba* var. *papyrifera*, showing cotyledons and expanded plumule. Drawn by C. M. King.

Betula alba var. *papyrifera* (Marsh) Spach. Paper Birch. Collected at Osage, Iowa, October, 1917, stratified outside, planted in greenhouse, March 14, 1918, germinated April 15, 1918, about 5 per cent. Germination epigaeous. Hypocotyl reddish, slightly pubescent, cotyledons small, about 3 mm. by 4 mm., granular in appearance; smooth below, with purple color.

Stem between the cotyledons and the first leaf with long scattered hairs, stipules small, lanceolate. First leaf wedge-shaped, petiolate, petiole pubescent, bright green; lower surface with a few scattered hairs. Margin with long scattered hairs. Upper surface of the leaf, glossy, smooth, with a few scattered scales. Leaves alternate. Trichomes simple, slender, of variable length. Occasionally of more than one cell. Base enlarged, wall thin, smooth. The teeth of the leaf bear glandular hairs resting upon a row of colorless epidermal hairs; beneath these a row of polygonal cells of about the same size. The gland is constricted at the base.

FAGACEAE.

Quercus coccinea. Muench. Scarlet Oak. The acorns were gathered at Clemson College, South Carolina, early in Decem-

Fig. 66.—Germination of the scarlet oak (*Quercus coccinea*). Scales show below the coarsely dentate margins with bristles. Photographed by Photo. Section, F. E. Colburn.

ber, 1917, and were planted in the greenhouse in black soil on December 7. The first indication of germination was on March 1, 1918. The second acorn germinated March 14, and a third appeared March 18. Percentage, 75. Germination hypogaeous. The young stem is pubescent, bearing small scales; the bud is somewhat more pubescent. The first two leaves are small, alternate, entire; the succeeding leaves larger, penninerved, pubes-

Fig. 67 Fig. 68

Fig. 69 Fig. 70

Fig. 71

Fig. 67. *Quercus coccinea*, germinating seedling; 1, radicle, 2 and 3, young stems. Drawn by C. M. King.

Fig. 68. Trichomes of *Quercus coccinea*. 1, from leaf; 2, from stem. Drawn by C. M. King.

Fig. 69. *Quercus ellipsoidalis*. 1, seedling; 2, same expanded. Drawn by C. M. King.

Fig. 70. Trichomes of *Quercus ellipsoidalis*. 1, 2 and 3, from stem; 4, under side of leaf; 5, upper side of leaf. Drawn by C. M. King.

Fig. 71. Trichomes of *Quercus ellipsoidalis*. 1, from stem; 2, from upper side of leaf; 3, from under side of leaf. Drawn by C. M. King.

cent on the upper and lower surfaces of the leaf. Margin undulate, the lobes with bristles. Trichomes of the reddish stem in groups, colorless, slender, pointed. Trichomes of under and upper sides of leaves similar to those of the stem; each trichome

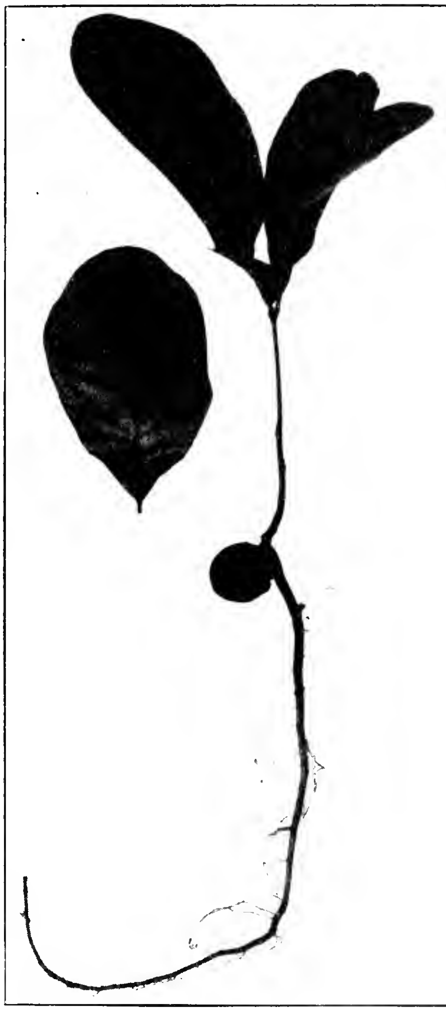


Fig. 72.—Spanish oak, *Quercus falcata*. Photographed by Photo. Section, F. E. Colburn.

in a single cell; fairly thick-walled. Basal portion larger.

Quercus ellipsoidalis. E. J. Hill. Yellow or Black Oak. Collected at Osage, Iowa, fall of 1917. Received October 10, and planted outside for wintering. Lifted and placed in greenhouse on March 20. Germinated April 12. Hypogæous; the curved caulicle pushing through the soil, reddish, pubescent. Scales on stem alternate. The unfolding leaves are very light green in color, dentate above the middle, slightly velvety in texture; abundant pubescence on both under and upper surfaces. Stipules narrow, acuminate, soon falling. Trichomes multicellular

Fig. 7: Seedling of *Quercus falcata*. Drawn by C. M. King.

or fascicled, about five in a group, variously curved, separate branches single-celled, walls rather thick. Trichomes of stem and back sides of leaf abundant. Acorns of *Q. ellipsoidalis* in out door seed bed, had germinated by June 5, 10 per cent.

Quercus falcata (Michx.). Spanish Oak. The acorns were gathered at Clemson College, South Carolina, about December 1, 1917, and planted in humus in greenhouse December 7, 1917. The first seed germinated on March 10, two about March 20 and one on March 22, 1918. Germination hypogæous, young bud somewhat rusty, pubescent, curved as it pushes through the ground. Hypocotyl with small scales, stipules small, pubescent,

Fig. 74.—Trichomes of *Quercus falcata*. 1, from under side of leaf; 2, from stem; 3, from upper side of leaf. Drawn by C. M. King.

soon falling. First leaves small, alternate, entire; upper surface rusty, pubescent, lower surface densely pubescent, young stem pubescent. Stem of older plants less pubescent, leaves becoming somewhat rugose, penninerved, later the upper surface of leaf with scattered groups of trichomes. Lower surface with scattered groups. Midrib above and below more pubescent. Trichomes of stem and leaves similar, slender, acuminate, in groups of four to six.

Quercus nigra L. Water Oak. From Clemson College, South Carolina, December 7, 1917. Wintered in greenhouse, germination hypogæous. Stem slightly pubescent. Young leaves with scattered pubescence on upper side, also hairs on branches. Lower surface somewhat less pubescent, margin entire.

Quercus imbricaria (Michx.). Laurel or Shingle Oak. Collected at Keosauqua, Iowa, September 29, 1918. Placed outside for stratifying, October 10. Planted in greenhouse, March 14. Germinated, April 14. Leaves narrowly elliptical, margin wavy strongly penninerved; slightly pubescent on upper surface, more pubescent on midrib of under surface. Stipules narrow, acuminate, pubescent. As the young leaf unfolds the margins are involute. Stem reddish, scales small. Seeds of *Q. imbricaria*, in out door seed bed, had germinated by June 5, 16 per cent.

URTICACEÆ.

Comparatively few of the woody Urticaceæ have been studied Baillon[15] figures the seed of *Celtis australis*. The *C. occidentalis* is described by Lubbock.[16] The same author describes *Maclura aurantiaca* and *Morus alba*. La Maout and Decaisne[17] figure the mulberry. Sudworth[18] states of *Celtis occidentalis* that the seeds are rather difficult to germinate, being apt to "lie over" for a season before they grow, unless planted or falling in a soil that is constantly moist. The germination of the seeds of the family is variable. *Celtis*, *Morus* and others require a period of rest, while elms germinate soon after the seeds are mature. Lubbock notes that seven different types of cotyledons have been observed by him in this family.

ULMUS L. Elm.

Ulmus L. Elm. The fruit is a one-celled and one-seeded samara, seed without endosperm and with large cotyledons. The seeds of only three species have been studied; namely the slippery elm (*Ulmus fulva* Michx.) and the American elm (*U. americana*) and the Chinese elm (*U. pumila*).

Ulmus americana L. American white elm. The seeds were placed in damp cloth and germinated in a few days. The germination is epigaeous.

Ulmus americana L. Bloom, May 1, seeds falling, May 27, 1917, collected May 31, 1917. The radicle usually appears first outside the samara. Then the caulicle pushes out, bearing two oval cotyledons and tiny plumule. The cotyledons fall soon after germination. The caulicle is pubescent. The cotyledons are glandular pubescent. Root hairs are abundantly produced upon

[15] Natural History of Plants, Engl. Translation, 5, p. 113.
[16] A contribution to our knowledge of seedlings, 2, p. 493, *f.* 646.
[17] Systems of Botany. Engl. Translation, p. 670.
[18] Forest Trees of the Pacific Slope, p. 323.

the radicle. Leaves of plumule glandular pubescent, serrate. The first pair of leaves small, apparently opposite, third and fourth pair similar, slightly hairy on lower surface, more hairs on the teeth, stem pubescent, hairs not glandular. Roots approximately alternate. Seeds placed in moist chamber June 30, 90 per cent germinated in five or six days. Seeds placed on moist surface of soil and exposed to laboratory atmosphere germinated 18 per cent. Seeds dried two weeks in laboratory germinated 0 per cent.

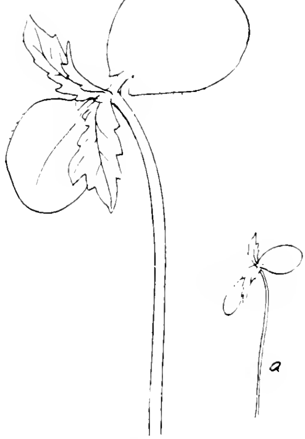


Fig. 75

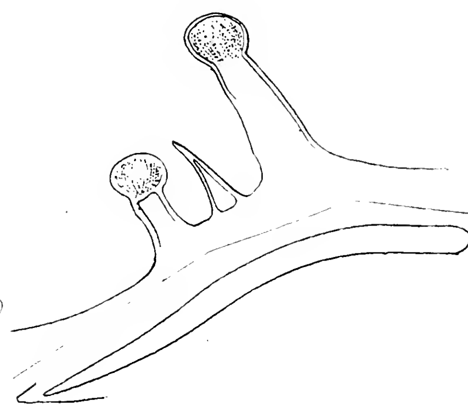


Fig. 76

Fig. 75.—*Ulmus americana,* seedling; a, natural size. Drawn by C. M. King.

Fig. 76.—Trichomes from leaf of seedling *Ulmus fulva*, showing two glandular hairs from the same leaf. Drawn by C. M. King.

Ulmus fulva Michx. Slippery or Red Elm. Bloom May 1, 1917, seeds falling May 26, 1917, seeds collected from field and kept in moist chamber, germinating in 14 days. Collected on campus, I. S. C., May 18, 1918, germinating freely in the field on date of collection, radicle appearing first, germination epigaeous, hypocotyl red, pubescent, a straight tap root, cotyledons auriculate, petiole pubescent, leaves oval, with scattered hairs on upper surface; pubescent on veins and margins of both upper and lower surface. Serrations of leaf glandular tipped, glands reddish, thin-walled, distinctly stalked; chlorophyll-bearing tissue entering up into the gland. Trichomes one-celled, thin-walled, slightly enlarged at base; either straight or slightly curved, of variable length. Germination in laboratory 10 per cent. The slippery elm, from our experience, does not germinate in the laboratory as freely as the Chinese elm and the American elm. Seeds germinating freely out of doors, May 25.

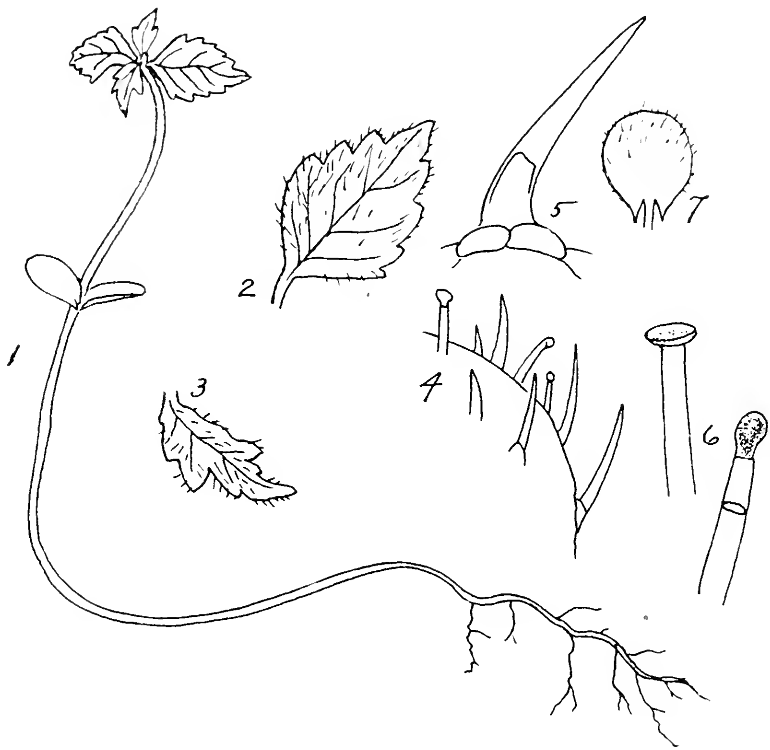


Fig. 77.—1. Seedling of *Ulmus fulva*; 2, 3, leaves of same; 4, margin of leaf; 5, trichome more enlarged; 6, glandular hairs; 7, cotyledon. Drawn by C. M. King.

Ulmus pumila L. Chinese Elm. Seeds of this elm were collected on the campus May 18, 1918. On May 20, the seeds showed a germination of 98 per cent. A young seedling collected from the field at the same time was used for description. Germination epigaeous, seeds germinate from the apical seed, caulicle light colored, glandular pubescent. Tap root straight, with numerous root-hairs and prominent root cap. Cotyledons fleshy, upper surface glandular pubescent; slightly auricled, truncate, soon falling, smooth above and below. Stem pubescent. First leaf thin, pubescent on veins and margins, dentate. Trichomes straight or curved, one-celled, pointed, slightly enlarged at base; cell wall thin, colorless. Seeds germinated freely out of doors by May 25.

Celtis occidentalis L. Germination epigæous, root dirty white, long, tapering; lower part of stem purplish; upper portion

Fig. 78 Fig. 79 Fig. 80

Fig. 78.—Germinating slippery elm (*Ulmus fulva*), sessile cotyledons, coarsely toothed petioled leaves. Photographed by Photo. Section, F. E. Colburn.

Fig. 79.—Chinese elm (*Ulmus pumila*), stalked cotyledons, coarsely toothed leaves. Photographed by Photo. Section, F. E. Colburn.

Fig. 80.—Seedlings of *Celtis occidentalis* from La Crosse, Wisconsin, showing cotyledons. Photographed by Photo. Section, F. E. Colburn.

roughened, but not pubescent; cotyledons short stalked, smooth, obcordate, deeply cut at apex in two lobes, obscurely 3-5 nerved, smooth above and below; buds in axils of cotyledons, stem above cotyledons pubescent. Leaf penninerved, reticulately veined, margin coarsely dentate. Base of leaf unequal, veins quite pubescent. Third leaf alternate, stem pubescent. Upper surface of leaf rugose pubescent, and lower surface reticulately veined, in older plants spreading fan-shaped. Lubbock[19] describes the seedlings of *Celtis occidentalis*. Trichomes of two types, longer ones simple, slender, acutely pointed, roughened longitudinally,

[19]A contribution to our knowledge of seedlings, 2, pp. 494-495.

wall fairly thick. Smaller trichomes short, slender, pointed, roughened, prickle-like in appearance. Dentations of leaf tipped with glandular teeth.

Fig. 81

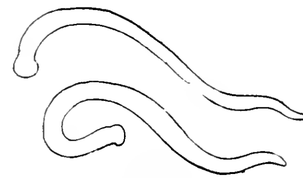


Fig. 82

Fig. 81.—Trichomes from leaf of *Celtis occidentalis.* Drawn by C. M. King.

Fig. 82.—Trichomes from seedling leaf of *Pyrus malus.* Drawn by C. M. King.

ROSACEÆ

Sachs[20] figured the germination and seedlings of *Prunus Cerasus* and *Amygdalus communis.* Lubbock[21] notes that the seedlings show a great similarity amongst the cotyledons of different species and genera. In one type the embryo is amygdaloid, the cotyledons are nearly all of the same outline, the petiole is short. In another type the cotyledons are emarginate, in a third form they are cordate. Of the trees Lubbock[22] studied *Pyrus Aucuparia* Gaertn, *Crataegus oxycantha* L., *C. Mexicana* D. C.

Pyrus malus L. Apple, cultivated, source unknown. Germination epigaeous, stem purplish above, white below, cotyledons fleshly, nearly obcordate, sessile, both surfaces smooth, slightly tapering at the base. Subsequent leaves alternate, stem purplish, pubescent. First leaves serrate, prominently veined above and below, smooth above and below. Third leaf with prominent dentate stipules; petiole smooth, prominently pinnately veined, smooth above and below. Fourth leaf smooth above and below, prominently veined, hairs on midrib. Trichomes long, slender, gradually tapering, inclined to be floccose; wall at point thickened, somewhat blunt, of medium thickness, colorless.

Crataegus mollis (T. and G.) Scheele. Fruit collected at Centerville, Iowa, September 28, 1917. Seeds planted in stratifying bed October 10; removed to greenhouse March 14. Germinated April 10, 5 per cent. Germination epigaeous, cauliclе reddish, smooth. Cotyledons elliptical, about 7 mm. by 13 mm., rather fleshy, veins not prominent. Plumule and stem above the coty-

[20]Bot. Zeit., *1859*, p. 185, *pl. 4*.
[21]A contribution to our knowledge of seedlings, *1*, 479.
[22]A contribution to our knowledge of seedlings, *1*, pp. 499-501.

ledons, especially the younger portion of the stem, pubescent. Leaves alternate, prominently veined, scattered hairs on upper and lower surfaces. Stipules conspicuously serrate, small, green, pubescent. First leaf coarsely dentate, dentations glandular tipped. Second leaf oval, dentate, slightly lobed, scattered hairs on lower surface, pubescent on margin, reticulately veined. Third leaf similar; doubly serrate. Trichomes broad, larger at

Fig. 83 Fig. 84

Fig. 83.—Seedling of the common apple (*Pyrus malus*), the root caulicle two cotyledons, the lower small leaves and stipule on the first fully formed leaf. Photographed by Photo. Section, F. E. Colburn.

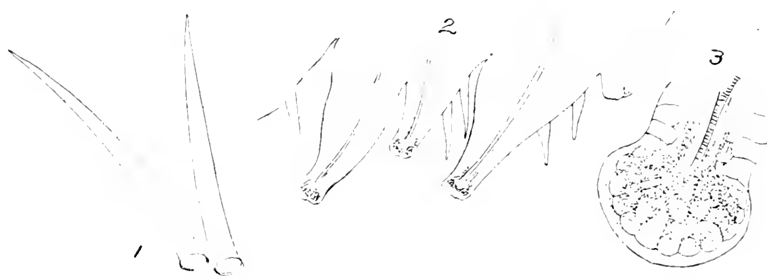
Fig. 84.—Common red haw (*Crataegus mollis*) radicle, caulicle, the fleshy opposite cotyledons, alternate coarsely toothed leaves. Photographed by Photo. Section, F. E. Colburn.

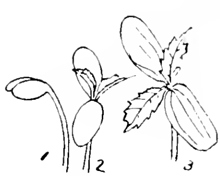
base, thin-walled, straight or slightly curved. The margin of the leaf bears glandular teeth. These spring from a group of colorless epidermal cells. A fibro-vascular bundle terminates in the tooth. Seeds planted in out door seed bed fall of 1917, germinated by June 1, 1918, 5 per cent.

Crataegus Crus-galli L. Hawthorn. Trichomes long or short, pointed, slightly roughened, somewhat larger at base; straight or slightly curved, colorless.

Prunus Padus L. The seeds of this ornamental European shrub germinate readily in the field. Thousands of the young plants come up under the bearing trees. The first plants appeared above the ground April 20 to 23, 1917, about the same time that the boxelder was observed. Germination in 1918, ob-

Fig. 85





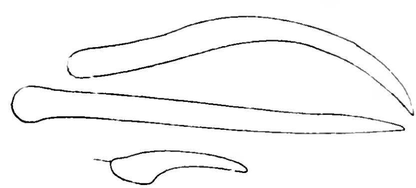


Fig. 86 Fig. 87

Fig. 85.—1, trichomes of *Crataegus mollis;* 2, portion of margin of leaf, showing glandular tips of serrations; 3, glandular tip, enlarged. Drawn by C. M. King.

Fig. 86.—*Crataegus mollis.* 1, cotyledons; 2, cotyledons and plumule; 3, same expanded. Drawn by C. M. King.

Fig. 87.—Trichomes from leaf of *Crataegus crus-galli.* Drawn by C. M King.

served April 10. Germination epigæous; hypocotyl smooth, with slight tinge of red; a tap root which lengthens rapidly; cotyledons of medium size petiolate, fleshy, smooth on upper and lower surface, slightly reddish, venation of the lower surface not evident. Stem above the cotyledons reddish, smooth, stipules linear, coarsely serrate. First pair of leaves alternate, smooth, shining, glossy, penninerved, margins serrate, nodes fairly short, stem purplish green, smooth; petioles reddish purple, serrations glandular at tip. Fourth leaf slightly larger, smooth above and below, serrate; petiole purplish, grooved on upper side; stipules pointed, serrate, soon falling from early leaves. Seeds germinating freely out of doors by April 10, 1917.

Fig. 88.—European May Day Tree (*Prunus padus*), showing radicle, caulicle and petioled fleshy cotyledons and alternate serrate leaves. Photographed by Photo. Section, F. E. Colburn.

Prunus serotina Ehrh. Wild Black Cherry. Seedlings taken from field where they were numerous, May 22, 1918. Germination hypogæous; the short stalked fleshy cotyledons do not push up, plumule arising between the two cotyledons. Caulicle short; root straight, brownish, lateral rootlets few. Stem above the cotyledons light in color, fleshy. Leaves alternate. First leaf prominently reticulately-veined, smooth above and below; serrate, dentations glandular tipped. Stipules slender serrate, acu-

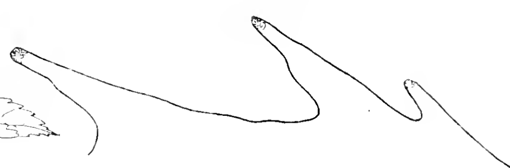
Fig. 89

Fig. 90

Fig. 89.—Serrations of leaf margin of *Prunus padus* seedling, showing glandular tips. Drawn by C. M. King.

Fig. 90.—Seedling of *Prunus padus*. Drawn by C. M. King.

Fig. 92



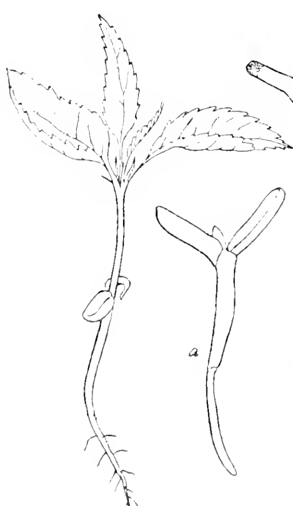


Fig. 91 Fig. 93

Fig. 91.—*Prunus cerasus*, seedling, a, early germination. Drawn by C. M. King.

Fig. 92.—Margin of young seedling leaf of *Prunus serotina*, showing glandular tips of serrations. Drawn by C. M. King.

Fig. 93.—1. Trichomes of *Gleditsia triacanthos*; 2, a short hair at greater magnification. Drawn by C. M. King

minate. Glands of many cells thin-walled, reddish. With respect to epigæous and hypogæous germination, the cotyledons of this species barely push out of the shell. They are not visible above the ground, or rarely so. The germination is, therefore, intermediate between the true epigæous and hypogæous seeds. Germinating freely out doors by May 18.

LEGUMINOSÆ.

The germination of a considerable number of the Leguminosæ have been described by Lubbock.[23] Of our trees he has described

Fig. 94.—Seedling of *Gleditsia triacanthos*, showing radicle, cotyledons and early leaves. Drawn by C. M. King.

Gleditschia triacanthos[24] and *Robinia Pseud-Acacia*.[25] Studies on seed coats of Leguminosæ, including Robinia, Gymnocladus and Gleditsia were made by Pammel.[26] Winkler has studied

[23]A contribution to our knowledge of seedlings, *1*, p. 382.
[24]L. c. 1, p. 456.
[25]L. c. 1, p. 422, *f.* 275.
[26]Anatomical characters of seeds of Leguminosae: Trans. Acad. Sci., St. Louis, 162, pp. 209-212.

Sarothamnus and *Ilex Europaeus*. The germination is also described in Sargent's Silva.[27]

Gleditsia triacanthos L. Seeds collected fall of 1911, buried three feet below surface, for six and one-half years. Germination 80 per cent, planted in greenhouse April 1; germinated April 8. Seeds gathered fall of 1917, and placed in greenhouse in the spring. Germination epigæous. Germinated 80 per cent. Hypocotyl very long, green, smooth; straight tap roots with numerous lateral roots.

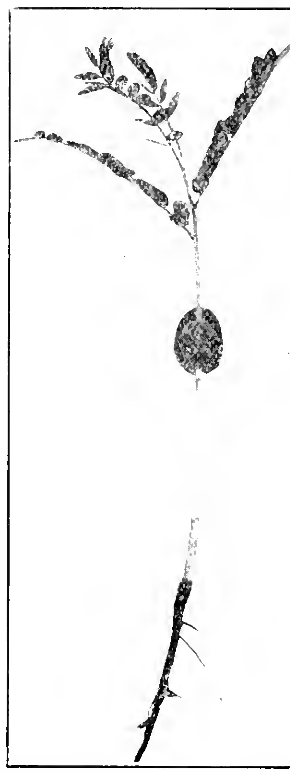


Fig. 95—Honey Locust (*Gleditsia triacanthos*). The stout radicle, cauicle, fleshy sessile cotyledons and alternately pinnately compound leaves. Photographed by Photo. Section, F. E. Colburn.

Cotyledons smooth, fleshy, elliptical, auricled at the base, sessile, 7 mm. to 8 mm. by 17 mm. to 20 mm. First internode slightly pubescent. Leaves alternate. First leaf pinnately compound with seven pairs of leaflets. Petioles slightly swollen at base, pubescent along the upper surface. Margins of leaflets somewhat serrate; at base of petiole is the conical

[27] Silva of North America 3: 67-71, 73-77.

back. Leaflets short stalked, the petiolules almost smooth, margins of leaflets somewhat serrate; at base of petiole is the conical pointed bud. Trichomes simple, curved, generally rather broad, walls thin, irregularly roughened. Seedlings of *Gleditsia triacanthos* collected fall of 1917. Stratified out of doors, placed in greenhouse March 10, germinated May 12. Seeds germinating in outdoor seed bed May 18, about 3 per cent.

Fig. 96.—Kentucky coffee bean (*Gymnocladus dioica*), seed, caulicle, radicle and pinnately compound leaves. Photographed by Photo. Section, F. E. Colburn.

Gymnocladus dioica (L) Koch. Seeds collected fall of 1911. Buried three feet below the surface for six and one-half years Removed to greenhouse April 1, 1918, germinated 80 per cent. Seeds collected fall of 1917 and placed in greenhouse in the spring germinated about the same. Germination hypogæous; hypocotyl thick, fleshy; radicle straight; root straight, with lateral branches; stem green with irregular greenish protuberances and conspicuous alternate wartlike projections. First, second, third and fourth leaves pinnately compound, each with eight elliptical to ovate, entire leaflets. Leaves alternate; petiole at base swollen, upper surface of petiole slightly hollowed lengthwise; leaves distinctly reticulately veined, ciliate on margin, upper surface smooth, a few scattered hairs. Petiole and petiolules pubescent. At axils of buds are small buds. No stipules, but a slight prominence. Trichomes numerous on margin of the leaf, occurring singly, curved, cell wall thin, surface roughened.

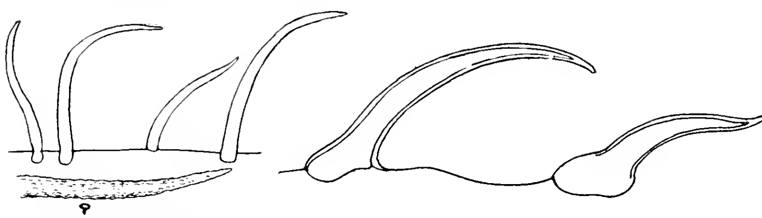


Fig. 97 Fig. 98

Fig. 97.—Trichomes of *Gymnocladus dioica;* a, showing striæ on surface. Drawn by C. M. King.

Fig. 98.—Trichomes on margin of leaf of *Ptelea trifoliata.* Drawn by C. M. King.

RUTACEÆ.

Ptelea trifoliata L. Hop Tree. Shrubby Trefoil. Germination about 5 per cent in greenhouse, epigæous; stem pubescent, hairs turned back and glandular; cotyledons 10 to 15 mm. long, 5 to 7 mm. broad, finely crenulate; petiole pubescent beneath. Leaves opposite, first pair with three fully formed leaflets, smooth, slightly hairy on mid vein. Third petiole greenish or purple. Bud in axil of the leaf. Sargent[28] gives notes on the seeds and germination of *Ptelea trifoliata.* Trichomes comparatively colorless, short, curved, pointed to blunt, walls roughened, thin, base enlarged. Secretion receptacles occur on the young leaves. In early stages the center of the receptacle is green. Trichomes of cotyledon upper surface, short, curved, one-celled, pointed, walls thin; nuclei often distinct. Glandular trichomes less frequent than simple trichomes.

SAPINDALES

The germination of the seeds of this family is variable, in some cases epigæous, in a few cases hypogæous. Most of the seeds require a period of rest; a notable exception, however, is

[28] Silva of North America, 1, pp. 76-77.

the soft maple which germinates soon after the seeds are ripe. The cotyledons are green in color.

Both *Acer saccharinum* and *Acer rubrum* germinate freely in the field. Sargent[29] states that the seeds of the two American species with precocious flowers, *Acer saccharum* and *Acer rubrum*, ripen at the end of a few weeks after the trees flower and germinate at once.

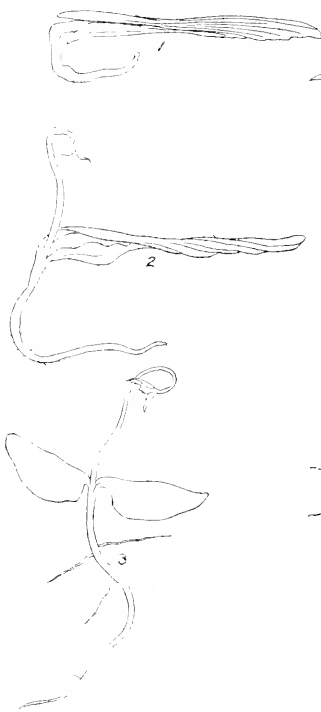


Fig. 99

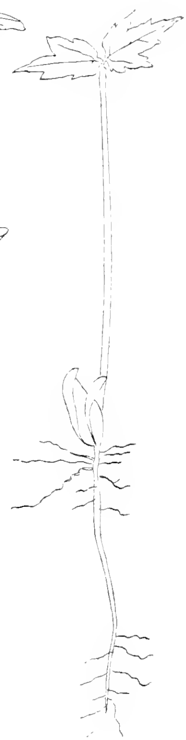


Fig. 100

Fig. 99.—Germination of *Acer saccharinum*. 1, radicle appearing first; 2, radicle and hypocotyl developing at same time; 3, cotyledons, radicle and plumule displayed. Drawn by C. M. King.

Fig. 100.—Seedling of *Acer saccharinum*. Drawn by C. M. King.

ACERACEÆ.

Acer. The seeds of the maples germinate in two days. Epigæous germination is represented by the common black maple (*Acer nigrum*) the sugar maple (*Acer saccharum*) the red maple (*Acer rubrum*) and the box elder (*Acer negundo*). The common soft maple (*Acer saccharinum*) is the only native tree species

[29] The silva of North America, 2, pp. 79, 104.

which has hypogæous germination. George B. Emerson[30] makes a very general statement about the germination of the maples, implying spring germination and that the dormant period is five or six weeks. The statement in regard to germination under natural conditions is incorrect.

Of the exotic maples Lubbock states that the seedlings of the Sapindaceæ studied by him came under three types. The cotyledons of Cardiospermum, the balloon vine, fall early, showing a transition between the hypogæous and epigæous germination. The *Acer Pseudo Platanus* is epigæous with 5-nerved strap-shaped cotyledons. The *Sapindus inaequalis* has hypogæous germination.

Acer saccharinum L. Silver or Soft Maple. The germination of this species has been frequently described. Asa Gray[31] in his structural Botany describes the germination of *Acer saccharum*, *Acer rubrum* and the Horse Chestnut, accompanying his descriptions with the well known classical figures. Lubbock[32] describes seedlings of a number of species of *Acer*. A study of the germination and vitality of seeds, kept under different conditions, was made by L. H. Pammel and C. M. King,[33] in which it was found that seeds of this species soon lost their vitality when subjected to dessication; that the vitality could be prolonged by keeping the seeds in a refrigerator at a low temperature. In such cases, after twenty-three days of drying, the seeds dropped from 75 per cent to 6 per cent of germination, the germination being distributed over a period of seventeen days. The germination of freshly gathered seeds when mature and kept moist proceeds after a few days. In the case at hand the percentage was 75, germination being distributed over a period of twenty-two days.

Seeds of the silver maple were collected for study, May 19, 1917, when they were falling from the trees, just four weeks from date of bloom, May 1, 1917. Fresh seeds placed in a moist chamber, in laboratory, germinated 98 per cent in five days. Seeds placed in moist sphagnum moss to simulate natural conditions, germinated 100 per cent in five days. Seeds dried in the laboratory atmosphere for two weeks and then placed in damp

[30]Report on trees and shrubs of Massachusetts growing naturally in the forests of Massachusetts, p. 482.

[31]The elements of Botany, Rev. Ed., p. 17, *f. 21-26*, 1887 and Structural Botany, 15-17, 20, *f. 11-25, 36-39*.

[32]Some contributions to our knowledge of seedlings, 1. pp. 360-365.

[33]Delayed germination: Proc. Iowa Acad. Science, Vol. 17, pp. 31-33.

moss germinated 4 per cent. Germination is hypogæous. Radicle pushes down, followed in a few days by appearance of plumule. Stem smooth, leaves of plumule distinctly veined, 3-lobed, lobes curled in at first; numerous hairs on the veins of the upper surface; on lower surface scattered hairs.

Acer saccharum Marsh. Sugar or Rock Maple. The seeds were collected for the department of botany, November 8, 1917,

Fig. 101

Fig. 102 Fig. 103

Fig. 101.—Trichomes from leaf of *Acer nigrum*. Drawn by C. M. King.

Fig. 102.—*Acer nigrum* seedling, showing cotyledons, plumule and radicle. Drawn by C. M. King.

Fig. 103.—Seedlings of *Acer negundo*, showing cotyledons, plumule and radicle. Drawn by C. M. King.

by Mrs. Tuttle, Osage, Iowa. They were placed for stratification in humus in cold frame and covered with straw-filled manure on November 11, 1917. The seeds were taken from the bed March 14 and planted in humus in the greenhouse. The first seed germinated March 24, 1918, germination in all 80 per cent. Germination is epigæous. The smooth, grayish and slightly curved caulicle first pushes out. The cotyledons, which are mottled with red, are at first folded, expanding later, directed obliquely upward, slightly curved toward the tip, fleshy, both under and lower surface smooth, glaucous on the under surface. The young leaves are lighter in color on the under surface, and slightly hairy, but are not glaucous.

Acer saccharum var. *nigrum* (Michx. f.) Britton. Black Sugar Maple. Described May 6, 1917. Height two inches. Plants germinating abundantly May 5, 1917. Germination epigæous; hypocotyl (caulicle) green, thickened, fleshy; root much smaller; cotyledons thickened, fleshy, smooth, entire, sagittate at the base; plumule slightly hairy. The first leaves palmately three lobed, with the form characteristic of the adult, green on both

Fig. 104 Fig. 105

Fig. 104.—Germination of black maple (*Acer nigrum*). Fleshy elongated cotyledons and the drooping leaves, coarsely toothed and rugose. Photographed by Photo. Section, F. E. Colburn.

Fig. 105.—Germination of box elder (*Acer negundo*), radicle caulicle, the erect cotyledons and simple opposite leaves. Photographed by Photo. Section, F. E. Colburn.

surfaces. Trichomes simple, walls fairly thick, a few longitudinal striæ giving the wall a roughened appearance. Protoplasmic contents granular, nucleus small. Hair tapering but not acutely pointed. Other slender trichomes present, unicellular, long, twisted like cotton fibers.

Acer negundo L. Box Elder. Germination epigæous. Seeds become stratified on the ground. Germination observed to begin April 19, 1917, and continued to May 1, 1917, about 80 per cent. Cotyledons yellowish at first soon becoming green, elongated, narrowly elliptical, smooth, fleshy; hypocotyl reddish, smooth, straight, tapering. The plumule appears as a little protuberance between the cotyledons; stem between the root and cotyledons reddish. In about ten days the plumule pushes out and is folded, slightly pubescent on midrib, more pubescent on the margin, conspicuously veined. Root soon produced, bearing lateral rootlets. First leaves two, opposite, acute, widely dentate or entire, some pubescence on the margin; third, fourth and fifth leaves simple.

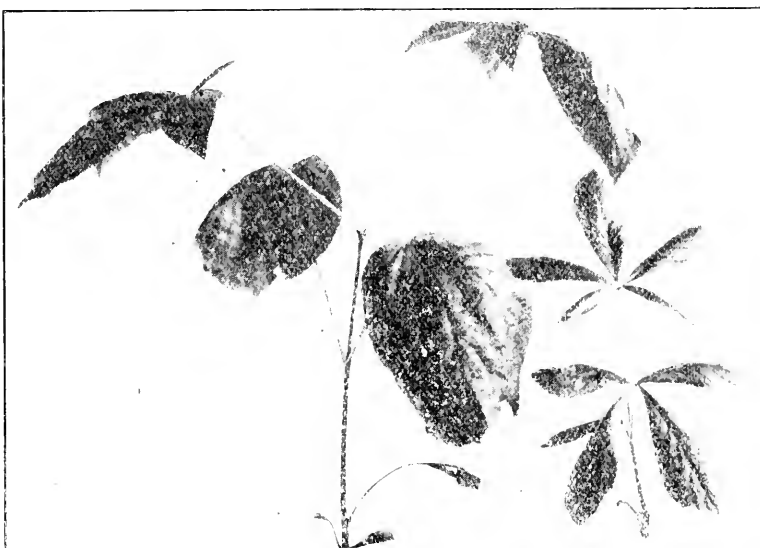


Fig. 106.—Germination of Ohio buckeye (*Aesculus glabra*), lower leaves small, gradually becoming larger, then compound, of five leaflets. Photographed by Photo. Section, F. E. Colburn.

SAPINDACEÆ.

Aesculus glabra Willd. Buckeye. Seeds gathered at Centerville, Iowa, on September 29, 1917; stratified in humus in cold frame covered with manure, on October 10, 1917. The seeds were removed to the greenhouse on March 14, 1918, just as the frost was leaving the ground. The first germination appeared March 23. Total germination 100 per cent. Germination hypogæous. Stem reddish, at first pubescent, becoming smooth. First two leaves (plumule) alternate, simple, reddish, slightly pubescent on the upper surface, smooth below, margin distantly dentate. The next leaves opposite when unfolding, pubescent, upper and lower surface of leaf pubescent. Two leaflets, the smaller leaf merely deeply lobed, the other leaf two-parted: leaves or leaflets penninerved; stipules wanting. The petioles and leaves are at first abundantly clothed with a soft pubescence of colorless hairs. These hairs have two to six cells, apical cell usually exceeding the remainder in width. Cell-wall thin, bearing deli-

Fig. 107 Fig. 108

Fig. 107.—Several-celled trichomes, from leaves of *Aesculus glabra* var. *arguta*. Drawn by C. M. King.

Fig. 108.—1. *Aesculus glabra*. 2. *Aesculus glabra* var. *arguta*. Both from Chariton river bottoms, Centerville, Iowa. Drawn by C. M. King.

cate roughenings, which give a striate appearance; apex rounded; hairs curved, often twisted. Older cells becoming yellowish; on the older seedling the hairs of stem and leaf become scattered. Germinated in out door seed bed, about May 10, 10 per cent.

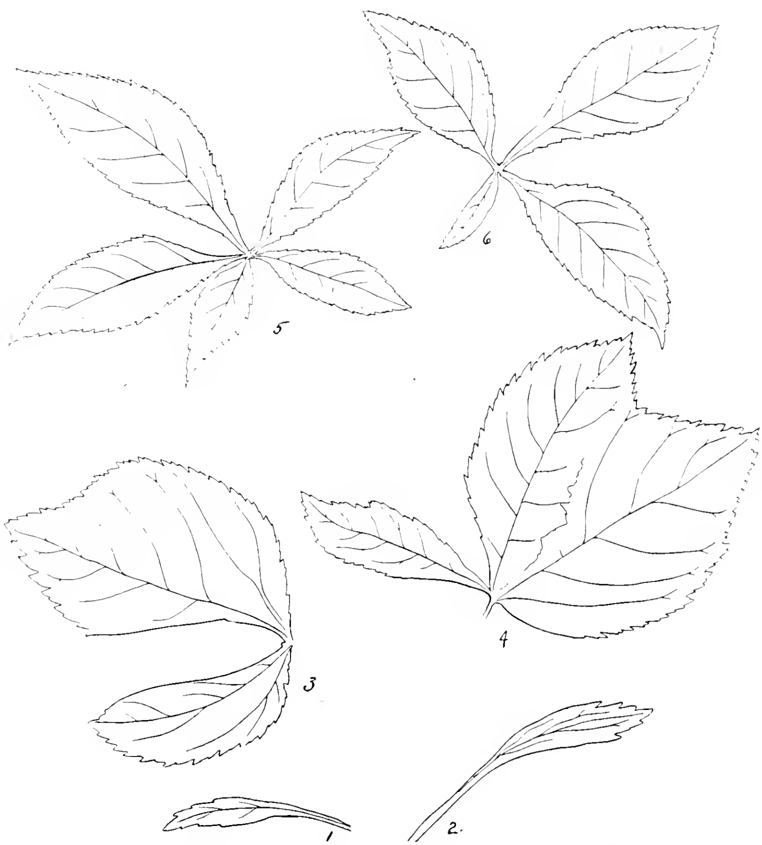


Fig. 109.—First six leaves of *Aesculus glabra*, var. *arguta*. Drawn by C. M. King.

VITACEÆ.

Vitis vulpina L. Lubbock[34] describes germination of *V. hypoglauca and V. cebennensis.* Germination epigæous, cotyledons long, stalked, broadly ovate to cordate in outline, fleshy, lower and upper surfaces smooth, petiole reddish, grooved, stem above the cotyledons reddish, slightly pubescent. First leaf palmately

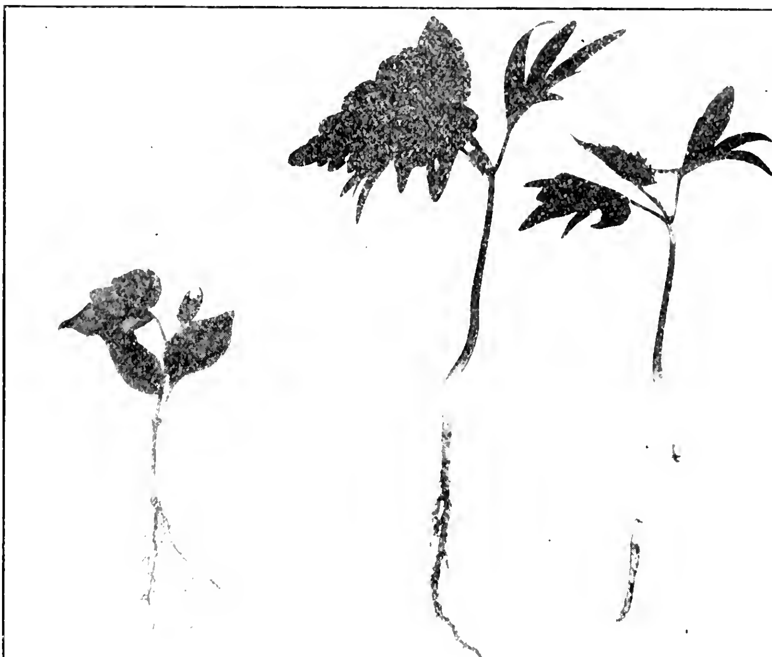


Fig. 110 Fig. 111

Fig. 110—Seedling of *Vitis vulpina*, showing cotyledons. Photographed by Photo. Section, F. E. Colburn.

Fig. 111.—Young germinating basswood (*Tilia americana*), the thick radicle, caulicle, and deeply toothed petioled cotyledons, first leaf coarsely toothed. Photographed by Photo. Section, F. E. Colburn.

three-nerved, veins reddish at lower end. Upper surface smooth, shining, bearing pubescence, margin coarsely dentate. Petiole of first leaf pubescent, enlarged at base. Trichomes several-celled, base fairly broad, gradually tapering to the apex, which is somewhat rounded. Protoplasmic contents granular, with a rather small nucleus, contents reddish, walls rather thin.

[34]Some contributions to our knowledge of seedlings, *I*, pp. 348-350.

TILIACEÆ.

There is considerable variation in the character of the cotyledons and the germination of members of this family, as indicated by Lubbock. Lubbock[35] describes two species of *Tilia*, the *T. petiolaris* and *T. vulgaris*.

Tilia americana L. Basswood. The seeds of this species were germinating abundantly in the field by the middle of May; there was no germination in the greenhouse. Germination epigæous; root stout, straight or twisted, hypocotyl smooth, often reddish;

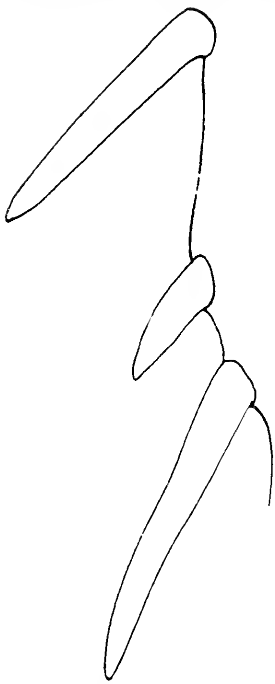


Fig. 112

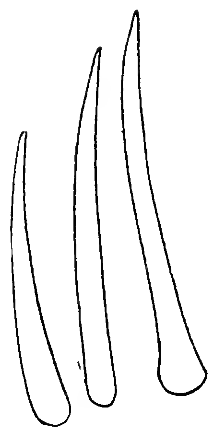


Fig. 113

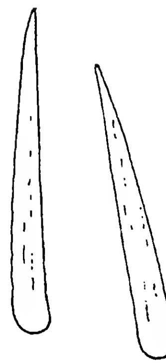


Fig. 114

Fig. 112.—Trichomes of *Vitis vulpina*. Drawn by C. M. King.

Fig. 113.—Trichomes from leaf of young seedling of *Tilia americana*. Drawn by C. M. King.

Fig. 114.—Trichomes from upper surface of leaf of seedling of *Cornus alternifolia*. Drawn by C. M. King.

cotyledons foliaceous, petioled, stalks pubescent, often reddish, deeply palmately 5-lobed, light green in color, slightly pubescent on the margins; plumule pubescent. Third leaf coarsely dentate, both surfaces smooth, prominently reticulately veined, slight pubescence on the midvein and margins. Veins on upper surface pale in color, on under surface darker. Stem and petioles

[35] A contribution to our knowledge of seedlings, *1*, p. 275.

pubescent. Fourth leaf similar, reddish pubescent above and below; young bud reddish. Trichomes pointed, one-celled, slender, straight or curved at end; wall of medium thickness, basal portion enlarged; cell contents slightly colored.

CORNACEÆ

Lubbock[36] describes seedlings of *Aucuba japonica* Thunb.

Cornus alternifolia (Tourn) L. Dogwood. Seeds collected in fall of 1917. Stratified out of doors in humus soil, planted in

Fig. 115 Fig. 116

Fig. 115.—Germination of Dogwood (*Cornus alternifolia*), showing radicle, caulicle, the cotyledons and the opposite entire leaves. Photographed by Photo Section, F. E. Colburn.

Fig. 116. Germinating green ash (*Fraxinus pennsylvanica* var. *lanceolata*). The right hand figure shows seeds attached, cotyledons sessile, erect, first leaves simple, alternate. Photographed by Photo. Section, F. E. Colburn.

greenhouse March 14, germinated April 15, 1918. Germination epigaeous; hypocotyl purplish; cotyledons elliptical, fleshy, smooth, size 3 mm. to 7 mm. by 10 mm. to 15mm., upper surface with scattered hairs. First pair of leaves opposite, broadly ovate.

[36] A contribution to our knowledge of seedlings, 2, p. 15.

acute, entire, pubescent on upper surface with scattered hairs. First pair of leaves distinctly purplish, no stipules, simple, slender, acute, colorless, surface of hairs roughened.

OLEACEÆ.

Lubbock[37] describes seedlings of *Fraxinus excelsior* L.

Fraxinus pennsylvanica var. *lanceolata* (Borkh) Sarg. Green

Fig. 117

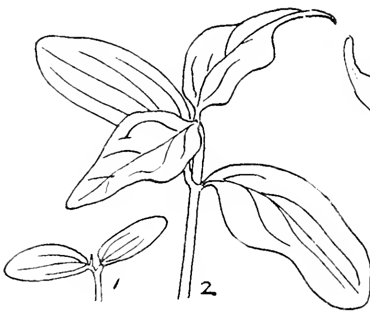
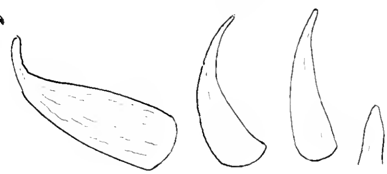
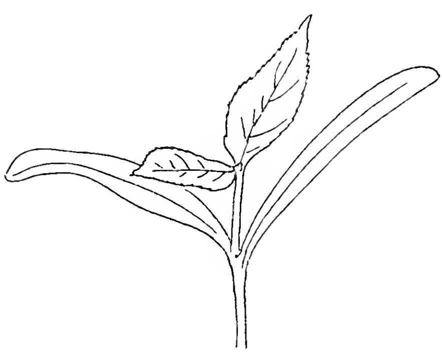


Fig. 118





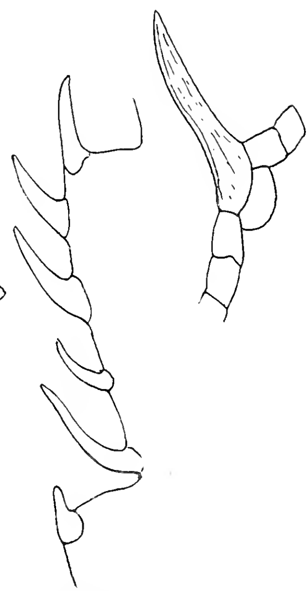


Fig. 119

Fig. 120

Fig. 117.—*Cornus alternifolia.* 1, Cotyledons; 2, Cotyledons and plumule expanded. Drawn by C. M. King.

Fig. 118.—Trichomes from leaf of *Fraxinus pennsylvanica* var. *lanceolata.* Drawn by C. M. King.

Fig. 119.—*Fraxinus pennsylvanica* var. *lanceolata* seedling. Drawn by C. M. King.

Fig. 120.—*Fraxinus pennsylvanica* var. *lanceolata.* 1, trichomes from lower leaf; 2, single trichome. Drawn by C. M. King.

Ash. Seeds gathered in fall of 1917, stratified out of doors, transferred to greenhouse March 14, 1918. Germinated April 15. Total germination 10 per cent. Germination epigæous; straight tap root with many rootlets; hypocotyl reddish; coty-

[37]A contribution to our knowledge of seedlings, 2, pp. 213-215.

ledons $4\frac{1}{2}$ to 5 mm. wide by 30 mm. long, narrowly elliptical, fleshy, entire, green above and below, stem purplish below, angular. Leaves opposite, obovate, penninerved, margin serrate bearing numerous small trichomes. Leaves smooth above, veins prominent below. Hairs short, straight or curved, pointed, with a broad base, walls relatively thin, longitudinally roughened. The seeds of this ash were germinating freely out of doors the early part of May.

BIGNONIA.

Lubbock[38] has described *Catalpa Kaempferi, C. syringaefolia* and *C. speciosa.*

Catalpa speciosa Warder. Seedling examined July 11, 1917. Germination hypogæous; cotyledons oblate, deeply bifid, with rounded lobes, surface paler in color than upper surface; hypocotyl slightly hairy, with long slender reddish trichomes. Petiole of cotyledon with short hairs on upper surface. Stem above the cotyledons reddish, slightly hairy. First pair of leaves opposite, prominently veined, under surface paler than upper surface, both surfaces smooth. Third pair of leaves similar, margins when young, as well as midvein, slightly pubescent. Tap root straight, prominent joint where radicle begins, roots long and slender.

[38]A contribution to our knowledge of seedlings, 2, p. 335. Le Maout and Decaisne, 602 f.

GERMINATION IN OUT DOOR SEED BED
SEEDS PLANTED IN THE FALL OF 1917

The months of April and the first half of May, cool and dry: germination slow. Period of unusual warmth during last half of May; period of heavy rainfall first week in June. Seed bed subject to some washing in June.

	No. seeds planted	No. seeds germinated last week of May	Germinated first week of June	Germinated second week of June	Total No. seeds germinated by June 11 1918
Quercus imbricaria (Keosauqua)	65	..	10	13	23
Quercus imbricaria (Centerville)	70	..	12	12	24
Quercus bicolor (Keosauqua)	20	..	3	4	7
Quercus bicolor (Keosauqua)	9	..	6	..	6
Quercus bicolor (Cedar river)	18	..	1	..	1
Quercus bicolor (Centerville)				13	13
Quercus velutina (Keosauqua)	5	..	3	..	3
Quercus velutina (Cedar river)	3	..	3	..	3
Quercus velutina (La Crosse)		..	..	6	6
Quercus macrocarpa (Keosauqua)	7	..	1	1	2
Quercus ellipsoidalis (Osage)	150	..	12	41	53
Quercus ellipsoidalis (Fairfield)	90	..	10	..	10
Quercus rubra (Ames)	20.	May 15, 12	..	6	18
Gleditsia triacanthos (Plant with hairy pods)	36	May 18, 1	..	4	5
Crataegus mollis (Centerville)	17	..	1	11	1
Crataegus coccinea (Fairfield)	90	..	2	..	2
Fraxinus pennsylvanica var lanceolata (Mason City)	75	..	3	2	5
Juglans nigra (Ames)	8	5	..		5
Juglands cinerea	18	1	..	..	1
Juglans cinerea	12	2	..	..	2
Carya cordiformis (Iowa)	20	1	..	..	1
Aesculus glabra	30	May 10, 3	..	2	5

Acer nigrum (seeded from campus trees), abundant.

Fraxinus pennsylvanica var. lanceolata (seeded from campus trees), abundant; still coming.

Eleagnus angustifolia (seeded from campus trees), free.

Tilia americana, in field, free.
Prunus padus, under trees, abundant April 10.
Acer negundo, under trees (campus), abundant May 18.
Ulmus americana, under trees (campus), abundant May 18.
Ulmus fulva, under trees (campus), abundant May 18.
Ulmus pumila, under trees (campus), free May 18.

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THE VEGETATIVE ORGANS OF SOME PERENNIAL GRASSES.

FLORENCE WILLEY.

INDEX

Frequently occasions arise when it is expedient to identify grasses from other than their flower or fruit characterizations. There have been many botanical descriptions of grasses written, but these have been for the most part descriptive, or of hay crops, or briefly given as from the standpoint of distribution. John Percival, in his text book on "Agricultural Botany"[1] gives brief attention to the sheath, ligule and rhizome.

Many grasses change in appearance from the spring to autumn form, others are never allowed to blossom. M'Alpine, "Grasses,"[2] gives a method whereby the grasses may be identified by leaf characteristics. Work by Hackel, "The True Grasses;"[3] Beal, "Grasses of North America"[4]; L. H. Pammel, Carlton R. Ball, and F. Lamson-Scribner, "Grasses of Iowa"[5]; in general give the keys based on botanical descriptive characters, other than the vegetative organs, together with their habitat and economic value.

Hitchcock has taken up the morphology of the vegetative organs of some of the grasses in his "Text Book of Grasses"[6]. Hitchcock and Chase have included descriptions of vegetative organs in their work on the species of Panicum, in "Contributions from the United States National Herbarium"[7]. Reference is made to the rhizomes and morphology by Pammel, Weems,

[1]Percival, John, Agricultural Botany.
[2]M'Alpine, A. N., Grasses.
[3]Hackel, Eduard, The True Grasses.
[4]Beal, W. J., Grasses of North America, I.
[5]Pammel, L. H., Ball, Carlton R., Lamson-Scribner, F., Grasses of Iowa, Part II. Iowa Geological Survey, 1903.
[6]Hitchcock, A. S., A Text Book of Grasses, f. 95-111.
[7]Hitchcock, A. S., and Chase, Agnes, The North American Species of Panicum: Contributions from the United States National Herbarium, Vol. 15.

Lamson-Scribner in "Grasses of Iowa."[8] Here may also be mentioned the work done by Clark and Malte on the "Fodder and Pasture Plants of Canada"[9], which included in some instances bud and rhizome characters. Hitchcock and Clothier, in a Kansas Experiment Station Bulletin on "Vegetative Propagation of Perennial Weeds"[10] have described the habits of growth of the rhizomes of various weeds including a few grasses. Another study of rhizomes is that of Pammel and Fogel on "The Underground Organs of a Few Weeds."[11] In this was included a description of *Agropyron repens*.

Lyman Carrier, in a U. S. Department of Agriculture Bulletin, has written a very comprehensive report on the "Identification of Grasses by Their Vegetative Characters."[12] He has given the bud characters, leaf, ligule and auricle, but he has not included a study of the rhizomes of perennials. In this study, the work of Carrier is followed, including in some cases different species and a study of the characters of the rhizomes of perennials only.

METHOD OF PROCEDURE.

The rhizomes of twenty-seven perennial grasses were gathered and planted in the greenhouse in fertile soil, the latter part of October. Duplicates of these were placed in the laboratory in sphagnum moss. Temperature readings were kept and development of new buds from the rhizomes was noted, also whether or not any of these grasses had a resting period.

The rhizomes in both instances were kept under uniform conditions as to moisture and temperature. The temperatures in the greenhouse ranged from 65° to 70° F., while those in the laboratory were much lower, ranging from 38° to 70° F. The rhizomes grown in the sphagnum were submitted to conditions undesirable for their best growth, such as lack of moisture, too much moisture, and lack of suitable lighting conditions. However, under these conditions *Agropyron repens*, *Poa compressa*, and *Dactylis glomerata*, put forth vigorous

[8]Pammel, L. H., Weems, J. B., Lamson-Scribner, F., The Grasses of Iowa: Iowa Geological Survey Bull. 1, 1901.

[9]Clark, Geo. H., Malte, M. Oscar, Fodder and Pasture Plants in Dominion of Canada: Department of Agriculture, Dominion of Canada, 1913.

[10]Hitchcock, A. S., and Clothier, Geo. L., Fifth Report on Kansas Weeds—Vegetative Propagation of Pesennial Weeds: Bull. Kan. Ag. Exp. Sta. 76, 1898.

[11]Pammel, L. H., and Fogel, Estella D., The Underground Organs of a Few Weeds. Proc. Iowa Acad. Sci., Vol. XVI, p. 36. 1909.

[12]Carrier, Lyman, The Identification of Grasses by Their Vegetative Characters. U. S. Dept. Agric. Bull. 461, 1917.

growths more conspicuously than any of the others. *Bromus inermis*, *Elymus robustus*, *Koeleria cristata*, and *Phleum pratense* failed to grow either in the laboratory or in the greenhouse. This might have been due to any number of possible causes, the most probable of which was failure to obtain a vigorous rhizome for planting. All of the figures were drawn from specimens of the greenhouse grasses, so that they are representative of uniform conditions.

Many of the grasses had resting periods. Striking illustrations of those having rest periods, are, *Muhlenbergia Mexicana*, *Muhlenbergia racemosa*, *Spartina cynosuroides*, *Stipa spartea*. The two species of Muhlenbergia had resting periods of four months, while the resting periods of the others were two months. All of the other grasses began to grow within three weeks, but none of them grew vigorously until March.

DEFINITION OF TERMS USED IN THIS DISCUSSION.

The use of the term "grasses" is restricted to those plants classed as Gramineæ. The Carex is used here as a means of contrast. The grasses may be distinguished from sedges by the following characters: stems jointed, unusually hollow, leaves in two ranks, alternate, the leaves consisting of the blade, sheath, ligule and collar. The blade is narrow and elongated; sheath, tubular in structure, usually enclosing the stem; the ligule, a membranous appendage at the base of the blade. The rhizome or rootstock consists of a thickened underground stem, by which the grass may perpetuate its growth and from which arise the true roots. Thus the perennial grass plant may be said to consist of root, rhizome, culm, leaf and flower. A perennial grass may be distinguished from an annual by the presence of the rhizome. It is frequently difficult to distinguish the rhizome of a perennial. But instead of a creeping rhizome as in the *Agropyron repens* there is developed a thickened basal portion from which buds arise, as in *Hordeum jubatum*. Generally this type of abbreviated stem, which may be classed as a short lived perennial or winter annual, sends out an abundance of fibrous roots. In case of the *Phleum pratense* the thickened base is a rudimentary corm.[13] Again, there is the type of rhizome rep-

[13]Kraemer, Henry, Botany and Pharmacognosy. p. 105. 'A corm is intermediate between a true tuber and a bulb, it is more in the nature of a thickened internode, being surrounded in some cases by thin membranous scales' as in *Phleum pratense*. W

resented by *Andropogon nutans*, where the coarse buds arise from the base of the growth of the previous year and develop a bunch grass. *Sporobolus cuspidatus* sends up new shoots at every node[14] of the thickened rhizome.

RHIZOMES.

The purpose of rhizomes is to absorb nutrition from soil and air through the roots, and to propagate the plants. The shoots may be aerial or subterranean. According to Kraemer, "roots and rhizomes represent those parts of plants which develop underground, the latter having all of the characteristics of stems except in their manner of growth."[15] They may be distinguished from the roots by buds, nodes, internodes and reduced leaves in the form of scales. Rhizomes may be upright, horizontal or oblique, depending upon their manner of growth,—determined when stem scars are horizontal. This, however, is not always possible to do, in case of the rhizomes of grasses. The rhizome, root-stock, and underground stem are synonymous terms: The rhizome may be slender, each branch terminating in a single shoot as in *Poa compressa*, or producing several slender shoots as in *Poa pratensis*, or it may be scalelike with nodes very close together as in *Muhlenbergia racemosa*.

ROOTS.

The roots of the grasses are usually slender and fibrous. Most of them vary in gross structure only as to the length, thickness, and number of root hairs. Thus, the roots are not a determining character.

CULM.

The culms of grasses, sometimes called stems, are either erect, decumbent or creeping. In case of the latter they are termed stolons, and root at the nodes. The culms are in most instances cylindrical as in *Agrostis alba*, but some are flattened, as in *Poa compressa*.

The sedges may be distinguished from the grasses by their three-angled stem and straplike leaves. The grasses have two ranked leaves while the sedges have three.

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[14]This is true in all instances noted.
[15]Kraemer, Henry, Botany and Pharmacognosy. p. 443.

LEAVES.

"The leaf is a lateral organ of the stem, borne singly at the nodes"[16]. The two conspicuous parts of the leaf are the sheath and the blade. The sheath or leaf base enwraps the stem and opens on the side opposite the leaf and is cylindrical in form. The color of the sheath is usually light green to white at the base but in some species it is distinctly colored. The blade forms the chief foliage organ and is usually flat, sometimes depressed in the middle along the midnerve. The *ligule* is formed at the top of the sheath at the junction of the blade and sheath. The ligule is membranous, seemingly a continuation of the lining of the sheath. The ligule is a significant character in the identification of young grasses. In some cases the ligule is absent, but when present it may be classed as to form; these forms are described, according to Carrier[17] "as entire, when there are no notches or indentations along the margin, lacerates, when the margin is much cut; truncate, when the apex is apparently cut off squarely; acute, when the apex terminates in a sharp point; and ciliate, when the margin is fringed with hairs."[?] The identification of the ligule is more difficult after the grass becomes older as the ligule becomes split and sometimes an entire ligule of a young shoot will appear ciliate when it becomes older. The collar when present is distinguished usually by a lighter colored band, or by a difference in texture at the junction of the sheath and leaf. It is scarcely distinguishable in some species, and in others it is a marked character. In some instances it is pubescent. It may be a continuous band extending across the leaf, arising at the base of the ligule and extending upward about 2 to 3 mm. In some species it is wider on either margin, in others it is completely divided into two parts by the midnerve. The auricles are membranous appendages projecting from the collar or from the top of the sheath.

The vascular system is represented in the grasses by nerves of the culm, midnerves of the leaf and nerves of the sheath which are continued in the leaf. They are very conspicuous in some species, as in *Agrostis alba*, and in others are scarcely discernible.

[16]Hitchcock, A. S., A Text Book of Grasses, p. 103.

[17]Carrier, Lyman, Identification of Grasses by Their Vegetative Characters: U. S. Dept. Agric. Bull. 461, 1917.

DESCRIPTIONS OF VEGETATIVE ORGANS

Agropyron repens. Quack Grass or Couch Grass. Figure 121 Pale green glaucous perennial, or sometimes a bright green, but lacking the bluish green color of *Agropyron Smithii.* This species had no resisting period when transferred to the greenhouse or to the laboratory. Often only one culm grows from a node. The rhizomes are vigorous, creeping, especially radiating from the

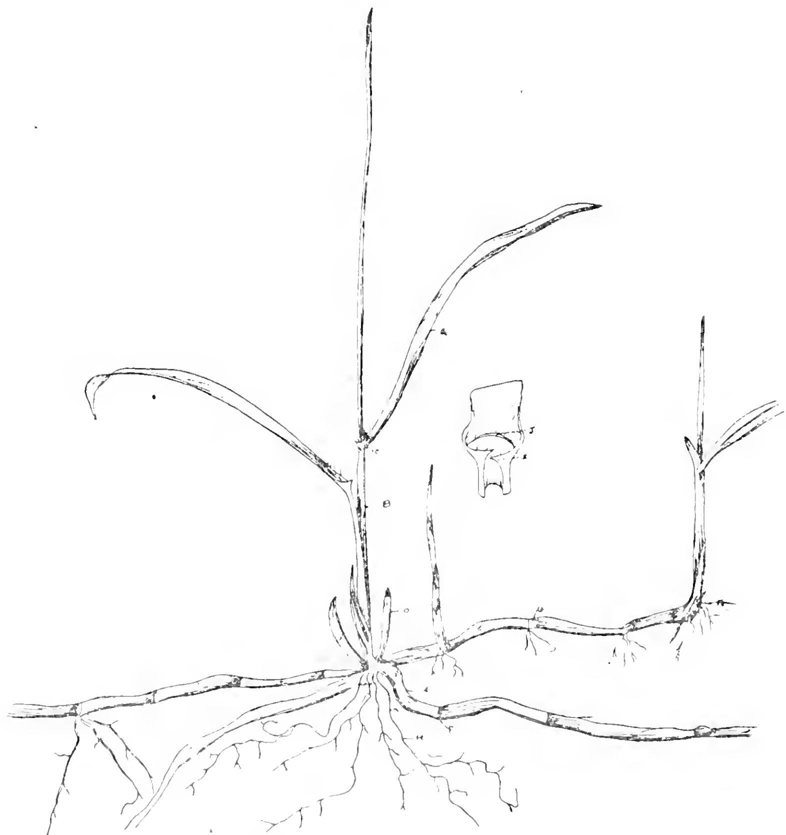

Fig. 121—*Agropyron repens.* Quack Grass. A, blade; B, sheath; C, collar; D, bud; E, old rhizome; F, node; G, scale; H, roots; I, auricle; J, ligule; K, terminal node and shoot.

terminal node of the last year's growth, or from the base of the old culms. The rhizomes are coarse, averaging one-third cm. in diameter. Scales are hairy and conspicuous, in some specimens reaching from one node to the other; nodes are one to one and a half cm. apart; buds arise at the nodes, the terminal node always budding, from which a new shoot makes its appearance.

Roots do not originate at every node. Roots are few, short and fibrous. Leaves rolled in the bud; ligule membranous, short, entire; sheath open, not compressed; blade flat, sharp-pointed, one-half cm. wide; nerves inconspicuous, broad, pubescent just above the ligule, especially on either side of the mid-nerve. Collar broad, narrow pubescent. Auricles present, slender, terminating in a hairlike appendage.

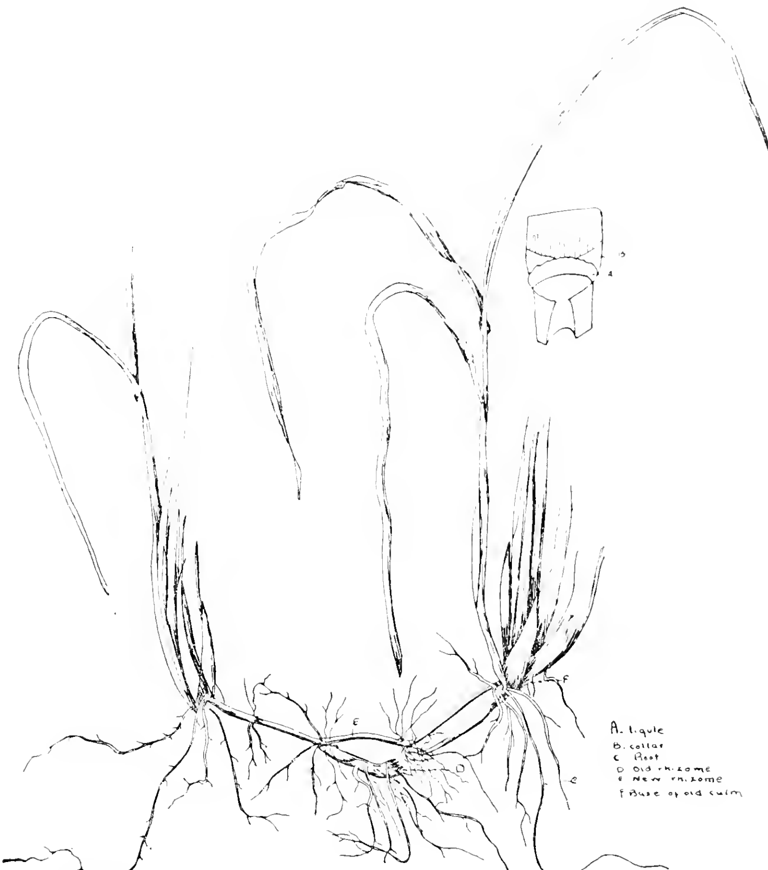

Fig. 122—*Agropyron Smithii.* Western Wheat Grass. A, ligule; B, collar; C, leaf rolled in bud; D, new rhizome; E, rhizome of previous year's growth.

Agropyron Smithii. Western Wheat Grass. Figures 122 and 123.

An upright, glaucous, bluish green perennial. Several culms in a cluster. Rhizomes creeping, slender, one to two mm. wide. Nodes are one to two cm. apart. The old rhizome dies, and from the node where a new rhizome arises there is an enlarged node and many roots. The scales on a young rhizome extend from one node to another and are not conspicuous until the rhizome becomes older, except that they are brown in color while the young rhizome itself is yellowish white. Extending from the rhizome is an abundance of very long, tough roots. Many more roots are found on this species than on *Agropyron repens.* New buds do

Fig. 123—*Agropyron Smithii.* Western Wheat Grass.

not always grow from terminal nodes of old root stock. Leaves rolled in the bud, sheaths tightly compressed in the young shoot. In older shoots, it leans away from stem. Blades two and one-half to five mm. wide, comparatively long and flat. Ligule finely toothed, narrow membranous; collar light, inconspicuous in young shoots but becoming green to white, widened at the margins in older plants. Nerves in blade, conspicious. Auricles absent.

Agropyron tenerum. Slender Wheat Grass. Figure 124.

An erect, smooth, soft leaved perennial, growing in bunches or tufts. Resting period two to three weeks. Rhizomes not creeping but forming a short, tough, thickened rootstock at the base of the previous year's growth. From this grow a number of culms, hence its descriptive term "bunch" grass. The nodes, scarcely distinguishable, are very close together and from them develop an abundance of long, tough, fibrous roots, having

Fig. 124.—*Agropyron tenerum.* Slender Wheat Grass. A, ligule; B, collar; C, auricles; D, rhizome; E, last year's growth.

many root hairs, the scales not conspicuous if present. The leaves are rolled in the bud, glaucous, three to six inches long, narrow, rather rigid and flat. Ligule membranous, short obtuse, slightly wavy along the upper edge. Sheathes compressed. Auricles present, conspicuous, pointed or clawlike. Blade narrow, glaucous, flat, sharply pointed, one and one-half to three mm. wide. Nerves rather prominent. Collar broadened at margin, narrow at the mid-nerve.

Agrostis alba. Red Top. Figure 125.

A perennial; the bases of the culms are decumbent. Rhizomes slender, one-sixteenth inch in diameter, scales formed at nodes; long fibrous roots found at every node. New shoots sent up from terminal bud of old rhizome followed by buds at intermediate nodes. Roots are numerous at base of a shoot, and a lesser number found at the nodes. Roots fibrous, slender. Leaves rolled in the bud, dark green, glabrous, linear. Blade, flat linear, sharply pointed, one-fourth to one-half cm. wide, somewhat rough on margin and surface, thin, coarsely nerved. Sheaths smooth,

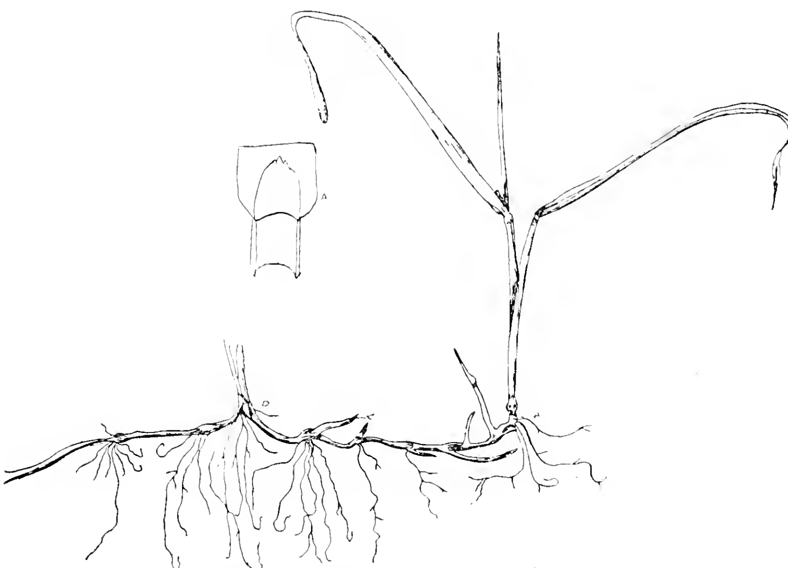

Fig. 125.—*Agrostis alba.* Red Top. A, ligule; B, terminal node and shoot; C, bud at node of rhizome; D, base of old culm.

not compressed, about the same length as the internodes. Ligule acute, long, toothed, membranous, thin, white. Collar rather narrow, divided into two distinct parts by a glabrous portion of the blade. Auricles not present.

Andropogon furcatus. Blue Stem. Figure 126.

An upright perennial. The resting period was from November to January. Rhizomes slender, woody, tough, clustered; nodes enlarged, conspicuous scales enwrap the internodes. New rhizomes appear first from the base of the old cluster. The new shoots make their first appearance from the base of the old culms, followed by those from the terminal bud which does not develop intermediate buds on the rhizome at the nodes. Roots are tough, long and very fibrous. Leaves dark green, folded in the bud. Blade broadened at collar, flat, margin slightly scabrous, nerves conspicuous. Sheath smooth, white to light green

Fig. 126.—*Andropogon furcatus*. Blue Stem. A, ligule; B, old culms; C, terminal node from new rhizome.

at base. Ligule slightly pointed in middle when blade is folded, membranous, short, continuous. Collar light green, becoming very conspicuous in older plants. Margin of collar slightly hairy.

Andropogon nutans. Indian Grass. Figure 127.

A stout perennial, having a long rest period. At the base of the old culm, the rhizomes resemble a group of thickened buds with coarse scales entirely covering them. The new shoots arise in a cluster about the base of the dead culm, the nodes of the rhizome being marked by a new series of scales. From the cluster of new shoots a branch rhizome may be sent out leading to another cluster. Long,

Fig. 127.—*Andropogon nutans.* Indian Grass. A, ligule; B, sheath; C, old culm; D, new shoot and bud; E, old rhizome.

coarse roots are sent out from the base of the old culm and nodes of the rhizome. Leaves, dull green, folded in bud. Blades flat, pubescent, compressed at base. Sheath compressed, pubescent. Ligule narrow, membranous, toothed, truncate. Auricles present in form of hairlike appendages, not distinct.

Andropogon scoparius. Little Blue Stem. Figure 128.

Upright perennial. Rhizomes slender, sending out many new shoots from the base of the old culm, also one or two new rhizomes. Internodes short, scales at node short, fringed. Nodes on a new rhizome conspicuous. The old rhizome dies. Roots few, fibrous. Leaf folded in bud, dull green. Sheaths not compressed. Blades flat, compressed at base, one to two and one-half cm. wide. Ligule narrow, membranous, acute.

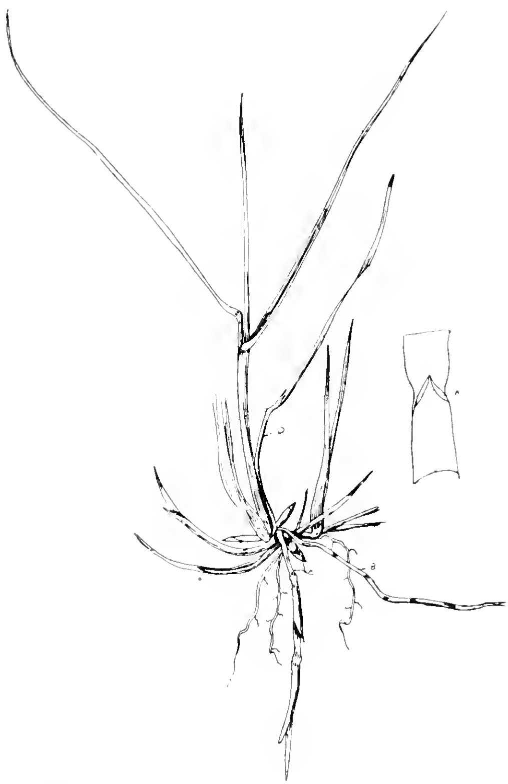

Fig. 128.—*Andropogon scoparius.* Little Blue Stem. A, ligule; B, old rhizome; C, new rhizome and bud; D, sheath.

Bouteloua curtipendula. Tall Grama Oats. Figure 129.

Tufted perennial. New buds did not arise from base of old culm but rather from terminal bud of rhizome, followed by a group of short rhizomes sending up shoots from terminal bud. Rhizome thick, tough. Roots from nodes, long, slender, many short root hairs. Leaves rolled from both sides toward middle. Sheaths loose, not compressed, sometimes sparsely pubescent, leaning away from bud. Collar not differentiated. Blades, scabrous, three to four mm. wide.

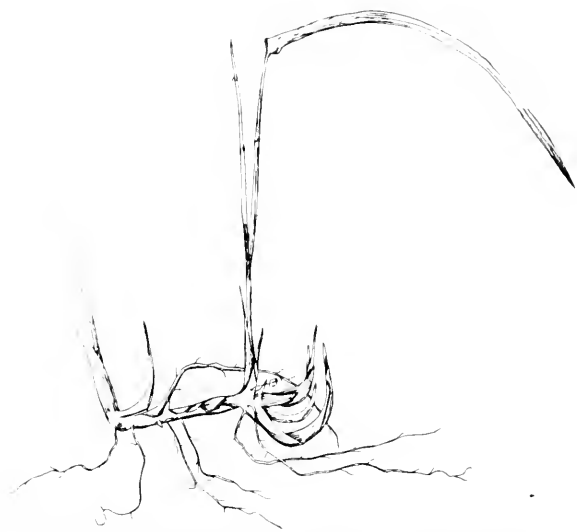

Fig. 129.—*Bouteloua curtipendula.* Tall Grama Oats. A, old culm; B, terminal shoot and buds; C, sheath.

Fig. 130.—*Dactylis glomerata.* Orchard Grass. A, ligule; B, collar; C, rhizome; D, base of new shoot; E, old culm.

Dactylis glomerata. Orchard Grass. Figure 130.

A coarse, light green, tufted perennial. Rhizomes, short, thick, nodes scarcely distinguishable, the new shoot growing from the old rhizome, followed by a number of shoots, forming a tuft, culms somewhat decumbent at base. Roots long, coarse, having many root hairs. Leaves when young conduplicate, long, keeled,

Fig. 131. *Hordeum jubatum.* Squirrel Tail. A, ligule; B, rudimentary corm; C, sheath; D, old culm; E, blade.

folded in bud along midnerve. Blade one-fourth inch or more wide, scabrous, flat, keeled, broad, soft in texture, drooping, sharp-pointed; culms erect, smooth; young shoots flat, keeled. Sheaths compressed, white at base, somewhat scabrous. Ligule elongated, toothed, membranous, lacerate. Auricles wanting. Collar light yellow, broad, conspicuous.

Hordeum jubatum. Squirrel Tail. Figure 131.

Slender, erect winter annual. This species does not have a creeping rootstock, but a short, somewhat thickened rhizome, shoots producing a tufted grass. An abundance of long fibrous roots are produced. Leaves smooth, rolled in bud; blade flat, long, linear, pointed, pubescent. Sheath compressed, pubescent. Ligule acute, toothed. Collar wanting.

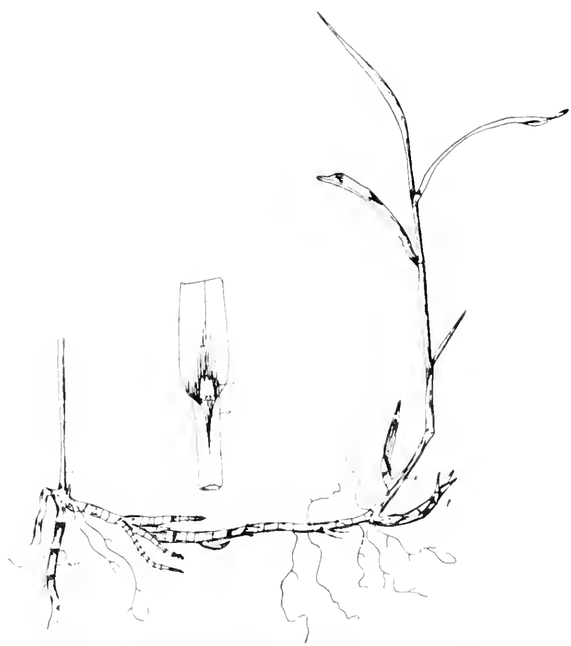

Fig. 132.—*Muhlenbergia Mexicana.* Mexican Drop Seed. A, ligule; B, sheath; C, old culm; D, old rhizome; E, new rhizome with terminal shoot; F, buds from new rhizome.

Muhlenbergia Mexicana. Mexican Drop Seed. Figures 132 and 133.

A decumbent, slender, glabrous perennial. Resting period from October until March. Rhizome, rather slender, creeping, many new rhizomes branching from the nodes. New culms do not always appear the following year at the base of the previous year's growth. First new shoot appears at terminal bud or end of rhizome, followed by several more from the same base. Rhizomes very scaly, nodes one-half to one and one-half cm apart. Roots very delicate, fibrous. Leaves, rolled in bud. Blades one-third to one-half cm. wide, thin, flat, pale green. Sheaths compressed, loose. Culms slender, short joints. Ligule acute, lacerate, membranous. Collar broadened on either margin. Auricles wanting.

Fig. 133.—*Muhlenbergia Mexicana.* Mexican Drop Seed.

Muhlenbergia racemosa (*glomerata*). Marsh Muhlenbergia. Figure 134.

A wiry perennial. Resting period from October to March. Rhizome thickened, much more so than in *Muhlenbergia Mexicana*, not as scaly. From the rhizome of the previous year's growth is sent up a new shoot, much branched, although not as much so as *Muhlenbergia Mexicana*. New rhizomes are sent out from the base of old culms. These rhizomes are markedly scaly. Roots are long, slender. Leaves rolled in bud, having the appearance of a series of many scales when young. Blade flat, scabrous, pointed, narrow and numerous; sheaths long; ligule narrow, lacerate; collar widening at either margin; auricle wanting.

Fig. 134.—*Muhlenbergia racemosa.* Marsh Muhlenbergia. A, ligule; B, collar; C, base of dead culm, and base of new shoot; D, dead culm of previous year's growth; E, new rhizome; F, rhizome scars.

Panicum Scribnerianum. Scribner's panicum. Figure 135.

A very erect perennial with a slender, very vigorous, creeping, almost white rhizome. The nodes are not conspicuous. New shoots arise in somewhat uniform growth from buds at the nodes but first appear at extremes of growth. Roots are long, rather tough, but not especially numerous. Leaves rolled in bud, blade flat, slightly scabrous, one-half to three-fourths cm. wide, sharp, pointed, glabrous. Sheath loose, striate, sometimes slightly pubescent. Ligule acute, slightly toothed. Auricles wanting. Collar broadened at margins, narrowed in middle.

Panicum virgatum. Switch Grass. Figure 136.

An erect perennial. Rhizome creeping, very tough, one-eighth to one fourth inch in diameter, scales conspicuous. The new shoots do not come from the terminal end of the old rhizome. New shoots may spring from base of old culms; new buds arising from nodes of rhizome are twisted, growing obliquely until they reach the surface of the ground. Roots few but long and coarse. Leaves glabrous, rolled in the bud, which is cylindrical. Sheaths ciliate along margin at the top, smooth, not compressed. Blade flat, narrowed at the base, one-eighth to one-half inch wide, pointed, glabrous, slightly scabrous. Ligule ciliate, dense, two to three mm. long. Collar hairy, auricles wanting.

Poa compressa. Canada Blue Grass. Figure 137.

A bluish green perennial. Resting period twenty-four days. Rhizomes creeping, slender, one sixteenth to one eighth inch in

Fig. 135.—*Panicum Scribnerianum.* Scribner's Panicum. A, ligule; B, sheath; C, shoot at node; D, terminal node and first shoot; E, rhizome.

diameter. One shoot from each branch; new shoots appear from bud at node of old rhizome which later dies. Roots fibrous and very slender but stout. Leaves folded in bud. Blades flat, long, linear, pointed, pale green, glaucous, double lines along midnerve by transmitted light. Sheath tinged with red at base, compressed, smooth. Ligule membranous, entire, acute, medium long. Collar very light green. Auricles wanting.

Poa pratensis. Kentucky Blue Grass. Figures 138 and 139.

A dark green erect perennial. Resting period same as *Poa compressa.* Rhizome extensively creeping, averaging two mm. in diameter, slender, having more conspicuous scales and nodes than *Poa compressa.* New shoots are produced from the ends of the rhizome only. Roots slender, fibrous, hairlike. Leaves in new shoot forming distinct sheath, dark green, glabrous. Blades two and one-half to four mm. wide, smooth, linear, compressed at base, pointed at tip, flat. Sheath, smooth, compressed,

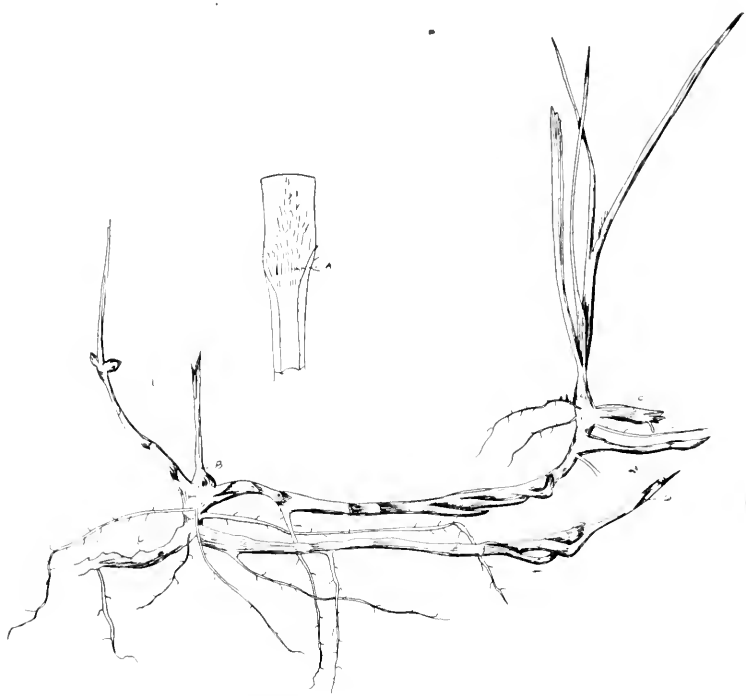

Fig. 136.—*Panicum virgatum.* Switch Grass. A, ligule; B, old culm; C, old rhizome; D, bud.

white at base. Collar light green. Ligule narrow, entire, memmembranous, truncate; auricles wanting.

Spartina cynosuroides. Slough Grass. Figure 140.

A stout, erect perennial. Rhizome brown, very thick, creeping, woody. Nodes at regular intervals, scales dark; roots coarse, having fine root hairs. Growth of new shoot takes place from base of old culm; rhizome at this point is very thick where the scales are somewhat twisted. Leaves rolled in the bud. Blades coarse, scabrous, four to eight mm. wide, glaucous. Sheaths compressed, coarsely nerved. Brown scales are numerous, coming from the base of the culms. Ligule ciliate, forming a fringe of hairs. Collar light green to yellow, conspicuous on the inside.

Sporobolus cuspidatus. Prairie Rush Grass. Figure 141.

Long resting period. Rhizome creeping. Buds appear at almost every node, also an abundance of very long, coarse, fibrous roots. Nodes conspicuous.

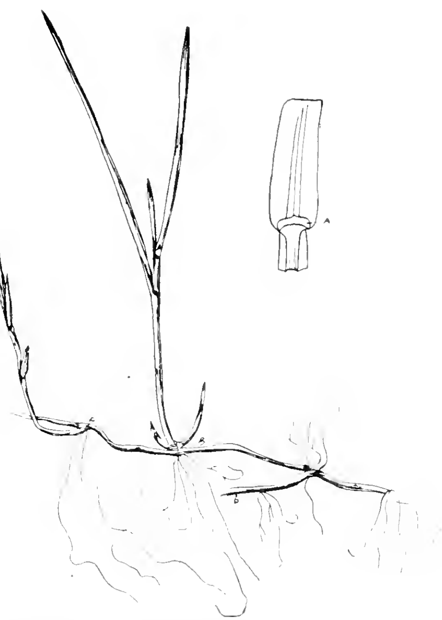

Fig. 137.—*Poa compressa.* Canada Blue Grass. A, ligule; B, first shoot and buds at node of old rhizome; C, node; D, old rhizome.

Sporobolus longifolius. Long Leaved Rush Grass. Figure 142.

Buds of rhizome arise in clusters.

Stipa spartea. Porcupine Grass. Figure 143.

An erect perennial. Resting period four months. Rhizomes creeping, the branching rootstocks of the main basal rhizome die the following year, while new rhizomes grow out and their terminal buds send up new shoots. The new rhizome extends in one direction only. The most vigorous growth takes place at the base of the old rhizome. Roots arising at nodes are rather short, stout, with many root hairs. Leaves folded in bud. Blades dull, dark green, nerves prominent, one and one-half to two mm. broad, sharp pointed. Sheath somewhat lighter green than blade, entirely enclosing bud, whitish to pale green near the ground. Ligule narrow, indented at mid-nerve, membranous, collar same color as sheath; auricles wanting.

Carex. Sedge. Figure 144.

Rhizome thicker than in the grasses; scales thick, coarse; buds very short; ligule narrow, entire.

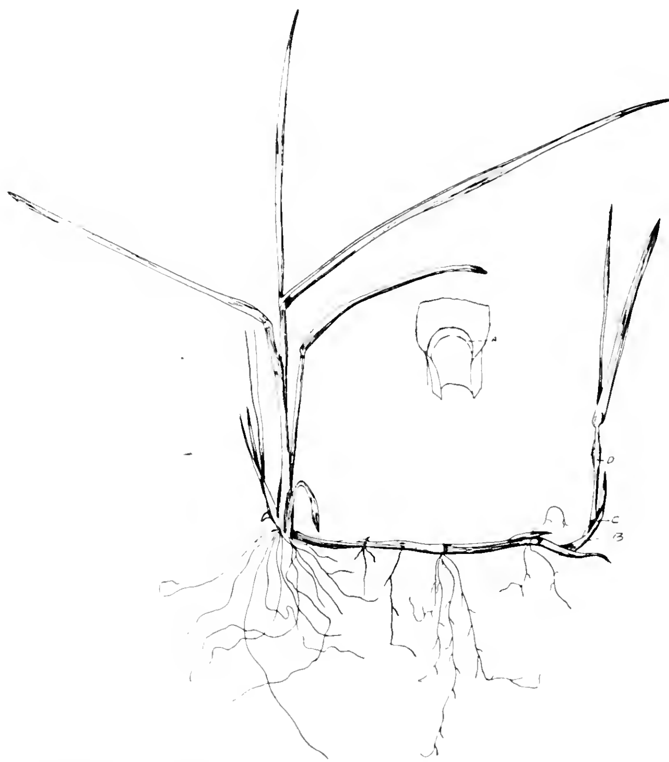

Fig. 138.—*Poa pratensis.* Kentucky Blue Grass. A, ligule; B, terminal shoot; C, scales; D, sheath.

SUMMARY.

1. Study was made of the vegetative organs of some perennial grasses which were grown in the greenhouse from October until May. Resting periods were variable.

2. *Sporobolus longifolius, Muhlenbergia Mexicana, M. racemosa, Spartina cynosuroides, Stipa spartea* had resting periods

of four months, while that of *Poa compressa* and *Poa pratensis* was two weeks.

3. A perennial grass is distinguished from an annual by the presence of a rhizome.

4. Rhizomes may be distinguished from roots by the presence of buds, nodes, internodes, and scales.

5. Rhizomes may be slender, terminating in a single shoot, or producing several shoots. They may be creeping rhizomes or rudimentary corms. In case of *Stipa spartea* the old rhizome

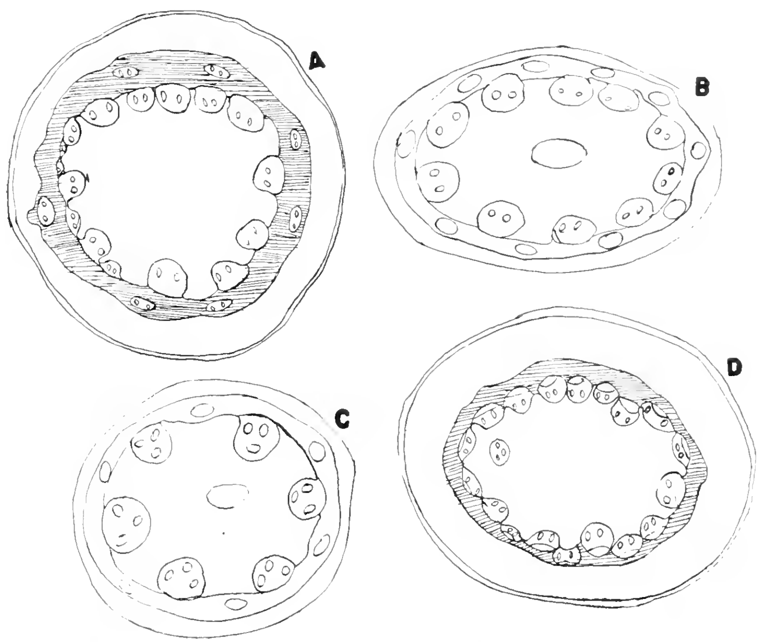

Fig. 139.—A, cross section of rhizome, *Poa compressa;* B, outline cross section of culm, *Poa compressa;* C, outline cross section of culm, *Poa pratensis;* D, cross section of rhizome, *Poa pratensis.*

dies, while the base of the old culm develops new shoots and subsequently new rhizomes which are comparatively short.

6. The roots of grasses are slender and fibrous, and vary in the same species as to gross structure; thus this is not a determining characteristic.

7. The culms of grasses are erect, decumbent or creeping, cylindrical or flattened.

8. The leaf is composed of the sheath and blade; the ligule is formed at the junction of the blade and sheath; the collar is

usually distinguished at the junction of the leaf and sheath by the color; the auricles are appendages projecting from the collar or top of sheath. These together with the rhizomes form very important basic characters for identification of grasses.

9. The vascular system is represented by nerves, in some species conspicuous. The arrangement and number of nerves is a character which aids in identification.

Fig. 110.—*Spartina cynosuroides*. Slough Grass. A, ciliate ligule; B, collar; C, rhizome; D, base of old culms, and new shoots and scales; E, node and scales of rhizome.

10. The character of the rhizome, blades in the bud, sheath, ligule, collar, and auricles may furnish a basis for further study of the identification of perennial grasses by their vegetative organs.

NOTE. Acknowledgment is due to Dr. L. H. Pammel under whose direction the work was begun, also to Miss King, Miss Hayden, and Mr. L. W. Durrell for helpful suggestions in regard to drawings.

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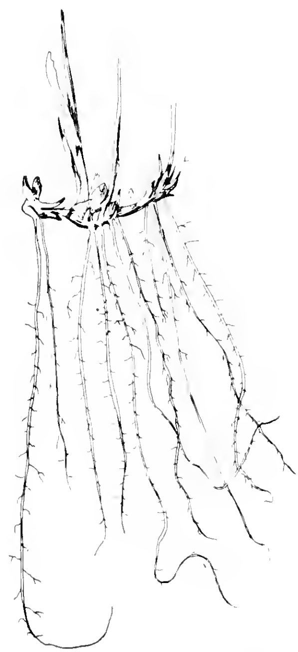

Fig. 141.—*Sporobolus cuspidatus.* Prairie Rush Grass. A, rhizome; B, base of old culm; C, new buds.

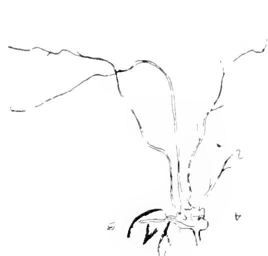

Fig. 142.—*Sporobolus longifolius.* Long Leaved Rush Grass. A, Base of old culm and rhizome; B, new buds.

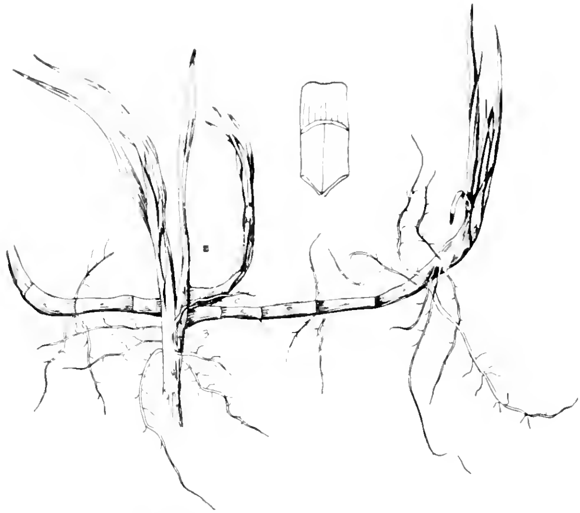

Fig. 143.—*Stipa spartea.* Porcupine Grass. A, scar of old rhizome; B, dead rhizome of previous year's growth; C, ligule; D, sheath; E, main stock of rhizome; F, new rhizome; G, terminal buds of new rhizome; H, sheath; I, sheath clasping stem.

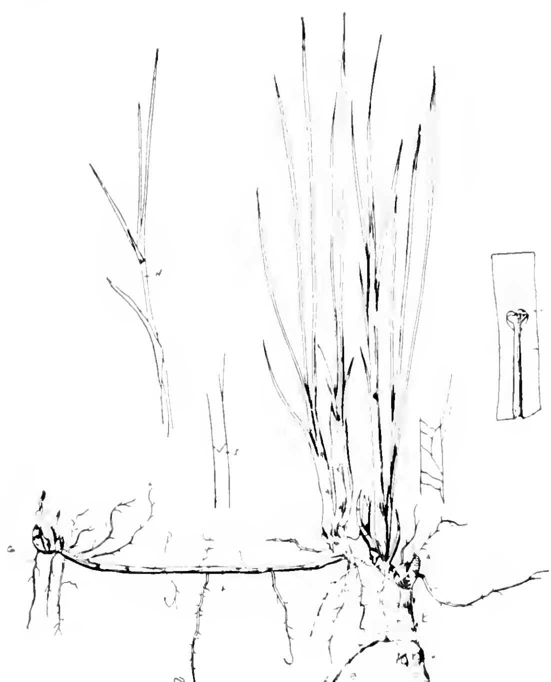

Fig. 144.—*Carex.* Sedge. A, ligule; B, old rhizome and base of new shoot; C, new shoots; D, node and scales; E, leaf.

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DEPARTMENT OF BOTANY,
IOWA STATE COLLEGE.

NOTES ON THE FLORISTIC FEATURES OF A PRAIRIE PROVINCE IN CENTRAL IOWA.

ADA HAYDEN.

The primeval prairie of Iowa is fast vanishing. This region where grass grew tall and prairie fires yearly swept over expanses bounded by the horizon or broken here and there by zones of forest along the streams, man, one of the most important of ecological forces, has selected for his permanent habitat. The prairie of former years now lingers in small patches bounded by wire fences and known as hay fields; or where the less ambitious farmer has failed to insert an arterial system of tile, occasional sloughs and swamps furnish homes for hosts of sturdy cat-tails, slim reeds, plumy grasses and their associates growing with all the glory of former generations. Several of these reserved prairie patches within a radius of a mile show representative growth including a range of characteristic species considerable for such an area. The gradual changes through a period of thirty years have been noted by one observer but only in the last ten years have specific notes been made.

Analyses of the soil, seasonal temperature, weather records, topographic and geologic features have been reported in Ecologic Topographic Notes on a Prairie Province in Central Iowa. Anatomic characters of some of these plants are discussed in Anatomic-Ecologic Notes on Some Plants of a Prairie Province.

ANALYSIS OF THE FORMATIONS OF THE PRAIRIE PROVINCES.

In this survey the intention is to state observations unadorned by nomenclature. Such terms as are used conform to Clement's system as stated in Research Methods in Ecology.

Schimper, Clements and Warming summarize the more important literature on the subject of ecological nomenclature. These writers do not agree in regard to the use of ecological terms. According to Farlow's report, the Brussels Congress of 1910 recommended the use of the terms "formation" in the broader and "association" in the restricted sense. This limitation of the term formation is, however, not defined. Clements claims that it should be synonymous with the term habitat while Schimper uses it with such a broad range of meaning as to embrace a prairie province or a forest province. Despite the differences in the limitation of the region embraced, the salient features in the conception of the formation are, as described by Warming, an expression of certain well defined conditions of life and are not concerned with floristic differences. On this basis the Prairie Province under inspection may be divided into the following regions with reference to:

A—Topography
- I Upland
  - Hilltop
  - Slope
  - Meadow
- II Lowland
  - Meadow
  - Swamp
  - Ponds

B—Formations
- I Upland prairie
- II Meadow
- III Swamp
- IV Pond

Stipa-Bouteloua Formation.
Soil gravelly, sandy loam or loam.
Arrangement: copious.
The main consocies as represented by more prominent species are:

A. Consocies—*Bouteloua.*
Location: Hilltop, gravelly loam.
The principal species are:
Bouteloua curtipendula, Bouteloua hirsuta, Koeleria cristata, Carex pennsylvanica, Astragalus caryocarpus, Comandra umbellata, Anemone cylindrica, Anemone patens var. *Wolfgangiana, Agoseris cuspidata, Oenothera serrulata, Solidago speciosa, Liatris cylindrica, Euphorbia corollata, Lithospermum canescens, Lithospermum angustifolium, Petalostemum purpureum, Polygala verticillata.*

The societies of the seasonal aspects are:

(1) Spring aspect.
Anemone patens var. *Wolfgangiana, Comandra umbellata, Agoseris cuspidata.*

(2) Summer aspect.
Bouteloua curtipendula, Bouteloua hirsuta, Koeleria cristata, Polygala verticillata.

(3) Fall aspect.
Bouteloua hirsuta, Bouteloua curtipendula,Andropogon furcatus, Liatris cylindrica, Aster azureus, Solidago speciosa.

B. Consocies *Stipa.*

Location: Slope or level prairie (Heuchera Hill type or upland level of Grove's Field).

Soil: loam to sandy loam.

Arrangement: Copious or slightly copious, gregarious.

The main species are:

Brauneria purpurea, Psoralea argophylla, Stipa spartea, Sporobolus, Coreopsis palmata, Liatris pycnostachya, Liatris squarrosa, Lespedeza capitata, Delphinium Penardi, Lilium

Fig. 145.—Kame Hill, Alluvial basin below, probably the pre-Wisconsin bed of Des Moines river.

philadelphicum, Phlox pilosa, Heuchera Americana, Pedicularis canadensis, Viola pedata, Baptisia bracteata, Eryngium yuccaefolium, Amorpha canescens, Gentiana puberula, Solidago speciosa, Solidago rigida, Petalostemum purpureum, Sisyrinchium angustifolium, Hypoxis hirsuta, Aster sericeus, Aster multiflorus.

Societies:

(1) Spring aspect:

Viola pedata, Pedicularis canadensis, Phlox pilosa, Baptisia bracteata, Sisyrinchium angustifolium.

(2) Summer aspect:

Brauneria purpurea, Lilium philadelphicum, Amorpha canescens, Heuchera Americana, Psoralea argophylla, Eryngium yuccaefolium, Desmodium illinoense, Lespedeza capitata, Lespedeza leptostachya.

(3) Fall aspect:

Aster multiflorus, Liatris pycnostachya, Liatris squarrosa, Gentiana puberula, Aster azureus, Aster sericeus.

Fig. 146.—Anemone patens Hill. West end of Alluvial Basin to the right.

The amount of rainfall and seasonal low or high temperature retards or hastens the time of appearance as well as affects the abundance and stature of most of these species. *Lilium philadelphicum* (consoc. II) shows marked reaction to seasonal conditions.

Variation in soil within small areas causes alteration in consocies, eliminating certain members; for example, the gravelly top of the *Anemone patens* hill, and the two lobes of the Heuchera hill have similar consocies. On the crest of Heuchera hill is a small knoll, more gravelly and drier than the immediately surrounding region. Here the species are sparsely arranged and some are eliminated, *Bouteloua hirsuta* and *Oenothera serrulata* being the principal survivors of this condition. The northeast crests of these hills are practically identical in physical struc-

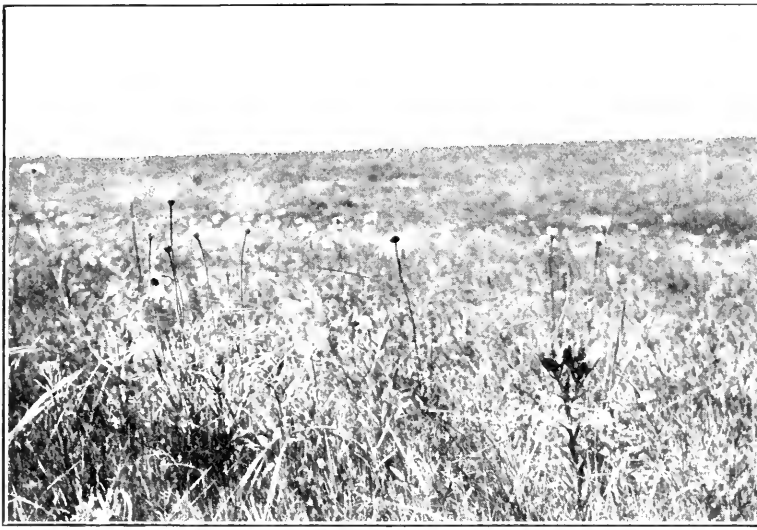

Fig. 147.—Kame Hill region—upland prairie. Heuchera Hill type. Lilium canadense. Brauneria purpurea.

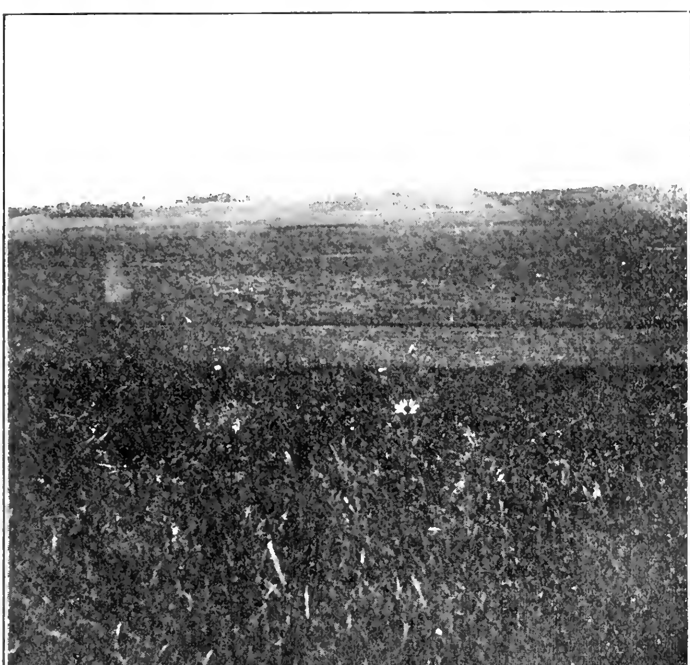

Fig. 148.—Fenced Prairie surrounded by pasture in Alluvial Basin. Swamp in distance. Top of Heuchera Hill, foreground. Brauneria purpurea.

ture. *Anemone patens* var. *Wolfgangiana* has grown abundantly for years on one of them while on the other two hills in a corresponding location one thriving plant is present on one hillside and six or seven plants on the other hill, but the plants do not increase in number.

REVERSION.

Adjacent to the Anemone patens hill are two strips of prairie, one of which has been uncultivated for twenty-one years and the other uncultivated for thirty-six years. The following lists show the constituent plants of these associations.

Fig. 119.—Alluvial Basin looking northeast from Heuchera Hill. Brauneria purpurea.

UNCULTIVATED PRAIRIE.

The species found in this area are:

Andropogon furcatus, Andropogon scoparius, Bouteloua curtipendula, Bouteloua hirsuta, Elymus robustus, Koeleria cristata, Sorgastrum nutans, Stipa spartea, Comandra umbellata, Anemone patens var. *Wolfgangiana, Rosa pratincola, Amorpha canescens, Petalostemon candidum, Petalostemum purpureum, Lithospermum canescens, Lithospermum angustifolium, Artemisia ludoviciana, Aster azureus, Aster sericeus, Cirsium lanceolatum, Coreopsis palmata, Heliopsis scabra, Sil-*

phium laciniatum, Solidago missouriensis, Solidago speciosa, Solidago rigida.

AREA TWENTY-ONE YEARS UNCULTIVATED.

The species included here are:

Equisetum laevigatum var. *robustum, Agrostis alba, Andropogon scoparius, Panicum Scribnerianum, Poa pratensis, Anemone cylindrica, Potentilla arguta, Rosa pratincola, Lespedeza capitata, Linum sulcatum, Euphorbia corollata, Oenothera biennis, Convolvulus sepium, Verbena hastata, Ambrosia artemisiifolia, Cirsium lanceolatum, Helianthus grosseserratus, Lactuca canadensis, Lepachys pinnata, Liatris squarrosa, Solidago rigida,*

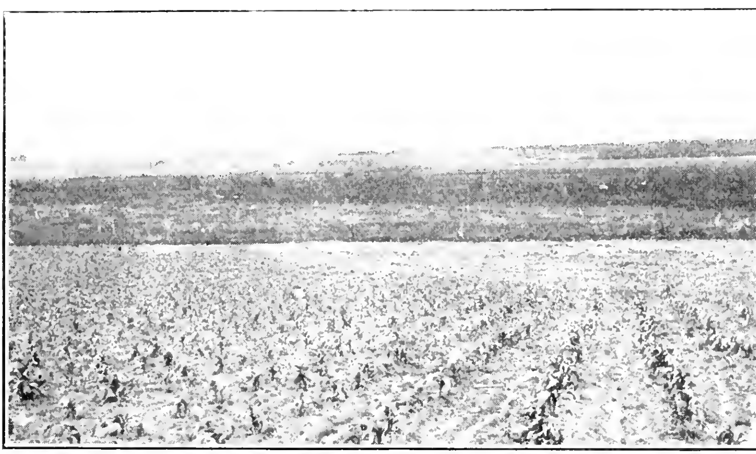

Fig. 150.—East end of Alluvial basin from Heuchera Hill.

Onosmodium molle, Monarda fistulosa, Pycnanthemum virginianum, Physalis lanceolata, Gerardia aspera, Veronica virginica, Aster multiflorus, Cirsium lanceolatum, Heliopsis scabra, Liatris pycnostachya, Eryngium yuccaefolium, Silphium laciniatum, Solidago missouriensis, Solidago speciosa.

AREA THIRTY-SIX YEARS UNCULTIVATED.

The species here found were:

Andropogon scoparius, Bouteloua curtipendula, Elymus robustus, Panicum Scribnerianum, Panicum virgatum, Poa pratensis, Anemone cylindrica, Potentilla arguta, Rosa pratincola, Rubus villosus, Astragalus caryocarpus, Baptisia bracteata, Desmodium illinoense, Lespedeza capitata, Petalostemum candidum, Petalostemum purpureum, Linum sulcatum, Euphorbia *corrollata*, *Rhus toxicodendron*, *Oenothera biennis*, *Oeothera serrulata*, *Ceanothus americanus*, *Eryngium yuccaefolium*, *Asclepias syriaca*, *Convolvulus sepium*.

Plants characteristic of the permanent prairie, such as *Solidago* and *Lespedeza*, were found most frequently near the edge of the uncultivated prairie strip. In the center of the cultivated area in the upturned earth around an animal's den were *Cirsium lanceolatum*, *Chenopodium album*, *Helianthus grosseserratus*, *Xanthium canadense*, *Monarda fistulosa* and *Lactuca canadensis*. The patch uncultivated for twenty-one years indicated that its flora was undergoing succession changes. It contained almost

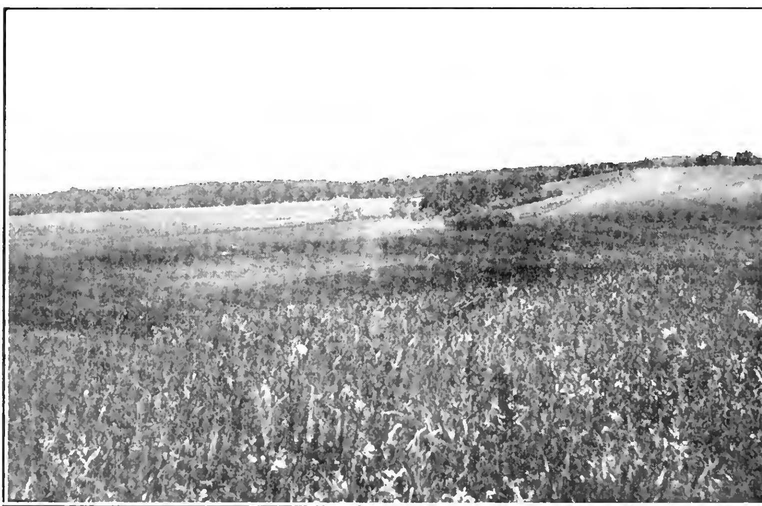

Fig. 151.—Fenced patch of prairie. Alluvial basin.

twice as many species as either of the other two areas, including species of both the newer and older associations.

Reversions from ruderal to prairie type after removal of the original prairie plants is relatively rare in this cool, relatively dry, wind swept region as compared with a moister, warmer climate.* This reversion is sometimes seen in the upland in this

*Near Houston, Texas, was observed an abandoned rice field located slightly above the level of a cypress swamp and bordered on two sides by forests of *Pinus taeda*, on one by a road and on the other by a pasture. The field was too low for the successful growing of rice, which must be kept wet only a portion of the year and then dried toward harvest time. After no cultivation for six years, this field had acquired the usual aspect of the prairie of that region and was being rapidly invaded by seedling trees of *P. taeda*, many of which were three or four feet high. Such a transition is not uncommon in this warm, moist climate.

In the same vicinity along the San Jacinto river a forest of *Pinus taeda* with large trees was growing on land which had forty years earlier been cultivated for crops.

vicinity though in the lowland ruderals well adapted to the moist habitat usually completely supplant the original flora.

A nearby plum-elm thicket in an unmowed ravine on the other side of this hill has caused the grass to disappear from the earth and it is replaced by grove plants. Here is a tendency toward preliminary forest formations.

II Meadow or Wet Prairie.

Panicum-Agrostis Formation.

Location: Between highland and marshes, extends up ravines bordering streams.

Soils: Alluvial, sandy to clay loam.

Fig. 152.—Pond in alluvial basin.

Arrangement: Copious, gregarious-copious.

The more important species are:

Andropogon provincialis, Sorgastrum nutans, Panicum Scribnerianum, Panicum virgatum, Agrostis alba, Muhlenbergia racemosa, Spartina cynosuroides, Sium cicutaefolium, Cicuta maculata, Gerardia aspera, Gerardia tenuifolia, Petalostemum purpureum, Petalostemum candidum, Fragaria virginiana var. *illinoense, Erigeron annuus, Rosa pratincola, Senecio aureus, Thalictrum dasycarpum, Anemone canadensis, Phlox maculata, Pedicularis canadensis, Pedicularis lanceolata, Lythrum alatum, Habenaria leucophaea, Steironema ciliatum, Steironema lanceolatum, Steironema quadrifolium, Lippia lanceo-*

lata, Mentha arvensis var. *canadensis, Lycopus americana, Gentiana puberula, Gentiana Andrewsii, Polygala incarnata, Polygala sanguinea, Rudbeckia hirsuta, Lilium canadensis, Helenium autumnale, Lobelia siphilitica, Caltha palustris, Ranunculus septentrionalis, Galium trifidum, Juncus tenuis,*

Fig. 153.—Edge of shallow pond in alluvial basin. Scirpus validus. Juncus tenuis. Polygonum Muhlenbergii.

Baptisia leucophaea, Viola cucullata, Viola pedatifida, Hypoxis hirsuta, Prunella vulgaris, Stachys palustris, Stachys tenuifolia, Teucrium canadense, Pycnanthemum virginianum, Ranunculus septentrionalis, Spiranthes cernua, Aster multiflorus, Solidago.

This formation is difficult to separate into consocies though certain grouping has been noted; yet it is not very distinct. The following data will indicate the trend of associations.

A. Consocies *Phlox maculata.*

Location: Near running water or pond.

Soil: Loam to clay loam.

The most representative species are:

Phlox maculata, Caltha palustris, Leersia oryzoides, Agrostis alba, Steironema ciliatus, Steironema quadrifolia, Ranunculus septentrionalis.

Fig. 154.—Grove's Field. Wet prairie of upland saucer pond region. Phlox maculata.

B. Consocies *Agrostis-Steironema-Lythrum.*

Location: Low, wet, flat land.

The more common species are:

Agrostis alba, Juncus tenuis, Helenium autumnale, Steironema lanceolata, Steironema quadrifolia, Lythrum alatum, Sium cicutaefolium, Anemone canadensis, Mentha arvensis var. *canadensis, Lycopus americana, Pedicularis lanceolata.*

C. Consocies *Panicum-Fragaria-Senecio.*

Location: Damp with better drainings than A or B.

Soil: Loam to clay loam.

Arrangement: Gregarious-copious.

The representative species are:

Panicum Scribnerianum, Panicum virgatum, Fragaria virginiana var. *illinoensis, Senecio aureus, Anemone canadensis, Viola cucullata, Hypoxis hirsuta.*

D. Consocies *Leersia.*

Location: Wet, low ground.

Soil: Loam to clay loam.

Arrangement: Gregarious.

The prominent species are:

Leersia oryzoides, Anemone canadensis, Physotegia virginiana, Muhlenbergia racemosa, Polygonum Muhlenbergii, Apocynum cannabinum

III. Swamp Location: Standing water present a part of the year.

Typha-Juncus-Penthorum Formation.

Soil: Loam to clay loam.

Arrangement: Aggregate zoned.

A. Consocies *Typha-Juncus.*

The principal species are:

Juncus tenuis, Cyperus sp., *Typha latifolia, Alisma plantago-aquatica, Sagittaria latifolia, Polygonum Muhlenbergii, Leersia oryzoides, Calamagrostis canadensis, Eupatorium, Asclepias purpureum* var. *maculatum.*

B. Consocies: *Penthorum.*

The more common species are:

Penthorum sedoides, Polygonum hydropiper, Polygonum acre, Lippia lanceolata, Steironema lanceolata, Stachys palustris, Epilobium coloratum, Lobelia siphilitica, Bidens cernua.

C. Consocies *Ludwigia-Sparganium.*

The outstanding species are:

Juncus tenuis, Scirpus lacustris, Iris versicolor, Penthorum sedoides, Calamagrostis canadensis, Ludwigia polycarpa, Sparganium eurycarpum.

D. Consocies: *Leersia.*

IV Pond

Ranunculus-Sagittaria Formation. Water present most of the time.

Arrangement: Gregarious, copious, zoned.

A. Consocies *Ranunculus.*

Ranunculus delphinifolius, Alisma plantago-aquatica.

B. Consocies *Sagittaria.*

Sagittaria latifolia, Polygonum amphibii.

The ponds of the saucer-shaped region of Grove's Field are practically identical in physical character, varying somewhat in depth of water, though not exceeding four feet. In some of these ponds, a few species, mostly rare, appear and are not found in other nearby ponds. Only one pond is present in the alluvial basin region. It is of the same type as those in the upland (Grove s Field).

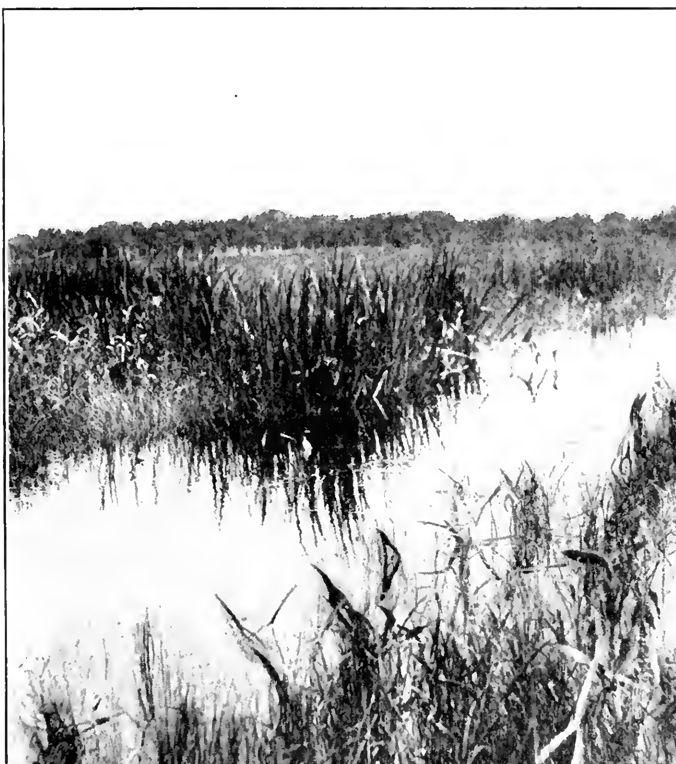

Fig. 155.—East end of alluvial basin. Iris versicolor. Sagittaria latifolia.

INVASION, COMPETITION, AND SUCCESSION.

Forest Invasion of Prairie Along Squaw Creek.

Bordering the narrow strip of timber along Squaw creek narrow tributary ravines cut into the morainal deposit adjacent to the flood-plain. Bordering the forest along the flood-plain are colonies of willow and cottonwood just outside the zones of elm and oak. Following these ravines a short distance from their mouths are lines of *Crataegus mollis*, *Pyrus iowensis*, *Populus deltoides* and *Ulmus fulva*. On the brow of one of these hills are thickets of *Rhus glabra* and young trees of *Ulmus americana*,

Fig. 156.—Anemone patens var. Wolfgangiana. The first and most prominent plant of the spring aspect.

Crataegus mollis, *Pyrus iowensis*, *Vitis vulpina* and *Celastrus scandens* are seen. These are typical pioneer wood trees of this region.

The morainal scallops of hills swing around the turn of the river and are wood covered as they run parallel with the river farther on. Next in the series to the *Rhus Ulmus* ravine is another on the sides of which are *Ulmus americana, Gleditschia triacanthos, Salix* and *Rhus glabra*, among which *Poa pratensis* and *Andropogon scoparius* grow. Beginning in the next glen and extending sparsely across the hillside to the established wood are seen *Ulmus americana, Populus deltoides, Fraxinus viridis, Acer negundo, Pyrus iowensis, Gleditschia triacanthos*, one tree of *Quercus macrocarpa*, one of *Q. rubra* and one of *Acer nigrum*. The ground herbage is blue grass, ruderals, *Andropogon scoparius* and *Artemesia ludoviciana*, which illustrates the overlapping of associations. *Fraxinus, Acer* and *Quercus* are final trees of the terminal forest of this region.

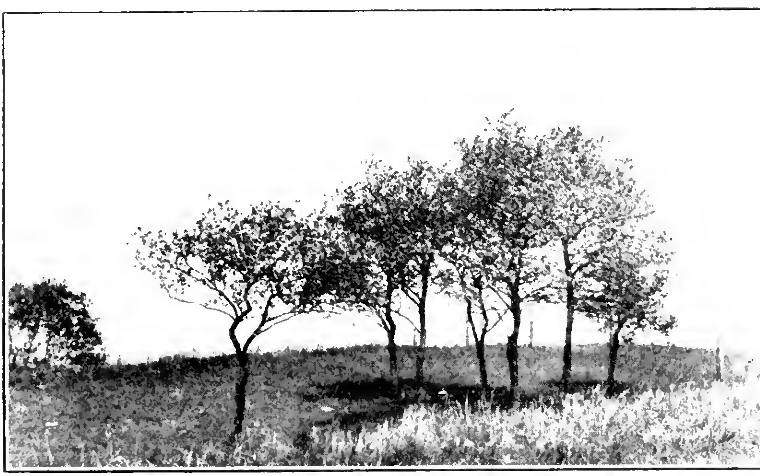

Fig. 157.—Pyrus Iowensis. A tree of the pioneer forest.

These preliminary trees are youngest, most remote from the wood. There are seedlings beneath them. They are seen in the order from the pioneer to the well-known type of the mature forest. There are no stumps or signs of decay in these preliminary clusters. Prairie grasses grow under the first stand of trees which are close enough together to cause much shade. These are in the adjacent established wood replaced by blue grass, wood ruderals and some typical wood plants, among the more conspicuous of which are heart leaved *Viola palmata*, while the dissected leaved *Viola pedatifida* occurs just outside on the prairie on moist slopes and *V. pedata* on slope and ridges. These indications show that forest is here encroaching upon the prairie.

INVASION OF RUDERALS ACCOMPANYING PASTURAGE.

This region has recently been pastured, which condition is affecting the prairie type materially. In the lowland alluvial areas and along the borders of ravines the prairie plants have almost exclusively been driven out by such ruderals as *Ambrosia artemesifolia, Verbena hastata, Polygonum pennsylvanicum, P. persicaria, setaria viridis and Poa pratensis*, though *Baptisia leucantha, Aster novae-angliae, Aster multiflorus* and *Kuhnia* still persist in spots. On the slope *Poa pratensis* is creeping in, giving a marbled appearance where its colonies are supplanting *Aster Drummondi, Solidago rigida, nemorosa, Gentian puber-*

Fig. 158.—Ulmus americana, Populus deltoides and Pyrus Iowensis.—pioneers of the forest advancing up the ravines.

ula, Andropogon scoparius, A. furcatus, Sporobolus cryptandrus, Bouteloua curtipendula, B. hirsuta and *Koeleria cristata,* Lichens, *Cnicus Hillii, Liatris, Cacalia tuberosa, Oenothera biennis* and *Astragalus caryocarpus.* These plants have hard, short, thick subterranean stems with intensive root systems occupying small space. They seem to thrive in the hard, gravelly, stony, dry soil of these hill crests where blue grass and other ruderal invaders have not penetrated. The most of the ruderals thrive best with more of moisture and a finer soil than is here found, hence these hill crest types by their tolerance of this habitat can maintain such a formation much longer after invasion processes have commenced than the hillside and alluvial associations can maintain stability, for the latter are seen to be driven out before the former have begun to give way.

The ability of blue grass to invade formations which for hundreds of years have maintained a balanced type is a phenomenon which has not been satisfactorily explained. It is usually associated with *Verbena stricta* on the hill areas, with *Ambrosia artemesiifolia* throughout its range and quite recently in the vicinity with *Melilotus alba*, which has made its denouement along roadsides and railroads and is continuing its march with blue grass into the prairies. While *Poa pratensis* and *Ambrosia artemesifolia* grow luxuriantly in moderately moist conditions, their

Fig. 159—Ulmus americana, Populus deltoides, Crataegus mollis,—pioneer forest trees on the edge of a prairie ravine.

range extends from hilltop to alluvial basin though they do not thrive where the soil is constantly saturated nor in stony graveled areas. Blue grass possesses a radially extensive, slender, active rhizome with a fine, close network of node roots which forms a firm sod. Its broad range of habitat combined with its virile rhizome system equips it with unusually good qualities for successful invasion. The fact that Ambrosia though an annual has an abbreviated tap root which fits easily between the roots or rhizomes of other plants while it also has a wide range of habitat makes it a good invader. *Melilotus alba* has a tough biennial root and fairly wide range of habitat, having a tendency to endure arid conditions. It is rapidly invading a dry gravelly knoll of one of the prairie hills along Squaw creek which is previously described as a stronghold of the intensive rooted *Andropogons*, *Asters* and *Solidagos*.

Invasion of the Alluvial Basin Meadow.

This blue grass—sweet clover type of invasion has taken place in the last five years in the alluvial basin region below Heuchera hill (See Lists) and in the vicinity there has been a rapid disappearance of the majority of the original plants, yet a few representatives of the original formation remain, among which are

Fig. 160.—Forest bordering Squaw creek advancing toward the prairie.

Panicum virgatum, *Senecio aureum*, *Fragaria virginiana*, *Sium cicutaefolium*, *Cicuta maculata*, *Veronica virginica*, *Lobelia spicata*. No decrease is noted in the number of plants of *Baptisia leucantha*. This plant has a long, tough, thick, deep branched root which is a good reinforcing character. It stands above the surrounding plants and thus has light advantages.

The pond adjacent to the wet meadow area lies also in the pasture but has apparently not been affected. No species have disappeared.

The swamp, though cut late in the year for hay, shows no change in its constituent species except that a willow thicket has grown up along a ditch beside a fence where the grass is not cut. Willows constantly appear in this wet area but are mowed off yearly.

Cutting does not change the constituent character of the highland plants.

Pasturage introduces ruderal plants but most of these do not affect the associations which approach hydrophytic or xerophytic conditions.

Most ruderal plants flourish in mesophytic conditions so that hydrophytic or xerophytic prairie types seem to have fewer competitors than mesophytes.

Fig. 161.—Zone of wood bordering Squaw creek. Populus deltoides and Salix along the edge. Crataegus mollis and Pyrus iowensis advancing toward the prairie.

SUMMARY.

Geology. This area is underlain by rock of the Carboniferous system and Paleozoic group. The present drift deposit of this area is the Wisconsin of the Pleistocene system and Cenozoic group.

Topography. The territory observed consists of: (1) Alluvial basin probably the pre-Wisconsin bed of Skunk river which may have drained a region now occupied by the head waters of Des Moines river; (2) Morainal deposits between the arm of Skunk river and the bend in Squaw creek near Ames.

Edaphic features. The soil types involved are alluvial, sand, sandy loam, loam, gravelly loam and clay loam.

(a) *Water Content.* It is shown by the graphic data that (1) the lowlands contains a materially higher percentage of water than the uplands. (2) There is greater divergence in the percentage contained by the upland surface, subsurface and subsoil than in these corresponding zones of the lowland. (3) The water table of the lowland is quite constant, showing a gradual dip in the autumn. (4) The subsoil curve of the upland is variable, showing an increase in the autumn. (5) The surface curve (loam) of the lowlands shows a higher water content than its subsoil (sand).

(b) *Temperature.* Graphic data concerning the temperature of the air (three feet above the earth) and surface soil (6 in.) taken at 3 p. m. and 5 a. m. show that (1) the temperature of the earth lags behind that of the air; (2) the lowland temperatures range slightly below the upland. A series of temperatures taken in the air three feet above the earth during the months of April, May, June, July, August, September, October and November show that the temperature of the air is materially higher than that of the soil; (3) The soil absorbs heat cumulatively and gradually radiates it, the lower layers lagging behind the upper in its absorption but retaining the heat longer.

Plant formations. This prairie province may be said to comprise four formations: (1) Upland Prairie (2) Meadow (3) Swamp (4) Pond. Every formation has a variety of local factors such as water content, soil and light, which give rise to constantly recurring groups or *associations* in the presence of the same conditions. The chief causes of difference in associations are their habitat features which are not common factors. The principal factors which are not common or which vary in marked degree are (1) type of soil and (2) water content of habitat. Structure of soil has a direct bearing on water content. Water content depends on the type of soil, drainage and rainfall.

Reversion takes place slowly and is rare. A denuded soil usually does not survive the activities of certain introduced ruderals such as blue grass.

Succession. Evidence of invasion of the prairie by forest in ravines or on moist slopes is not uncommon though it seems limited in progress and restricted to moist locations.

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DEPARTMENT OF BOTANY,
IOWA STATE COLLEGE.

A STUDY OF THE POLLEN AND PISTILS OF APPLES IN RELATION TO THE GERMINATION OF THE POLLEN.

J. N. MARTIN AND L. E. YOCUM.

INTRODUCTION.

The failure of a fruit tree to develop a normal amount of fruit may be due to a number of causes as stated by Kraus in volume VI of the Journal of Heredity. However, unless a plant develops fruit parthenocarpically, the development of fruit depends primarily upon how the pollen and pistil function relative to each other. As Kraus points out, fertilization by no means insures the development of a fruit, for very commonly the fruit does not develop despite the fact that normal fertilization occurred, but, on the other hand, in the absence of fertilization, fruit seldom develops among apples.

The aim of the work reported in this paper was as follows: (1) to determine the content of the pollen; (2) to investigate the germination of the pollen in solutions and on membranes with a view to discovering the requirements of the pollen for germination; (3) to determine the effects of different temperatures, of age, and of drying on the germination of the pollen; (4) to determine the structure and content of the stigma and style, whether or not secretions are present on the stigma, and the behavior of the stigma with reference to the germination of the pollen.

It was thought that such investigations might give some information concerning: (1) the effect of rainy weather during the blooming period on the setting of fruit; (2) the condition of the stigma at the time horticulturists regard it as receptive; (3) the time at which artificial pollination can be done most successfully; and (4) whether or not the bagging of flowers practiced by horticulturists in experiments involving artificial pollination has any effect upon the results of pollination due to increasing the moisture content of the air about the flowers.

It is claimed by some that rains during the blooming period prevent the pollen from functioning properly by washing away or diluting the stigmatic secretions. The glistening of the stigma at the time it is considered receptive is interpreted by some as due to the presence of a secretion. If apple flowers can be successfully pollinated at the time they are emasculated then much time can be saved in experimental work involving artificial pollination. Keeping flowers enclosed in bags during pollinating experiments may have considerable effect upon the germination of the pollen. The air enclosed in the bag becomes moist due to the transpiration from the flowers and, if the germination of the pollen is delicately adjusted to a certain amount of moisture, increasing the atmospheric moisture about the stigma may have an effect upon the germination of the pollen.

The apples included in the investigation were Ben Davis, Gano, Wealthy, Dutchess, and Jonathan. The Winesap was included at first but it was found to have very little normal pollen and was discarded. The investigations extended over three consecutive seasons which differed considerably in the character of the weather as to rainfall and temperature during the blooming period, but the requirements for the germination of the pollen and the average percentages of germination obtained under the same experimental conditions were practically uniform for the three seasons. The flowers were collected from the same trees each season and from one tree of each variety. It was not a part of the investigation to determine whether or not different trees of the same variety differ in respect to the germination of their pollen.

SIZE AND SHAPE OF POLLEN.

Excepting the slight bulging of the germ pores, apple pollen in the varieties studied is nearly globular when turgid, and, when measured in a 5 per cent cane sugar solution, ranges in diameter from 34μ to 46μ in Ben Davis, Wealthy, and Dutchess, and 30μ to 38μ in the Jonathan and Gano.

Apple pollen loses water very rapidly when exposed to the air, and in a few minutes the wall folds as a result of shrinking, as shown in figure 163. In this condition one diameter is very much shortened and the other somewhat lengthened. Comparative measurements of pollen in this condition are not reliable because the dimensions vary with the amount of shrinking of the contents and the folding of the walls. Pollen shrinks so rapidly that under ordinary pollinating conditions, it is shrunken when it reaches the stigma. Examinations of pollinated stigmas showed them covered with pollen in the shrunken condition.

CONTENT OF THE POLLEN.

In the young bud, three or more days before the flowers opened, the pollen grains contained much starch as shown in figure 164. The remaining tests were made on pollen from open flowers, and at this time there was no trace of starch, except in a very few apparently undeveloped grains. Occasionally slight traces of sugar were seen, when tested with phenylhydrazine

Fig. 163

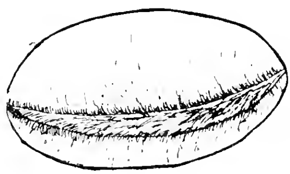
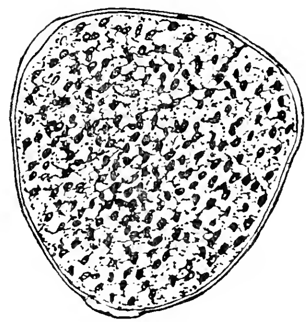


Fig. 164



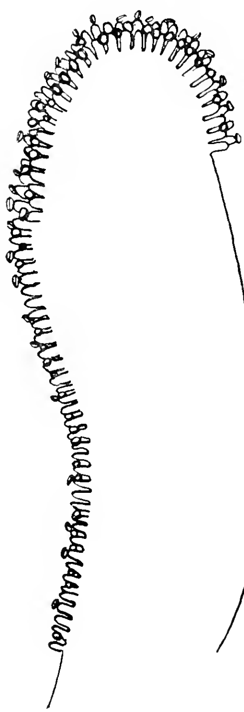


Fig. 165

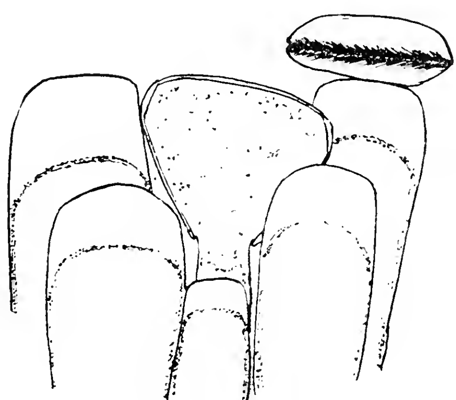


Fig. 166

Fig. 163.—A pollen grain, shrunken and wall folded, a condition of apple pollen after a few minutes exposure to the air.

Fig. 164.—A pollen grain containing much starch.

Fig. 165.—A pollinated apple stigma, showing its papillate character and position of pollen with reference to the papillae.

Fig. 166.—A portion of an apple stigma, at time of pollination, showing papillae with their shrunken protoplasts, one pollen grain which has germinated and another lodged on the end of a papilla and in a shrunken condition.

hydrachloride and sodium acetate, but most of the pollen grains were apparently free from sugar at this stage. With Sudan II and alkanin no reaction for fat was obtained. With Millon's reagent, the pollen turned distinctly red. This reaction was interpreted as indicating the presence of proteins or amino acids. When treated with ruthenium red the contents became distinctly pink and were not decolored by washing. Also the walls reacted slightly to ruthenium red. The pronounced reaction of the contents with ruthenium red is likely due to amino acids. With the methylene blue the walls and sometimes the contents adjacent to the walls stained violet, indicating the presence of pectin. Both Congo red and haemotoxylin stained the walls, thus indicating the presence of cellulose. From the tests it appears that the stored food of the pollen is present in the form of starch in the young bud, but consists of proteins or amino acids, some pectic substances, and occasionally slight traces of sugar at the time of pollination. The constituents of the wall are cellulose and pectic substances.

THE WATER ABSORBING POWER OF APPLE POLLEN.

The water absorbing power of the pollen of the five varieties was found to lie in the same range of variation. Even pollen from the same anther varied much in ability to absorb water. A very small number of pollen grains in some samples became turgid in 70 per cent cane sugar solution after 72 hours. Ninety per cent remained plasmolyzed in 55 per cent cane sugar during 48 hours, while in a 35 per cent solution about 90 became turgid in less than one hour and practically all within 48 hours. The absorbing power of most of the pollen was, therefore, overcome by the osmotic force exerted by cane sugar solutions ranging from 35 to 55 per cent. Calculated according to Berkeley and Hartley[1] these solutions represent an osmotic force ranging from 45 to 105 atmospheres. Even dead pollen showed considerable absorbing power and when put in the weaker solutions dead pollen became turgid in a short time and many burst.

GERMINATION OF THE POLLEN.

In germinating the pollen in solutions, chiefly cane sugar solutions were used, although other sugars were tried and found to be good. The solutions are given in percentages and were made up by adding to the number of grams corresponding to the desired percentage of sugar enough water by weight to make 100

[1]Physical chemistry, Phillips, J. C., p. 51.

grams. About one-half c.c. of the various concentrations were spread over the bottoms of watch glasses and after the pollen, usually ranging from 50 to 200 grains in amount, was introduced, the watch glasses were sealed to prevent as far as possible changes in concentration resulting from evaporation.

The membranes used were pieces of beef's bladder, and were about 1 cm. square. After being soaked 15 or 20 minutes in distilled water and then dried between two blotters, the membranes were put in watch glasses, pollen was spread on their surfaces and the watch glasses were then sealed.

In a mass of pollen from the same flower as well as from different flowers there was such a wide variation in the requirements for germination, that no conclusions could be drawn except from the averages of a large number of tests.

In table I are given the results obtained in two germination tests to show the variations that occurred in the behavior of the pollen in the cane sugar solutions.

TABLE I.

VARIATION IN PERCENTAGES OF GERMINATION OF POLLEN IN WATER AND SUGAR SOLUTIONS AS SHOWN BY COMPARING THE RESULTS OF TWO TESTS.

Medium	Percentage of Germination in Set No. 1.	Percentage of Germination in Set No. 2.
Distilled Water	45	10
2½ per cent cane sugar	55	80
5 per cent cane sugar	50	70
10 per cent cane sugar	60	40
15 per cent cane sugar	70	40
20 per cent cane sugar	75	10
25 per cent cane sugar	30	0
30 per cent cane sugar	8	0

A temperature from 22° to 25° C. was found most favorable for germination. The pollen of the five varieties was quite uniform in requirements and average results obtained in the germination tests of any one variety are representative of those obtained for other varieties.

The investigation first had to do with determining the behavior of the pollen in distilled water and various concentrations of cane sugar solutions at a temperature of 22° to 25° C., this being the temperature found most favorable by other investigators. Table II gives the results obtained with pollen of the Wealthy.

TABLE II.

PERCENTAGES OF GERMINATION AND LENGTH OF TUBES OBTAINED IN DIFFERENT MEDIA IN 16 HOURS AT A TEMPERATURE OF 23° C.

Medium	Percentage of Germination at the End of 16 Hrs.	Approximate Length of Tubes.
Distilled Water	25	1-2 mm
2½ per cent cane sugar	70	1-2 mm
5 per cent cane sugar	60	¾-1
10 per cent cane sugar	60	½-1
15 per cent cane sugar	50	¼-1
35 per cent cane sugar	25	⅙-¾

The average percentage of germination was highest in the 2½ per cent cane sugar solution. As the concentration increased up to 65 per cent, the per cent of germination decreased. A concentration of 65 per cent was the maximum for germination when the period allowed for germination was no longer than 16 hours. However, in some tests, as much as 2 per cent germination was obtained in 72 hours in concentrations of 70 per cent.

The fact that the pollen germinated to a considerable extent in distilled water suggested that the sugar solutions functioned in the germination of the pollen only in controlling the water supply. Comparative tests run in sugar solutions and on membranes (shown in table III) gave further evidence that this was true.

TABLE III.

A COMPARISON OF THE PERCENTAGES OF GERMINATION OBTAINED IN SUGAR SOLUTIONS WITH THOSE OBTAINED ON MEMBRANES, THE TIME PERIOD BEING 12 HOURS.

Variety	In 2½ Cane Sugar Solution.	On Animal Membrane
Wealthy	68	85
Gano	64	90
Jonathan	75	88
Dutchess	80	90

Table III shows that a higher percentage of germination was secured on the membranes than in the sugar solutions. Germination also took place more rapidly and the tubes grew faster and were more nearly normal in appearance on the membranes. In the tubes grown in the solutions, there was clumping of the cytoplasm and some bursting after a few hours, while on the membranes the tubes of the same age were normal in appearance. The membranes were found suitably dried when the surface moisture was removed and this was accomplished by pressing them once between blotters.

The longest tubes obtained in any of the sugar solutions and on the membranes were about 2 millimeters. This limit in growth was attributed to the exhaustion of stored food in the pollen grain, and since no more growth was made in the sugar solution than on the membrane, it was again evident that the pollen tubes did not use the sugar as a food. Even when grown on membranes soaked in sugar solutions, thus eliminating the feature of poor aeration, the tubes were no longer than on membranes soaked in distilled water. It is evident from the behavior of the pollen in water, in the sugar solutions, and on the moist membranes that germination depends only upon a water supply. This water requirement is a little less than the amount of water absorbed when the pollen is in pure water, as is shown by the fact that the largest percentage of germination was obtained in the least time in $2\frac{1}{2}$ per cent cane sugar solution and on membranes. In stronger sugar solutions the pollen, although germinating very little in 2 hours, gradually took up water until the required amount was obtained and then germinated, thus often showing a fair per cent of germination at the end of a long period. In table IV are shown the comparative rates of germination in the different per cents of sugar solution.

TABLE IV.

THE PERCENTAGES OF GERMINATION AND LENGTHS OF TUBES OBTAINED IN THE SAME SOLUTIONS WITH TIME PERIODS OF DIFFERENT LENGTHS.

Solution	Time 2 Hours		Time $6\frac{1}{2}$ Hours		Time 22 Hours	
	Percentage of germination	Length of tubes	Percentage of germination	Length of tubes	Percentage of germination	Length of tubes
Water	15	1/10 mm	15	1 mm	15	$1\frac{1}{2}$ mm
$2\frac{1}{2}$ per cent cane sugar	20	1/6-1/3"	65	$1\frac{1}{2}$ mm	65	$1\frac{1}{2}$ mm
10 per cent cane sugrr	1/20	1/100-1/50	25	$\frac{1}{2}$ mm	60	$\frac{3}{4}$-1 mm
15 per cent cane sugar	1/20	1/100-1/50	25	$\frac{1}{4}$-$\frac{1}{2}$ mm	60	$\frac{3}{4}$-1 mm
20 per cent cane sugar	1/20	1/100-1/50	15	1/50-$\frac{3}{4}$mm	45	$\frac{1}{4}$-1 mm
35 per cent cane sugar	0		0		30	1/10-$\frac{1}{2}$ mm
50 per cent cane sugar	0		0		10	1/20-$\frac{1}{4}$ mm
70 per cent cane sugar	0		0		some germination a end of 72 hours.	

From table IV it is seen that the difference between the percentages of germination in the different concentrations is not so marked at the end of long periods as at the end of short periods. In the long periods there was time for many of the pollen grains in the stronger solutions to secure the required amount of water and germinate. In determining the most favorable solution for germination, it is obvious that it is essential to consider the time element.

UNIFORMITY OF GERMINATION IN THE FIVE VARIETIES.

All of the five varieties, excepting Duchess, have been reported either partly or entirely self-sterile in the work of Lewis, and Vincent (11). Self-sterility in some cases is known to be local, and these varieties may not be sterile in the orchard at Iowa State College. Nevertheless, it was thought worth while to investigate the uniformity of the water requirements of the five varieties by using membranes which had given a more even and a higher per cent of germination than the solutions. This was done by sowing the pollen of the five varieties on a piece of membrane about 2 inches long and 1 inch wide, the pollen of each variety occupying a line running the full length of the membrane. Table V gives the results obtained.

TABLE V.

PERCENTAGES OF GERMINATION AND GROWTH OF TUBES OF THE POLLEN OF THE FIVE VARIETIES UNDER SIMILAR CONDITIONS.

Variety	Percentage of Germ. at the End of 3 Hrs.	Length of Tubes.
Duchess	90	½-1 mm.
Jonathan	92	½-1 mm.
Wealthy	85	½-1 mm.
Gano	90	½-1 mm.
Ben Davis	80	½-1 mm.

Table V shows some variation in the germination of the pollen of the different varieties, but so little that all five can be considered uniform in the water requirement for the germination of their pollen. It is, therefore, obvious that self-sterility, self-fertility and inter-fertility among these five varieties do not depend upon a difference in the water requirement for the germination of their pollen. Some pollinating experiments were carried on in the orchard to test out this assumption. For example Jonathan, reported as entirely self-sterile by the Oregon Agricultural Experiment Station, was self-pollinated and stigmas examined after 48 hours. On 20 stigmas examined 118 pollen grains were counted and 24 of the number had germinated, the number of germinations on a stigma ranging from 2 to 6. The results show that the pollen of the Jonathan can germinate on its own stigma and if this variety is self-sterile in the orchard of the Iowa State College the cause can not be attributed to the inability of the pollen to germinate on the stigmas of the Jonathan.

THE EFFECT OF AGE AND DRYING ON THE GERMINATION OF THE POLLEN.

In determining the effect of age and drying, pollen was taken from buds about two days previous to opening, from flowers in which the anthers were dehiseing, and from flowers which had been stored in paper bags in the laboratory. The average of a number of germination tests of pollen from buds and open flowers were 75 and 87 per cent. The results show that pollen taken from flowers just previous to their opening or about the time the flowers are emasculated in pollinating experiments is about as good as pollen from anthers which are dehiseing. The pollen stored in the paper bags all died within 18 days and very little was found viable after 12 days' storage. It was also found that exposure to sugar solutions in which the pollen remained plasmolyzed soon resulted in death. More than 90 per cent were killed when exposed to a 70 per cent cane sugar solution for 72 hours.

EFFECT OF TEMPERATURE ON GERMINATION.

Table VI shows the effect of varying the temperature on germination of the pollen of the Wealthy, and the same was true for the pollen of the other varieties.

TABLE VI.

EFFECT OF TEMPERATURE ON RATE OF GERMINATION AND GROWTH OF TUBES.

Temperature 23°	Time 3 hrs.		Time 18 hrs.	
Medium	Percentage of germination	Length of tubes	Percentage of germination	Length of tubes
Water	25	1/10 1/5 mm.	30	1-2 mm.
2½ per cent sugar so.	55	1/10-1/5 mm.	80	1-2 mm.
5 per cent sugar so.	25	1/20-1/10 mm.	60	½-1 mm.
10 per cent sugar so.	15	1/20-1/10 mm.	50	¼-½ mm.
Membrane	70	1/10 1/4 mm.	95	1-2 mm.
Temperature 10°				
Water	0		35	¼-½ mm.
2½ per cent sugar so.	0		60	¼-½ mm.
5 per cent sugar so.	0		40	1/10-¼ mm.
10 per cent sugar so.	0		30	1/10-¼ mm.
Membrane	10	1/20-1/10 mm.	65	
Temperature—1.5°				
Water	0		0	
2½ per cent sugar so.	0		0	
5 per cent sugar so.	0		0	
10 per cent sugar sol.	0		0	
Membrane	0		5	1/20-1/10mm.

From table VI it is seen that low temperatures retard germination but do not prevent it, even at —1.5° C. With more time allowed the percentage of germination at —1.5° would very likely have been greater. In accord with the results of other investigators, the pollen was found to be exceedingly resistant to cold. Pollen kept frozen up solid in water and sugar solutions for three or four hours gave a normal percentage of germination when its germination capacity was tested, thus showing no bad effects from cold.

PISTIL.

THE NATURE OF THE STIGMA.

The stigma is papillate as shown in figure 165. At the opening of the flower the papillæ have reached their full development. They have very thin cellulose walls which in some cases contain pectin and their protoplasm consists of a very thin peripheral layer enclosing a single large vacuole. The sap filling the vacuoles occasionally contained small traces of cane sugar and sometimes substances reacting to the tests for pectin. The amount of pectin in the walls varied in different papillæ on the same stigma, some giving no evidence of any, while others showed a distinct color reaction with ruthenium red and methylene blue. There was no reaction with Sudan III, or Millon's reagent. At the opening of the flower the protoplasmic layer had pulled away from the wall at the apex of some of the papillæ as shown in figure 166. This shrinking continued in the open flowers, and in a few days, ranging from three to six, when flowers were left exposed on the trees, the walls of the papillæ over the upper surface of the stigma were completely collapsed and the protoplasm was becoming brown. This death of cells moves rapidly down the style and in a period of a few days, both stigma and style are dead and withered.

It is the reflection and refraction of light from the vacuoles and from the outer surface of the plasmic membranes when pulled away from the walls that cause the glistening which by some is regarded as an indication that the stigma is receptive. At this stage the papillæ would not become turgid when water was supplied and they showed no change when immersed in strong salt or sugar solutions. Judging from the behavior of their protoplasms toward solutions, the papillæ are dead at the period of pollination. The brown color which the stigma soon takes on after the flower opens is further evidence of the early death of the papillæ.

The styles and stigmas are much more sensitive to cold than the pollen. As indicated by taking on a brown color and becoming dry and brittle very soon, the styles were killed by an exposure of an hour to a temperature of —1° C.

THE SECRETIONS AND THE GERMINATION OF THE POLLEN ON THE STIGMA

The stigma is commonly considered a secreting organ, and the notion is prevalent that stigmatic secretions have much to do with the germination of the pollen. Stigmatic secretions may have much to do with the germination of pollen in many plants, but very likely too much has been attributed to them.

During the blooming period of 1916 there were a number of warm, bright days which afforded an opportunity to study the stigmas. Warm, bright days favor insect pollination and statistics show that such days during the blooming period are most favorable for the setting of fruit. On warm, bright days the stigmas should be free from condensed atmospheric moisture and thus any liquids present could be regarded as secretions. In the study of the stigma, pistils left exposed and pistils enclosed in paper bags and cheese cloth were used.

Stigmas ready for pollination and some that were pollinated under control were brought into the laboratory and examined for secretions. On bright, warm days when the pollen was germinating well on the stigma, no liquids could be seen on the surface of the stigma with the compound microscope. When mounted in oil there was no evidence of any liquid in the space between the papillæ. The liquid was being lost from the papillæ by evaporation and not by exudation. Even on stigmas kept enclosed in paper bags no liquid was found.

Only a small percentage of the pollen on a well pollinated stigma is suitably located for germination. The favorable location is between the papillæ as shown on figure 166. Those on the tips of the papillæ were only rarely observed to absorb enough moisture to become turgid. The observations on the five varieties studied, showed that the germination of the pollen does not depend upon stigmatic secretions, which exude from the stigma but upon the ability of the pollen to draw liquids from the papillæ, and it is obvious from the nature of the pollen that water is the only liquid necessary to start germination. Pollen lodged between the papillæ was able to absorb from the papillæ the required amount of water for germination. The problem as to what effect liquids have on germination when present on the stigma was not worked out. Since apple pollen germinates poorly in water, it is reasonable to infer that pollen germinates poorly on a stigma wet with rain, and the fact that rain during the blooming period is unfavorable to the setting of fruit may be attributed in part to this. Of course such weather is usually accompanied by a low temperature, which retards the germination of the pollen, and such weather is also unfavorable to pollination by insects. A number of factors are concerned, but so far as we could determine, there is no basis for the theory that rains wash away or dilute the stigmatic secretions and thereby prevent the setting of fruit.

It has also been stated that freezing temperatures kill the stigmas which consequently do not function properly and as a result pollination is not effective on the stigma. This point was investigated, but to a very limited extent. Clusters of flowers were exposed to freezing temperatures until the styles were killed. The flowers were then removed to a temperature of about 25° C. and their stigmas pollinated with pollen that had been at room temperature. On the stigmas of these dead styles very good germination of the pollen was obtained.

THE STYLE.

The style is grooved just below the stigma, the groove being almost a millimeter in length. In this region there are many small vascular strands which reach to the base of the stigma and within a few cells of the papillæ. The outer walls of the epidermal cells are cutinized. When stained with safranin the line separating the papillæ of the stigma and the epidermis of the style is quite distinct. Tests for sugar at the time of pollination with phenylhydrazine hydrochloride and sodium acetate gave the results shown in table VII.

TABLE VII

Variety	Reaction of Styles to Sugar Tests.
Duchess	Abundance of cane sugar about 2 mm. below stigma and occupying a section of about 2 mm.
Gano	In some cane sugar about 3 mm. below stigma and occupying a section of about 2 mm.
Jonathan	No sugars found.
Ben Davis	Abundance of cane sugar about 2 mm. below stigma and occupying a region of about 2 mm.
Wealthy	Same as Gano.

In some cases in the same flower, some styles showed abundance of cane sugar while others showed none. In Gano there was much more cane sugar in the styles before the flowers opened than at pollination. The sugar when present was found abundant in the sieve vessels.

DISCUSSION.

The investigations so far show that there are two classes of pollen grains, one requiring only water for germination, the other requiring besides water the addition of chemical substances such as acids, sugars and salts. Plants having pollen belonging to the first class have long been known, Mohl (15) having discovered in 1834 that the pollen of the *Marina* would germinate in water. As investigations go on the list of plants known to have this type of pollen is being rapidly extended. Hansgirg (5) germinated the pollen of *Phalaris brachystachya* in water. The pollen of other grasses investigated by him bursts in water. Lidfors (9, 10) germinated the pollen of some species of *Rhododendron, Azalea, Erica, Nicotiana* and *Glaucium* in distilled water. Molisch (16) germinated the pollen of *Amorpha fruticosa, Colutea arborescens* and fifteen other species of plants in saturated air. Jost (7) found that the germination of the pollen of a number of the grasses depended upon a limited water supply, and he was able to germinate the pollen of *Arrhenatherum elatius, Dactylis glomerata, Bromus mollis, Glyceria aquatica, Secale cereale, Zea Mays* on starch paste and on parchment paper soaked in water or sugar solutions and properly dried. The pollen of *Dactylis* germinated when spread on the under surface of the leaves of *Limnanthemum nymphaeoides*. The pollen of a number of the *Compositae* and *Umbelliferae* Jost germinated on parchment paper only when they were soaked in sugar solutions and properly dried. He did not determine whether or not the sugar had any other function than that of controlling the water supply. Martin (13, 14) found the germination of the pollen of *Trifolium pratense, Trifolium hybridum and Medicago sativa* to depend upon water supply which could be controlled artificially by germinating the pollen on animal membranes soaked in water and properly dried.

Tokugawa (22) found that the pollen of some of the *Compositae and Umbelliferae* which previous investigators failed in germinating, germinated in 25 to 50 per cent sugar solutions and on parchment paper. He concluded that the germination of the pollen of these plants depended only upon water supply. An examination of the stigmas of these plants showed that there was no secretion and that the pollen absorbed the required amount of water from the papillae. Tokugawa (22) germinated the pollen of *Brassica campestris* on the under epidermis of leaves of *Vicia faba*. He concluded after germinating the pollen of a number of plants, that, in general, germination depended upon a proper water supply.

In the germination of the pollen of the second class, in addition to water the addition of some chemical substance has been found to increase the percentage of germination. The addition of various percentages of sugar has been found helpful in germinating the pollen of many species. Rittinghaus (18) and Max Pfund (17) found that the pollen of a large number of species would germinate in cane sugar solutions, the concentrations ranging from 20 to 50 per cent. Kny (8) and Mangin (12) found that better germination was secured when gelatin was added to the sugar solution. Careful investigations of the function of those substances such as sugar, gelatin and some others which seem necessary for the germination of the pollen of some species may show that they function only in controlling water absorption. In some cases there is evidence that the pollen uses the sugar as a food. In some cases, the substance seems to act as a stimulant and only very small percentages are required. Molisch (16) found that the addition of about 0.01 per cent of calcium malate or malic acid to the sugar solution caused the pollen of *Azalea* and *Rhododendron* to germinate. In the germination of pollen of some species of *Erica* and *Menziesia*, Lidfors (9) observed that the addition of a small amount of citric acid to the sugar solution increased germination. Burck (2) was able to germinate the pollen of some species of *Mussaenda*, *Begonia*, and *Pavetta* in distilled water only after the addition of a portion of the stigma or a trace of levulose. Sandsten (19) found that a slightly acid medium is required for the germination of tomato pollen.

Both Strasburger (21) and Tokugawa (22) have shown that in many cases pollen will germinate on the stigmas of plants differing widely in relationship. The pollen of some Monocotyledons germinated on the stigmas of Dicotyledons, and vice versa. In ealh case the tubes penetrated the stigma ,but their growth was checked in the style and hence they did not reach the ovules.

As to the content of pollen, Van Tieghem (23) found that the pollen of many plants at the time of pollination contains much starch which disappears as germination proceeds. Sandsten (19) found starch in the pollen of a number of plants but does not state the age of the pollen or whether or not apple pollen was included in the investigation. In apple pollen, we found abundance of starch present in the early bud stage but none at the time of pollination.

Sandsten (19) and Adams (1) have investigated the germination of apple pollen, both using sugar solutions, but neither determined the function of the sugar in the solutions or investigated the stigma in relation to the germination of the pollen. Of the five varieties included in our work, Sandsten included the Duchess. We found 2½ per cent cane sugar solution most favorable for germination, which is closely in accord with their results, Sandsten using 3 per cent and Adams 5 per cent solutions. In our work the sugar was found to aid only in controlling the water supply. Better germination was secured on membranes soaked in distilled water and then dried until surface moisture was removed. Examinations of stigmas under ordinary conditions of pollination showed no liquids on the surface and that the situation of the pollen on the stigma is similar to that on the membrane.

The temperature found in our work to be the most favorable for germination was in accord with the observations of Sandsten and Adams. Schaffnit (20) and Chandler (3) exposed apple pollen to temperatures of —17° C. and —18° C. for long periods when the pollen was dry without any apparent injury. Sandsten (19) found that an exposure of apple pollen to a temperature of —1.5° for less than one hour resulted in very little injury. He exposed the pollen on dry watch glasses. Chandler (3) does not state how the pollen was exposed which he considered not dried and found not injured by a temperature of —8° C. We found that pollen could be frozen up solid in water and sugar solutions without being injured.

Sandsten found the stigmas more susceptible to cold than the pollen. They were killed when exposed a few hours to a temperature of —1.5° C. He does not state how the injury was indicated. We found that the stigma at the time of pollination is apparently dead under ordinary conditions, but that temperatures a little below freezing kill the style. We also found that pollen germinates on a stigma which has been exposed to a temperature low enough to kill the style.

The length of time which pollen can remain viable in storage depends very much upon storage conditions. Lidfors (9, 10) and Pfundt (17) have shown that pollen kept uniformly dry remains viable much longer than pollen exposed to variations in moisture. Tokugawa (22) kept some pollen of four species of plants stored under uniformly dry conditions and some stored in a room where it was exposed to the fluctuating moisture content of the air. The pollen in constant dryness retained its vitality from 31 to 98 days while that stored in the room retained its vitality only from 9 to 24 days. Molisch (16) found the longevity in storage to range from 12 to 72 days in a number of plants which he investigated. In the grasses Jost (7) found the longevity to range from 1 to 8 days.

Sandsten (19) obtained some germination in apple pollen after a storage of six months. Adams (1) obtained germination after a storage of three months. Lewis and Vincent (11) found apple pollen to be effective after a storage of three weeks in vials plugged with cotton. Crandall (4) found that apple pollen which had been stored more than 11 days did not give satisfactory results in pollination experiments. In our work, the pollen of flowers kept in paper bags on a table in the laboratory, gave no germination after a storage of 18 days.

Observations and statistics show that the weather conditions at the time of pollination have an important influence on the setting of fruit. Hedrick (6) concluded from statistics ranging over a period of twenty-five years, that rain and the accompanying cold and wind cause the loss of more fruit than any other climatic factor. In his opinion there are several ways in which wet, cold weather interferes with the setting of fruit. One is that the stigmatic secretion, which he thinks is very much essential to the proper germination of the pollen, is either washed away or so diluted that the pollen does not germinate. His statistics show that bright, warm, dry weather at the time of blossoming is the most favorable for good crops of fruit. He adds that under these conditions there is more and better pollen produced, and that the stigmas show a greater amount of secretion. On bright, warm days, we found no evidence of any secretion on the surface of the stigmas in the five varieties of apples investigated. The pollen germinated when lodged between the papillæ in the absence of any secretion. It was found that immersing in water and low temperatures retarded the germination of the pollen. If the weather is cold and wet at the time of blossoming, both the presence of water on the stigmas and a low temperature may interfere with the proper functioning of the pollen. On bright days the stigmas were more glistening than on cloudy days, due to the greater reflection and refraction of light by the papillæ, which to the unaided eye resembled small drops of liquid.

SUMMARY.

The pollen of the five varieties of apples studied contain proteins or amino acids, some pectin and occasionally small amounts of sugar at the time of pollination. The walls are composed of cellulose and pectin. In the early bud stage there was much starch present. The ability to absorb water varied much for different pollen grains, but most of them remained plasmolyzed in 55 per cent cane sugar solution.

The concentrations of cane sugar solutions for germination varied much for different pollen grains, ranging from pure water to 70 per cent concentration. The most favorable concentration was found to be 2½ per cent. The pollen was able to germinate in any concentration from which it could absorb the required amount of water. As the length of the germinating period increased in the higher concentrations the per cent of germination and length of tubes increased. The sugar in the solution was found to serve only in controlling the absorption of water, and better germination and tubes fully as long were obtained when the pollen was germinated on animal membrane. The conditions required for germination were found to be the same in the five varieties.

A temperature ranging from 22° C. to 25° C. was found most favorable for germination. Lowering the temperature slowed germination. Apple pollen is very resistant to cold, apparently suffering no injury from being frozen.

Pollen from flowers stored in paper bags and left on table in the office were all dead at the end of 18 days.

The stigma is papillate. The papillæ have thin cellulose walls and a thin peripheral layer of protoplasm enclosing a single large vacuole. The cell sap of the papillæ is very dilute, exerting very little osmotic pressure and at the time of pollination the papillæ covering the apex of the stigma are much shrunken and in a few days collapse and become brown. The styles of the pistils in most cases were found to contain much cane sugar, but the sugar was always found at some distance below the stigma.

No secretions were found on the stigma when conditions were most favorable for pollination. The favorable location of the pollen grains on the stigma was found to be between the papillæ. When so located they absorbed the required amount of water and germinated. The pollen on the ends of the papillæ was observed in nearly all cases to remain plasmolyzed.

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NOTES ON AN INTRODUCED WOODLAND FLORA.

R. I. CRATTY.

It is seldom that one sees a tract of our original prairie broken up, planted to trees and then left in such a condition that the natural agencies for the distribution of plants are given a free hand in introducing a typical woodland flora. Such, however, was the good fortune of the writer, and a few brief notes regarding the matter may not be devoid of interest to the members of this Academy.

Just across the road from what was the writer's home for forty years, there is located an artificial grove of two or three acres, on section twelve, Armstrong Grove township, Emmet county, Iowa, which was planted about 1870 when the land was part of the homestead of C. B. Mathews. Like all the artificial groves set out by the early settlers it was intended to serve as a windbreak, the owner expecting to build a new house just south of it. But after proving up he sold his land to the owner of the adjoining quarter on the east and the grove, which had been thoroughly cultivated, the original flora being almost entirely destroyed, was left to the kind hands of Mother Nature to furnish the undergrowth plants. The grove being three-quarters of a mile from the new owner's residence, it was left entirely alone so far as regards any depredations by poultry, hogs or other kinds of stock.

As the ground sloped gently towards the northeast the moisture was fairly well conserved, and in a few years after the trees, which were cottonwood, Lombardy poplar and white willow, had attained a considerable size, a typical woodland humus was formed, and the introduction of new species of plant life began.

The nearest native timber is about three miles south along the east fork of Des Moines river. Six miles north occurs a larger tract around Iowa lake, and another grove is found on the south shore of Swan lake, about ten miles west.

The introduced plants were undoubtedly almost entirely indebted to the birds for their new location. Some grew from seeds which passed uninjured through the digestive tract, others perhaps adhered to their feathers, while two ferns very likely owed their introduction to the spores being carried on the muddy feet or legs of our feathered friends.

Among the trees and shrubs were many specimens of the common wild plum, *Prunus americana* Marshall, and prickly ash, *Zanthoxylum americanum*, Mill. while the Virginia creeper, *Psedera quinquefolia* (L.) Greene, and wild grape, *Vitis riparia*, were everywhere common and on the hedge along the highway grew the climbing bitter sweet *Celastrus scandens* L. Numerous clumps of the smooth-fruited wild gooseberry, *Ribes gracile* Michx., the wild black currant, *Ribes floridum* L'Her. and the black raspberry, *Rubus occidentalis* L. occurred throughout. The latter shrub, however, probably was introduced from the cultivated form on some neighboring farm. Sweet cicily, *Osmorrhiza brevistilis* D. C., was very common, as was beggar ticks, *Lapula virginiana* (L.) Greene. Dogbane, *Apocynum androsaemifolium* L., was fairly common, as was also a species of brome grass, *Bromus ciliatus* L. A beautiful little orchid and one of the rarest species in the state, paid the grove a visit, but remained only a few years—the tway-blade, *Liparis loesellii* Richards. Two of the most interesting plants found were ferns, *Asplenium filix-foemina* Bernh. and *Onoclea sensibilis L.*, of which there were several clumps, all comparatively close together, and giving every indication of having been introduced at the same time. The many forms of lower plant life which occurred probably owed their introduction in a large measure to the wind. Among the great number and variety of fungi were beautiful specimens of the earth-star fungus, a species of *Geaster*. Numerous mosses and lichens were found on the trees. It is interesting to note that one day when Dr. Thomas H. Macbride of our State University was a guest of the writer, in company with him a half hour was spent under favorable weather conditions in searching for slime-moulds in this grove, with the result that over a dozen species were found and identified by him.

The quarter-section is now in possession of a new owner who has erected a set of buildings just south of the grove and in the two years that have elapsed since this occurred the plants I have here noted have, with the exception of the hardy shrubs, been very largely exterminated.

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SOME PHENOLOGICAL RECORDS OF SPRING FLOWERING PLANTS OF HENRY COUNTY.

H. E. JAQUES.

For four years, a record has been kept of the date of the first flower to be found growing in open ground out of doors, of our native and introduced plants of Henry county. In practice nearly all of the specimens have come from in and around Mount Pleasant. Much of the collecting has been done by students in the college classes, the number employed each year ranging from fifteen to forty.

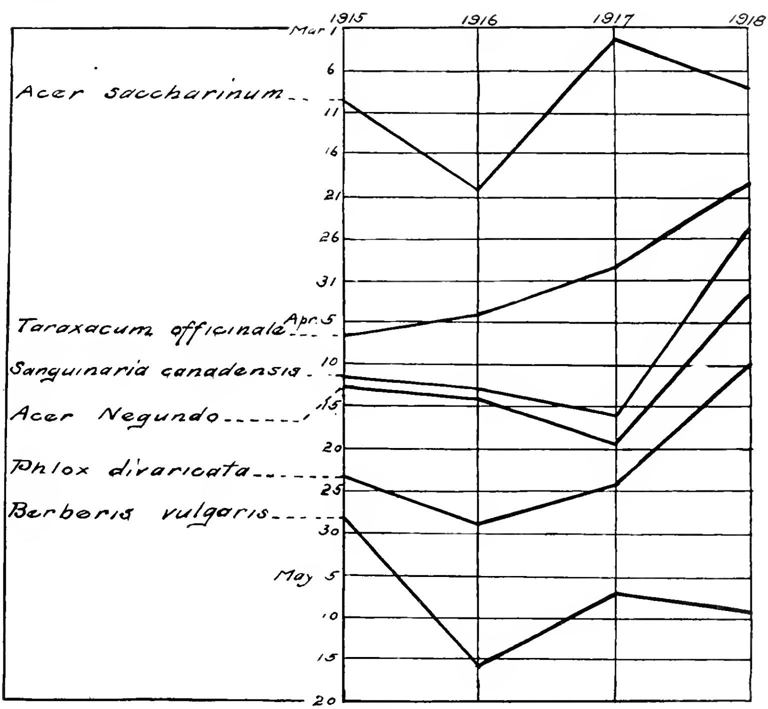

Figure 162

The plan followed has created such keen rivalry among the collectors that the dates represent the earliest appearance of flowers. The dissemination of pollen has been the test of the flowering stage in cases of doubt. The number of species reported up to June 1 have averaged about 240.

The accompanying table shows the date for each of the four years on which the first flower of a number of representative plants was collected. A comparison of the four springs in terms of plant development may more readily be had from the graph. It is interesting that while the spring of 1918 did not start off as early as the spring of 1917, it soon became earlier and was the earliest of the four years studied until about the middle of April when the few weeks cold weather caused it to become relatively later.

If opportunity is afforded, the writer hopes to continue the record for several years, which will make possible a more complete and more accurate study.

Scientific Name	Common Name	1915		1916		1917		1918	
Galanthus nivalus	Snow Drop	March	9	March	11	Feb.	26	March	8
Acer saccharinum L.	White Maple	March	9	March	20	March	3	March	8
Populus tremuloides Michx.	American Aspen	April	6	April	4	March	3	March	18
Ulmus americana L.	White Elm	April	6	April	4	March	7	March	18
Trillium nivale Riddell	Dwarf White Wake Robin	April	7	April	4	March	26	March	18
Taraxacum officinale Weber	Common Dandelion	April	7	April	4	March	29	March	19
Hepatica triloba Chaix	Liverleaf	April	11	April	4	March	2[illegible]	March	19
Capsella Bursa-pastoris (L.) Medic.	Shepherd's Purse	April	7	April	4	April	10	March	18
Dicentra Cucullaria (L.) Bernh.	Dutchman's Breeches	April	12	April	5	April	10	April	1
Anemonella thalictroides (L.) Spach	Rue Anemone	April	11	April	15	April	2	April	2
Sanguinaria canadensis L.	Bloodroot	April	12	April	13	April	16	March	25
Populus deltoides Marsh.	Cottonwood	April	14	April	18	April	13	April	2
Claytonia virginica L.	Spring Beauty	April	15	April	15	April	12	April	2
Acer Negundo L.	Box Elder	April	13	April	14	April	19	April	2
Fragaria sp.	Strawberry	April	17	April	15	April	26	April	10
Amelanchier canadensis (L.) Medic.	Service Berry	April	19	April	18	April	21	April	9
Ranunculus abortivus L.	Small Flowered Crowfoot	April	20	April	19	April	20	April	12
Erythronium albidum Nutt.	White Dog's-tooth Violet	April	19	April	18	April	21	April	15
Phlox divaricata L.	Blue Phlox	April	23	April	28	April	23	April	10
Berberis Vulgaris L.	Common Barberry	April	28	May	16	May	7	May	9

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Iowa Wesleyan College.

THE FERN FLORA OF NORTHEASTERN IOWA.

T. J. FITZPATRICK.

The writer spent the months of June and July, 1895, in this portion of Iowa, camping and traveling along Oneota or Upper Iowa and the Mississippi rivers. While all available botanical specimens were collected special attention was given to the ferns and a good representation was secured. In the following year Mr. Herbert Goddard, then a resident of Decorah, Winneshiek county, sent the writer a collection he had secured in the vicinity of his home. During the years from 1899 to 1902 the writer had a valued correspondent, Mr. Ellison Orr, who resided at Waukon, Allamakee county. Mr. Orr's fine specimens were accompanied by many valuable critical notes. From these sources of information the following article has been written.

This portion of Iowa possesses for Iowans a peculiarly quiet scenic beauty, being the most broken or rolling and the most wooded of any portion of the state. Iowa as a whole is a broad expanse of gently undulating prairie with the characteristic flora modified by civilization. In northeastern Iowa there are more high hills, rugged cliffs, deep ravines, perennial springs, piny woods, rapid flowing streams than there are to be found in any other region of the same size in the state. Being the least affected by cultivation many natural park sites are available, some of which are destined to be utilized in the near future.

In the region under consideration Winneshiek and Allamakee counties are bounded on the north by Minnesota; and Allamakee, Clayton, and Dubuque counties lie along the west bank of Mississippi river. Most of the region lies in what is known as the driftless area, that is an area of rounded hills with no drift mantle or debris while all the surrounding region is heavily drift covered.

Geologically this region, generally speaking, is the oldest in the state. The Saint Croix sandstone of the Cambrian era, the Oneota limestone, the Saint Peter sandstone, the Trenton limestone, the Galena limestone, and the Maquoketa shales are successively exposed from the state line southward.

A locality with so varied a topography readily gives many favorite habitats for ferns. Almost every fern native of Iowa may be found and many of them are quite abundant in occurrence.

OPHIOGLOSSACEÆ.

Botrychium virginianum (L.) Swartz. Rich woods; numerous; Winneshiek, Allamakee, Clayton, and Dubuque counties.

OSMUNDACEÆ.

Osmunda claytoniana L. Rich woods; common; Winneshiek, Allamakee, Clayton, and Dubuque counties.

POLYPODIACEÆ.

Onoclea sensibilis L. In rich moist soil; plentiful; Winneshiek, Allamakee, Clayton and Dubuque counties. This species is very abundant on the high islands in Mississippi river, east of Waukon Junction; there is also a small colony in a springy slough near Postville.

Onoclea struthiopteris (L.) Hoffm. (*Matteuccia struthiopteris* (L.) Todaro.) The specimen was collected in Allamakee county by Mr. Ellison Orr who reports that the species is abundant in rich soil at the foot of bluffs along the Mississippi river at Waukon Junction and north of Lansing, also north of McGregor and near Beulah, Clayton county; there are also occasional plants along Village creek and Oneota river, in Allamakee county, in suitable localities. The species has been collected also in Dubuque county.

Woodsia obtusa (Spreng.) Torrey. The specimen from Allamakee county was collected by Mr. Orr who found it growing on great fragments of rock at the foot of the bluff, one-half mile east of Ion, on Yellow river. The species has also been found in Winneshiek county.

Woodsia ilvensis (L.) R. Br. Professor B. Shimek reports finding this species in two localities northeast from Hesper, Winneshiek county.

Woodsia scopulina D. C. Eaton. In 1900 Mr. Herbert Goddard, of Decorah, sent the writer a specimen found nearby which at the time was reluctantly referred here, but on further examination it is considered to belong to the preceding species

Cystopteris fragilis (L.) Bernh. (*Filix fragilis*(L.) Underwood). Rich calcareous or moist soil in woods; common; Winneshiek, Allamakee, Clayton, and Dubuque counties.

Cystopteris bulbifera (L.) Bernh. (*Filix bulbifera* (L.) Underwood). Rich calcareous soil; common; Winneshiek, Allamakee, Clayton, and Dubuque counties.

Aspidium goldianum Hook. (*Dryopteris goldiana* (Hook.) A. Gray). Winneshiek and Allamakee counties, in rich woodsy soil in timber growing on bluff sides near Decorah and south of Waukon Junction and north of Lansing, and other similar localities. The species is rather rare even in localities where found.

Aspidium thelypteris (L.) Sw. (*Dryopteris thelypteris* (L.) A. Gray.) Winneshiek and Allamakee counties; wet soil; plentiful. This species is common on marshy islands of Mississippi river and occasionally is found in sloughs in this region. The writer also has a specimen from the neighboring county of Fayette.

Aspidium marginale (L.) Sw.(*Dryopteris marginalis* (L.) A. Gray). The only specimen the writer has from this region is from Allamakee county, sent by Mr. Ellison Orr who writes: "growing on a timbered, shady, steep north slope of a sandstone bluff capped by limestone, about seven miles northeast of Postville on Yellow river, only one colony—a fine one—discovered so far in the county." This is a rare fern for Iowa.

Phegopteris dryopteris (L.) Fee. (*Dryopteris dryopteris* (L.) Britton). The writer has specimens from Winneshiek and Allamakee counties which are referred here. The habitat is moist rocky woods.

Phegopteris robertiana (Hoffm.) A. Br. (*Phegopteris calcarea* Fee. *Dryopteris robertiana* (Hoffm.) C. Chr.) This species closely simulates the preceding of which it may be a variety or only a form. Specimens are at hand from Winneshiek and Allamakee counties. The specimens from Allamakee county are from Mr. Orr who writes: "very abundant where collected on mossy, partly shaded, rocky talus at foot of, and on north side of high and steep bluff along south side of Yellow river, the only station I know in Allamakee county."

Phegopteris hexagonoptera (Michx.) Fee. (*Dryopteris hexagonoptera* (Michx.) C. Chr.). Allamakee county, the writer's specimen is from Mr. Orr who reports: "a few scattering plants on north side of wooded bluff, Waukon Junction, Iowa."

Camptosorus rhizophyllus (L.) Link. Winneshiek, Allamakee, Clayton, and Dubuque counties; rocky limestone soil in woods; abundant; often growing on the tops of large detached boulders at the bottom of deep, shaded ravines.

Asplenium angustifolium Michx. (*Asplenium pycnocarpon* Spreng.) Allamakee county; in rich shaded wood soil on slopes and at the foot of timbered bluffs at Waukon Junction and at

Lansing; uncommon or rare; seemingly preferring the bluffs near Mississippi river. A specimen from Jackson county also is at hand.

Asplenium filix-foemina (L.) Bernh. (*Athyrium filix-foemina* (L.) Roth). Winneshiek, Allamakee, Clayton, and Dubuque counties. Woods and thickets, the most abundant fern and very common throughout this region as well as all the wooded portions of the state.

Asplenium acrostichoides Sw. (*Asplenium thelypteroides* Michx. *Athyrium thelypteroides* (Michx.) Desv.) Allamakee and Dubuque counties. Mr. Orr writes: "two small colonies near Waukon, one at Lansing, probably rare in the county."

Adiantum pedatum L. Winneshiek, Allamakee, Clayton, and Dubuque counties; rich woods; common.

Pteris aquilina L. (*Pteridium aquilinum* (L.) Kuhn). Winneshiek, Allamakee, Clayton, and Dubuque counties; quite common. The habitat is medium dry or moist soil along hillsides covered with thickets or woods.

Pellaea atropurpurea (L.) Link. Winneshiek, Allamakee, Clayton, and Dubuque counties. Found also in the neighboring counties of Fayette and Delaware. This species prefers limestone cliffs but grows on sandstone. Mr. Orr notes: "Abundant throughout Allamakee county on all limestone rocks. Shows most luxuriantly where rocks are moist and shaded. Grows abundantly in rock cuts of C. M. & St. P. R. R. west of McGregor. I have seen very fine specimens near Harpers Ferry, Iowa."

Pellaea stelleri (S. G. Gmel.) Watt. (*Pellaea gracilis* Hook. *Cryptogramma stelleri* (Gmel.) Prantl.) Winneshiek, Allamakee, Clayton, and Dubuque counties. Frequent to common in limestone or sandstone cliffs. Mr. Orr writes for Allamakee county: "very abundant in moist soil in pockets and crevices of a ledge of St. Peter sandstone, three miles east of Waukon, Iowa, also found at stations near Myron on Yellow river, growing in moist soil in crevices of Trenton limestone".

Cheilanthes lanuginosa Nutt. (*C. Féei* Moore. *C. gracilis* (Fée) Mett.) Winneshiek, Allamakee, Clayton, and Dubuque counties; exposed dry ledges of Oneota limestone, common. This species is abundant on the face of rocky cliffs of a prominent hill in Allamakee county known locally as "Big Elephant".

Polypodium vulgare L. Allamakee and Clayton counties. Cliffs, frequent, even common on shaded outcrops of St. Peter sandstone in Allamakee county and on the "pictured rocks", at McGregor, Clayton county. The species has been reported also from Winneshiek county.

SALVINIACEÆ.

Azolla caroliniana Willd. This species is found floating in quiet waters. It was found by Miss King in Allamakee county (Plant World, 5:225). The writer has specimens from Muscatine and Louisa counties, from bayous along Mississippi river, farther south than the region under consideration. There are in hand, also, specimens collected by J. P. Anderson from Lake Wabonsi in Fremont county, the southwest corner county of the state. This species is rarely collected but it is probably more frequent than collections indicate, being overlooked.

EQUISETACEÆ.

Equisetum arvense L. Moist sandy or clay soils, waysides and waste places, common; Winneshiek, Allamakee, Clayton, and Dubuque counties. This species is extremely abundant on islands of Mississippi river, in many cases growing in the water.

Equisetum laevigatum A. Br. Common in moist clayey soil, along waysides and banks; Winneshiek and Allamakee counties.

Equisetum robustum A. Br. This species has been found in Winneshiek, Clayton, Dubuque, Clinton, and Jackson counties. It occurs abundantly in moist to wet soil, along banks.

Equisetum hyemale L. Specimens from Winneshiek, Allamakee, and Dubuque counties have been referred here.

LYCOPODIACEÆ.

Lycopodium lucidulum Michx. This species has been found in moist woods near Hesper, Winneshiek county.

SELAGINELLACEÆ.

Selaginella rupestris (L.) Spring. Dry rocky soil; plentiful at least locally; Winneshiek and Dubuque counties.

ISOETACEÆ.

Isoetes melanopoda J. Gay. This species has been collected in Clinton county.

THE UNIVERSITY OF NEBRASKA,
STATION A, LINCOLN.

PIONEER PLANTS ON A NEW LEVEE.—IV.

FRANK E. A. THONE.

The present paper is the fourth of a series of brief notes on succession in the vegetation invading the slopes of a new levee in Des Moines, first populated with plants in the spring of 1914.[1] The first three papers recorded the events of the first three seasons, the present will note very briefly the conditions during the fourth.

The record of the first season noted the presence of the pigweed, *Amaranthus retroflexus,* as the dominant plant over the greater part of the area in question, with the exception of certain arid sand-heaps on the opposite side of the river, on which practically nothing grew. During the second season, it was noted that the position of the pigweed was completely usurped by the goosefoot, *Chenopodium album,* and that the tall ragweed, *Ambrosia trifida,* was invading the levee from its originally restricted area at the eastern end of the levee. During the third season the Chenopodium in its turn gave way to the wild lettuce, *Lactuca scariola.*

During these seasons also there were changes in the terrain itself. The river, tearing through its new and narrow channel at high water, was eating a wider course for itself, so that by the end of the third season the sand heaps originally noted on the opposite shore had almost wholly disappeared, as had also part of the upper, or southwestern, end of the levee, necessitating certain regrading operations there. In addition the flat ground between the base of the main part of the levee and the lip of the channel was largely engulfed, together with a small part of the main embankment itself.

The high water preceding the season of 1917 was especially severe, and the erosion was correspondingly great, so that the river carried away not only the last vestige of the sand heaps mentioned above, and a great part of the southwestern end of the levee, but a great portion of the main embankment itself. The remaining portion was regraded and in many places filled in with entirely new material, so that as a matter of fact the vegetation of 1917 can not really be said to represent at all a true stage in the succession described in previous papers, but

[1]See Proceedings Ia. Acad. Sci. XXII, 135; XXIII, 423; XXIV, 457.

rather the beginning of a new succession resulting from the break-up of an old one.

It might be interesting to follow the fortunes of this new succession, but the changed occupation of the writer prevents. Moreover, it is a bit discouraging to trace the changing dynasties in a kingdom where rivals for supremacy are so interested in securing a "place in the sun" that they neglect the important matter of securing a place in the earth, and let the very ground crumble under their feet as they struggle with each other. A few short notes on conditions during the season of 1917 will therefore serve the present purpose, and bring the series to a close.

It was noted above that most of the southwestern end of the levee disappeared and was replaced with new material. This was in part earth, but mostly garbage and manure from the city, and the vegetation here was therefore extraneous and unnatural. Mushrooms were very plentiful, most conspicuous being two or three species of *Coprinus*. In several patches there were thick stands of watermelon seedlings, and elsewhere seattering plants of field corn. The dominant in this "artificial" vegetation was common oats.

In the third paper of this series mention was made of a portion of the levee which was regraded in the spring of 1916, and on which a stand of *Amaranthus retroflexus*, the dominant of the first season, made its appearance again as dominant. During the season of 1917, while the succession was not nearly so sharply marked nor the replacement nearly so complete as was the case with the original cycle, the pigweed was again driven out by its old rival, *Chenopodium album*.

The rest of the levee had been almost completely regraded, and here everything was chaos and anarchy. In only one place was there any trace of the old succession. Here patches of wild lettuce alternated with horseweed, *Erigeron canadensis*, which was evidently in the process of crowding out the lettuce just as the latter had crowded out the goosefoot. The invasion made by the tall ragweed during the earlier seasons was pretty completely wiped out by the grading operations and the weed driven back to its original terrain.

For the rest, the vegetation was rather a hodge-podge, consisting mostly of *Amaranthus retroflexus, Chenopodium album* and *Abutilon theophrasti,* the plants being mixed together indiscriminately, with many bare patches of ground in between. Only in a few places were there any foci of possible new formations, these mostly grasses. In one such spot *Panicum Scribnerianum* was the dominant, in another, *Panicum dichotomiflorum*, in a third, *Ambrosia artemisaefolia*. An occasional thornapple, *Datura stramonium*, made itself conspicuous.

Thus in downfall and crumbling ruin ends the age of the weeds. They were given a little corner of the earth to possess, and they failed to hold it, even for themselves. Men will build a new embankment, and will cover it with grass or some other serviceable plant. It would seem that in any place such as this, where a tenacious root is required as well as a braggart top, organisms dedicated to the survival-struggle as frankly as are the actors in the little drama we have been watching, are after all not fitted to survive.

Following is a list of species noted during the season of 1917. Those marked with an asterisk are species which were noted during the first season and which have survived throughout.

Zea mais
Panicum Scribnerianum
Panicum capillare
Panicum dichotomiflorum
Echinochloa crus-galli
Setaria glauca*
Muhlenbergia mexicana
Avena sativa
Poa pratensis*
Carex sp.*
Salix sp.*
Populus deltoides*
Cannabis sativa*
Humulus Lupulus
Rumex crispus*
Polygonum pennsylvanicum*
Chenopodium album*
Salsola tenuifolia
Amaranthus retroflexus*
Amaranthus blitoides*
Stellaris media*
Lepidium virginicum*
Brassica nigra*
Brassica oleracea
Trifolium pratense*
Trifolium repens
Trifolium hybridum
Melilotus alba*
Phaseolus sp.
Vitis vulpinus*
Abutilon theophrasti*
Ipomoea purpurea*
Convolvulus arvensis*
Verbena stricta*
Lycopersicum esculentum
Datura stramonium*
Plantago major*
Citrullus vulgaris
Solidago serotina*
Aster salicifolius*
Erigeron canadensis
Ambrosia trifida*
Ambrosia artemisæfolia*
Xanthium commune*
Helianthus annuus*
Helianthus tuberosus*
Bidens sp.
Arctium minus*
Lactuca scariola.

CAMP DODGE, IOWA.

PLANTS OF SOUTHEASTERN ALASKA.

J. P. ANDERSON.

The following list of species is based on collection and observations by the writer except in the case of a few grasses and sedges from Sitka of which specimens are in the herbarium of the U. S. Agricultural Experiment Station at that place.

Proper facilities for the determination of all the species not being at hand, sets were sent away for determination. The Sitka collections were sent to the U. S. National Herbarium while the plants from Juneau were sent to the New York Botanical Garden where they were determined by Dr. P. A. Rydberg.

In regard to the localities mentioned the following notes may prove helpful.

Sitka is situated on the west or seaward side of Baranoff island in latitude 75° 3′ N. and longitude 135° 20′ W. The winters are mild and with but little snow. The summers are cold. Numerous small islands abound. Large bogs occur near the town.

Sanitarium, generally known as Sitka Hot Springs, is located 16 miles south of Sitka on Baranoff island. It is a health resort. Here are several hot springs of mineral water.

Juneau is located on the mainland in latitude 58° 18′ N. and longitude 134° 24′ W. The winters are several degrees colder than at Sitka and generally with considerable snow. The summers are slightly warmer.

Mendenhall is a small settlement about 11 miles northwest of Juneau. As used in this list it comprises a glacial plain about five miles long extending from the sea to the present foot of Mendenhall glacier. The flora here differs somewhat from that of the surrounding country and some strictly alpine plants occur.

One trip was made up the Taku river in September, 1917. The collections were made about three miles from the mouth of the stream.

Jualin is located on the east side of Lynn Canal about half way between Juneau and Skagway. A few specimens were collected here in October, 1917.

Perseverance Basin is directly back of Juneau, the Perseverance mine being at the head of the basin about five miles from town.

No mention is made of the occurrence of species at the smaller places except as they may differ from Juneau or Sitka. Between the two latter places there is considerable difference as will be noted from the list which follows.

The whole region is comparable to a series of submerged mountain ranges with the sea filling the valleys. It is heavily forested except the mountain tops and small areas of bog or of flats at the mouth of streams. Timber line is about 2,500 feet at Sitka and somewhat less at Juneau. Rainfall is abundant with much cloudy weather. Typical peat bogs or Muskeg occur while wet and springy places are found everywhere.

Synonyms are given only in cases where they have been in common use or were used by one or the other of those who made determinations. Common names are given only when well established by general or local use.

POLYPODIACEÆ.

Polypodium vulgare occidentale Hook. Common in moss on rocks, logs, and trees. Considered by some to be *P. glycyrrhiza* D. C. Eaton.

Thelypteris phegopteris (L.) Slosson. (*Phegopteris phegopteris* (L.) Keyserling.) (*Dryopteris phegopteris* (L.) C. Chr. A fairly common woodland species.

Thelypteris dryopteris (L.) Slosson. (*P. dryopteris* (L.) Fee.) (*D. dryopteris* (L.) Christ.) Common in woods.

Pteridium aequilinum pubescens Underw. Brake or Bracken. Moderately frequent at Sitka but not collected at Juneau.

Cryptogamma acrostichoides R. Br. Found in the crevices of rocks on the mountain sides.

Adiantum pedatum aleuticum Rupr. Maiden Hair Fern. Quite common on wooded mountain sides. Rare near sea level.

Struthiopteris spicant (L.) Weiss. (*Lomaria spicant* (L.) Desv.) Common in woods around Sitka and collected at Jualin but not observed around Juneau. Deer are said to be very fond of it, hence it is called Deer Fern.

Asplenium viride Huds. A small fern frequent in the crevices of rocks.

Athyrium cyclosorum Rupr. Our largest fern. It often fills low, wet places with a rank growth three to five feet high.

Athyrium alpestre (Noppe) Rylands. Collected in an alder thicket at about 2200 feet elevation near Juneau.

Polystichum braunii (Soenner) Fee. Common in woods, beginning a short distance from the sea.

Polystichum lonchites (L.) Roth. Collected on the mountain side near Juneau at about 2000 feet.

Dryopteris spinulosa (L.) Kuntze. Collected along Taku river.

Dryopteris dilatata campyloptera Kuntze. A common woodland fern.

Filix fragilis (L.) Underw. Moderately frequent from sea level to considerable elevations.

EQUISETACEÆ.

Equisetum arvense L. Common Horsetail. Common in wet sandy soil.

Equisetum fluviatile L. Common along the margin of lakes and ponds.

Equisetum laevigatum A. Br. Collected in a small pond below the glacier at Mendenhall.

LYCOPODIACEÆ.

Lycopodium alpinum L. Fairly common at high elevations and along Taku river.

Lycopodium annotinum L. Common on the marshes, the stems creeping through the moss. The writer pulled one out of the marsh near Sitka that measured 102 inches in length with a lateral branch 42 inches long.

Lycopodium clavatum L. Collected on marshes about twenty miles south of Sitka and about fifteen miles north of Juneau.

Lycopodium complanatum L. This species is quite common along Taku river.

Lycopodium poraphilum Lloyd & Underwood. Quite common in the forests, especially on wet rocks.

PINACEÆ.

Juniperus nanus Willd. Dwarf Juniper. A low spreading shrub occurring in swampy places, occasional around Sitka and common further south.

Chamaecyparis nootkatensis (Lamb) Spach. Alaska or Yellow Cedar. Common around Sitka and many other parts of southeastern Alaska. Ranges from sea level to about 2000 feet elevation and attains a diameter of two feet or more. Wood very valuable.

Pinus contorta Dougl. Lodgepole Pine. This species occurs mostly in and around the marshes where it is often only a stunted shrub. Some fair sized trees occur. The wood is heavy and resinous.

Abies amabilis (Loud.) Forbes. What appears to be this fir occurs along Taku river.

Picea sitchensis (Bong.) T. & M. Sitka or Tideland Spruce. This is the dominant forest tree of southeastern Alaska. Attains large size and is the chief source of lumber and firewood. The lumber has recently come into great demand for aeroplane building.

Tsuga heterophylla (Raf.) Sarg. Western Hemlock. Next to Sitka spruce this is our largest and most abundant forest tree. Attains a diameter of four feet.

Tsuga mertensiana (Bong.) Carr. Black or Mountain Hemlock. A small tree, infrequent near sea level but increasing in abundance as one ascends. It is essentially a timber line tree, on alpine summits often forming masses of spreading bushes a few feet high but with trunks sometimes eight to ten inches in diameter.

SPARGANIACEÆ.

Spahganium angustifolium Michx. Collected in Swan lake, Sitka.

Sparganium minimum Fries. Collected in some small pools at Mendenhall.

NAIDACEÆ.

Potamogeton heterophyllus Schreb. Both this and the following species are frequent in lakes and ponds around Sitka.

Potamogeton natans L.

Zostera marina L. Eel Grass. Very common off the shore, rooting just below low tide.

SCHEUCHZERIACEÆ.

Triglochin maritima L. Common along the seashore, especially the parts of tide flats covered only at the very high tides.

POACEÆ.

Echinocloa crus-galli (L.) Beauv. Barnyard Grass. Has been introduced with feed but does not seem able to maintain itself.

Phleum pratense L. Timothy. This grass has been introduced around towns, canneries, etc., where it finds no difficulty in maintaining itself.

Phleum alpinum L. Mountain Timothy. Fairly common in wet soil along streams and on open mountain sides.

Cinna latifolia (Trev.) Griseb. A frequent species around Juneau.

Agrostis alba L. Redtop. This has been introduced and established at Sitka.

Agrostis hyemalis geminata (Trin.)) Hitchc.

Agrostis exarata Trin. Common in wet soil.

Agrostis melaleuca (Trin.) Hitchc.

Agrostis borealis Hartm. Frequent in the crevices of rocks near the beach at Sitka.

Podagrostis aequivalvis (Trin.) Scribn. & Merrill. A common marsh species.

Calamagrostis aleutica Trin. A tall, stout grass that is abundant around Sitka but not observed at Juneau.

Calamagrostis langsdorfii Trin. The most abundant and valuable grass at Juneau and almost as common as *C. aleutica* at Sitka.

Calamagrostis canadensis (Michx.) Beauv. Bluejoint. Occurs at Juneau.

Deschampsia elongata (Hook.) Munro. Collected at Juneau.

Deschampsia caespitosa (L.) Beauv. Hairgrass. Collected at both Sitka and Juneau, as was also the following.

Deschampsia atropurpurea (Wahl.) Scheele. Mountain Hairgrass.

Trisetum cernuum Trin. A common grass around Sitka.

Trisetum subspicatum (L.) Beauv. Collected at Juneau.

Trisetum alaskanum Nash. Collected at Juneau.

Avena sativa L. Oats. Found commonly along the roadside.

Dactylis glomerata L. Orchard Grass. Naturalized around Sitka.

Poa alpina L. Mountain Bluegrass. A common alpine species at Juneau.

Poa trivialis L. A common grass, often becoming a weed.

Poa pratensis L. Kentucky Bluegrass. Very common.

Poa leptocoma Trin. Sitka is the type locality for this species, but the writer is not sure that he has colleced it.

Poa stenantha vivipara Trin. A moderately frequent form.

Poa lanata Scribn. & Merrill. Collected at Juneau.

Poa eminens Presl. A tall, stout species common on the beach at Juneau.

Poa crocata Michx. Collected at Juneau.

Panicularia pauciflora (Presl.) Kuntze. Common around bogs.

Puccinellia angustata (R. Br.) Nash. This and the following species are found on the beaches around Sitka.

Puccinellia maritima (Huds.) Parl.

Festuca rubra glauciflora S. & M. Among rocks on the beach at Sitka.

Festuca brachyphylla Schultes. Collected at Juneau.

Festuca saximontana Rydb. Occurs at Juneau.

Bromus hordeaceus L. Collected at Juneau.

Bromus pacificus Shear. In thickets at Sitka.

Bromus sitchensis Trin. In wet soil around thickets and near the sea at Sitka.

Bromus secalinus L. Cheat. Collected along the roadside at Juneau.

Agropyron repens L.? Collected at Juneau.

Hordeum jubatum L. Squirrel-tail Grass. Collected near Juneau.

Hordeum boreale Scrib. & Smith. Northern wild Barley. Quite common around Sitka.

Hordeum nodosum L. Meadow Barley. Common along the beach at Juneau.

Hordeum vulgare L. var. *hexastichon*. Six-rowed Barley. Collected along the roadside at Juneau.

Elymus howellii Scribn. & Merrill. Collected at Juneau.

Elymus borealis Scribn. Occurs at Sitka.

Elymus mollis Trin. Beach Rye. A large robust grass common on the beach.

Triticum durum Desf. Durum Wheat. Found along the roadsides at Juneau.

CYPERACEÆ.

The following species of Carex occur at Sitka but were not collected at Juneau although some of them doubtless occur.

Carex canescens L. A common species.

Carex laeviculmis Meinsch.

Carex leiocarpa Meyer.

Carex pauciflora Lightf. A common bog species.

Carex stellulata Good. Common.

Carex cryptocarpa C. A. Mey. Near the beach.

Carex gmelini Hook. Among rocks on the beach.

Carex stylosa C. A. Mey. Common.

Carex utriculata Boott. Frequent.

The following species were collected at Juneau only.

Carex anthrostachya Dewey.

Carex bicolor All.

Carex hendsii C. B. Clarke.

Carex lyngbyei Hornem.

Carex nigricans C. A. Mey.

Carex pachystachya Cham.

Carex stenochleana (Holm.) Mack.

Carex stipitata Muhl.

The following species are common in both regions.

Carex pyrenaica Wahl.

Carex stygia Fries. The commonest sedge on the peat bogs.

Carex macrochaeta C. A. Meyer. In peat bogs.

Carex mertensii Prescott. This and the following species are large and conspicuous forms.

Carex sitchensis Prescott.

Eriophorum polystachyon L. Cotton Grass. Occurs in boggy places at the higher elevations where it is sometimes quite abundant.

Eriophorum scheuhzeri Hoppe. Common in bogs and wet places.

Scirpus microcarpus Presl. A common species.

ARACEÆ.

Lysichiton camtschatcense (L.) Schott. Skunk cabbage. Abundant in wet or marshy places. A tropical looking plant, the leaves sometimes measuring three to four feet or more in length and half as much in width.

JUNCACEÆ.

Juncus arcticus Willd. Collected at Juneau.

Juncus balticus Willd. Collected at Juneau.

Juncus bufonius L. A common species.

Juncus castaneus Smith. Collected at Juneau.

Juncus drummondii Meyer. Collected at Juneau.

Juncus effusus L. Collected at Sitka.

Juncus ensifolius Wiks. Collected at Sitka.

Juncus haenkei E. Meyer. Collected at Sitka.

Juncus mertensianus Bong. Frequent at high elevations.

Juncus oreganus Watson. A common species.

Juncoides campestre (L.) Kuntze. Common around Sitka.

Juncoides parviflorum (Ehrh.) Coville. Quite common.

MELANTHACEÆ.

Tofieldia intermedia Rydb. Quite common in bogs.

Veratrum eschscholtzianum (R. & S.) Gray. Common along streams and in the forests almost to timber line.

LILIACEÆ.

Fritillaria camtschatcensis (L.) Ker-Gawl. Black Lily. Indian Rice. Common on low flats. The bulblets resemble rice grains and are used by the natives.

CONVALLARICEÆ.

Kruhsia streptopoides (Ledeb.) Kearney. Common in the forests at Sitka.

Streptopus amplexifolius (L.) DC. A tall growing species which is quite common. Locally called cucumber plant, as the young plant has somewhat the flavor of that vegetable.

Streptopus curvipes Vail. A common woodland species.

Unifolium eschscholtzianum (Anders. & Bess.) Wight. A very common species.

IRIDACEÆ.

Iris arctica Easlw. Frequent on flats north of Juneau.

Sisyrinchium littorale Greene. Found around Sitka near the beach.

ORCHIDACEÆ.

Corallorhiza mertensiana Bong. Coral Root. Grows in leaf mold in dense woods and thickets.

Cytherea bulbosa (L.) House. (*Calypso borealis* Salisb.) Found around Sitka, especially on some of the small islands.

Ophrys cordata (L.) R. Br. (*Listera cordata* R. Br.) Common on forested mountain slopes.

Ophrys convallarioides (Sw.) W. F. Wight. (*L. convallarioides* (Sw.) Torr.) Occurs in the woods around Sitka.

Limnorchis leucostachys (Lindl.) Rydb. Frequent in marshy places.

Limnorchis stricta (Lindl.) Rydb. Frequent in marshes.

Malaxis diphyllos Cham. This interesting little orchid is common in crevices of rocks along the beach near Point Baranoff south of Sitka.

Peramium sp. Rattlesnake Plantain. A single plant was collected on a small island six miles south of Sitka. It is probably *P. repens* (L.) Salisb.

MYRICACEÆ.

Myrica gale L. Sweet Gale. Occurs on the marshes but is not generally distributed.

SALICACEÆ.

Salix arctica Pall. Collected at Mendenhall and at about 2,500 ft. elevation near Juneau.

Salix barclayi Anders. Collected at Juneau and at Mendenhall.

Salix commutata Bebb. ? Collected near Juneau.

Salix conjuncta Bebb. Collected on the flats at Mendenhall, as was also the following.

Salix glauca L. (*S. seemannii* Rydb.)

Salix reticulata L. (*S. orbicularis* Anders.) Quite common at Mendenhall, and at high elevations.

Salix sitchensis Sanson. Common. The only willow the writer found at Sitka. It is the largest of the species listed here.

Salix stolonifera Coville. (*S. unalaschensis* Cham.) Collected at Mendenhall and at about 2,500 feet elevation.

Populus trichocarpa T. & G. Cottonwood. Common in the valleys near Juneau.

BETULACEÆ.

Betula papyrifera Marsh. Paper Birch. Occurs in the Taku valley.

Alnus fruticosa Rupr. Occurs in the Taku valley. Very bushy.

Alnus oregona Nutt. Red Alder. Common along stream courses; attains a diameter of twelve to sixteen inches and is much sought for fuel.

Alnus sinuata (Regel.) Rydb. (*A. sitchensis* Sarg.) Mountain Alder. A very abundant species, often covering the steeper mountain slopes, where the trunks and branches bend downward, having been forced to such position by snowslides.

URTICACEÆ.

Urtica lyallii Wats. Nettle. A common weed of open places and in woods.

LORANTHACEÆ.

Razoumofskya tsugensis Rosendahl. On Tsuga heterophylla causing witches' brooms. Very common around Sitka.

POLYGONACEÆ.

Oxyria digyna (L.) Hill. Mountain Sorrel. Frequent in wet rocky soil.

Rumex acetosella L. Sheep sorrel. A very common weed.

Rumex confinis Greene. Collected along the roadside at Juneau.

Rumex crispus L. Sparingly introduced as a weed at Sitka.

Rumex mexicanus Meisn. Moderately frequent at Juneau.

Rumex salicifolius Weinm. Moderately frequent at Sitka. Although the specimens gathered differ somewhat in appearance this may be the preceding species.

Rumex obtusifolius L. Rather sparingly introduced as a weed at Sitka.

Rumex occidentalis Wats. Fairly common near the seashore.

Polygonum convolvulus L. (*Tiniaria convolvulus* (L.) Webb Moq.) (*Bilderdykia convolvulus* (L.) Dum.). An introduced weed.

Polygonum islandicum Meisn. (*P. litorale sitchense* Small). ? Common along and near the beach.

Polygonum pennsylvanicum L. (*Persicaria pennsylvanica* (L.) Small). Introduced at Sitka.

Polygonum sp. Introduced at Juneau.

Polygonum viviparum L. (*Bistorta vivipara* (L.) S. F. Gray). An abundant and variable species found along the beaches and in the swamps.

CHENOPODIACEÆ.

Atriplex alaskensis S. Wats. A large species found at Sitka.

Atriplex gmelini C. A. Mey. Common on and near the beach.

Chenopodium album L. Lamb's quarters. An introduced weed but not troublesome.

AMARANTHACEÆ.

Amaranthus retroflexus L. Pigweed. An infrequent weed at Sitka.

PORTULACEÆ.

Claytonia sibirica L. (*Montia sibirica* (L.) Howell). (*Linnia sibirica* (L.) Haw.) A very common plant.

Claytonia asarifolia Bong. Sitka is the type locality for this species.

Montia fontana L. A small plant common in wet soil or running water.

ALSINACEÆ.

Silene acaulis L. Moss campion. Moderately abundant around Juneau.

Agrostemma githago L. Cockle. Introduced with oats at Sitka.

Tissa marina (L.) Britt. On and near the beaches.

Spergula arvensis L. Spurry. A common weed.

Cerastium alpinum L. A common species.

Cerastium behringianum Regel. Along ravines at Juneau.

Cerastium viscosum L. Numerous at Sitka.

Cerastium vulgatum L. Collected at Juneau.

Alsine borealis (Bigel.) Britt. A common species in woods and along streams.

Alsine brachypetala (Bong.) Howell. Collected at Juneau.

Alsine crispa (C. & S.) Holz. Common in the woods at Sitka.

Alsine media L. Common Chickweed. This is our most persistent weed. It causes more trouble than all other weeds combined. If a garden is neglected it will overrun everything in the course of one season.

Alsinopsis propinqua (Richards) Rydb. Collected at Juneau.

Sagina nivalis Fries. Collected at Mendenhall.

Sagina occidentalis Wats. In springy ground at Juneau.

Sagina crassicaulis Wats. Collected at Sitka.

Ammodenia peploides major (Hook.) Wight. Common along the seashore.

Vaccaria vaccaria (L.) Britt. Sparingly introduced at Sitka.

NYMPHAEACEÆ.

Nymphaea polysepala (Engelm.) Greene. Yellow Pond Lily. Found in the lakes and some of the small ponds.

RANUNCULACEÆ.

Anemone globosa Nutt. High on the mountains near Juneau.

Anemone narcissiflora L. Alpine meadows around Sitka. Uncommon at low elevations.

Thalictrum alpinum L. Collected in the basin back of Juneau.

Ranunculus hyperboreus Roeth. A small aquatic species collected near Juneau.

Ranunculus reptans L. Collected along Salmon creek at the head of Silver bay near Sitka.

Ranunculus abortivus L. Collected at Juneau. Rather rare.

Ranunculus bongardi Greene. A common species.

Ranunculus occidentalis Nutt. Our commonest species. May be var. *robustum* Gray. A smaller form occurs on the mountains near Juneau.

Ranunculus eschscholtzii Schlecht. ? Collected at about 1,800 feet elevation near Juneau.

Ranunculus macounii Britton. A large, coarse species collected near the beach at Juneau.

Ranunculus repens L. This species has thoroughly established itself at Sitka.

Ranunculus acris L. ? A single large thrifty plant collected at Sitka in 1916.

Arctoranthis cooleyae (Vasey & Rose) Greene. An alpine plant.

Aconitum chamissonianum Reich. Quite common on the mountain sides at Juneau.

Aconitum delphinifolium DC. Moderately abundant on forested mountain slopes at Sitka.

Aquilegia columbiana Rydb. Common. Generally given as *A. formosa* Fisch.

Caltha palustris L. Marsh Marigold. Common in wet places around Juneau.

Actaea arguta Nutt. Present on mountain slopes.

Coptis asplenifolia Salisb. (*Chrysocoptis asplenifolia* (Salisb.) Nutt.) This species of Gold Thread is very common.

Coptis trifolia (L.) Salisb. Gold Thread. Fairly common in marshy places at Sitka.

CRUCIFERÆ.

Arabis intermedia DC. Collected at Sitka.

Arabis lyrata occidentalis Wats. In sandy soil along streams. Sitka.

Arabis ambigua DC. Quite common at Juneau.

Arabis hirsuta L. Frequent in gravelly places along streams. Sitka.

Arabis rupestris Nutt. Collected at Juneau.

Cardamine umbellata Greene. Common in wet places.

Cardamine bellidifolia L. Collected at Sitka as was also the following species.

Cardamine parviflora L.

Brassica campestris L. A form of this has become well established as a weed at Sitka.

Brassica juncea (L.) Cass. Collected at Sitka.

Brassica napus (L.) Collected at Juneau.

Brassica nigra L. ? Moderately abundant.

Sisymbrium altissimum L. Uncommon.

Sisymbrium officinale (L.) Scop. Hedge Mustard. Sparingly introduced at Sitka.

Draba umbellata Greene. Collected at Sitka.

Draba macouniana Rydb. Occurs on the mountain sides at Juneau.

Draba sp. (near *D. nitida* Greene). An alpine species collected at Juneau.

Neodraba grandis (Langsd.) Greene. In crevices of rocks along the seashore near Sitka.

Cochlearia groenlandica L. On and near the beach at Sitka.

Cochlearia officinalis L. Common along the beaches.

Radicula clavata (Rydb.) J. M. Macoun. Occurs near the beach at Juneau.

Radicula nuttallii Rydb. Collected along the beach at Jualin.

Radicula palustris (L.) Moench. Abundant in wet places.

Bursa bursa-pastoris (L.) Weber. Shepherd's Purse. A rather common weed.

Camelina sativa (L.) Crantz. Introduced with oats at Sitka.

DROSERACEÆ.

Drosera rotundifolia L. Sundew. Common in bogs.

SAXIFRAGACEÆ.

Parnassia fimbriata Koenig. Common, generally at some elevation.

Parnassia kotzebui Cham. Collected at Mendenhall, as was also the following species.

Parnassia palustris L.

Leptarrhena pyrolifolia (D. Don) R. Br. Occurs high on the mountains near Juneau.

Spatularia brunoniana (Bong.) Small. (*Saxifraga brunoniana* Wall.) Frequent around Juneau.

Saxifraga nootkana Small. Frequent around Sitka.

Saxifraga tricuspidata Ritz. (*Leptasea tricuspidata* (Ritz.) Haw.). On rocks around Juneau.

Saxifraga aestivalis Fisch. (*Micranthes aestivalis* (F. & M.) Small). Collected at Juneau.

Saxifraga lyallii Engler. (*Micranthes lyallii* (Engler) Small). Collected at Juneau.

Saxifraga mertensiana Bong. (*Heterisia mertensiana* (Bong.) Small). Wet places. A common species.

Saxifraga nelsoniana D. Don. Collected at Sitka.

Saxifraga rivularis L. Collected at Sitka.

Rhodiola integrifolia Raf. Abundant on wet rocks at Juneau.

Chrysosplenium tetrandrum Th. Fries. Common in springy places at Juneau.

Tiarella trifoliata L. A common woodland species.

Tellima grandiflora (Pursh) Dougl. Common along the edge of the forests.

Pectianthia pentandra (Hook.) (*Mitella pentandra* Hook.). Collected at Juneau.

Heuchera glabra Willd. A common species of wooded hill-sides.

GROSSULARIACEÆ.

Ribes echinatum Lindl. (*Limnobotrys echinata* (Lindl.) Rydb.). Common around Juneau. This is the species most generally listed as *R. lacustre* (Pers) Poir. It is intermediate between gooseberries and currants.

Ribes laxiflorum Pursh. Stink Currant. This common species is of a somewhat trailing habit and is frequently found covering old stumps.

Ribes bracteosum Dougl. Wild Black Currant. This species is quite common and bears long racemes of black berries covered with a white bloom. It is of considerable culinary value, making a delicious marmalade.

Ribes triste Pall. Wild Red Currant. It has been confused with *R. rubrum* but is quite distinct from the garden currant. The growth is shorter and darker with more shreddy bark. It flowers two weeks earlier and has highly colored flowers. The fruit ripens earlier and is a bright clear red and inclined to be oblong.

ROSACEÆ.

Lutkea pectinata (Pursh) Kuntze. A pretty little alpine plant common on the mountains.

Aruncus acuminatus (Dougl.) Rydb. A common and very ornamental species.

Rubus chamaemorus L. Cloudberry. A common bog plant. Fruit is quite good and much sought by the Indians.

Rubus stellatus Smith. Quite common in wet places. The red fruit is of fine quality; the best of any native species of Rubus.

Rubus pedatus Smith. A very common herbaceous trailing species.

Rubus viburnifolius Greene. Collected along Taku river.

Rubus spectabilis Pursh. Salmonberry. A very common large-growing species with perennial canes.

Rubus parviflorus Nutt. (*Rubacer parviflorus* (Nutt.) Rydb. Thimbleberry. Rather common. The red fruit is composed of numerous small druplets.

Rosa nutkana Presl. Occurs rather sparingly.

Sanguisorba sitchensis. S. Wats. Occurs in wet places.

Sanguisorba menziesii Rydb. Common in the bogs around Sitka.

Geum macrophyllum Willd. An abundant species in open places.

Sieversia calthifolia (Menz.) D. Don. Common at high elevations, less so at lower altitudes.

Potentilla monspeliensis L. Rare. Observed at Juneau and along the Taku.

Potentilla villosa Pall. Common in rocky places near the seashore.

Argentina anserina (L.) Rydb. (*Potentilla anserina* L.). Occurs at Sitka.

Argentina occidentalis Rydb. Abundant along the seashore.

Sibbaldia procumbens L. In the mountains around Juneau at medium and high elevations.

Comarum palustre L. Abundant in wet places, especially the shores of lakes.

Fragaria chiloensis (L.) Duch. Wild Strawberry. This species appears as an escape at Sitka and Juneau but is native to some portions of the coast of Alaska.

MALACEÆ.

Malus diversifolia (Bong.) Roem. (*Pyrus rivularis* Dougl.). Crabapple. Common around Sitka. rather rare around Juneau.

Sorbus sitchensis Roem. Mountain Ash. A medium to large shrub of moderate abundance.

Sorbus occidentalis (Wats.) Greene. A low shrub found at high elevations near Sitka.

FABACEÆ.

Lupinus nootkatensis Donn. Lupine. Rather rare at Sitka, more common around Juneau, especially toward Mendenhall.

Trifolium repens L. White Clover. Along roadsides and in gardens and lawns. Common.

Trifolium hybridum L. Alsike Clover. Roadsides. Rather abundant.

Trifolium pratense L. Red Clover. Rather common along roadsides and elsewhere.

Medicago denticulata Willd. A rather common weed at Sitka.

Vicia angustifolia (L.) Roth. A few plants collected at Sitka. Probably introduced with feed.

Vicia sitchensis Bong. Common along the edge of the forest facing the sea at Sitka.

Lathyrus maratimus (L.) Bigel. Beach Pea. Occurs on some islands southwest of Sitka and is common at Mendenhall.

Homalobus debilis (Nutt.) Rydb. Collected in the Perseverance basin near Juneau.

Aragallus campestris. (*Oxytropis campestris* D. C.) Collected in the Perseverance basin and along Taku river.

GERANIACEÆ.

Geranium erianthum DC. Common around Juneau and in some localities near Sitka.

Erodium cicutarium (L.) L'Her. Alfilaria. A single plant at Juneau where manure had been applied.

OXALIDACEÆ.

Ilanthosalis corniculata (L.) Small. (*Oxalis corniculata* L.) A greenhouse weed.

EUPHORBIACEÆ.

Euphorbia peplus L. A greenhouse weed.

CALLITRICHACEÆ.

Callitriche palustris L. Frequent in pools and lakes.

EMPETRACEÆ.

Empetrum nigrum L. Crowberry. One of the commonest of all species in the bogs at low elevations and on dry peaty soil at high elevations.

ACERACEÆ.

Acer douglasii Hook. Dwarf Maple. Occurs in the Perseverance basin and along Taku river.

BALSAMINACEÆ.

Impatiens occidentalis Rydb. Touch-me-not. Common around Juneau. Often considered synonymous with *I. nolitangere* L.

VIOLACEÆ.

Viola palustris L. Rather common in wet soil.

Viola langsdorfii Fisch. Common in wet places near Juneau.

Viola glabella Nutt. Common in the forests.

ONAGRACEÆ.

Chamaenirion angustifolium (L.) Scop. (*Epilobium angustifolium* L.). (*Chamaenirion spicatum* (Lam.) S. F. Gray. Fireweed. Very common. Showy when in flower.

Chamaenirion latifolium (L.) Sweet. (*Epilobium latifolium* L.). Quite common in wet open places on the mountains.

Epilobium bongardi Haussk. Collected at Sitka.

Epilobium hornemanni Haussk. Collected at Juneau.

Epilobium anagallidifolium Lam. A common alpine species.

Epilobium luteum Pursh. Collected near Juneau.

Epilobium glandulosum Lehm. (*E. affine* Bong.). A common weed. Often determined as *E. adenocaulon* Haussk.

Circaea alpina L. Common in springy places.

HALORAGIDACEÆ.

Hippuris montana Ledeb. Common in wet alpine meadows near Sitka.

Hippuris tetraphylla L. f. Collected on the tide flat at Sanitarium.

Hippuris vulgaris L. Mare's Tail. In lakes and ponds. Abundant when occurring.

ARALIACEÆ.

Echinopanax horridum (Smith) Dec. & Planch. Devil's Club. Common in wet places in the forests and very difficult and disagreeable to travel through.

UMBELLIFERÆ.

Osmorrhiza purpurea (Coult. & Rose) Suks. Rather frequent.

Heracleum lanatum Michx. Cow Parsnip. A common species. The young leaf petioles are eaten by the natives. Locally called wild celery.

Angelica genuflexa Nutt. Collected along Taku river.

Ligusticum scoticum L. Common along the beaches.

Ligusticum sp. (related to *L. leibergii*) On the beach at Juneau.

Coleopleurum Gmelini (DC.) Ledeb. Common in wet places.

CORNACEÆ.

Cornus canadensis L. (*Chamaepericlimenum canadensis* (L.) Ascherson & Greabn. Pigeon Berry. A common woodland species at all elevations up to nearly 2,000 feet.

Cornus stolonifera Michx. (*Svida stolonifera* Nutt.). Frequent around Juneau.

PYROLACEÆ.

Moneses uniflora (L.) Gray. Fairly common in the forests around Sitka. Known locally as wax plant.

Chimaphila occidentalis Rydb. ? Collected along Taku river.

Pyrola secunda L. (*Ramischia secunda* (L.) Garke). Fairly common at Sitka, common in many localities near Juneau.

Pyrola bracteata Hook. Plentiful in wet places around Juneau.

Pyrola minor L. (*Erxlebenia minor* (L.) Rydb.). Collected near Juneau.

ERICACEÆ.

Gaultheria shallon Pursh. Salal. Collected at Sanitarium, about sixteen miles south of Sitka.

Arctostaphylos uva-ursi (L.) Spreng. Bearberry. Collected in open forests along Taku river.

Cassiope mertensiana (Bong.) G. Don. Common on the mountains above tree growth.

Harrimanella stelleriana (Pall.) Coville. Same habit as preceding but not so abundant.

Loiseleuria procumbens (L.) Desv. A common alpine plant. Less common at lower altitudes.

Ledum groenlandicum Oeder. Labrador Tea. A common and characteristic bog plant.

Cladothamnus pyrolaeflorus Bong. An abundant shrub at high elevations.

Phyllodoce glanduliflora (Hook.) Coville. Common on the mountains at and above the limit of trees.

Kalmia microphylla (Hook.) Hell. Abundant in bogs.

Andromeda polifolia L. Wild rosemary. Same habit as preceding.

Menziesia ferruginea Smith. An abundant shrub of the lower mountain slopes.

VACCINIACEÆ.

Vaccinium uliginosum L. A common bog plant.

Vaccinium caespitosum Michx. Abundant at high elevations and also at low altitudes.

Vaccinium ovatifolium Smith. This is the Blueberry most often gathered. It is very common at low and medium elevations.

Vaccinium parvifolium Smith. Red Huckleberry. Common around Sitka and Jualin but not observed at Juneau.

Vaccinium sp. There is a species of blueberry common around Sitka and occurring also at Juneau which is of shorter and stockier growth with thicker and more angled twigs, larger leaves, larger and later berries of poorer quality than *V. ovalifolium.*

The fruit varies from wine-black without bloom to black with abundant bloom, and from pyriform to slightly oblate spherical. There seem to be no bush characters that distinguish the plants bearing the different types of berries. The writer has seen specimens collected in Alaska by Thos. Howell and bearing the name *V. chamissonis* Bong., while plants collected by the writer were determined by competent authorities as *V. membranaceum* Dougl.

Vaccinium vitis-idea L. Mountain Cranberry. Abundant at Sitka but not so common around Juneau.

Vaccinium oxycoccus L. (*Oxycoccus oxycoccus* (L.) MacM.). Swamp Cranberry. Common in sphagnum bogs.

PRIMULACEÆ.

Dodecatheon jeffreyi Moore. Shooting Star. Common in wet places.

Trientalis arctica Fisch. Common in bogs and wet places.

Glaux maritima L. A common beach plant.

GENTIANACEÆ.

Gentiana douglasiana Bong. A common bog plant.

Gentiana platypetala Griseb. Rather common in alpine meadows.

Condrophylla prostrata (Haenke). Collected at Mendenhall.

Swertia sp. Collected at Mendenhall. This has been confused with *S. obtusa* of Asia.

MENYANTHACEÆ.

Menyanthes trifoliata L. Buckbean. In bogs and lakes. Rather rare.

Nephrophyllidium crista-galli (Menzies) Gilg. Deer Cabbage. Abundant in alpine meadows and quite common in wet soil at lower elevations. Deer are very fond of it.

POLEMONIACEÆ.

Polemonium pulcherrimum Hook. Collected at about 2,000 feet elevation near Juneau and along Taku river.

HYDROPHYLLACEÆ.

Romanzoffia sitchensis Bong. A common plant of moist to wet soil.

Nemophila menziesii Hook. & Arn. A few plants of this species were found at Sitka.

BORRAGINACEÆ.

Amsinckia menziesii (Lehm.) Nels. & Mack. A rather rare weed. Juneau.

Amsinckia tesselata Gray. An uncommon weed. Sitka.

Myosotis alpestris Schmidt. Forget-me-not. Escaped at Sitka. In June, 1916, the writer's attention was called to a bunch of native Forget-me-nots said to have been gathered at Haines that appeared to be this species.

Myosotis scorpoides L. (*M. palustris* Lam.). The true Forget-me-not of Europe spread from cultivation.

MENTHACEÆ.

Galeopsis tetrahit L. Hemp Nettle. A common weed at Sitka.

Prunella vulgaris L. Self Heal. Common locally.

Nepeta cataria L. Catnip. Collected at Sitka, the seed probably having been introduced with feed.

Mentha piperita L., the peppermint, and *M. spicata* L., Spearmint, have a tendency to establish themselves where introduced by cultivation.

SOLANACEÆ.

Solanum nigrum L. Black Nightshade. A sparingly introduced weed.

Solanum villosum Mill. A greenhouse weed.

SCROPHULARIACEÆ.

Verbascum sp. A single plant at Juneau. Seed probably introduced with feed.

Mimulus langsdorfii Don. Common in wet places.

Veronica serpyllifolia L. A common weed, especially among grass.

Veronica americana Schwein. A common weed of roadsides and cultivated ground.

Veronica wormskjoldii R. & S. Rather rare.

Veronica stelleri Link. Collected at Sitka.

Veronica buxbaumii Tenore. Collected at Juneau.

Veronica peregrina L. Rather common.

Digitalis purpurea L. Foxglove. Escaped from cultivation at Sitka.

Castilleja pallida Kunth. Abundant. May be var. *unalaschensis* Cham.

Castilleja parviflora Bong. A common alpine plant.

Castilleja tristis Wight. Common around Sitka.

Euphrasia disjuncta Fern. & Wieg. Collected on the flats at Mendenhall.

Pedicularis pedicellata Bunge. Collected at Sitka.

Pedicularis sudetica Willd. Collected at Juneau.

Pedicularis verticillata L. A common alpine species.

Rhinanthus crista-galli L. Locally common along the beach at Sitka.

Rhinanthus rigidus Chab. Collected along Taku river.

OROBANCHACEÆ.

Boschniakia glabra C. A. Mey. (*B. rossica* Cham. & Schl.?). Abundant. Appears to be parasitic on the roots of *Alnus sinuata*.

LENTIBULARIACEÆ.

Pinguicula vulgaris L. Common in very wet places.

Pinguicula villosa L. Rather common in the bogs at Sitka but so small and inconspicuous that it is seldom noticed.

PLANTAGINACEÆ.

Plantago macrocarpa C. & S. A common beach plant.

Plantago maritima L. This also is a common beach plant.

Plantago major L. (*P. asiatica* L.). A common weed at Sitka and Juneau.

RUBIACEÆ.

Galium aparine L. Abundant in wet places.

Galium trifidum stubbiflorum Wieg. Common at Sitka.

Galium triflorum Michx. Collected at Juneau.

CAPRIFOLIACEÆ.

Sambucus callicarpa Greene. Red Elderberry. A very common shrub often considered to be *S. pubens* Michx.

Viburnum pauciflorum pylaie. Highbush Cranberry. Abundant along the banks of streams.

Linnaea americana Forbes. Twin Flower. A common woodland species.

VALERIANACEÆ.

Valeriana sitchensis Bong. A common alpine plant.

CAMPANULACEÆ.

Campanula alaskana (Gray) Wight. Bluebells. Common on rocks near the sea.

Campanula petiolata DC. Bluebells. Abundant among wet rocks. Juneau.

Campanula lasciocarpa Cham. Collected near the top of Mount Verstovia near Sitka.

COMPOSITÆ.

Scorzonella borealis (Bong.) Greene. Abundant at Sanitarium on wet meadows.

Leontodon taraxacum L. Dandelion. Common along roadsides and similar localities.

Sonchus arvensis L. Sparingly introduced at Juneau.

Sonchus asper (L.) Hill. An introduced weed at Sitka.

Nabalus hastatus (Less.) Heller. Common along banks and cliffs.

Hieracium gracile Hook. Common in alpine meadows near Juneau.

Hieracium triste Willd. Common in alpine meadows near Sitka.

Hieracium albiflorum Hook. Collected along Taku river.

Aster foliaceus Lindl. Abundant along banks.

Erigeron peregrinus (Pursh) Greene. Common in alpine meadows, less common at lower altitudes.

Erigeron unalaschensis (DC.) Ryd. Collected at Mendenhall.

Solidago multiradiata Pursh. Collected at Mendenhall.

Solidago lepida DC. Rather rare in the bogs at Sitka.

Solidago sp. Collected along the Taku.

Antennaria macounii Greene. Collected at Juneau.

Anaphalis angustifolia Rydb. Rather uncommon at Juneau.

Anaphalis margaritacea (L.) Benth. & Hook. Rather uncommon. Sitka.

Achillea borealis Bong. Milfoil or Yarrow. Roadsides and open places. Common.

Anthemis cotula L (*Maruta cotula* (L.)DC.) Mayweed. An introduced weed not yet common.

Chrysanthemum arcticum L. Arctic Daisy. A few found in the valleys north of Juneau.

Matricaria matricarioides (Less.) Porter. (*Chamomilla suaveolans* (Pursh) Rydb. A common weed.

Artemisia arctica Less. A common alpine plant.

Artemisia maccallae Rydb. Collected along Taku river.

Pelasites corymbosa (R. Br.) Rldb. Coltsfoot. A rather rare subalpine species.

Arnica latifolia Bong. Common at high altitudes, less so at lower elevations.

Arnica rivularis Greene. Locally common on open mountain sides at Juneau.

Senecio vulgaris L. A common weed.

Senecio triangularis Hook. Abundant in alpine meadows at Sitka.

Saussurea americana D. C. Eaton. An alpine plant occurring around Juneau.

JUNEAU, ALASKA.

THE OIL IN CHERRY PITS.

HAROLD L. MAXWELL AND NICHOLAS KNIGHT.

It has been the subject of much speculation as to how the Germans have been supplied with fats for food and to furnish the glycerine from which the important explosives, dynamite and nitro-glycerine, are made. They have been charged with having extracted fat from their enemy dead to be used in making the explosives.

An important source of oil in Germany is doubtless the cherry pits and it is quite likely that German thrift and efficiency would not be slow to utilize that material. There is scarcely any other country on the globe where the cherries have reached so high a degree of perfection as in Germany. Cherry trees are everywhere and the cherries are unusually large and constitute an important article of food during the early summer. We thought it might not be devoid of interest to investigate the oil content of the cherry pits.

We secured a quantity of the dried seeds of the common cherry *Prunus erratus* and by cracking we obtained fifty grams of the kernels. These we crushed in a mortar, removed to a cloth sack and placed in the flask of the extraction apparatus. The oil which adhered to the mortar, as a result of the crushing, was washed with ether and added to the contents of the flask.

After the extraction had continued for fifty-six (56) hours, the oil laden ether was taken from flask B and to it was added the ether from flask A, in order to insure against the loss of even the smallest quantity of the oils. The ether and oil mixture was distilled at the lowest possible temperature. The boiling point of the ether being 34.9°C., the mixture began to distill at a slightly higher temperature, about 36° C. By fractional distillation the oil was separated from the solvent. To insure the evaporation of all the ether, the oil was placed in an open beaker and heated on a water bath at 76° C. for three hours. After this treatment, even the faintest trace of ether could not be detected.

The yield was unusually large. From the fifty grams we secured 18.8 grams of the oils or a yield of 37.6 per cent. The oils have the characteristic odor of almonds. The taste is pleasant, resembling nuts. They are light amber in color and have about the consistency of warm castor oil.

The German Pharmaeopeia states that pure almond oil should remain clear at -10° C. This specimen became opaque, showing that we had a mixture of oils and not one individual. At low temperatures the oils showed marked changes. The first change in color began at -5° C. when white globules separated out and settled to the bottom. This indicated that one of the oils solidified at that temperature. We kept that temperature constant until all the oil which had a tendency to solidify, had sep -rated out. We set this oil aside for further study which we record later. The amber oil, which constituted about 90 per cent of the whole oil content, was drawn off with a pipette and subjected to lower temperatures. At -18° C. there was no sign of solidification but at -19° C. the oil became viscous while at -20° C. it began to become solid.

The specific gravity of the oil was next determined by weighing out several portions of two centimeters each on a watch glass of constant weight, and computing the weight per centimeter of the oil. We found the specific gravity to be .922, .925 and .924 in three respective cases. This is consistent with the results secured by T. Mäben wh 'nvestigated the oil in almond nuts. He records the specific gravity of that oil as .918 to .923.

Two grams of the oils were weighed out on a constant watch glass and set aside at room temperature for a period of forty hours. After that time the oil was weighed again, noting the loss in weight. The oil is slightly volatile, since during that period it had lost one and one-half per cent of its original weight.

In determining the saponification equivalent of the oil under examination, we first prepared a normal solution of KOH in absolute alcohol. This was done by dissolving 56 grams of KOH in 800 cc. of the solvent and then diluting to a litre. We weighed 4.317 grams of the oil into an eight ounce flask and added to it exactly 30 c.c. of the alcoholic solution of KOH. The flask was connected with an inverted condenser and the contents kept at a boiling temperature for thirteen hours. We cooled the flask and added 200 c.c. of water. Then to determine the amount of the oil which had been saponified by the KOH, we titrated the contents of the flask with normal HCl, using phenolphthalein as an indicator. The difference between the number of cubic centimeters of the normal KOH used and the number of cubic centimeters of normal HCl necessary to neutralize the remainder after the saponification, represents the number of cubic centimeters of the KOH neutralized by the oil. Then, knowing the strength of the solution and the nature of the oil, we can determine the percentage of the saponifiable oil. The saponification equivalent is the object of this experiment and to compute that we divide the weight of the oil in milligrams by the number of cubic centimeters of KOH solution neutralized by the oil. In this case we found it to be 276.8. E. E. Valenta investigated the oil from almond nuts and found the saponification equivalent to be 285 and that in some cases it ranged as high as 296, depending on the purity of the speciment. Thoerner, in a study of the mixed fatty acids of almond oil, found the equivalent as low as 204.

It has been observed by various investigators that many fatty oils produce highly colored products when treated with sulphuric acid. After this suggestion, we set out with this method to determine the nature of the two oils.

Taking first the light amber oil, which constituted the main portion of the mixture of oils, we added two drops of concentrated sulphuric acid to twenty drops of the oil. At first there was no color, but on stirring with a glass rod the oil and acid mixture became brown and in a few minutes it began to solidify. This also is characteristic of almond oil.

Some of the smaller portion of the oil which had separated out on being cooled in the first part of the investigation was given the same treatment with a few drops of sulphuric acid. When the mixture was stirred the color turned from a yellow to a reddish brown with a purple cast. This indicated the presence of arachis oil, the principal oil in peanuts. There was only a small amount of this oil present in the specimen. This was not sufficient for a complete and thorough analysis.

There are three sources from which almond oil may be obtained, almond nuts, peach kernels and apricot kernels. Then since the cherry seed belongs to no one of these three classes, our next question might well be: Which one of the three does it most resemble?

Samples of almond oil from each of the three sources vary in specific gravity, bromine absorption, and color tests. In the first two instances the variation is so slight that, allowing for even the smallest error, the line of difference is indistinct. It is then the color tests that mark the dividing line beween the almond, peach, and apricot oils. The zinc chloride test is the one employed, as follows: Add five drops of the strong zinc chloride solution to ten drops of the oil. If there is no change in color after stirring, the oil is identical with that from the almond nut. If the color changes to purple or brownish purple, the oil is like that from the peach kernel. If the mixture changes to a muddy or a dirty brown, the oil is the same as that from the apricot kernel. In the sample of oil being examined, there was no change in color, showing that the oil in this analysis is the same as that from the almond nuts.

The taste and odor of cyanogen in the freshly cracked cherry pits is evidence of the presence of nitrogen. By the use of the Gunning method we determined the percentage of nitrogen in the kernels and found it to be no less than 5.6. It is to be expected that the ether extraction would remove a part of the cyanogen with the oil. We took a gram of the dried residue after all the oil had been extracted and made another nitrogen determination. In this we found 4.2 per cent of nitrogen, showing that the main portion of the nitrogen was neither extracted by the ether nor expelled by the long heating on the water bath.

The residue from the crushed cherry pits was taken from the flask and dried in the air for ten hours. Then it was heated on the water bath at 100° C. for fifteen hours to expel the remaining ether and the moisture. The dry residue was weighed and the loss in weight found to be 20.9 grams. The oils extracted weighed 18.8 grams, leaving a difference of 2.1 grams. This is no doubt the weight of the water expelled from the residue when it was heated to drive off the remaining ether.

When cherry seeds or oil bearing nuts are ground up with cold water the amygdalin breaks up in an emulsion. The oil is partly broken down in the process and glucose sugars constitute one of the resulting products. To confirm the presence of the glucose sugars in the water extraction, we treated a quantity of the dried seeds with water for twenty-four hours. We titrated a fractional part with standard Fehling solution and found 13.8 per cent of sugar present. Reaction:

$$C_{20}H_{27}NO_{11}+2H_2O=C_7H_6O+HCN+2C_6H_{12}O_6$$

The cherry oil, which has been found to be essentially the same as the almond oil, consists of olein with a small quantity of stearin and palmitin. Olein is the chief constituent of the fatty oils and may be made by heating glycerine with an excess of oleic acid at 204° C. Its formulæ is $C_{57} H_{104} O_6$.

It is not to be expected that the Central Powers, with their urgent need of oil for food and explosives, have overlooked such a productive source of glycerine as we have found in the cherry pits. The production of the countless tons of explosives necessary to carry on a war, has called into service every resource of the nation. This is an item then, not to be under estimated, for already the cherry seed oil has contributed its bit to the great world war.

DEPARTMENT OF CHEMISTRY,
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SOME PROBLEMS OF WATER SUPPLY FOR TROOPS.

JACK J. HINMAN, JR.

The problems of water supply under field conditions are very different from those of the average city or town, even though the same fundamental principles apply to both. The city or town will in all probability make an extensive and careful survey of all water supply prospects and then choose that source which seems likely to offer the cheapest means of getting enough water that will be safe to use for drinking and other domestic purposes. Once the source is decided upon, expensive pumping and purification plants are erected and a complex distribution system is installed. A high degree of physical attractiveness is required in addition to the bacterial safety of the water so that the plant must be kept operating at a high degree of efficiency. This, of course, requires a trained staff of operators.

In the field, however, the opportunities for discriminating selection of water supplies and the development of water systems cannot be expected as a rule. Moreover the quantity of water which is available in a district may be entirely insufficient. This lack of water makes necessary the fullest use of existing supplies and in some cases necessitates the use of tank trains or ships or long pipe lines. The allied forces in the Gallipoli campaign were obliged to depend to a great extent on water which was brought to Anzac from Alexandria and Port Said in tank ships.

Operations in any particular territory bring about a great concentration of men in the district. This means that the quantity of water required will probably exceed that provided for in peace time by the inhabitants. It also means much greater amounts of soil pollution as well as contamination by seepage from latrines, burial pits and wastes in general. That is to say, there will be increased possibilities for contamination of water supplies and greater needs for the water.

In the present war it appears that actual poisoning of wells has occurred in addition to intentional defilement of wells and springs by means of manure, dead bodies and the excrements of the troops of the enemy. The use of chemical poisons—arsenical animal dips, extracts of poisonous mushrooms and probably other substances—are rather difficult to take out of water, but would probably best be removed by dilution on continued pumping of the well. The intentional or accidental defilement by body wastes and decomposing organic matter is serious on account of the possibilities of infection of the water by the specific organisms of such diseases as cholera, the typhoid fevers and the dysenteries. Advancing troops are likely to be visited with such of these diseases as have affected the retiring enemy. After the battle of the Marne, for example, the French suffered from paratyphoid fever believed to have been disseminated by carriers of the disease among the German troops.

It should not be concluded that these water-borne diseases have troubled only the recent armies, for the effectiveness of the older ones has suffered, too. Sanitary arrangements during wars have probably always been very poor and for this reason the disease-caused mortality has usually been much greater than that due to battle. The intestinal diseases have ranked high among army diseases. I do not mean to convey the idea that the cases of intestinal diseases are all water-borne because contact, flies, food and the general unclean surroundings also are contributory. However, the diseases are so serious in their results and so fatal to the effectiveness of an army that all available preventive measures should be employed.

In the present war the disease ratio is said to have been much reduced. It certainly should be, in the light of increased sanitary knowledge and the prophylactic or preventive measures applied. Among these preventive measures the inspection of drinking waters and their purification have high rank.

In order to know whether a water is poisoned or not, or whether or not it has been contaminated, inspections, sanitary surveys and analyses are made. Inspections of well casings may be made by lowering lights or by throwing a beam of light from a hand mirror into the well. Such inspections can detect the points where surface water is entering and may reveal the presence of bodies or other foreign objects if the well is pumped out. These objects may be removed by grappling or by descending into the well. The point of entrance of the surface drainage may be repaired to exclude the contaminated water. Before beginning the descent into any well, a candle should be lowered to see whether or not there is enough carbon dioxide in the well to cause suffocation. Wells which have been defiled are cleaned, pumped out repeatedly and treated with a heavy dose of chloride of lime or potassium permanganate. They are not used as sources of drinking water in the presence of sufficient pure supplies.

In many cases a sanitary survey of the surroundings of the source of water is valuable in locating the contaminating influences. Once located, steps to abate the nuisance may be taken.

Sanitary analyses and the more complete bacteriological examinations are usually limited to completely equipped laboratories. The motor field laboratories in use by the British armies and their allies are capable of handling this work. In addition to these, smaller and more portable laboratories have been designed. Some of these small laboratory outfits have a very limited field of usefulness. The smaller equipment can, however, be used with small bodies of troops or when the more cumbersome nature of the motor laboratory would interfere with the hurrying up of additional combatant units. Under the press of such conditions the examinations would in all probability have to be dispensed with and all drinking water presumed to be unsafe. The French had provided more than two hundred portable toxicological laboratories as early as the middle of 1915. These laboratories are particularly charged with determining whether or not wells have been poisoned by mineral poisons, alkaloids, glucosides, cyanides and the like. They are also expected to investigate the character of the gasses used by the enemy and to devise emergency defensive measures.

The Medical Department in our army is also charged with making such boiler analyses as are required for the military railways operated by the Engineers.

The use of the unstable hypochlorites of calcium and sodium in purifying water necessitates frequent analysis of the chemical employed in order to be sure that a sufficient quantity of the active chlorine is applied. Sometimes the water which has been treated by the hypochlorites is tested by means of potassium iodide and starch. In the presence of any free chlorine the familiar blue color of iodide of starch appears. A compound of zinc iodide and starch claimed to be very stable is also issued at times.

In the absence of data regarding the quality of water supplies as has been mentioned, all the water used is to be considered contaminated. When the quality of several sources is known, the water from the least polluted should be used, even though it is necessary to purify it by some artificial means. None of the processes commonly employed—excepting of course distillation—is able to remove such poisonous mineral substances as arsenic and the like. All are aimed at freeing the water from dangerous bacteria. Poisoning by mineral poisons can only affect the man who actually drinks the water, but a case of typhoid fever or cholera derived from a water may be communicated to a large number of others who are susceptible.

In order to reduce the necessary purification to a minimum the existing water supplies must be protected from further pollution. The curbing of wells may be repaired or built up so that water thrown near the well runs away at once. Good native wells are placarded and put under guard to prevent nuisances in their immediate neighborhood.

Where the supply is to be taken from a stream, the senior officer is required to designate the point at which the drinking and cooking water is to be taken. Down stream from that point places are selected for the bathing of men and animals as well as the usual fording back and forth. Considerable pollution of a stream may sometimes occur as a result of the necessity for crossing a river before selecting the source of the supply. Once the source is designated it is protected in the usual manner by means of notices and guards.

While good use may frequently be made of the better sort of native wells, the troops will sometimes be faced by the necessity of constructing new ones. Circumstances will dictate whether it is better to construct dug wells, or driven, drilled or bored ones. Driven wells are rapidly put down where the rock is not too hard and do not usually require a great amount of apparatus. On the other hand, they do not offer much opportunity for the storage of water. The British army has made use of a variety of the driven well which they called the Norton tube well. It was intended to be used by marching troops and for this purpose it was not a success, due chiefly to the amount of time required. It was adapted to loose mantle rock to a depth of only twenty-five feet. It took some time to get the water clear and it was often high in bacteria due to the contamination introduced in driving, for most new wells require some time to get rid of the bacteria introduced in putting them down. As a means of increasing a supply, however, the Norton tube well would have some use where the troops were expected to remain for a time in camp.

The actual purification of the water in the field is usually carried out in one of three ways: by heat, by filtration or by chemical disinfection. To be satisfactory the process used should comply with the following requirements: (1) it should be efficient under field conditions with the sorts of waters which the troops will encounter, (2) the apparatus and supplies should be light enough to be readily transportable, preferably without the aid of wheeled transportation, (3) the rough treatment likely to be received in the field should not throw the apparatus out of adjustment or render it unsuitable, and (4) skilled attendance should not be necessary to insure proper purification since the operator may be incapacitated in service.

There is no doubt that boiling offers the best means of rendering a polluted water safe. If the water is boiled for a few minutes nearly all bacteria are killed. A very small amount of apparatus and material is required. In some cases, however, the fuel is scarce or must be carried. The great disadvantages of the method, however, are the amount of time consumed in heating up the water and cooling it, and the flat taste which the water has unless re-aerated. In winter there is no trouble in cooling the water, of course, and the cooling may be hastened at other times by using porous jars, canvas bags or boilers wrapped in burlap. The outer surfaces are moistened and the evaporation of the water from the surface removes heat from the vessel. In practice the cooling is usually done over night. The vessels in which the cooled water is stored should be protected from dust and the men should never be allowed to dip their water bottles into the water. Any infection of the water will be followed by rapid bacterial growth since food conditions and the lack of opposition favor rapid multiplication of bacteria.

The heat-exchange sterilizer is an apparatus which has been designed to do away with the time lost in heating and cooling water in boilers of the ordinary sort. The apparatus is arranged so that the cold impure water is used to cool the hot purified water and at the same time effect a saving in heat. In order to have the apparatus efficient and yet deliver the treated water at a temperature near that of the raw water, the heat exchange surfaces must be as large as possible. This is accomplished by bending a dividing wall into a sort of accordion pleating or having the hot water pass through narrow tubes surrounded by the cold, impure water. An apparatus of this sort is efficient and can deliver purified water at a temperature only about five degrees above that of the raw water. The disadvantages are the necessity for skilled attendance, difficulties with sticking valves and the liming of the kettle and heat exchange surfaces as well as occasional difficulty in securing fuel. The Forbes sterilizer, which is of this type, was adopted by the United States Army in 1898, but has been abandoned on account of the troubles in the field. Wheeled mountings for these sterilizers have been designed in addition to the smaller portable types. Among the foreign apparatus are the Griffith, Rietschel and Henneberg, and Vaillard-Desmaroux types.

Filters of all sorts have been designed for use in the field. Improvised barrel filters made of two barrels—one within the other and the space between them filled with sand—are mentioned by most writers on military hygiene. There are also filters of cloth, sponge and charcoal. At the other extreme are the exceedingly fine candle-filters such as the Berkefield, Pasteur and Chamberland filters which operate under pressure.

Of course the filter should be constructed according to the service expected of it. The cloth, sponge and coarse sand filters can only be expected to remove the larger animal and vegetable forms of life, and the coarser suspended matter. They will not take out the finer suspended matter and bacteria unless they are aided by coagulants. In filtering a water containing much suspended matter the candle filters soon clog. They are intended to remove such small objects as the bacteria.

In the museum of the Equipment Board at Rock Island there are a number of filter-canteens. In these some sort of a candle-filter is set into the neck of the canteen and expected to operate by suction applied by the mouth. If these filters yield water sufficiently rapidly to satisfy the soldier, they cannot be fine enough to retain the bacteria, and if tney yield the water too slowly, the soldier will surreptitiously remove the filter and drink the unfiltered water.

The candle-filter has been widely used in military posts and has given good service when properly handled. It is necessary to clean and sterilize the candles frequently, as bacteria begin to grow through them in a few days. The cleaning and sterilization of a hundred or more of these fragile candles is quite bothersome. There is, moreover, continual difficulty in keeping the candle-housings tight under pressure. For these reasons the candle-filter is not considered satisfactory for field use. The British army had a water filter-cart in use at the beginning of the war. It was a 110 gallon cart provided with a Pasteur filter preceded by a preliminary sponge filter. It was soon found that the filter candles were so fragile and unreliable that the carts were ordered used for the treatment of the water by chemical disinfection. The German army has experimented very extensively with all sizes of candle filters ranging from a single-candle knapsack filter to multiple-candle filters with a capacity of 2000 liters per hour.

Where coagulation is employed, a comparatively coarse filter may be used for bacterial removal. Chemical coagulation is dependent upon the production of a gelatinous precipitate in the water to be purified. This precipitate entangles the bacteria and suspended matter, thus gathering them into larger particles which may be more readily removed. Sometimes sedimentation alone is depended upon for the purification of the coagulated water and sometimes filtration is employed. The coagulant usually employed in military practice is alum.

Of the field filters using coagulation the most important are the Ishiji, Darnall, and drifting sand types. The Ishiji was the filter used by the Japanese in the Russo-Japanese war. The filter was a conical canvas baf with two radial arms or spouts a short distance above the bottom. In each of these arms there was a filter of charcoal and sponge.

The Darnall filter is the invention of Lieut. C. R. Darnall of the Medical Department. It consists of three nested galvanized cans in a crate, a siphon of iron pipe and a filter frame which attaches to the siphon. The filter frame carries a specially woven cotton-flannel filter cloth which is wrapped around the cylindrical metal frame when in use. A coagulant composed of equivalent amounts of potassium alum and sodium carbonate is supplied. In practice the apparatus is assembled and the filter sterilized by siphoning hot water through it. The chemical is then added (rate one pound to 550 gallons) and the siphon is started. The filter can deliver fifty gallons of water with a bacterial removal of 95 to 98 per cent. It weighs about fifty-two pounds when knocked down for shipment. Although the bacterial removal is sufficient to render safe a moderately polluted water, the filter should be depended upon only as a means of clarification. This is a very important office since chemical sterilization is more satisfactory with a well-clarified water.

The drifting sand filter is an adaptation of a devise perfected at Toronto. It has been put in use in the war zone chiefly through the efforts of Lt. Col. Nasmith, chief of the mobile laboratories of the Canadian army. The advantage of the apparatus is the continual cleaning and replacing of the soiled sand layer on the surface of the filter. It is larger, heavier and of greater capacity than the Darnall and Ishiji filters and therefore not so valuable for small bodies of moving troops.

The more important chemical disinfectants which have been used for field purification of water are the permanganates, the acid sulphates, iodine, bromine and chlorine. The latter is used in the form of the hypochlorites of calcium and the alkalies, as a liquid, or as a gas.

Ozone has also been employed, but it has the disadvantage of requiring considerable heavy apparatus including a gasoline engine and dynamo, as well as expert attendance. The same objection applies to the ultra violet ray apparatus which has been proposed.

Potassium permanganate is a slow and uncertain germicide. However, it will produce a brownish precipitate which may be used to advantage as a coagulant. The chief use of the permanganates has been in India where they have been extensively used in the disinfection of wells at times of cholera epidemics.

The acid sulphates—usually represented by sodium bisulphate—are dependent on their acid character for their disinfecting power. They, too, are particularly effective against the cholera organism. As much as one gram per pint is employed. The unpleasant acid taste is obscured by compounding into the tablets lemon oil and saccharin. They are not suitable for continued use on account of the laxative character of the sodium sulphate formed. They were supplied to the New Zealand troops during the Boer war and have been used during the present war by the British cavalry. The acid attacks the metal of the canteen and some canteens may yield toxic metals to the water. Troops who are to use these sodium bisulphate tablets are supplied with aluminum water bottles.

Iodine and bromine are not usually used for purification because they are more expensive than the chlorine compounds. Their germicidal powers are about the same. Any excess of the chemical remaining after treatment must be removed by some other chemical such as sodium thiosulphate. Bromine was strongly advocated in Germany about 1897 but has fallen into disrepute on account of the difficulties of administration. The French recommend the use of iodine only when chlorine or the permanganates are not at hand.

The most important process at the present time, however, is the chlorine treatment and I shall therefore describe it much more fully than I have described the uses of the other chemicals.

Chlorine is used in American municipal water purification in one of two forms, calcium hypochlorite or liquid chlorine. For treatment of water in the field the alkaline hypochlorites and lately aromatic chloramines also are employed. The action with all of these is probably much the same, namely, an oxidation and a substitution of chlorine for the hydrogen of amido groups in the bacterial protoplasm.

The germicidal power of calcium hypochlorite—also called chloride of lime or bleaching powder—was known in the early fifties. Koch's work in 1881 showed the great germicidal power of the substance in a more practical way for he tried out its germicidal action on anthrax bacteria and their spores, using the thread method. From these results and those of Nissen (113), Traube (131) took his cue for the application of calcium hypochlorite to the purification of drinking water. Traube used a little less than four parts per million of the chemical, corresponding to a little more than one part per million of "free chlorine." He added about two parts per million of sodium thiosulphate to remove the excess of free chlorine. Later experimenters followed Traube and tried both the calcium and the alkaline hypochlorites in water purification. The success of the hypochlorite treatment at the Bubbly Creek filter plant in Chicago in 1908 (106) showed the utility of the chemical for municipal water works and almost immediately this method of treatment was adopted as a standard procedure all over the country. About 1911 liquid chlorine began to supplant the hypochlorite on account of the greater mechanical advantages of the former in its administration. Chlorination of drinking water is now depended upon by hundreds of cities as a final safeguard for their water supplies. In the treatment of the stored surface water or lake supplies of some great cities like New York (using five hundred fifty million gallons of water a day) and Chicago (pumping seven hundred million gallons) chlorination is the only means of purification applied.

Such then, is the history of chlorination as applied to municipal supplies. Cantonment supplies, (as has been mentioned before), take on many of the characteristics of city supplies. At least sixteen of our cantonments and large camps in the country are using liquid chlorine and are applying it in the manner used by municipal plants. For the smaller quantities of water special procedures are employed—though the principles of the action are the same.

The great difficulty in the chlorination by hypochlorites is the loss of strength due to the escape of the free chloride or its combination with other substances. This difficulty is increased in warm climates—a fact which has suggested to certain Indian army officers some methods of using the chlorine as a gas. Calcium hypochlorite is not completely soluble. The sludge left after making up the solution is bothersome and retains some of the active chlorine. To avoid as much as possible of the loss of chlorine from decomposition the chemical is usually packed in air-tight cans.

When an excess of chlorine is used, an objectionable taste and odor will result. Different waters contain various sorts of organic matter which absorb varying quantities of the reagent. Sometimes the chlorine may combine with these substances giving rise to compounds which themselves have odors and tastes similar to those developed in the presence of an excess of the chemical. For this reason, the mere taste of the chemical in the water is not always an indication that a sufficient quantity has been used. The employment of coagulants—or their use in larger amounts—by removing much of this organic matter (including the bacteria) will in many cases tend to reduce this difficulty and at the same time give better bacterial removal.

Inasmuch as it is essential for good results that there be a residue of free chlorine in the water after the absorption, the different waters will require different amounts of the hypochlorite. The usual quantity applied in ordinary water works practice is from one to two parts per million of the calcium hypochlorite by weight. This is equivalent to .3 to .6 parts per million of free chlorine. (Weight U. S. gallon 8.3 pounds, British Imperial gallon 10 pounds.) It is customary in field work to add a sufficient amount of the chemical to give the potassium iodide-starch test after half an hour. Sometimes this result is secured by making the test on the treated water and sometimes the use of an overwhelming quantity of chemicals is depended upon. The excess is then removed by sodium thiosulphate.

A point of practical importance that is seldom mentioned in this connection, is the influence of low temperature on the treatment of water. It is well known, of course, that chemical reactions usually proceed more slowly or with decreased intensity at a low temperature. The influence of this retarded action in the coagulation of water is very easily noticed. The flakes of coagulant can no longer be seen floating in the water, or as the water works operator says, you have "pin-point coagulation." In the chlorination of water the retarding of the reaction is not so readily seen. The odor and taste are the cause of more complaints in the winter time and although the water will give the test for free chlorine after half an hour, the bacterial removal is not always satisfactory. The difficulties in the winter appear, however, to be more troublesome when calcium hypochlorite is the germicide than when the liquid chlorine is used.

In applying the hypochlorite, it is very convenient to make up a small amount of a stock solution using a known weight of the chemical and a definite volume of water. The desired amount of this solution may then be measured into known volumes of the water to be treated and carefully mixed. The Thresh method (130) provides sealed quarter pound tins of calcium hypochlorite and half pound packages of sodium thiosulphate. One tin of the hypochlorite is mixed into a gallon of water and the package of sodium thiosulphate is dissolved in another gallon of water to form the antichlor. The hypochlorite is sufficient for 8,000 gallons of water, making one part of the chemical in 320,000 parts of water (since the British Imperial gallon weighs ten pounds). The free chlorine employed is therefore a little more than one part per million. After fifteen minutes a volume of the thiosulphate solution equal to that of the bleaching powder solution is added to destroy the excess chlorine. It might be of interest to note that while ordinary bleaching powder contains 25 to 37 per cent of its active ingredient—available chlorine, the Bayer Company, a German concern, at the opening of the war produced a similar compound containing 75 per cent available chlorine.

The French have been using Javel water or solutions of sodium hypochlorite containing about 85 to 90 grams of free chlorine per liter. More dilute solutions rapidly lose their strength, especially if left exposed to the air and light. Since there is some loss even in the more concentrated solution, this must be titrated from time to time to determine its exact strength. The volume of this solution which is to be used naturally depends upon the strength of the solution. The amount of free chlorine recommended for use in polluted waters is 0.8 parts per million. The sodium hypochlorite has the advantage of being a relatively clear solution. It is, however, much more bulky than the bleaching powder containing the same amount of free chlorine. In addition the container is likely to be broken with consequent damage to any goods with which the solution may come in contact.

The Rhein method (124) uses antiformin instead of Javel water. To every liter of water 2.1 c.c. of antiformin and 1.1 c.c of 25 per cent hydrochloric acid are added. (Antiformin is similar to Javel water but is usually strongly alkaline with caustic soda.) The acid sets free the chlorine and it may reach a concentration of 110 p.p.m. After five minutes a tablet containing 0.45 grams of sodium thiosulphate and 1.7 gms. of $NaHCO_3$ is added. Gothe (103) has shown a number of errors in this paper, but the most important fault to be found with the process is the necessity for making accurate measurements of powerful chemicals. The ordinary untrained man might easily make a mistake.

Tablets or capsules of calcium hypochlorite have been suggested by a number of writers. All of these are open to the objection that they lose chlorine and are not suitable for use after a few weeks on that account even when packed in tight vials of amber glass. The tablets have been made of the chemical alone or in combination with sodium carbonate, lactose and so on. The density of the tablets is objectionable—especially when composed of the hypochlorite alone—since they must be crushed or else a considerable amount of the substance will be kept from taking part in the reaction. Vincent and Gaillard (134) claim that by mixing sodium chloride with the hypochlorite, crushing is made unnecessary. The salt dissolves out leaving the tablet so porous that all of the active chlorine escapes into the water within ten minutes. The tablet designed for one liter of water contains 3 to 3.5 milligrams of active chlorine. This will mean that the water will receive 3 to 3.5 parts per million of free chlorine.

Chloramine-T (sodium toluene sulphamide), one of the Dakin antiseptics, has been tried by Mackenzie Wallace in India. The antiseptic is very slightly soluble. Its action is very slow, although there is a marked retardation of the aftergrowth of the bacteria which usually results when the effect of the sterilizing agent has worn off or a re-infection of the sterile water has taken place. As much as .4 gm. of the disinfectant and ten hours' time are required for the sterilization of a liter of water. Another one of the chloramine group of antiseptics has been proposed by Dakin and Dunham (2) under the name of "Halazone," (para sulphon di chlor amino benzoic acid). This is said to be effective in a concentration of 1:300,000 with an interval of half an hour. The advantages claimed are less rapid loss of chlorine on storage and less rapid combination of the chlorine in use. It is supplied in tablets packed in amber glass bottles. The tablets have a chlorinous odor.

On account of the difficulty of securing and preserving calcium hypochlorite in a tropical climate, Treherne and Nelson (112) of the Indian army developed a chlorine gas method in 1912. The chemicals used are potassium chlorate and hydrochloric acid. The acid is in the concentrated form and the chlorate is in the form of five grain tablets. Two unbreakable bottles are supplied. The larger has a capacity of 24 ounces; the smaller of one ounce. Twenty ounces of water are put in the large bottle and three tablets of potassium chlorate are put into the small bottle with two drachms of the hydrochloric acid. The chlorine produced is bubbled through the water in the large bottle. When the reaction is finished, the contents of the small bottle are added to those of the large one. One ounce of the chlorine water added to 5 gallons of the water to be treated gives a dilution of 1:440,000. In half an hour the water is declared safe. With this apparatus weighing twelve pounds 9600 gallons of water can be sterilized without refilling. Rishworth, who has had experience with this method in the field, has suggested an apparatus similar to a siphon bottle for making the stock solution. Chlorine stored in small steel bulbs under pressure could be dissolved in the water.

The Lyster bag employed in the United States Army could be used for any of these methods of purification. It was devised by Major Wm. L. Lyster of the Medical Department. It is a bag of specially woven canvas 20 inches in diameter by 28 inches in depth. It is slung from a folding ring. Near the bottom are five self-closing faucets which are small enough to fit inside the neck of a canteen. It weighs about seven and a half pounds when empty and is intended to be carried by one of the men. When filled the weight is about 330 pounds. The chemical actually used is bleaching powder, which is put up in sealed glass tubes, containing fourteen or fifteen grains. A package (7½ inches x 3½ inches x 4¼ inches) containing sixty of the tubes weighs ten ounces. To treat a bag of water, one of these tubes is broken at the file mark it carries, and the contents mixed in a cup of water. The mixture is put into the bag which is then filled. In half an hour the water is ready for use. If the raw water is turbid, it is strained through a filter cloth or blanket. This of course will not remove fine turbidity. Comprehensive experiments have demonstrated that typical and dysentery bacteria, active amoebæ, ciliates and the like are killed within 15 minutes. According to Hurst (6) chlorination as usually practiced does not destroy encysted amoebæ.

SUMMARY.

1) Experience has shown that careful control of the drinking water supplied is essential to the health of the troops. The control measures include protection of existing supplies, development of new ones, inspection of all questionable sources and the purification of all contaminated or suspected supplies.

2) In the present conflict it is necessary to know whether or not a well has been deliberately poisoned as well as to know whether it is polluted with sewage-like material or decomposing animal matter.

3) The bacterial purification of water is best accomplished by heat or chemical disinfection, preceded, if necessary, by a preliminary clarification.

4) In spite of the possibility of unpleasant tastes and odors the chlorine compounds are the most satisfactory—as well as the cheapest means of treating water when heat is not practicable.

5) Bacterial multiplication in sterilized water is rapid in case of re-infection. Care should be taken to avoid dipping into the water with unclean vessels or allowing dust to blow into the container.

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A STUDY OF CERTAIN GREEN MANURE CROPS IN MAKING ROCK PHOSPHATE AVAILABLE IN SOILS.

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At the present time the world is in the midst of the greatest conflict ever staged. The byword on the lips of every thoughtful American is, "Food will win the war." In order that food may be conserved it must first be produced. Therefore, increased crop production must be stimulated. We must produce larger crops upon a given area, that is, intensive farming should be practiced.

Primary among the controlling factors in securing increased crop production is an abundant supply of active organic matter and sufficient soluble phosphorus for the entire needs of the growing crop.

Available or soluble phosphorus is obtained commercially by mixing raw phosphate with sulfuric acid. At the present time sulfuric acid is difficult to obtain. Accordingly the idea was conceived of growing a green manure crop on soil to which raw rock phosphate had been applied. By selecting a green manure crop which is able to utilize so-called inert phosphate obtained from raw rock and by plowing the same under, the succeeding crop should derive at least two beneficial effects. In the first place an essential and desirable amount of active organic matter would be supplied to the soil, also a quantity of soluble phosphorus might be made available for the following crops.

Accordingly in order to study this problem a miami silt loam soil was selected. This soil contained a small amount of organic matter and an analysis showed the total phosphorus content to be .033 per cent. Ten pounds of this miami soil was placed in pots of one gallon capacity. The equivalent of 1200 pounds per acre of Tennessee brown rock phosphate was added to the miami silt loam soil. Soluble salts containing plenty of the other essential plant foods were added and thus phosphorus was made the controlling element in the crop production.

The following green manure crops were sown on this soil: buckwheat, Japanese millet, German millet, both bearded and beardless barley, rape, Iowa 103 oats, durum wheat, soy beans, cane, alfalfa, alsike and red clover, cow peas and timothy. Manure crops were allowed to grow for three months and then were turned under. It has been found that Japanese millet is not able to utilize so-called inert phosphorus from raw rock. Accordingly Japanese millet was immediately seeded on these green manured soils. The millet was allowed to mature and then was harvested. The yield was calculated and the amount of phosphorus contained in the crop was compared with the yield of millet. Analyses were made also to determine the amount of phosphorus in the soil at different stages of growth, soluble in fifth normal nitric acid. In connection with this problem approximately 550 determinations of so-called available and total phosphorus were made.

It was found that the greatest yield of millet was produced from the soils on which alfalfa, bearded barley, durum wheat, and cow-peas had been turned under as green manures. These higher yields accompanied a lower percentage of residual phosphorus in the soil and a consequent lower availability of this residual supply. Where any one of the four above mentioned crops was used as a green manure and thus available phosphorus was formed a profitable increase in total yield of millet was obtained over the check.

There are numerous common cereal crops besides millet which make a much better growth if the phosphorus in the soil is in an available form.

From the results of this experiment it seems possible that the practice of manufacturing soluble or available phosphorus in the soil by aid of certain green manure crops may prove a valuable asset to an increased crop production in the United States.

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THE COMPOSITION AND DIGESTIBILITY OF SUDAN GRASS HAY.

W. G. GAESSLER AND A. C. McCANDLISH.

INTRODUCTION.

The introduction of Sudan grass (*Andropogon sorghum* var.) into the United States took place less than nine years ago, but since then this crop has become widely known and its popularity is rapidly increasing. Sudan grass, being an annual, does not make a good pasture plant, but gives excellent results as a hay or soiling crop; it might also be successfully made into silage if mixed with a legume.

RESUME OF PREVIOUS WORK.

A considerable amount of work has been done on the production of Sudan grass, and, though the yields of hay obtained varied considerably, they were as a rule satisfactory.

TABLE I.

AVERAGE YIELDS OF SUDAN GRASS HAY.[1]

State Experiment Station	Dry Hay Per Acre
	Tons
Virginia	3.4
Tennessee	2.6
Mississippi	5.5
Louisiana	3.3
Georgia	3.6
Arkansas	1.1
Texas	3.9
Oklahoma	2.9
[2]Ohio	4.3
[3]Kansas	3.1
Average	3.4

The average yields of Sudan hay, as stated in Table I, have not all been calculated by the same method but the results show that as a rule a yield of three to four tons of field cured hay per acre can be expected.

The material available to show the composition of Sudan grass hay is limited but a compilation of the published analyses is included here. There is a wide variation in the moisture contents

[1]Farm Bul. 677; U. S. Dept. Agric.
[2]Monthly Bul. Vol. 1, No. 3; Ohio Sta.
[3]Bul. 212; Kans. Sta.

of hays, due to a considerable extent to the lack of uniformity in the conditions under which curing takes place, so in Table II the various constituents are expressed as percentages of the total dry matter present in the samples of hay analyzed.

TABLE II.

COMPOSITION OF DRY MATTER OF SUDAN GRASS HAY.

	Maryland 4	Virginia 5	Texas 6	Oklahoma 7	Average
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
Total Dry Matter ...	90.12	96.49	.	92.80	93.14
Protein	6.57	4.83	12.42	8.56	8.10
Nitrogen-free-extract	51.99	51.09	45.56	48.98	49.41
Crude Fiber	34.83	36.92	29.93	34.01	33.92
Ether Extract	1.88	1.32	1.93	2.42	1.89
Ash	4.74	5.85	10.16	6.03	6.70

The analyses of Sudan grass hay that have been reported are fairly uniform in all their constituents except protein and ash, which show rather wide variations due perhaps to the conditions under which the crops were grown, and the stage of growth at the time of cutting.

It is generally understood that the majority of crops alter materially in composition as ripening progresses. This change is due not only to the increase in the amount of dry matter and the decrease in the amount of water but also to a variation in the relative proportions of the individual constituents of the dry matter. These changes usually go on until the crop is practically ripe but that this is not so in the later stages of ripening in the case of Sudan grass has been shown by Piper.

TABLE III.

COMPOSITION OF DRY MATTER OF SUDAN GRASS HAYS[8] MADE AT VARIOUS STAGES OF RIPENESS.

Stage of Cutting	Before Heading	Heads Appearing	Beginning to Bloom	In Full Bloom	Seeds Fully Mature
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
Protein	8.08	6.28	5.34	4.83	4.38
Nitrogen-free-extract	51.23	53.41	53.76	51.09	55.85
Crude Fiber	32.00	33.11	34.42	36.92	36.02
Ether Extract	1.79	1.44	1.27	1.32	1.55
Ash	6.89	5.75	5.20	5.85	5.85

[4]Bul. 194; Md. Sta.
[5]Circ. 125; Bur. Plant Ind., U. S. Dept. Ag.
[6]Bul. 172; Tex. Sta.
[7]Bul. 103; Okla. Sta.
[8]Circ. 125; Bur. Plant Ind., U. S. Dept. Ag.

As would be expected there is a decrease in the protein and a slight increase in the crude fiber content. These changes are marked in the case of the protein but the other constituents are fairly constant. The significance of this is that from the time Sudan grass heads out until it is fully ripe there is very little change in the fiber content of the dry matter and consequently the time of cutting can be delayed without much risk of the hay becoming too coarse. This suggests a distinct advantage if the haying season is wet—the cutting of the Sudan grass may advantageously be postponed for a week or ten days if there is a prospect of the weather improving.

In spite of the fact that Sudan grass is now grown in quite an extensive territory it has been fed but little experimentally. Large amounts of Sudan hay are consumed annually yet only in one or two cases have accurate records been kept of the results it produced.

So far only one digestion trial has been conducted with Sudan grass hay. This work consisted of a five day test period with a two-year-old bull and the results of it are given below.

TABLE IV.

DIGESTIBILITY OF SUDAN GRASS HAY.[9]

Constituent	Digestion Coefficient
	Per Cent
Dry Matter	60.6
Crude Protein	35.4
Nitrogen-free-extract	63.3
Crude Fiber	67.1
Ether Extract	41.2

The digestion coefficients for Sudan grass hay obtained at the Maryland Experiment Station compare well with those for other nonleguminous roughages.

At the Kansas Experiment Station Sudan grass hay was compared with alfalfa hay as a roughage for dairy cows. Two lots of three cows each were used. There were two thirty-day test periods. In the first period Lot I received alfalfa hay and Lot II Sudan grass hay, while in the second test period the roughages for the two lots were reversed.

[9]Bul. 194; Md. Sta.

TABLE V.

SUDAN GRASS HAY VS. ALFALFA HAY[3] FOR MILK PRODUCTION

	Roughage		Gain due to Alfalfa
	Sudan Grass	Alfalfa	
	lbs.	lbs.	lbs.
Milk Produced	4022	4112	90
Fat Produced	168	178	10
Average Body Weight	1053	1077	24

This shows a difference in production of 0.5 pound of milk per head per day in favor of the alfalfa hay. This is not a large difference but if the experiment had been run for another thirty-day period so as to facilitate the elimination of the decrease in production due to advance in lactation, there is little doubt but what the Sudan grass hay would have shown up even less favorably. The fact that the cows increased in weight when receiving the alfalfa is significant.

The Kansas records also show that when the herd of milking cows was turned from a native pasture on to a Sudan pasture the average daily production of milk was increased 3.2 pounds per head even though Sudan grass is not a first class pasture plant. In addition they also found that for wintering work horses and mules and young beef cattle Sudan grass hay was of considerably less value than alfalfa hay.

EXPERIMENTAL WORK.

The Sudan grass used in the work reported in this paper was grown on the College dairy farm. During the two years this crop has been grown there it has given good results as a soiling crop, the average yield being eleven tons of green feed per acre for one cutting. In 1916 a small amount of second growth was made into hay. Sudan grass seems to be palatable and much relished by the stock and good results have been obtained in the feeding of both the soiling and the hay.

In 1915 analyses were made of the crop at various stages of growth. The samples were all taken from one small plot in the centre of the area grown for soiling and the results of the analyses are expressed as percentages of the total dry matter present.

[3]Bul. 212; Kans. Sta.

TABLE VI.

COMPOSITION OF DRY MATTER OF SUDAN GRASS AT VARIOUS STAGES OF GROWTH.

	Before Heading	Headed Out	Full Bloom	Half Ripe	Ripe
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
Total Dry Matter ..	20.80	20.96	25.74	30.08	31.92
Protein	8.80	9.78	6.57	5.02	4.29
Nitrogen-free-extract	48.12	46.04	50.19	53.32	53.73
Crude Fiber	32.98	35.50	32.36	32.98	33.83
Ether Extract	2.31	2.62	3.53	2.10	1.66
Ash	7.79	6.06	7.35	6.58	6.49

As the moisture decreases and the dry matter content increases in the later stages of growth of Sudan grass, a few minor changes take place in the relative proportions of the individual constituents of the dry matter. In the earlier stages of ripening the protein seems to increase while it decreases in the later stages. The changes in the fat content are very similar to but lag behind those of the protein content. The changes in the proportions of nitrogen-free extract and ash are in the opposite direction to those of the protein and ether extract. Peculiarly, the relative proportion of the crude fiber to the other constituents of the dry matter appears to be greater when the plants have headed out than when the crop is ripe. The difference is not great, however, and can probably be explained by the fact that the seed, of which the yield is quite heavy, is very low in crude fiber. It has been found at the Maryland Station[4] that cleaned Sudan grass seed contains only 1.19 per cent of crude fiber. Considering the changes broadly it is evident that from the time the crop heads out until it is ripe no very marked alterations take place in the relative proportions of the various constituents of the dry matter present and consequently Sudan grass does not materially deteriorate in feeding value on ripening.

The hay used in the digestion trial was from a plot yielding 2.94 tons of field-cured hay per acre at one cutting. It was cut on August 5, 1916, when in full bloom and was harvested in good condition. It was kept in the mow till used for the digestion trial in December, 1916.

The animals used were two three-quarter blood Guernsey heifers about a year and a half old and averaging 600 pounds in live

[4]Bull. 194; Md. Sta.

weight. These animals were of 75 per cent the same breeding, being sired by Rouge of Ames, 24405, a son of Rouge II's Son, while their dams were sired by Rouge II's Son, 18587. From birth until the start of the digestion trial these heifers received the same care and feed. Both were pregnant and in fair condition at the beginning of the experiment, and though No. 298 was rather larger than No. 301, they were a very uniform pair in all other ways.

TABLE VII—ANIMALS USED IN TRIAL.

	Herd No. 298	Herd No. 301	Average
Age	1 yr. 6 mo. 17 da.	1 yr. 5 mo. 27 da.	1 yr. 6 mo. 7 da.
Days Bred ...	63	152	108
Weight, lbs. .	650	550	600

The digestion trial was run for a period of five days preceded by a preliminary period of seven days during which Sudan grass was fed as the only source of nutriment to the heifers. In the preliminary period it was found that 20 pounds per head per day of the hay would be a convenient amount to feed, so this allowance was used throughout the experiment and the material left was weighed back daily.

It has been found that the animals had no special need of being watered twice daily so the watering was done at the beginning of each twenty-four hour period and the animals were weighed before and after watering. The attendant collected the feces with a scoop and deposited them in tarred galvanized iron vessels which were provided with covers.

A composite sample of the hay fed and one of the orts were made at the end of the trial period. The feces from each heifer were mixed thoroughly and sampled at the end of each twenty-four-hour period and these samples air-dried. At the end of the trial an aliquot composite sample was made for the feces produced by each of the heifers during the five-day trial period.

The composite samples of feces, together with those of hay and orts were chemically examined according to the official methods.

In Table VIII is given a summary of the hay and water consumed and the feces produced daily by each of the heifers. Only the net consumption of hay is given and the feces production recorded opposite a daily consumption of hay is the weight of feces produced in the twenty-four hour period following the day during which the recorded amount of hay was consumed.

TABLE VIII—SUMMARY OF FEED AND FECES.

	Hay Consumed		Water Consumed		Feces Produced	
Heifer No.	298	301	298	301	298	301
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Day 1	14.2	13.4	24	27	19.1	14.9
2	17.0	16.7	39	29	21.8	20.9
3	13.0	11.6	31	17	24.6	18.4
4	7.9	10.5	28	27	21.4	21.8
5	12.4	14.1	24	26	23.9	19.8
Total	64.5	63.3	146	126	110.8	95.8

The heifers had very similar capacities for hay consumption, the difference in their average daily consumption being only about one-third of a pound. Their capacities for water consumption were also very much alike; the heifer which consumed the smaller amount of hay drank on the average four pounds more water per day than did the other heifer. The feces production followed the water consumption very closely and the heifer which consumed the smaller amount of hay and the greater quantity of water produced the greater weight of feces.

TABLE IX. COMPOSITION OF HAY.

	Hay Offered	Hay Refused	Hay Consumed
	Per Cent	Per Cent	Per Cent
Moisture	13.19	11.64	14.01
Dry Matter	86.81	88.36	85.99
Protein	5.97	4.10	6.96
Nitrogen-free-extract	43.63	42.85	44.04
Crude Fiber	28.65	34.50	25.55
Ether Extract	1.62	1.08	1.91
Ash	6.94	5.83	7.52

As was to be expected the hay refused was a little more fibrous than the whole sample. The difference is so small, however, that the digestion coefficients found for the hay consumed will apply equally well to the whole sample.

TABLE X. COMPOSITION OF FECES.

Heifer No.	298	301
	Per Cent	Per Cent
Moisture	82.39	79.13
Dry Matter	17.61	20.87
Protein	2.13	2.54
Nitrogen-free-extract	8.32	9.74
Crude Fiber	4.35	5.24
Ether Extract	.47	.54
Ash	2.34	2.81

The analyses given for the feces represent their composition when moist. Heifer No. 301, which consumed less hay and more water than did heifer No. 298, produced the feces with the higher moisture content. The bulk of the feces evidently depends to a large extent on the amount of water consumed.

TABLE XI.

SUMMARY OF NUTRIENTS CONSUMED AND DEFECATED.

Heifer No.	298		301	
NUTRIENTS	Consumed Total	Defecated Total	Consumed Total	Defecated Total
	lbs.	lbs.	lbs.	lbs.
Dry Matter	55.44	19.51	57.03	19.99
Protein	4.51	2.36	4.59	2.43
Nitrogen-free-extract	28.42	9.22	29.19	9.33
Crude Fiber	16.40	4.82	17.02	5.02
Ether Extract	1.24	.52	1.26	.52

This table again demonstrates the similarity between the powers of the two heifers for using roughage and also indicates that their powers of digestion are very nearly equal.

TABLE XII.

COEFFICIENTS OF DIGESTIBILITY.

Heifer No.	298	301	Average
	Per Cent	Per Cent	Per Cent
Dry Matter	64.8	65.0	64.9
Protein	47.7	47.1	47.4
Nitrogen-free-extract	67.6	68.0	67.8
Crude Fiber	70.6	70.5	70.6
Ether Extract	58.1	58.7	58.4

This shows that the nutrients in Sudan grass hay are all fairly easily digested. The digestion coefficients range from 47.4 per cent in the case of the protein to 70.6 per cent in the case of the crude fiber, while that for the total dry matter is 64.9 per cent.

A comparison of the work done at this Station with that done at the Maryland Station shows that the coefficients of digestibility obtained agree fairly closely for most of the nutrients present in Sudan grass hay.

TABLE XIII.

COMPARISON OF DIGESTION TRIALS WITH SUDAN GRASS HAY.

	Digestion Coefficients[4]		
	Maryland	Iowa	Average
	Per Cent	Per Cent	Per Cent
Dry Matter	60.6	64.9	63.5
Protein	35.4	47.4	43.4
Nitrogen-free-extract	63.3	67.8	66.3
Crude Fiber	67.1	70.6	69.4
Ether Extract	41.2	58.4	52.7

The Iowa results are in all cases higher than those obtained at the Maryland Station but only in the case of the crude protein and ether extract is there a very marked difference. This may perhaps be due to differences in the conditions under which the hays were grown, though they are very similar in composition, or more probably to variations in the digestive powers of the animals used. Whatever the factor or factors are that bring about this difference they apparently are selective in their action.

TABLE XIV.

SUMMARY OF WORK ON SUDAN GRASS HAY
NUTRIENTS IN 100 POUNDS OF HAY.

	Nutrients	
	Total	Digestible
	lbs.	lbs.
Dry Matter	91.6	58.2
Protein	7.7	3.3
Nitrogen-free extract	48.3	32.0
Crude Fiber	30.9	21.4
Ether Extract	1.8	.9

[4]Bul. 194; Md. Sta.

A comparison of Sudan grass hay with timothy and millet hay shows that these feeds are very similar in composition. The digestible nutrients in 100 pounds of dry matter of the various feeds have been calculated from Henry & Morrison's tables[8] while the digestible true protein and net energy value of 100 pounds of dry matter have been obtained from Armsby's work.[9]

TABLE XV.

DIGESTIBLE NUTRIENTS IN 100 LBS. OF DRY MATTER.

	Timothy Hay	Millet Hay	Sudan Grass Hay
	lbs.	lbs.	lbs.
Protein	3.4	5.8	3.6
Carbohydrates	48.4	53.6	58.3
Fat	1.4	2.1	1.0
Total	54.0	64.2	64.2

This shows that Sudan grass hay provides considerably more nutrients than does timothy hay and though it contains rather less digestible protein than does millet hay it appears to furnish about the same amount of total nutrients. These comparisons are made on the dry matter basis so as to eliminate variations due to changes in the moisture contents of the feeds.

TABLE XVI.

DIGESTIBLE TRUE PROTEIN AND NET ENERGY. VALUES PER 100 POUNDS OF DRY MATTER.

	Timothy Hay	Millet Hay	Sudan Grass Hay
Digestible True Protein, lbs.	2.5	4.6	2.7
Net Energy Value, Therms.	48.67	54.80	64.42

The net energy value of the Sudan grass hay has been calculated according to Armsby's method. While the digestible true protein is taken as 75 per cent of the digestible crude protein. These figures show that Sudan grass hay, though deficient in protein, provides more net energy, per 100 pounds of dry matter, than does hay from timothy or millet.

[8] Feeds and Feeding.
[9] Bul. 142; Pa. Sta.

SUMMARY.

1. The dry matter of Sudan grass changes slightly in composition from the time of heading until the crop is ripe.

2. The content of fat and protein increases in the early stages of ripening and decreases later while the changes in the nitrogen-free-extract and ash content are in the opposite direction.

3. Either as a green feed or as hay, Sudan grass is very palatable.

4. Sudan grass hay has a comparatively high apparent digestibility.

5. Sudan grass hay supplies energy to cattle much more efficiently than it does protein.

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Agricultural Experiment Station,
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THE OCCURRENCE AND POSSIBLE TOXICITY OF MOLDS IN CORN SILAGE.

ALVIN R. LAMB.

Frequent cases of suspected forage poisoning in this state which apparently were traced to moldy silage, led to this study. The silage in a silo below the surface layer is almost always free from mold, at least when properly packed and containing a sufficient amount of moisture. Occasionally, however, clumps of mold are found far below the surface and in the interior of the mass where the amount of oxygen is almost negligible. In order to secure a considerable number of samples of such moldy silage, notices were sent out to the newspapers of the state through the press bulletin, "Better Iowa."

A number of samples of the kind of material wanted were received. In all cases, as in the case of samples previously sent in for examination, the molds present were of the same characteristic red or green color. In the samples studied the red mold was in each case isolated and identified[1] as *Monascus purpureus* Went, which was found in silage some years ago by Buchanan.[2] This mold forms in silage thick cottony masses of white mycelium, often tinged with carmine red. In cultures well advanced in age the whole mass takes on this characteristic color. The red pigment is easily soluble in water and diffuses through the surrounding silage, coloring the kernels of corn a homogeneous pink or carmine. The fact that this pigment penetrates beyond the moldy region is sometimes a source of confusion in the examination of such silage.

This mold was grown successfully on various modifications of Raulin's medium. The addition of silage juice to the medium did not generally increase either the color or the luxuriance of the growth. The growth was most luxuriant, of course, with sugar in the medium, but the production of the red pigment was more marked in the absence of sugar. Both on agar and liquid media the pigment was produced below the surface of the medium.

The greatest production of the pigment was obtained in cultures grown on rice flour paste after the method of Buchanan.

[1]The identity of these two species was very kindly confirmed by Dr. Charles Thom of the Bureau of Chemistry, Washington, D. C.
[2]Mycologia, Vol. 2, pp. 99-108, 1910.

Growth was luxuriant and the entire medium was deeply colored. According to Buchanan, *Monascus purpureus* is used by the Chinese in the preparation of "red rice," which is used as food.

The green mold was isolated and identified as *Penicillium roqueforti* Thom, which is often referred to in dairy literature as *Penicillium glaucum* Link. It is always found on Roquefort cheese and also occurs on other cheeses. The mycelium is characteristically green or grayish green and becomes a deep brown when two to four weeks old, if exposed to the air. The medium is not colored. It grows equally well on Raulin's medium and on silage juice agar.

From the experience of the writer it seems that these two molds are practically the only ones found in well preserved silage below the surface. Other molds have been isolated from samples of silage, but the fact to be considered is that moldy silage is not generally found except where the silage was not moist enough to be well packed and thus thoroughly exclude the air. If air is not excluded, various molds may be found, but such conditions are not considered here.

TOXICITY TESTS.

Following the methods used by Gortner and Blakeslee,[3] water extracts of the mycelium of these two molds were made by grinding the mycelium, grown on agar, with pure ignited sand and filtering with suction. The filtrate was heated just to boiling and quickly cooled, taken up in a sterile glass hypodermic syringe and injected with the usual precautions into the ear veins of rabbits. Various concentrations and amounts, up to 2 c.c. of the concentrated extract, were injected into four different rabbits. In no case was any injurious effect noted. In order to check the procedure, cultures of *Rhizopus nigricans*, the mold used by Gortner and Blakeslee, were grown and water extracts made as above described, using amounts of *Rhizopus* mycelium comparable to those used as mentioned above. The characteristic reaction, followed by death in a few hours, was obtained when the extract was injected into the ear of one of the rabbits.

After going on short rations for a day, two of the rabbits readily ate silage on which these molds (*M. purpureus* and *P. roqueforti*) had been grown. One of the rabbits consumed in two days

[3] Observations on the toxin of *Rhizopus nigricans*, Amer. Jour. of Physiol., Vol. 34, pp. 353-367, 1914.

one quart of corn silage, which had been sterilized and inoculated with *Monascus* and which was very thickly covered with the mycelium. No ill effects whatever were noted in either case.

These findings confirm practical experience in feeding moldy silage to cattle. It was reported by at least two of the farmers who sent in samples of silage, which were in good condition except for occasional clumps of moldy silage, that the cattle preferred to eat the moldy silage and would leave the good silage untouched until they had eaten the moldy material. They reported that they observed no ill effects. In most of the instances where moldy silage has been suspected in cases of "poisoning" of cattle reported to the Station, the cause has been found to be some acutely infectious disease. In cases where the molding of silage, to which atmospheric air has had more or less access, has progressed to the extent where the silage acids have been destroyed and putrefactive bacteria have begun to grow in the material, the need for caution in feeding is evident. In such cases the possible harm done can not be considered as being due to the mold but to the bacteria. Unpublished results by Grindley and Rusk at the Illinois Station privately reported to the writer show, however, that cattle are apparently resistant to the ill effects of rather badly spoiled silage. It is evident, on the other hand, that where spoiling by bacteria has begun, the possibilities of contamination by very harmful organisms are present. It is known that horses are very susceptible to the bad effects of spoiled silage. This study is, however, concerned only with silage on which mold grows in the absence of air and where further spoiling has not taken place. Using reasonably large amounts of material, it has been found that the two molds here studied are not toxic to rabbits.

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SOME OBSERVATIONS ON E. C. KENDALL'S METHOD OF ESTIMATING IODINE IN THYROID PREPARATIONS.

S. B. KUZIRIAN.

In presenting this short note on Kendall's method of estimating iodine in thyroid preparations, it is perhaps desirable to give a short review of the method. For the details of manipulation of the method the writer recommends a careful study of the original paper.[1-2]

The procedure is essentially to oxidize the organic matter by fusion with sodium hydroxide with the aid of small quantities of potassium nitrate in a nickel crucible. The fused mass is dissolved in hot water, one c.c. of a ten per cent solution of sodium bisulphite and a few drops of methyl orange are added. It is acidified with 85 per cent sirupy phosphoric acid. The hydroiodic acid produced is oxidized to iodic acid by addition of a few drops of liquid bromine. The whole mass is placed on a hot plate and with the aid of talc powder is boiled to remove excess of bromine. Ten to fifteen drops of a solution of sodium salicylate are added to take up any bromine that might have escaped expulsion, the mixture is then cooled, after which five c.c. of a ten per cent solution of potassium iodide and three to five c.c. of sirupy phosphoric acid are added and the iodine liberated is titrated with 0.02 N. sodium thio-sulphate.

While Kendall's modified method was used by the author of this paper for analysis of a large number of feeds and samples of ewes' milk for their iodine content, some difficulties were met with on account of interference of ash and added bromine. Forbes, Beegle, and others, seem to have encountered the same difficulties, as shown in their bulletin.[3]

Satisfactory results were obtained, however, when the following details were carefully observed:

1. In destroying organic matter, it is advantageous to use more sodium hydroxide and less potassium nitrate to obviate the formation of large quantities of nitrite, which tends to liberate iodine.

[1]E. C. Kendall, Jour. Biol. Chem., 19, pp. 251-254, 1914.
[2]E. C. Kendall, Jour. Amer. Chem. Soc., 34, 894, 1912.
[3]Forbes, Beegle, and others, Bul. 299, Ohio Agr. Exp. Sta., Wooster, O.

2. Organic substances with high ash content often contain iron or some other interfering element, which ought to be eliminated before reliable results can be obtained. According to the author's experiences, filtration at this point did not altogether eliminate the interfering action of ash. When, however, the sodium hydroxide fusion melt was taken up with hot water, a few grams of sodium bicarbonate (C.P.) and some talc added, brought to boiling and kept boiling for a few minutes, set aside for two hours and filtered, the filtrate was free from interfering basic elements.

3. In acidifying the above filtrate with 85 per cent sirupy phosphoric acid, the author's experience was well in accord with Forbes, Beegle, and others, who found that one or two drops of phosphoric acid in excess was insufficient to assure expulsion of all bromine. An addition of even one and a half to two cubic centimeters in excess would boil off all of the bromine without causing any loss of iodine. This was shown by taking an aliquot of accurately standardized alcoholic solution of iodoform and estimating iodine according to Kendall's method. No loss of iodine occurred when two cubic centimeters of acid was added in excess.

4. In boiling off the bromine it was made a practice to dilute the filtrate to over 400 cubic centimeters and boil down to 250 cubic centimeters, thus assuring a complete expulsion of bromine.

Under the conditions specified in this short note the author found the method applicable for tankage, roughage and other organic substances with a high percentage of ash.

CHEMISTRY SECTION,
AGRICULTURAL EXPERIMENT STATION.

[4]Bulletin 299, Ohio Agr. Exp. Sta., p. 422.

SOME IMPROVED LABORATORY METHODS.

W. S. HENDRIXSON.

Three laboratory experiments for students in beginning chemistry are here submitted in the hope that they may be found useful to other teachers of chemistry as they have been helpful in the author's laboratory.

1. *Bleaching powder, potassium hypochlorite and potassium chlorate* may be prepared in one experiment by use of the apparatus illustrated in figure 167. In the flask is evolved chlorine

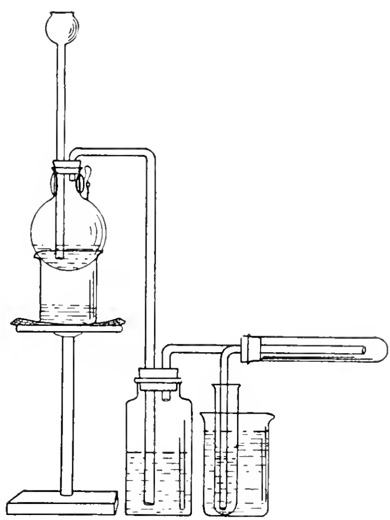

Fig. 167

in the usual way by use of manganese dioxide and hydrochloric acid. The gas passes into the bottle which contains diluted sulfuric acid, in the proportion, 1 of water to 4 of acid by volume. Acid of this concentration will absorb most of the water and gaseous hydrochloric acid. The horizontal test tube contains about three grams of lime spread evenly throughout the length. The excess of chlorine passes from this tube into the second test tube which contains a solution of five grams of potassium hydroxide in fifteen c.c. of water. This tube must be kept cool during the first part of the operation. After two to three liters of chlorine have been passed through about one-third of the contents of tube two should be set aside as a solution of potassium hypochlorite. The remainder is heated to boiling and the stream of chlorine passed through it for a few moments. One to two grams of potassium chlorate will crystallize out on cooling, and it should be purified by crystallization. The characteristic reactions of both salts should be brought out by suitable tests.

2. *The preparation of Sulfuric Acid*:—Probably most teachers who have used the usual cumbersome apparatus for laboratory illustration have found it disappointing and wanting in reality. The apparatus shown in figure 168 has been successfully used in this laboratory.

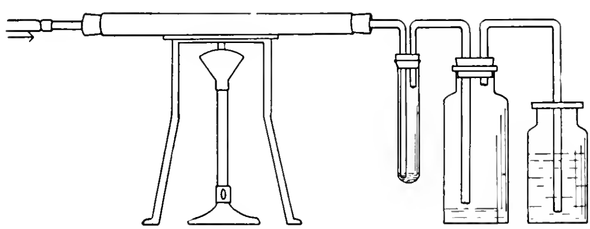

Fig. 168

The great European war has made difficult or impossible the securing of good combustion tubing. Ignition tubes of hard glass have always been expensive and hard to get ready made. For them the writer has substituted tubes made of half inch gas pipe for general use in experiments requiring high temperatures, such as in the preparation of nitrogen dioxide by heating lead nitrate, methane, oxygen from potassium chlorate alone, ammonia. In all these cases is used a piece of pipe ten inches long capped at one end while the other end is reamed to take smoothly a rubber stopper.

In the ignition tube, figure 168, is placed ten to twenty grams of granulated iron pyrite. The test tube contains about three c.c. of concentrated nitric acid. The larger bottle may be used with only its walls wet if it is desired to produce the "chamber crystals"; otherwise it should have its walls wet, and a few c.c. of water on the bottom. The second bottle has an alkaline solution to absorb the excess of gases, but is really not necessary. Air is forced through from the pressure system. If no such system is available the exhaust system or filtering pumps may be used. One lamp is sufficient. Once the combustion is started little external heat is required, and too high a temperature drives off unburned sulfur.

At the end of about twenty minutes the contents of the larger bottle and the test tube with rinsings should be evaporated till the fumes of sulfuric acid appear. A run of even ten minutes will give three to four grams of concentrated sulfuric acid.

3. *Conductivity of Electrolytes.*—It is very desirable to have every beginning student do some work on electrical conductivity and electrolysis. Probably every teacher who has tried to have large numbers of beginners do work in this line has felt the need of a suitable conductivity cell. A cell with platinum electrodes

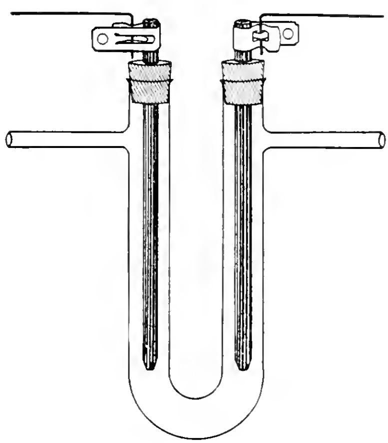

Fig. 169

at the present price of platinum is practically out of the question, and we are limited to carbon for this purpose.

A conductivity cell which the writer has used with great satisfaction is shown in figure 169. The only merit he claims is the discovery that the spring binding post or connector of the Fahnestock Electric Company, Long Island City, New York, has just the right bend to clamp firmly a three-eighth carbon rod. This connector and wire as shown makes a perfect union of the rod and the source of electricity: The cell may be used in many ways. Delivery tubes may be attached to the side arms of the U tube and the cell used to illustrate the so-called electrolysis of water, test tubes of the same diameter serving to collect the hydrogen and oxygen. Copper may be deposited on the negative electrode.

In using the cell in comparative conductivity in this laboratory several taps are provided. At each is a lamp socket so that the direct lighting current may be cut down with lamps of various resistances. The glow of the lamp itself gives a rough quantitative measurement of the strength of current transmitted by the cell, but in addition it is better to introduce ammeters reading as low as one one-hundredth of an ampere. In each test the cell is filled to the same height as indicated by some suitable mark, such as gummed paper. Tenth normal solutions are made up in quantity for general use. The following have been found instructive: hydrochloric acid, sodium chloride, acetic acid, sodium acetate, ammonia, sodium hydroxide, distilled and ordinary tap water.

The experiment offers a good opportunity for the review of electrical terms and relations. Knowing the wattage of the lamp and the electromotive force of the current the resistance of the lamp may be calculated. The current transmitted by the lamp alone may be calculated and the result verified by the ammeter. From the current transmitted by both lamp and cell the resistance and conductivity of the solution in the cell may be calculated.

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FURTHER WORK ON ACID POTASSIUM PHTHALATE AS A STANDARD IN VOLUMETRIC ANALYSIS.

W. S. HENDRIXSON.

Neary three years ago the writer showed that acid potassium and acid sodium phthalates may be used with advantage as standards in volumetric analysis.[1] They can be easily prepared in a state of great purity, they have large molecular weights, and the acid potassium salt has the distinct advantage of absence of water of crystallization. So little work on these salts has been done and so limited is the knowledge of them that it was thought desirable to make further study of the properties and value as a standard of at any rate the potassium salt. The particular objects in view were:

1. To determine the practicability of the preparation, and use of the salt as a standard, by other hands.
2. To determine the extent of the work of purification of the salt for ordinary use, and the yield on the basis of the phthalic anhydride used.
3. To study the hygroscopic character of the salt, the necessary means to dry it, and its stability at higher temperatures.

The laboratory work represented in this paper was done under the writer's direction by Mr. Sereno G. Norton, an undergraduate in Grinnell College, and to his skill and industry is due very largely whatever merit the paper may have.

Acid potassium phthalate was prepared by the method described in the paper already cited. Several preparations were made and titrated as described in the former paper. There is one chance of error which should be mentioned, since the error might easily be made by comparatively inexperienced hands. Phthalic anhydride is very sparingly soluble in water, even in hot water. If not quite enough potassium carbonate is used in neutralizing the anhydride a portion of the latter will be left undissolved, and may be easily overlooked since the sparingly soluble acid salt is likely to form a layer of crystals over the surface of the hot solution. Since the neutral potassium phthalate is extremely soluble even in cold water there is no danger of its contaminating the acid salt. Therefore a slight excess of potassium carbonate should be used, and of course the hot solution should be filtered in the first instance at any rate.

[1]Journal of the American Chemical Society, Vol. XXXVII, p. 2352.

A large volume of standard hydrochloric acid was made by the method of Hulett and Bonner so as to contain .003647 gram of HCl to 1 c.c. This acid was further titrated with benzoic acid specially purified for such purposes by the Bureau of Standards, which gave .003648 gram HCl to 1 c.c. This concentration was confirmed by means of silver. A solution of sodium hydroxide was prepared as described in the first paper and was used as the intermediary between the acid potassium phthalate and the hydrochloric acid. The indicator was phenolphthalein, and as already pointed out its error in marking the neutral point was cancelled by the method of titration.

Titrations were made of samples of the acid phthalate which had been three, four and five times re-crystallized from hot water. The objects were to determine the number of crystallizations necessary to secure a sufficiently pure product, and to determine the constancy of the acid salt as an individual com pound. It is well known that successive crystallization of some so-called acid salts does not secure a constant product. The results are shown in the following table: in which "Third," "Fourth" and "Fifth" show the number of re-crystallizations of the potassium acid phthalate, and following each the values given for the standard hydrochloric acid.

	Third	Fourth	Fifth
	.0036489	.0036470	.0036519
	.0036473	.0036475	.0036455
	.0036484	.0036449	.0036448
	.0036480	.0036450	.0036410
	.0036471		
	.0036475		
	.0036478		
	.0036463		
	.0036463		
	.0036455		
Average	.0036473	.0036461	.0036458

The results seem to show that there is nothing to be gained beyond three re-crystallizations. Other titrations seem to show that even two re-crystallizations, that is three crystallizations in all will give a salt pure enough for ordinary purposes. There seems to be no ground to doubt the constancy of the composition of the acid salt.

Working with no special care our results showed that about 50 per cent of the theoretical yield of the acid salt may be obtained after four crystallizations from hot water. In normal times pure sublimed phthalic anhydride and pure potassium carbonate are cheap, and this standard is, therefore, one of the most cheaply and easily obtained.

We next directed our attention to the hygroscopic character of acid potassium phthalate. It is very desirable that a substance used as a standard should have the minimum of hygroscopicity. To test this character we carried out two sets of experiments. The first consisted in heating the air dried salt in an electric oven at different temperatures and determining the losses; the second in exposing the salt thus dried in air of known moisture content and determining the amount of moisture taken up from the air.

In carrying out the first series of experiments about twenty-one grams of the salt was heated in the electric oven in a platinum dish. At the end of each period the loss was determined and a portion of the salt was taken out without loss and titrated. The losses and titrations would thus form checks on each other. There were eleven such time periods with their corresponding losses and titrations. Since only four different temperatures were used I have reduced the results to this number.

Weight of Salt	Time	Temp.	Loss	Value of HCl
21.5940	4 hrs.	110	.0006	.0036471
20.4956	2 hrs.	110	.0024	.0036469
16.0100	8 hrs.	130	.0034	.0036490
11.6910	8 hrs.	150	.0006	.0036473

This is a very remarkable showing. We all know the difficulty of securing accurate weights of substances owing to their hygro scopic character or that of the containing vessels. Here an air dried substance weighing twenty-one grams and in a platinum dish lost no more on heating at 110° C. than could be accounted for on the basis of change in temperature in the balance case and the hygroscopic character of the dish itself. As stated there were eleven determinations. The total loss of weight was about 1 part in 3,000, which is within the limits of accuracy of volumetric analysis in any case. The loss was comparatively constant and apparently independent of the temperature and time of heating. It was probably due in part to a constant error in the method. This consisted in letting the dish and contents stand in the air of the room while taking the sample for titration and weighing it. The dish was then weighed for the next heating.

On the other hand the loss on heating was determined by weighing the dish as soon as taken from the desiccator.

To throw more light upon this low hygroscopic value about seven grams of the finely divided salt which had been dried in the above series of experiments was exposed in a desiccator over sulfuric acid of such concentration as to give a humidity of the enclosed air equal to 70 per cent, which is not likely to be exceeded in the ordinary laboratory. It was left over the acid forty-seven days and about every four days a weighing was made. There were small variations as always, due to changes of temperature and the like, the largest being two milligrams. Summing up the minus and plus differences they show a net loss of one-tenth milligram in the forty-seven days. These two sets of experiments seem to justify the conclusion that the hygroscopicity of the acid potassium phthalate is practically nil, and in using it and weighing it attention need be directed only to the containing vessel. By use of an open platinum crucible this source of error may be almost completely avoided.

It seemed desirable to know the solubility of acid potassium phthalate in water, and this was determined at three different temperatures. At 25° and 35° the method used was that recently described by the writer in these Proceedings.[2] For the solubility at the boiling point the method of Pawlewski was used.[3] The following are the results:

	Wt. Solution	Wt. Acid Phthalate	Per Cent in Sol.
At 25 degrees	21.025	2.1531	10.23
	21.028	2.1553	10.25
At 35 degrees	21.198	2.6859	12.67
At Boiling Point	9.18	3.3158	36.12

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[2]Proc. Iowa Acad. Sci., Vol. XXII, pp. 217-224, 1915.
[3]Berichte d. Deutsch. Chem. Gesel., Vol. 32, p. 1040.

MILK AS THE SOLE DIET OF RUMINANTS.

A. C. McCANDLISH.

From time immemorial milk has been regarded as the food best adapted to the nourishing of mammalia. It is the sole diet of all mammals during the earlier part of their postnatal development and is also recognized as an excellent staple in the diet of the adult human, especially in the case of invalids. On the farm it is used extensively in the feeding of young animals and in the case of the hog it is fed in large quantities to more mature individuals.

Within the last decade much investigational work has been done on the nutritive value of milk and other food-stuffs and throughout these investigations milk has measured up to all expected standards. The object of this paper is to show that in spite of the high nutritive value of milk there are limitations to its use; limitations which are inherent, not in the milk itself, but in the class of animals to which it is fed.

PREVIOUS WORK.

The food nutrients recognized as essential to the animal organism are carbohydrates, fats, proteins, ash and water and Table I demonstrates that all of these constituents are abundant in milk.

TABLE I.

AVERAGE COMPOSITION OF MILK.[10]

Constituent	Per Cent
Water	87.17
Fat	3.69
Casien	3.02
Albumen	.53
Sugar	4.88
Ash	.71

The proteins, fats and carbohydrate are present in the proportions that are recognized as being best suited for the growth of young animals, and the ash constituents also are abundant.

Within recent years it has been shown that all proteins are not of equal value for nutritional purposes as the nutritive value of a protein is determined by its amino-acid constitution. Some proteins are inefficient due to the fact that they do not contain all the amino-acids necessary for the life, growth and normal physiological development of animals. It has been shown, however, that the milk proteins are efficient,[6] that is, they will in the presence of a sufficiency of non-protein and inorganic nutrients, support life, promote growth, and foster all normal physiological functions.

The ash is another food constituent which, though present in sufficient quantities, may not be qualitatively suited to the requirements of the animal, but it has also been proved that the ash of milk satisfactorily meets the demands of the young, growing animal.[8] In other words, the ash of milk provides in the proper proportions all of the inorganic constituents needed for the proper functioning of the animal body.

Still another factor has been recognized as limiting the nutritive value of feeds and that is the presence or absence of substances known as "food-accessories," "vitamines," or "fat-soluble A and water-soluble B." These are complex compounds of an unknown nature which are antineuritic in action and both are absolutely essential to life. They are found only in minute quantities and many foodstuffs are lacking in one or both of them. It has now been proved beyond doubt that whole milk contains sufficient of these unknowns to give complete physiological functioning.[7]

Milk, consequently, fulfills both quantitatively and qualitatively all the chemical requirements of a good ration for mammalia, but in spite of this fact it can not be successfully used as the sole feed of ruminants at all times. Ruminants are especially adapted to the handling of bulky feeds such as hay, silage, roots and other roughages and begin to use these at a very early age; in the case of calves usually when about three weeks old and in practice they are generally provided with such roughages as soon as they can consume them.

In only a few instances have records been obtained of ruminants being fed for any considerable time on rations lacking roughage, but Sanborn[9] reports that in the case of both sheep and cattle fed on grain alone the stomachs weighed less than normal and this was most noticeable in the case of the rumen—the stomach compartment specially adapted for the handling of bulky material. Davenport[1] found that calves could not be raised on a diet consisting of milk alone or grain alone and also noticed that as a rule no digestive disturbances accompanied such a ration.

The fact that milk can successfully act as the sole diet of mammalia other than ruminants has been demonstrated by McCollum[2] who was able to raise a sow to maturity on milk alone and the sow also reproduced normally.

EXPERIMENTAL WORK.

In the work reported here two calves were used and they were fed on milk alone from birth until the time of their death.

TABLE II.

ANIMALS USED.

Calf No.	355	366
Breeding	Grade Jersey	Grade Holstein
Date of Birth	9/25/16	12/17/16
Birth Weight	65 lbs.	90 lbs.

Both calves were allowed to remain with their dams for a few days after birth and were then put on a whole milk ration. The amount of milk fed was limited to what the calves seemed able to handle satisfactorily and though they might possibly have become accustomed to large quantities it was deemed advisable to keep their consumption of milk comparable to that of other animals of similar weight in the herd and thus prevent digestive troubles as far as possible.

No roughage, grain, or water was offered to either of the calves, and at first no salt was given but from the time Calf No. 355 was 70 days old a salt roll was kept in front of him at all times and the same treatment was given Calf No. 366 from the time he was 30 days old.

The calves were kept in a pen bedded at first with shavings and later with sand as they showed a tendency to eat the shavings.

TABLE III.

Feed Consumption by Ten-day Periods.

Period No.	Calf No. 355		Calf No. 366	
	Milk lbs.	Salt lbs.	Milk lbs.	Salt lbs.
1	36		90	
2	90		90	
3	90		90	
4	90		90	.04
5	128		111	.05
6	120		129	.06
7	120		150	.04
8	126	.32	150	.03
9	146	.25	150	.11
10	150	.17	150	.21
11	150	.05	150	.10
12	150	.02	150	.03
13	150	.04	150	.04
14	150	.06	150	.03
15	141	.05	150	.03
16	120	.03	150	.02
17	120	.07	174	.03
18	120	.18	108	.03
19	123	.17		
20	142	.02		
21	99	.03		

In the first 10 day period Calf No. 355 sucked for 6 days and No. 366 for 3 days. The last period for No. 355 contains only 8 days and that for No. 366 only 6 days as No. 355 died when 208 days old and No. 366 at the age of 176 days.

It will be noted that up until he was about 100 days old No. 355 had an increasing capacity for milk but from that time the appetite remained regular for a little over a month and then declined though there was an increase in milk consumption for a week or so before death. In the case of No. 366 maximum capacity was reached earlier and remained constant until about the same length of time before death when it again increased.

The animal, No. 355, that received no salt until 70 days old, showed an enormous appetite for salt during the first 30 days in which it was available. From this time on his salt consumption decreased and with the exception of a short time between the ages of 170 and 190 days did not again reach a marked elevation during the experiment. Calf No. 366 received salt earlier in his life and did not at any time have such an excessive consumption though between the ages of 80 and 110 days his consumption of salt was large.

There were no marked digestive disturbances, except in the case of Calf No. 366, which was bloated for a few days before death, the bowels of the animals being usually laxative though not noticeably so. The feces were rather foul smelling. The calves showed by their actions that their rations were not entirely complete. They ate to a slight extent the shavings that were at first used as bedding, gnawed the wood in the walls of the pen, and licked the hair from each other. These substances however, were not consumed in amounts sufficient to cause very noticeable digestive derangements.

Records of the live weights and body measurements of the calves were obtained every thirty days. The live weights given are the averages for three successive daily weighings. The body measurements taken were height at withers, depth of chest, and width at hooks. For the sake of comparison the measurements of the heifer calves in the herd fed normal rations are given. Difference in sex will not have much influence on these figures for comparative purposes owing to the sexual immaturity of the animals and also to the fact that Calf No. 355 was castrated when 22 days old.

TABLE IV.

LIVE WEIGHTS AND BODY MEASUREMENTS.

Calf No. 355

Age Days	Weight lbs.	Height in.	Depth in.	Width in.
Birth	65			
30	76	29.9	12.6	7.1
60	107	31.1	13.0	7.5
90	132	32.3	13.8	7.9
120	145	33.9	15.0	8.3
150	144	35.0	15.4	8.3
180	137	34.6	15.0	8.3

Calf No. 366

Age Days	Weight lbs.	Height in.	Depth in.	Width in.
Birth	90			
30	103	28.0	14.3	7.5
60	139	30.3	14.3	7.9
90	165	32.7	14.7	8.7
120	174	35.0	15.7	8.7
150	172	35.4	15.7	9.1
180				

TABLE IV, Continued.

Average for 66 Heifers.

Age Days	Weight lbs.	Height in.	Depth in.	Width in.
Birth	65			
30	76	28.0	11.0	6.3
60	96	29.5	12.3	6.7
90	131	32.7	13.5	7.9
120	180	33.9	14.7	8.7
150	235	36.2	16.1	9.8
180	289	37.8	17.3	11.0

It can be seen that the experimental animals grew fairly well until they were about three months of age but from this time on they did not thrive. They continued to gain slowly in weight for another thirty days after which their live weights decreased gradually until the time of death. The body measurements appeared to increase about normally until the time the live weight increase ceased to be rapid and from this time on the measurements changed very slightly—in fact they were almost constant. A greater increase in height than is shown by the figures probably did occur but owing to the fact that the animals began to go down on their pasterns about the time the live weight ceased to increase, the true height could not be measured.

The increases in live weight and body measurements can be more easily appreciated when they are shown as percentages of the original figures. The increases in live weight from birth, to the time of death in the case of the experimental animals, and to the age of six months in the case of the herd average, are expressed as percentages of the birth weights while the body measurements are compared in the same way from the time the animals were thirty days old.

TABLE V.

PERCENTAGE INCREASE IN LIVE WEIGHT AND BODY MEASUREMENTS.

Calf	Weight	Height	Depth	Width
No. 355	111	14	19	17
No. 366	91	27	11	21
Av. for 66 Heifers	345	35	57	75

During their lifetimes the experimental animals practically doubled their live weights while during similar lengths of time calves normally fed attained weights about four times as great as their birth weights. Similarly the increases in body measurements were much less than normal in the case of the calves fed milk alone. Of the increases in body measurement the height was the most nearly normal while width was farthest from it.

In addition to the variations in weight and body measurements there were other abnormal symptoms which though very appreciable were not capable of being directly measured or determined. The animals became very much emaciated and quite unthrifty in appearance. Their coats were long and staring and the hair fell out freely. Patches of the body became practically devoid of hair and sores also were apparent. As has already been mentioned the animals were down on their pasterns and could not stand up properly and they walked with a very stiff gait.

One very noticeable feature of the experiment was the occurrence of fits. These fits were first apparent when the animals were between three and four months of age and continued to occur at frequent but irregular intervals up until about three weeks before the death of the animals. These fits were all very similar and frequently started for no apparent reason and could almost always be induced by leading the animal around for a few minutes. The animal would fall down, and bellow as if in pain; the jaws would stick open and the legs become rigid; the muscles became tense and hard; respiration slowed and in severe attacks entirely stopped. Where respiration did not stop the animal would recover in a few minutes and where breathing ceased artificial respiration had to be resorted to, to resuscitate the calf. The fits were practically identical with those of an epileptic nature.

Post-morten examinations of both calves were made. The bones of No. 355 were very flexible as if insufficient ash were present; the leg bones could be bent comparatively easily while the ribs had a very thin coating of hard material with a soft core. None of the bones were as rigid as would be expected in an animal of similar age. There was one atrophied kidney (perhaps congenital) with hypertrophy of the other. The mesenteric lymph glands were much enlarged and there was an apparent leucemia. The rumen was of normal size but the walls were evidently atonic, due apparently to a development of lymphoid tissue. The omasum was smaller than would be expected though the two remaining compartments of the stomach appeared to be normal. The contents of the rumen resembled thin cottage cheese mixed with hair.

The bones of Calf No. 366 appeared to be in fairly good condition though one or two of the ribs might previously have been broken and healed. The mesenteric lymph glands were enlarged and both kidneys were in bad condition with cysts. All the stomach compartments were of about normal size but there were streaks of dark brown or black pigment on the inner wall of the abomasum. The contents of the rumen were similar to those in the case of Calf No. 355.

DISCUSSION OF RESULTS.

A diet of whole milk alone though apparently giving good results until the animals are about three months old very probably can not be relied on as the sole ration for calves of greater age. Its inability to properly nourish older calves is not due to any defect in the quantity or quality of the nutrients it supplies. Cattle and other ruminants begin to consume roughages at an early age and the lack of roughage may consequently give an explanation of the results obtained in this work.

In Table VI are given the food requirements of the experimental calves according to the modified Wolff-Lehmann feeding standard and the amounts of nutrients with which they were actually supplied.

TABLE VI.

NUTRIENTS REQUIRED BY AND SUPPLIED TO CALVES.

Age Days	Weight Lbs.	Milk Lbs.	Nutrients Supplied			Nutrients Required		
			Dry Matter Lbs.	Digestible Crude Protein. Lbs.	Total Digestible Nutrients. Lbs.	Dry Matter Lbs.	Digestible Crude Protein. Lbs.	Total Digestible Nutrients. Lbs.
0-30	168	579	79	19	104	71	16	84
30-60	213	668	91	22	120	102	21	107
60-90	272	842	115	28	151	158	27	139
90-120	309	900	122	30	161	196	30	160
120-150	318	873	119	29	166	205	31	165

In this table the animals have been taken together rather than individually and the milk consumption is taken for all 30-day periods which were completed. It was presumed that the daily milk consumption of the calves while suckling was the same as in the succeeding days of the first 10-day period. From these figures the total amounts of nutrients actually consumed by the animals were obtained while the nutrients required to keep the animals in good growing condition were obtained from the modified Wolff-Lehmann feeding standard.

The actual surplus or deficit of nutrients supplied will be more valuable for comparative purposes.

TABLE VII.

EXCESS OF NUTRIENTS SUPPLIED TO CALVES.

Age Days	Excess of Nutrients Supplied		
	Dry Matter Lbs.	Digestible Crude Protein Lbs.	Total Digestible Nutrients Lbs.
0-30	8	3	20
30-60	-11	1	13
60-90	-43	1	12
90-120	-74	0	1
120-150	-86	-2	1

It is evident that throughout the experiment the calves were receiving enough total digestible nutrients to keep them growing and increasing in live weight though the excess of nutrients decreased as the work advanced. The same holds true for the supply of digestible crude protein though in this case the excess was never so great and in the last 30-day period considered there was a small deficit. The supply of dry matter was sufficient for the needs of the calves during the first 30-day period only and from then on there was a deficit which rapidly became larger.

Apparently the calves were being supplied with sufficient digestible nutrients to keep them growing and in good thrift, but they were not able to utilize those nutrients. At first their demand for dry matter, other than digestible nutrients, was negligible, but as they became older this demand increased more rapidly than did the need for digestible nutrients. The absence of this dry matter, which should have been provided in the form of roughage, led to inefficient digestive activity and consequently the animals were unable to utilize the nutrients which they consumed and so they failed to grow normally.

The digestive tract of a ruminant is large and capacious and before digestion can be normal bulky feeds must be present to distend the digestive organs, stimulate peristalsis, separate the particles of more concentrated feeds and so allow of their being properly mixed with and acted on by the digestive fluids. Milk, being highly digestible and free from fibrous material, is not a "bulky" feed, though its nutrients are present in a rather large volume of water, and so it can not, when fed alone, induce the digestive system of older ruminants to function properly though it is quite efficient with young calves as in their case the rumen is relatively smaller in comparison with the rest of the digestive tract than it ultimately becomes.

Where digestion is retarded or hindered, as would occur when the digestive system became atonic due to the absence of roughage, the materials not completely acted on by the digestive juices would remain in the alimentary canal and undergo putrefactive changes. The products of such putrefaction are toxic and when absorbed from the alimentary canal can produce auto-intoxication with symptoms similar to those found with the experimental animals in this case.

Another fact worthy of note is that these calves were at times, when averaging about 150 pounds, in live weight, consuming over half as much salt per day as would a thousand-pound animal. It has been found at this station that normally fed calves of similar weight will consume about .01 pound salt per day while the experimental animals consumed as much as .03 pound per day.

This excessive salt consumption may have been an attempt to correct digestive disturbances, or it may have been caused by other physiological demands, or it may simply have been due to the calves forming a pernicious habit.

That sodium chloride can produce tetanic convulsions such as were evident in the case of the experimental calves has been shown on several occasions. Loeb[3] demonstrated the contractions and final tetanus of muscles in contact with certain salt solutions and he later[4] showed that solutions of common salt could cause rhythmical twitchings and an increase in the irritability of muscles and nerves. This is due to an increase in the concentration of sodium ions and can be counteracted by the addition of calcium salts. It has also been pointed out by MacCallum[5] that intravenous injections of solutions of sodium chloride increase peristalsis. There is a possibility therefore that the fits to which the experimental calves were subject may have been due in some way to excessive salt consumption.

SUMMARY.

Milk, though capable of forming the sole diet of young ruminants, can not be used for such purposes with more mature individuals. This is due not to the fact that its nutrients are present in improper quantities or poor in quality but probably to the inability of the animals to properly digest and utilize it unless they are provided with some roughage at the same time

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EXPERIMENTS WITH SOY BEAN MEAL AS A SUBSTITUTE IN THE ARMY RATION.

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The use of soy beans for human food has of late been the subject of a number of scientific investigations. The literature is not available to the writer at the present time, hence will not be discussed in this brief paper. The nutritive value of soy beans has, however, been established, and a future for this commodity as an article of human food is almost certain. The Chinese and Japanese have used soy beans for many years and prepared them in quite a variety of ways. In our own country little is known of soy beans except as a forage crop for cattle and swine.

While conducting a food survey of the National Army, National Guard and Aviation Camps in the Southern Department, the writer has had opportunity to make a few tests of the suitability of soy bean meal as a substitute in the army ration. In view of the present movement toward the conservation of our wheat supplies, suitable substitutes are being sought. On "wheatless" days, corn meal is commonly used. It is known, however, that corn protein is inferior to that of wheat because of its deficiency in certain amino acids. Soy bean protein, on the other hand, is a more complete protein.

The army ration prescribes eighteen ounces wheat flour, which may be in part substituted by other cereals. Since the army represents only one per cent of our total population, the saving of wheat effected by observance of wheatless days in army camps is comparatively small. However, many of the organizations in these camps are observing wheatless days. Other substitutes in addition to corn are therefore desirable for the sake of variety.

The company messes in an army camp afford a splendid opportunity for such experiments. At each mess one hundred to two hundred men are fed, all of them normal individuals with good, healthy appetites. They have little opportunity for obtaining food outside of the messes, except an occasional parcel from their friends at home, a meal now and then in the neighboring town, and the candy and cookies purchased at the regimental post exchanges. The men therefore eat what is served to them at their company messes, notwithstanding all manner of gratuitous comments on their food.

The few tests described here were made at Camp Travis, San Antonio, Texas. The 360th Infantry Regiment was selected because it was under direct supervision of a very efficient School for Bakers and Cooks. Similar tests were made also at the Officers Mess of the 165th Depot Brigade. Thus we were able to get the opinions of both officers and enlisted men.

Our experiments thus far have been confined to a soy-meal and a soy bean flour, both of the following chemical composition:

	Per Cent
Moisture	6.5
Protein	44.1
Fat	3.3
Fiber	5.9
Carbohydrates	35.5

The meal and flour were by-products from the oil industry. The pressed cake from the oil presses had been subjected to a process of regrinding and sifting, and the product had somewhat the appearance of graham flour.

The meal was used for making soup, in the proportion of one and one-half ounces to a pint of boiling water. It was boiled five minutes, and then various articles of seasoning were added. With the addition of beef stock, onions, tomatoes, celery and salt a very palatable dish was prepared. In the companies of this regiment where the soup was served, the mess sergeants report that it was well liked. At the officers' mess, all of the officers ate the soup and many of them were well pleased with it. Without proper seasoning the soup would not be very palatable, but with the judicious use of beef stock, onions and tomatoes the dish proved popular.

A soy bean flour of practically the same chemical composition was used for experimental bread making. The officer in charge of the Post Bakery at Fort Sam Houston cooperated in this experiment. One hundred pounds of bread were baked, using a mixture of 80 per cent wheat flour and 20 per cent soy bean flour. The dough was prepared and baked according to the standard army practice. However, instead of baking it in sheets of six loaves each as is customary, individual loaves were baked. The product was darker in color than wheat bread and the height of the loaves considerably less. The flavor, however, was excellent. The bread was distributed to several company messes and officers messes. Practically all of the comments the writer heard were favorable. More than 20 per cent soy bean flour would not be advisable, since the loaves would tend to become soggy. It is believed that 10 per cent would yield the best results.

The use of soy bean meal does not decrease the nutritive value of bread, since it is not a mere filler like bran. It has a high protein content, 90 per cent of which is digestible as shown by actual experiments conducted elsewhere.

Although these tests were carried out on rather a small scale, it is safe to predict that soy bean flour will some day become recognized as a useful article of food and appear on the market as such.

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CONTRIBUTIONS TO THE GEOLOGY OF SOUTHWESTERN IOWA.

GEORGE L. SMITH.

During the past summer (1917) Geologic work has been engaged in as opportunity offered in Montgomery, Page, and Fremont counties. The fault line north of Thurman has been definitely located, on East Nishnabotna river much information of importance has been obtained by observation and study of the different outcrops from Essex north to Stennett, and on Nodaway river at Clarinda, Shambaugh, and Braddyville outcrops were visited and fossil collections made.

The Braddyville and Shambaugh outcrops, at the present time, are greatly obscured, and little of value can be secured at these places. Search of the mine dumps at New Market and Clarinda was made to secure additional material for paleontological study of the shales in immediate contact with the Nodaway coal. The writer is convinced the complex geology of southwestern Iowa is not sufficiently known or recognized at the present time. Instead of having great simplicity in its structure and stratigraphy, there are numerous complications caused by erratic dips and by the great Jones Point deformation, and the extent and influence on the local geology of the Brownville syncline that reaches into Iowa to the southeast corner of Cass county has not been appreciated. To all this complexity is added the enormous difficulty caused by the Pennsylvanian being deeply buried, except in a few scattered localities, by Pleistocene deposits which in the divides between the streams in places reach a depth of 200 feet. In the valley of East Nishnabotna river as far south as Coburg the Pennsylvanian is overlain unconformably by Cretaceous sandstones and shales upwards of one hundred feet in thickness. Exposures of strata are few in number and distant from each other, which necessitates wide correlations with increased chances of error. The finality in the interpretation of the geology of southwestern Iowa has by no means been reached as yet. In the future many attempts will be required to accurately fix the stratigraphic relations of the puzzling succession of the limestones and shales found in the Missouri stage of Iowa. Without any desire to excite controversies as to what has been found in other states it may be expedient for the writer to state the conclusions he has arrived at after at least a diligent study of the geology of southwestern Iowa.

In the past correlations of strata have almost exclusively been founded on the different limestones, to the general neglect of the coal seams and black shales; these latter are much more constant and certain horizon markers than the former. Although the limestones of the Missouri stage are fairly constant they are nevertheless given to coalescing with each other and feathering out; the gradual introduction of additional layers to a ledge may change its appearance within a few miles and cause it to be erroneously correlated. Also the splitting of a thick limestone by a thin shale parting in one locality and the increase in the thickness of the shale in another not far distant may divide the ledge by many feet, and so give the appearance of two separate ledges of limestone which seem to belong in an altogether different place in the general section. The paleontological method does not much help the situation as there is no abrupt change in the fauna throughout the whole succession of strata. The continued studies of the writer have so extended the range of the brachiopod element as to show that different species range through the whole section. The pelecypods are of more value in correlations, especially as the Tarkio is an important Myalina horizon, and in the shales immediately above the Tarkio there are many small pelecypods of difficult determination. Also the main limestone at Stennett has an exceedingly abundant echinoid fauna. The corals and gastropods are found sporadically through the whole section. It is thought the bryozoa may be of the utmost value in correlations and that in the future all precise paleontological correlation must be done by the bryozoa. However, their study is most difficult and repellant to the student and practically nothing has been done in that line in Iowa. Many years ago the late Doctor Calvin in conversation with the writer stated that the fauna of the Missouri stage was found in colonies, and the different species in each colony were very similar. The correlation of the strata in southwestern Iowa must mostly be done by the stratigraphical method although paleontology affords a useful check. In a geological field where outcrops will average twenty miles apart correlations should be made with the greatest caution. Especially would the writer deprecate attempts to correlate the strata in Iowa with those of localities in other states several hundred miles distant.

In the past the writer has not favored the giving of taxonomic value of formations to limestone caprocks and shale partings that will not average a yard in thickness. However Condra and Bengtson in their recent report on the "The Pennsylvanian Formations of Southeastern Nebraska" have for the different limestones applied the term ledges, and have named and numbered twenty-six ledges found in the Pennsylvanian of their state. Although this method introduces a multiplicity of names it serves a most useful purpose and avoids much circumlocution in description. As certain of these ledges can readily be recognized in Iowa the Nebraska names and numbers will be adopted by the writer.

In the Page county report Volume 11, Iowa Geological Survey, Doctor Calvin described and named the Tarkio formation, and gave as a type section one three miles northeast of Norwich. In this section two ledges of limestone are shown divided by twelve feet of shale. In the Nebraska report the Tarkio is only given the taxonomic rank of a ledge, and the name is applied to the upper ledge, while the lower ledge is named the Preston ledge. This is an injustice to the late Doctor Calvin, as this formation was clearly delimited above and below and a type section given. However, to avoid complications in descriptions the Nebraska method is reluctantly accepted. In Volume 19, Iowa Geological Survey, the writer extended the City Bluffs beds of Broadhead up to the Tarkio as at that time there seemed to be no constant horizon to divide upon. The records of the different coal mining shafts included only one hundred feet of shale underneath the Pleistocene, directly above the cap rock of the Nodaway coal, and above this thick shale no outcrops were known in Iowa showing the rest of this interval. Also the records of core drilling are not in close agreement with one another, as to the stratigraphy found above this shale. It is now known that the one hundred feet immediately underlying the Tarkio contains three limestone ledges; including the Tarkio, the Nebraska geologists have named them commencing with the highest Tarkio, Preston, Fargo, and Burlingame. The Rulo has not been found in outcrop east of Missouri river. Condra and Bengtson have divided the strata in the interval between the Nodaway coal and the Tarkio into two formations, the upper one hundred feet being named the Nemaha formation, with its lower limit at the Rulo and its upper at the Tarkio. They retain the name City

Bluffs for the lower one hundred and twenty-five feet reaching from the Rulo to the Nodaway coal, thus returning to the original use of the name as given by Broadhead. This is more correct than the former use of the name and is acceptable to the writer.

However, the Nemaha of Condra and Bengtson, and the McKissicks Grove of Smith should have no standing in geology as both of these formations are included in the Atchison county Group of Broadhead, who in 1872 gave this name to a series of strata in Atchison county, Missouri, exposed in the bluffs along Missouri river. At the base of the exposure was a limestone, number 28 of his section, now known to be the Burlingame, the third limestone ledge below the Tarkio, and the section extended upward to a red shale, his number 3, the latest of the Pennsylvanian found east of Missouri river. Broadhead's Atchison county Group was accurately defined according to modern standards. This section has recently been reviewed in the field and found to be correct in detail. No geologist of the present time having any regard for the permanency of his own work can afford to ignore the accurate work of his predecessors. Keyes' Atchison formation has no application here as he places the lower limit of his Atchison at the Forbes at least one hundred and fifty feet lower than the base of the Atchison county Group.

During the past summer several days were spent in tracing the different outcrops and strata exposed in the base of the Missouri river bluffs, from two miles south of Thurman along the bluff road north to Wabonsie creek, a distance of nearly seven miles. The utmost care was exercised to secure accurate results in this work as the object was to definitely locate the fault line north of Thurman and obtain a solution of one of the greatest problems in Iowa geology. Some of the most intricate geologic structure in the state is present in the vicinity of Lake Wabonsie and requires additional study. The stratified rocks in this part of Iowa are so obscured by heavy deposits of drift, and in the vicinity of Missouri river by loess, that the effect on the local geology caused by the Jones Point deformation, the interpretation of which is fraught with difficulty, is liable to be misconstrued. The writer has not spared time and effort to give a correct solution to some of these problems but much remains for future investigation, and his present interpretations may be greatly modified.

On the Baylor and Mann farms two miles south of Thurman, on the bluff road, are found outcrops of a sandstone separated from an overlying limestone by a shale two feet thick. Udden in the Mills and Fremont counties report, Volume 13, Iowa Geological Survey, gives a composite section of these outcrops, and as his lithogical descriptions are unusually perfect his section will be given verbatim.

XV. SECTION IN THE BLUFFS TWO MILES SOUTH OF THURMAN.

	Feet
6. Bluish gray sandstone of fine texture cemented by a crystalline calcareous matrix	½
5. Gray shale, not calcareous, evidently in part originally a black shale	10
4. A dark gray blotched limestone cut by straight and vertical joints into large blocks and containing numerous spheroidal lumps about one-fourth inch in diameter. In section is seen to be composed of an agglomeration of indurated lumps of calcareous mud, of all sizes up to one-half inch in diameter, and in varying color due to weathering. The larger of these are themselves occasionally composed of agglomerations of smaller nodules. Some show shrinkage cracks and fissuring. In this mass are a few shell fragments, joints of crinoid stems and quartz grains	3
3. Soft bluish gray shale, partially concealed	2
2. Grayish blue sandstone of fine texture and indurated by a crystalline calcareous matrix, in straight lines below, ripple marked above	3
1. Shale, not well exposed	1

Lower strata found in a coal prospect shaft near one of the outcrops continue the section to the Nyman coal.

RECORD OF BAYLORS SHAFT SOUTH OF THURMAN.

	Feet	Inches
6. Blue limestone	3	
5. Sandstone	5	
4. Shale	20	
3. Limestone		6
2. Coal, Nyman	1	2
1. Shale and sandstone		
Total	29	8

This coal has also been prospected on the Mann and McCartney farms farther north toward Thurman and found to have a thickness of six inches to one foot. In the distance from these outcrops to Thurman the same strata are found in numerous outcrops along the bluff road. From Plum creek no outcrops are to be seen until the north line of the village of Thurman is reached where the same strata are again exposed in outcrop. For a distance of one-half mile north of this locality the sandstone ledge is seen outcropping at a number of places in the bank adjacent the wagon road with a few exposures of the limestone ledge above it. In this distance one of the rare exposures in the Missouri river bluffs of the Aftonian gravel bed was noted in the ditch along the roadside. Besides the usual diabase and quartzitic gravel there were several bowlders of Sioux quartzite up to six inches in diameter, and one of gray granite at least one foot in its greatest dimension. The wagon road leaves the bluffs and turns west and then north on the bottom lands for three-fourths of a mile before it again reaches the bluffs. In this distance the bluffs were carefully searched for outcrops but none were found.

In the bluff at the residence of Chas. Baldwin at an elevation of about twenty-five feet above the wagon road the same strata traced for four miles from the Baylor farm are again found immediately south of the fault line. Udden's Section XIII was evidently taken at this place when the quarry was in operation. As the strata were better exposed at that time than at present his section will be given in full with his lithogical descriptions.

XIII. SECTION OF THE UPPER PART OF THE EXPOSURE IN BLUFF NEAR THE NORTHWEST CORNER OF SEC. 26, SCOTT TOWNSHIP, FREMONT COUNTY.

	Feet
4. A dark bluish limestone of fine texture along some layers and along other seams almost wholly made up of very small and thin shell fragments, lying flat, barely visible under a good hand lens; thin and wavy plates of cone in cone and fibrous calcite occur in this ledge	2
3. Shaly silt	1
2. Dark gray, in places brownish, limestone, with some fossils. A ground specimen is seen to consist of thin pieces of shells, 1 to 3 millimeters across, lying flat in a sparse matrix holding a few small quartz grains	¾
1. An arenaceous and calcareous rock of fine texture and of bluish color, consisting of a siliceous, well assorted silt or sand imbedded in calcareous material. It contains frequent specimens of a Cythere, also a Fenestella, other bryozoa, and fragments of brachiopod shells	2½

Both the limestone and sandstone weather into irregular slabs with a rough granular surface, a good example of which is shown in figure 41 of Volume 17, Iowa Geological Survey, giving a view of the retaining wall in front of Chas. Baldwin's residence. This ledge of limestone and sandstone was not named in Condra and Bengtson's Nebraska report. While reluctant to add to an overburdened terminology the writer would suggest the name Nebraska City ledge for this double ledge. The type section is the upper strata in the brick yard shale pit one-fourth mile south of the Missouri river bridge at Nebraska City, Nebraska. This ledge is not a constant horizon; in passing south it grades into sandstone and can not be recognized a few miles south of the state line in the state of Missouri. In recent years, Wabonsie creek has been diverted into Wabonsie Lake. At the present time the lake is silted up, no standing water is visible and the old lake bed is grown up with marsh grass. At one time the

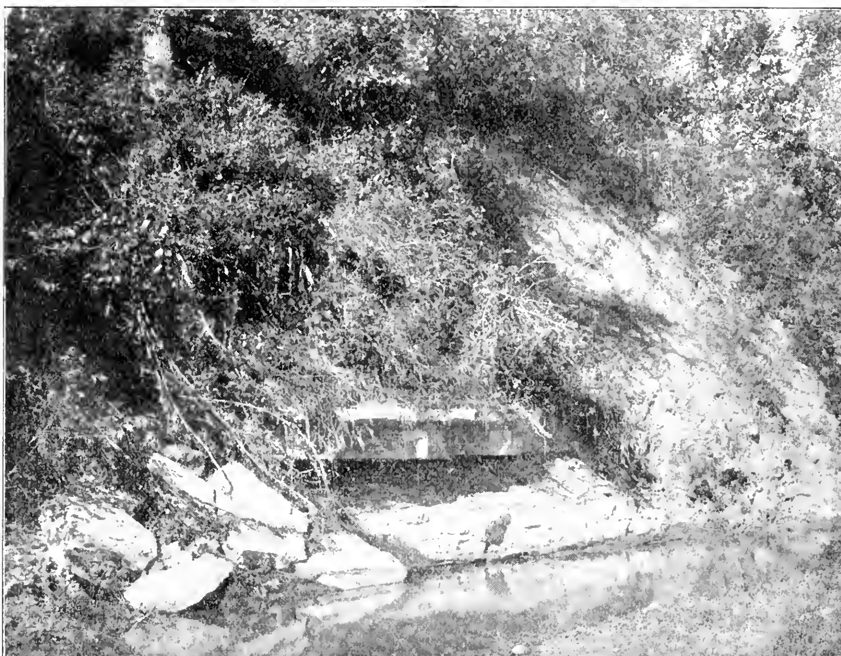


Fig. 169a.—Exposure of the "blue ledge" and associated strata southeast of Essex. (Calvin.)

main channel of Missouri river evidently was at the foot of the rock ledges in the bluffs east of the lake. At present a road grade twelve or fifteen feet in height above the marsh has been constructed at the foot of the bluffs, concealing strata seen by White and described in his "Section at Wilsons," Volume 1, Iowa Geological Survey, 1870. For a distance of nearly one-half mile the lake is bordered by a ledge of light gray, irregularly bedded, shattered limestone, twelve to fifteen feet thick. In one place the base of the limestone was seen resting on a black shale. South of the Wilson residence there are numerous outcrops of the thick limestone ledge with higher strata resting upon it. One-half mile south of the Wilson house on Murder hill, named in allusion to an occurrence that took place in a house the ruins of which are at the foot of the bluff, is exposed fifteen feet of the Forbes limestone overlain by a complete section of the Braddyville formation, the only one known in the state. This outcrop includes the Meadow, Union, Louisville, and South Bend ledges of the Nebraska geologists.

The upper ledge, South Bend, is the bottom rock of the Nodaway coal. Across a ravine and less than two hundred yards distant is the old quarry in the bluff at the rear of Chas. Baldwin's residence. The bottom of this ravine is on the fault line about fifty yards north of the Baldwin house. It was not possible to run a level between these two points by reason of trees and thick undergrowth. However, the ledge at Baldwin's has approximately the same elevation as the Meadow ledge in Murder hill. The downthrow of the fault to the south includes the Braddyville, forty feet, City Bluffs, one hundred and twenty-five feet, Nemaha, one hundred feet, McKissicks grove, fifty feet, the total amount of displacement being about three hundred and twenty-five feet.

Keyes has named this deformation the Red Oak fault; however Condra and Bengtson's name Jones Point deformation has priority of one year and is moreover a more appropriate name as it is not in all places if indeed it is in a majority of cases a true fault.

All known outcrops on East Nishnabotna river from Essex north to Stennett have been visited, the purpose being correlation of the different exposures and the study of the geologic structure along this stream. From two miles southeast of Essex on Rocky Branch no outcrop of Pennsylvanian rocks is known in the valley of this river until Mill creek south of Riverton is reached. In the Page county report, Volume 11, Iowa Geological Survey, Doctor Calvin in Plate No. 34 gave a view of the outcrop on Rocky Branch as then exposed. Subsequent quarrying operations and erosion of the creek bed have uncovered a still lower ledge of limestone. The section at present is as follows:

		Feet	Inches
9.	Limestone, light gray, weathered yellow		8
8.	Shale, weathered		6
7.	Limestone, blue, weathered yellow		16
6.	Shale, yellow	2	
5.	Shale, blue	7	
4.	Limestone, gray, impure and shaly, in three layers	1	
3.	Shale, weathered	1	
2.	Limestone, bluish gray, one layer cut by vertical joints into large rhombohedral blocks	2	
1.	Limestone, blue, weathered brown, broken into small blocks	1	
	Total	16	6

If the Fusulina layer of the Tarkio is present here it is now concealed by slumping. Doctor Calvin seems to have found it exposed. Numbers 1, 2, 3, 4 represent the Preston and 7, 8, 9 the Tarkio. In a part of the outcrop there is exposed seven feet of Nebraskan drift, crumbly black clay, diagonally jointed, containing pockets of sand and small pebbles of white chert. Eighty rods north of the creek bridge, along the roadside, is seen the Kansan drift, very arenaceous, containing diabase and quartzite gravel and bowlders of Sioux quartzite. Several fragments of friable Cretaceous sandstone were found which could have not been transported in a drift sheet from ledges far distant.

At Coburg in the bluff east of the village there is an excellent exposure of Cretaceous sandstone. It was examined by Lonsdale twenty years ago and is still in good condition.

SECTION IN BLUFF EAST OF COBURG.

		Feet
3.	Shale, light gray, in wagon road cut, south of pit	11
2.	Conglomerate, quartz pebbles, arenaceous limonite matrix, dark brown	8
1.	Sandstone, yellow, cross bedded, friable, with streaks of gravel	24
	Total	43

In the deep road cut about one hundred yards south of the sandstone pit the ferruginous conglomerate is overlain by eleven feet of light gray, poorly bedded shale giving a thickness of forty-three feet of Cretaceous strata in this bluff. Eighty rods south of the wagon road a quarry was opened many years ago which now is much obscured. Immediately under a light covering of drift five or six feet of the Cretaceous conglomerate is seen in place. The quarry was opened in Carboniferous limestone underneath the conglomerate. No undisturbed layers of limestone in place can be seen. However, among loose blocks and debris it was found that the layers quarried were eight inches of light gray iron stained limestone, and fourteen inches of bluish gray limestone in one layer. A few fossils were found sufficient with the lithogical character of the limestone to justify a correlation with the Tarkio.

At the old Keystone mill site near Red Oak on the Nebraska City branch of the Chicago, Burlington & Quincy railway, in the first bluff south of the main line, an excavation shows Cretaceous sandstone, yellow, friable, massive, cross bedded, with concretions of limonite. The thickness exposed is twelve feet, eight feet of which is above the level of the railroad track. At the time of the visit of Doctor Calvin and the writer eighteen years ago about one hundred yards south of this sandstone pit an outcrop showed above the railroad track ten feet of Cretaceous shale, poorly bedded, arenaceous, with limonite concretions, gradually passing upwards into fifteen feet of light gray shale, free from concretions, jointed, and well bedded; below the railroad track was nine or ten feet of contorted friable sandstone resting unconformably on eighteen inches of light gray Carboniferous limestone in one layer. Doctor Calvin at that time collected specimens of Angiosperm leaves in this sandstone. This is probably the same locality from which Meek collected fifty years ago. A short distance still farther south, where the river at high water washes the railroad embankment, is the place where White obtained his section showing Cretaceous shale extending down to the limestone ledge at water level in the river, with absence of all sandstone.

SECTION NEAR RED OAK, IOWA GEOLOGICAL SURVEY, VOL. 1, 1870.

	Feet
Fine grained sandy and clayey micaceous shale	20
Bluish compact impure limestone	1½
Total	21½

At the present time the railroad embankment has been reinforced to guard against erosion by high water in the river, covering all exposures below the level of the track.

A short distance farther south, on the north side of a deep ravine, close to the railroad right-of-way, at an elevation of two feet above the track and thirteen feet above extreme low water in the river, is a one foot ledge of yellow Carboniferous limestone in one layer, underlain by several feet of weathered shale. The river at this point is only a few yards distant from the railroad track and is flowing in a rapid, paved with many bowlders of gray limestone evidently derived from the lower ledge. In the hill south of the ravine Cretaceous shales only are seen reaching thirty feet above the railroad track.

The correlation of the limestone ledges is difficult and is attempted with hesitation, as the outcrop is meager. However, fossils were collected both from the upper ledge and from a pier of the old Keystone mill which evidently was constructed with stone from the lower gray limestone whose outcrop, now concealed, was only fifty feet distant. The fauna and lithology of the limestones are not in close agreement with the limestones near Essex. Lonsdale states that a deep drilling was done in this immediate vicinity and it was claimed a coal seam eight inches thick was found ninety feet below the river. If this record is correct the coal without doubt is the Nodaway coal, and the limestones can be correlated, the lower with the Burlingame and the upper with the Fargo. The Rulo apparently is absent in the Brownville syncline in Iowa.

COMPOSITE SECTION ON RIVER SOUTH OF RED OAK.

		Feet
6.	Shale, light gray, friable, with streaks of orange colored sand	9
5.	Shale, arenaceous, micaceous, light gray, concretions	11 to 27
	Unconformity	
4.	Sandstone, yellow, unconformity, friable, massive, with limonite concretions	0 to 16
3.	Limestone, yellow, one layer	1
2	Shale, blue	11
1	Limestone, light gray, one layer	1½
	Total	49½

There is much of interest in these outcrops that extend along the river for half a mile. Although now somewhat obscured they show the unconformity between the Carboniferous and Cretaceous as well as one within the Cretaceous.

Four miles north of this locality and two miles north of the city of Red Oak, at the site of the old Clark mill, on East Nishnabotna river, there is exposed above water level a ledge of limestone eleven feet thick overlain by ten feet of dark yellow friable Cretaceous sandstone. The limestone is impure, light gray and yellow in color, unevenly weathered. Some layers are composed of a mass of comminuted fossils and the whole ledge is heavily Fusulina bearing. This limestone is the Forbes, which is so prominent at Stennett. The visit here was made in December, the river was frozen over, and the weather was extremely cold accompanied by snow squalls which precluded any attempts at fossil collecting. From the Wayne stennett quarry on Pilot creek near Stennett to this outcrop the course of East Nishnabotna river is coincident for five miles with the strike of the Forbes as it dips east on the northwest limb of the Brownville syncline. Two miles north of the Clark mill site outcrop, the Cedar Creek ledge is exposed along the roadside well above the bottom land and less than a mile from the river. This ledge is about twenty feet lower in the general section than the Forbes. In the absence of a topographic map and precise leveling it is estimated the dip on the northwest limb of the Brownville syncline is S. 60 degrees E., at the rate of sixty feet to the mile. It is probable the Forbes is present only in a limited outlier west of the river at Stennett and vicinity. There is no evidence of a fault near Red Oak, the heavy dip being sufficient in the four miles from the Clark mill to the Keystone mill to bring in the City Bluffs at the latter place.

The main limestone ledge at Stennett has been regarded as equivalent to the limestone at Forbes, Missouri. The Missouri Geological Survey, in Volume 13, has correlated the Forbes limestone with and adopted the name Deer Creek of Kansas. However, as it is at least fifty miles from the nearest outcrop of the Deer Creek in Missouri to that in Iowa near Corning, where the Stennett main ledge is exposed in the bed of the East Nodaway river this very wide correlation is subject to much criticism. The Missouri Survey gives the following section for the Deer Creek in that state.

		Feet
5.	Limestone, gray, cherty, thick or thin bedded.... . ..	13 to 15
4.	Shale, black and slaty in the middle	5
3.	Limestone, gray, fine grained with specks of calcite....	2
2.	Shale	7
1.	Limestone, soft, buff, argillaceous	5

This does not correspond with any sequence of strata known in Iowa. Until the connection between these limestones has been traced in the field it would be more judicious to avoid all correlations. The writer has carefully studied the faunal lists given by Girty in the Missouri report referred to and finds the Iowa limestone to be paleontologically allied with the Topeka. There are many chances of error in exact correlations fifty miles apart in a heavy drift covered region.

Two miles southeast of Clarinda the writer was fortunate to discover an excellent exposure of the cap rock of the Nodaway coal at the site of the old Shambaugh mill, locally known as Pinhook. A drainage canal has diverted the course of the river some distance to the west. The old river bed is silted up, with brush growing in it. The outcrop is not in as good condition as it was at the time of Doctor Calvin's visit when he obtained his section at an old mine drift now completely slumped away. However, the cap rock and roof shale of the coal are well exposed. Doctor Calvin's section is better than any to be obtained at present and will be given:

SECTION AT PINHOOK NEAR CLARINDA.

		Feet	Inches
9.	Yellow weathered shale	4	
8.	Black shale	1	
7.	Yellow shale	1	3
6.	Yellowish impure limestone which at the north end of the exposure is in two layers, the upper 14 and the lower 18 inches in thickness. The lower bed thins and runs out in a few yards to the south. Average thickness	2	
5.	Yellowish shale, present in some parts of the exposure and absent in others		6
4.	Black, slaty shale		6
3.	Grayish, fossiliferous, non-laminated shale which disappears and re-appears in distances of a few yards. Among the fossil species noted are: *Lophophyllum profundum*, plates and spines of Zeacrinus, *Rhombopora lepidodendroides*, *Chonetes granulifer*, *Productus pertenuis*, *Derbya crassa*, represented by numerous small, fragile individuals, *Spiriferina kentuckiensis*, *Ambocoelia planoconvexa*, represented by detached valves but very abundant, *Athyris subtilita*, *Straparollis catilloides*, *Bellerophon percarinatus*, *Bellerophon carbonarius*, and a small pleurotomaria	2	
2.	Coal	1	6
1.	Drab shale down to river	8	

Doctor Calvin's faunal list of the roof shales gives the dominant fossils of this horizon. The lithology of the cap rock is such that it can be readily recognized. It is an impure limestone, subcrystalline, in many places reddish in color, and breaks with a splintery fracture. This cap rock has been correlated with the Howard formation of Kansas, a name derived from a locality near the southern border of that state. It is inconceivable a thin ledge of limestone less than three feet thick should preserve an unbroken continuity for a distance of two hundred and fifty miles. No such other instance is known in American geology. This cap rock no more deserves the taxonomic rank of a formation than the similar cap rocks over the Elmo and Nyman coals. The writer again would advise that correlations in this geological field be carefully considered, as it is impossible that correct interpretations of its stratigraphic relations can be achieved by only a few days of reconnoisance work. The statement of Doctor F. V. Hayden in Final Report on Nebraska, Page 15, "These Upper Coal Measure rocks seem to be as changeable in their lithogical characters as those of the Tertiary period. What adds to the difficulty, also, is the fact the same species of fossils, with few exceptions, run through all the beds" has much application even today.

Condra and Bengtson's report "The Pennsylvanian Formations of Southeastern Nebraska" is difficult to obtain, and their ledge names and numbers will be given as far as they are exposed in outcrop in the six counties of the two southern tiers of counties in southwestern Iowa:

	Nebraska City.	12.	South Bend.
	Nyman coal.	11.	Louisville.
18.	Tarkio.	10.	Union.
17.	Preston.	9.	Meadow.
16.	Burlingame.	8.	Forbes.
15.	Fargo.	7.	Cedar Creek.
	Nodaway coal.		

The Ashland (13) and Rulo (14) ledges of Nebraska are not definitely known to be present in Iowa.

PALEONTOLOGY.

Collections of fossils have been made at Essex, Coburg, Red Oak, also at Pinhook, and the different coal mine dumps near Clarinda. This continued study without greatly increasing the number of species already known has extended the range of many species, so that it may be stated there is no abrupt change in the fauna throughout the whole section. During the greater part of a season a species may be searched for in vain when by fortuitous accident it can be collected by the dozen at a horizon where hitherto it has not been found. This well illustrates the statement made by Doctor Calvin many years ago that the fauna of the Missouri stage is found gregariously in colonies. There has been much difficulty experienced in the identification of species in the genus Marginifera. Norwood and Pratten in 1855 described three small species of productids of which *Productus* *splendens* and *P. wabashensis* were for years afterwards generally identified as *P. longispinus* Sowerby. Meek in the Final Report on Nebraska, following Davidson, referred, though doubtfully, the Nebraska species to *P. longispinus*, at the same time stating that it was identical with *P. wabashensis* N. & P. Stuart Weller in Carboniferous Invertebrates, Bulletin 153, U. S. Geological Survey, gives *P. splendens* as synonym of *P. longispinus* and gives full generic value to *P. wabashensis*. The writer in the past has endeavored to follow Weller in identifications. With the usual imperfect material found it seems impossible to discriminate these two species. Although the extremes can be differentiated it is thought they merge into one another, and the identification of much the greater number of specimens is largely a matter of personal opinion. It would simplify things greatly if all the Marginifera were referred to *M. wabashensis*. The same condition is found with the genus Chonetes where the same species vary so greatly in the number of the cardinal spines, prolongation of the ears, and depth of the mesial sinus as to cause difficulty in coming to a decision whether one is dealing with only a variety or with a good species. There is also difficulty with the gastropods as the greater number are found in shale and in an imperfect condition. *Sphaerodoma primogenia* has been listed as found in these strata. However, White states in Indiana Report for 1883 that this species is without a columnar fold whereas all specimens of Sphaerodoma collected, so far as can be ascertained with rather poor material, have such a fold. Meek in the Final Report on Nebraska refers his species to (*Macrocheilus*) *S. intercalaris*. However, his figure does not show the aperture and he gives no diagnosis. Meek and Worthen in a figure in Illinois Paleontology, Volume 2, show this species without a columnar fold. Most of the specimens can be identified as *S. paludinaeformis*, leaving much material conjectural, though this may be included in *S. intercalaris*. Many small pelecypods are found which can not well be classified, and their identification is fraught with difficulty and is questionable. The writer has been criticised in his identification of *Marginifera muricata* in the Forbes and City Bluffs. In Bulletin 211 U. S. Geological Survey Girty lists *M. muricata* as present in the Lecompton and Deer Creek of Kansas. This species or one closely allied to it is present in the Iowa formations. However, the writer does wish to be dogmatic as to the possible species in the genus Marginifera. Stuart Weller's determinations in the monograph on "Mississippian Brachiopoda," Illinois Geological Survey, have been followed in placing Derbya as a synonym of Orthotetes. The identification of *Orestes nodosum* is made with confidence from Girty's excellent descriptions and figures, without type specimens, thus greatly extending the range of this species. Detached stem fragments and plates of crinoids are abundant throughout the whole series of strata. The identification of crinoid species from a single separate plate is extremely hazardous. As Meek states, Erisocrinus and Ceriocrinus can not be distinguished by detached plates. It is unusual that Fusulina can not be found in any limestone ledge. The writer has in great measure been dependent on the "Final Report on Nebraska," Meek and Hayden, for his identification of species as Meek's well known paleontological work in this report was done in the same geological field as the writer's. Where Meek has given descriptions and figures his identification of species is accepted without question. The recent "Fauna of the Wewoka Formation" by Girty has been of great service, although the nomenclature given there has not in all instances been followed. Paleontological nomenclature at present is in a transitory state, and there probably will be many changes in the future.

The faunal expression is somewhat earlier in type than found in equivalent horizons farther to the southwest according to faunal lists published in other states. It is quite possible that in the great trough of the Brownville syncline, life conditions in the Pennsylvanian were such that species continued later than in the more abyssal seas of the southwest.

ESSEX FAUNA—TARKIO.

Fusulina secalica.	Ambocoelia planoconvexa.
Lophophyllum profundum.	Heustedia mormoni.
Ceriocrinus hemisphericus.	Meekella striatocostata.
Rhombopora lepidodendroides.	Productus costatus.
Fistulipora nodulifera.	Orthotetes crassa.
Pugnax uta.	Spiriferina kentuckiensis.
Marginifera wabashensis.	Allorisma terminale.
Chonetes granulifer.	Myalina swallovi.
Chonetes geinitziana.	Pleurotomaria subdecussata.

ESSEX FAUNA—PRESTON.

Fusulina secalica.	Fenestella perelegans.
Lophophyllum profundum.	Orthotetes crassa.
Archaeocidaris dinnini.	Enteletes hemiplicata.
Polypora submarginata.	Seminula argentea.
Fistulipora nodulifera.	Chonetes granulifer.
Rhombopora lepidodendroides.	Productus punctatus.
Septopora biserialis.	Edmondia nebraskensis.

The dominant fauna of the Preston is bryozoa. Besides the species listed several indeterminata were found.

COBURG FAUNA—TARKIO.

RED OAK FAUNA—BURLINGAME.

Fistulipora nodulifera.
Rhombopora lepidodendroides.
Enteletes hemiplicata.
Orthotetes crassa.
Spirifer cameratus.
Chonetes granulifer.
Spirifer cameratus.
Chonetes granulifer.
Bellerophon bellus.
Hydreionocrinus, spines.
Ambocoelia planoconvexa.
Aviculopecten occidentalis.

RED OAK FAUNA—FARGO.

Fusulina secalica.
Lophophyllum profundum.
Archaeocidaris dininni.
Hydreionocrinus mucrospinus.
Polypora submarginata.
Fistulipora nodulifera.
Septopora biserialis.
Rhombopora lepidodendroides.
Chonetes granulifer.
C. verneuiliana.
Ambocoelia planoconvexa.
Seminula argentea.
Spirifer cameratus.
Spiriferina kentuckiensis.
Orthotetes crassa.
Productus nebraskensis.
Productus semireticulatus.
Aviculopecten mccoyi.

PINHOOK FAUNA—NODAWAY COAL CAP ROCK.

Fusulina secalica.
Fistulipora nodulifera.
Rhombopora lepidodendroides.
Polypora submarginata.
Productus semireticulatus.
Productus cora.
Productus pertenuis.
Productus nebraskensis.
Chonetes granulifer.
Marginifera wabashensis.
Chonetes verneuiliana.
Seminula argentea.
Ambocoelia planoconvexa.
Myalina perattenuata.
Myalina swallovi.
Nucula ventricosa.
Edmondia nebraskensis.
Edmondia reflexa.
Bellerophon crassus.
Orestes nodosus.
Naticopsis altonensis.

CLARINDA MINES FAUNA. NODAWAY COAL SHALES.

Lophophyllum profundum.
Lophophyllum distorta.
Ceriocrinus hemisphericus.
Hydreionocrinus mucrospinus.
Rhombopora lepidodendroides.
Seminula argentea.
Ambocoelia planoconvexa.
Hustedia mormoni.
Productus pertenuis.
Productus nebraskensis.
Orthotetes crassa.
Edmondia reflexa.
Nucula ventricosa.
Euomphalus catilloides.
Euphemus carbonarius.
Sphaerodoma brevis.
Spiriferina kentuckiensis.
Chonetes granulifer.
Chonetes verneuiliana.
Chonetes geinitziana.
Marginifera wabashensis.
Trepospira sphaerulata.
Phanerotrema grayvillensis.
Worthenia tabulata.
Bellerophon percarinatus.

SHENANDOAH.

RELATION OF THE WISCONSIN DRIFT TO THE IOWAN DRIFT AS REVEALED IN WORTH COUNTY.

E. J. CABLE.

This paper is the result of an attempt to determine, if possible, the relation of the Wisconsin drift to the Iowan drift, not only along the immediate border of the Wisconsin drift, as outlined in the Iowa State Geological Survey Reports, but within the Wisconsin drift plain itself. A careful and detailed investigation was made along the eastern border of the Wisconsin drift from the northern boundary of Worth county, where the eastern edge of the Wisconsin drift enters the state, as far south as Hardin county. Examination of drift cuts, well logs, and a recently excavated coal shaft, located in Hardin county on the border of the Wisconsin drift, failed to reveal, in any positive way, the

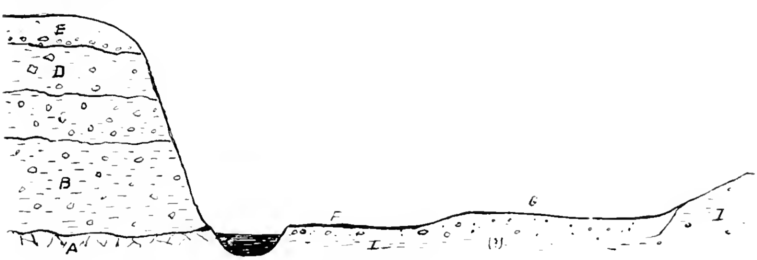


Fig. 170

presence of Iowan drift beneath Wisconsin drift. Many instances could be cited where unquestioned Wisconsin drift was found superimposed upon, (a) Yarmouth deposits and, (b) Kansan till. One of the best exposures along the Wisconsin drift border showing the relation of the Wisconsin drift to the underlying drift, is found along the south bluff of Lime creek, southeast quarter, section 35, and south one-half of section 36, Fertile township, Worth county. Lime creek, in this particular locality, is cutting on its southern bank into a high bluff of Wisconsin drift and affords the following section:

SECTION ALONG THE SOUTH BANK OF LIME CREEK, FERTILE TOWNSHIP, WORTH COUNTY.

		Feet
E.	Sand and gravel, largely sand near the top and more gravelly near the base; many of the included pebbles are covered with a coating of iron oxide	16

D.	Grayish brown calcareous clay, somewhat jointed, highly iron stained along the joints; grading into (B) rather sharply....	20
C.	Yellowish gray clay, highly calcareous; contains small bowlders, and grades gradually into (D)	20
B.	Yellowish gray clay grading into bluish black jointed clay beneath; highly calcareous	30
A.	Dense, fine-grained bluish black, jointed clay; contains small quartz pebbles and pieces of wood; is highly fossiliferous; to the water's edge..	2

Horizons B, C, D, E are Wisconsin drift lying on what is unquestionably Yarmouth interglacial deposits. North of the river

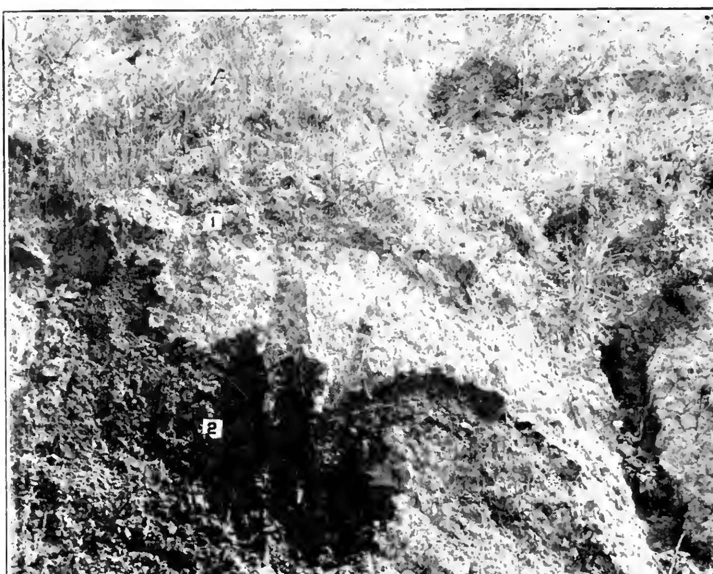


Fig. 171

at this point, figure 170, are two terraces, F and G. A section in the drift material of the upper terrace revealed a thick deposit of peaty soil, filled with shells. The material of the upper terrace is unquestionably Wisconsin in age and was deposited in a lake which filled this valley during the retreat or advance of the Wisconsin ice. Following the valley of Lime creek eastward, it was found that the peaty material disappears and a thin covering of drift is visible. An examination of the drift shows it to be very much like Iowan drift. Light colored bowlders may be seen similar to those so common on the Iowan drift. If Iowan drift is present in the valley where the section in figure 170 is given, it is impossible to tell it. It may be that the material marked I in figure 170 is Iowan. Another section along this same stream a quarter of a mile to the west of the section shown in figure 170 affords the following:

SECTION ALONG LIME CREEK, FERTILE TOWNSHIP, WORTH COUNTY.

1.	Wisconsin drift composed of sand and gravel in the upper portion while the lower thirty feet is a bluish gray clay filled with bowlders and limestone pebbles........................	50
2.	Black, compact, fine-grained jointed clay, containing quartz pebbles; the upper part is highly fossiliferous and contains pieces of wood.	

Fig. 172

The upper portion of horizon (2), figure 171, is undoubtedly Yarmouth interglacial deposits. It has about the same elevation with reference to the stream as horizon A in figure 170 Here, as in the previous section, Wisconsin drift rests upon Yarmouth deposits. A few rods to the west of the section shown in figure 171, is a very narrow, steep-sided gully. The depth at its lower end just where it enters the river is about thirty feet. This gully is of such recent origin that little weathering of the drift has taken place, and since it is deep enough to cut through the Wisconsin drift into the underlying drift, it affords an interesting study.

SECTION OF A GULLY WALL, FERTILE TOWNSHIP, WORTH COUNTY.

The west wall of the gully shows a dense, bluish black jointed clay, (1) of figures 172, beneath Wisconsin; the clay is highly jointed, the upper portion showing rather marked contortion; no bowlders are present, but numerous small pieces of quartz are visible. The material marked (2), in figure 172, is fine sand with highly distorted laminae.

A section of the west bank of the north-south gully, is shown in figure 173.

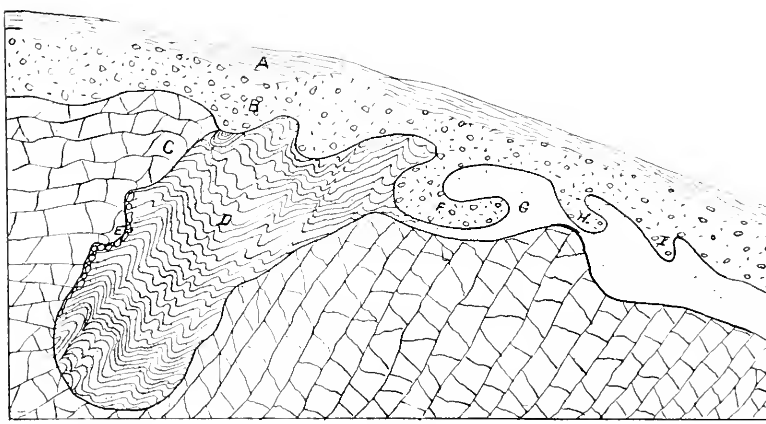


Fig. 173

SECTION OF A GULLY WALL IN FERTILE TOWNSHIP, WORTH COUNTY.

		Feet
A.	Soil filled with roots	$1\frac{1}{2}$
B.	A grayish clay, highly calcareous, showing distortion, (Wisconsin drift)	2
C.	Dense bluish black, jointed clay, calcareous, the upper part showing contortion, and containing fossil shells and pieces of petrified wood. Exposed to the base of the gully..........	15
D.	Large sand inclusion, 8 feet wide, and extending from immediately beneath the Wisconsin drift to the bottom of the gully; sand laminated and highly distorted and having the edges of the laminæ iron stained.	
E.	Pebbles and gravel along contact of the sand with the Kansan drift; the pebbles range in size from one-half inch to two inches in diameter and are cemented together by iron oxide.	

The age of the drift here beneath the Wisconsin is Kansan. To the south of the sand pocket the joints of the Kansan drift in the upper portion, instead of being vertical, dip to the south and show some distortion which suggests strongly shearing planes resulting from the pressure of the overriding Wisconsin ice. To the north end of this same exposure, figure 173, Wisconsin drift is found resting upon sand. Here the Wisconsin drift is disturbed by small synclines projecting into the sand beneath F, H, I, figure 173, and shown also in figure 174.

The contact line between the sand and the Wisconsin drift is well defined. The sand has a fresh appearance, shows little weathering, and is probably of Wisconsin age. It seems probable that the sand pocket is not an inclusion of sand in the Kansan drift, but was, previous to the advance of the Wisconsin ice, a gully cut into the Kansan drift. With the coming of the Wisconsin ice, the outwash from the edge of the ice filled

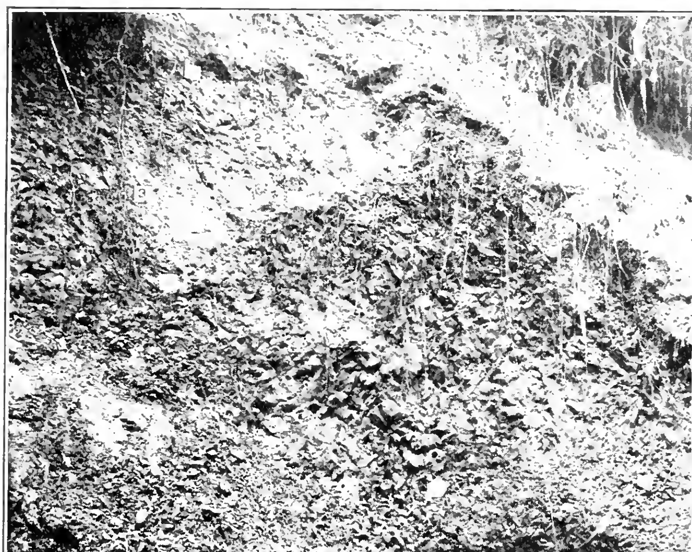


Fig. 174. View showing the folded Wisconsin drift projecting into the sand below.

the gully. In the filling of the gully, the structure now seen in the sand was effected, while the distortion of the laminæ has resulted from the pressure of the overriding Wisconsin ice.

Many other instances could be given, not only in Worth county, but in Franklin and Hardin counties as well, where Wisconsin drift is found superimposed upon what appears to be unquestionably Kansan drift. From a careful study of the two drifts in the previously mentioned counties, the following conclusions would seem warranted: (1) if Iowan drift is present beneath Wisconsin drift, it is so thin that the vigorous Wisconsin ice ploughed it up and mixed it so thoroughly with the Wisconsin drift as to destroy all its identity; (2) the Iowan ice sheet may have extended no further west than the east margin of the Wisconsin drift; (3) the time interval between the retreat of the Iowan ice sheet and the advance of the Wisconsin ice sheet may have been of sufficient length to permit of the removal by erosion of the Iowan drift before the advance of the Wisconsin ice, or (4) the Iowan drift does exist beneath the Wisconsin, but as yet has not been discovered.

DEPARTMENT OF NATURAL SCIENCE,
STATE TEACHERS COLLEGE.

PROVINCIAL UNITY OF CONTINENTAL INTERIOR COAL-FIELDS.

CHARLES KEYES.

With their extreme simplicity of geological structure it seems almost incredible that the coal-fields of the Continental Interior should remain so long without even approximate correlation of their several parts. That the Arkansas district, the Western Interior area, the Eastern Interior field and the Michigan basin are essential parts of a single stratigraphic province there is now little reason to doubt. Recent regional planation manifestly separates a once continuous plate by removing the coal measures over the crests of broad gentle folds and preserving from the effects of erosion the deposits lying in the troughs.

The physiographic conditions existing when the coal measures were laid down are not so very hard to restore in fancy. The great plane of unconformity which characterizes the floor over such a large part of the region is clearly a Mid Carbonic peneplain of remarkable extent and smoothness. It represents perhaps the largest and most perfect peneplain known. It extends from central Arkansas north and northeast far upon the crystalline Canadian shield beyond the Great Lakes. Without interruption and with gradual encroachment the marine coal-marshes doubtless crept up towards the pole far into Canada. Late Carbonic, Comanchan, Jurassic and Triassic warpings of the earth's crust were wide spread over the coal region. In southern Minnesota the flexing devolved into a lofty mountain range that rivaled the Appalachians of today. Other folds broader but perhaps not so high developed elsewhere through the Continental Interior. Between the base-leveling of Cretacic and Tertiary times all topographic eminences were completely and smoothly worn down. The once vast and continuous coal-field thus became broken up into a number of separate basins possessing much the character that they have at the present day. Inattention to these fundamental stratigraphic facts is no doubt the main cause of the failure to correlate the several State sections.

Half to three-quarters of a century ago, when the coal measures of the region first came in for systematic consideration, it was widely thought that careful comparisons of the contained fossils would furnish an exact vertical section and a ready means of paralleling coal-seams and guide-horizons in localities widely separated from one another. As time went on this proved notably unsatisfactory and inconclusive. As a practical method of correlation the scheme was long since abandoned. In view of the peculiarities of original sedimentation and the rapid alternation of lithologic and consequently physical conditions it now appears to be extremely doubtful whether the organic remains of these formations will ever prove to be effectual correlative features. This is particularly true of Kansas where the method experienced the severest test.

With the complete break-down of the fossils as correlative criteria in Kansas, Missouri and Iowa and in fact throughout the Western Interior coal-field, correlation was largely conducted by direct tracing of strata from point to point, until there resulted one of the most complete and precise rock-classifications known. In the meanwhile similar detailed field-work in the Eastern Interior coal-basin lagged. Through fortunate preservation of a narrow belt of coal measures by drop-faulting* a part of the western section was traced across the supposed barren area along the line of the Mississippi river, that was so long regarded as completely isolating the two great coal-fields.

The wide lithologic homogeneity and terranal continuity of many of the beds constituting the coal measures permits single units to be traced over surprisingly long distances. That the Illinois and Missouri sections have never been matched up, as it were, or that the Arkansas and Kansas-Missouri strata have not been closely paralleled is doubtless due largely to the circumstances that public systematic investigations seldom transgress state boundaries. The workers in one part of the province are wholly without intimate knowledge of what has been done elsewhere. The great force of this shortcoming led, not so very long ago, to a critical personal inspection of the conditions existing in states contiguous to those in which principal investigations had been previously carried on. Among the facts discovered were that the southern coal measures were mainly beneath the base of the Missouri and Iowa measures, and that there was actually great similarity between the general sections of the Eastern Interior and Western Interior Coal-fields. A host of once incongruous features was thus readily explained.

*Proc. Iowa Acad. Sci., Vol. XXIV, p. 53, 1917.

The detailed comparison of the Eastern Interior and Western Interior sections is rendered easy for the reason that it was found that instead of being separated by a wide belt of older rocks the two are actually continuous. This is made evident by the profound Cap-au-Grès displacement which crosses the Mississippi river near the mouth of the Missouri river. This fault having a throw of 1,000 feet drops the coal measures down so that there is now an unbroken belt of them extending from Indiana to Kansas. In this trough also the basal limestones of the Missourian, or Upper Coal, series are brought nearly 100 miles closer together than had been previously suspected.

The problem of comparing the Eastern Interior and Western Interior sections thus consists merely of matching up, after some little special investigation at critical points, the sequence of beds on the two limbs of a broad arch the crest of which is removed through erosion. In the west, in Missouri and Kansas, the details of the rock succession are more clearly discerned on account of the country there being free from glacial debris. The wealth of detail there deciphered is at once the joy of geologists who work in the region and the dispair of outsiders who are unacquainted with such refinements of stratigraphical conditions It is the most completely differentiated section of the coal measures in the United States.

On the other hand the coal measures of Illinois are the longest known and least understood stratigraphically of any coal deposits on the American continent. Notwithstanding the circumstance that one of the very first discoveries of mineral coal in America was made in 1680 near the present city of Peoria, the Illinois section remains today almost as completely undifferentiated according to modern standards as it was three centuries ago.

With the exception of an early attempt, when the Permian controversy was at its height in this country, to show by the contained fossils that certain beds near La Salle were to be compared with the Kansas Permian section (*i. e.*, Permo-carboniferous, or Missourian) all efforts appear to have been towards establishing correlative relationships with eastern sections. This tendency seems all the more pronounced since a concerted movement was inaugurated to take the Pennsylvanian section out of the provincial class and make it the standard succession for the entire continent. In so doing important affinities are wholly lost sight of. Paleogeographical relations are forgotten. Paleontologic evidences are not analyzed. Lithologic similarities are overlooked. Similarity of lithologic sequence is passed over as if of inconsequential character. Fundamental canons of correlation are completely ignored.

Another important feature directly bearing upon the consanguinity of the Illinois or Eastern Interior with the Western Interior field is the recent determination of the eastward extension of the Bethany limestone or basal member of the Upper coal measures far beyond its previously recorded limits. This discovery in the trough of the great Cap-au-Grès fault in north-central Missouri places the boundary of that member more than 50 miles in advance of any hitherto recognized eastern outcrop, and within only 50 miles of the Illinois line.

There are several advantages in selecting for the Illinois area the coal measures section constructed by A. H Worthen. This section is made up in the same way as was the eastern Kansas section. It was erected under the guidance of F. B. Meek, who was at the time a co-laborer of Worthen and than whom no worker was more familiar with the Kansas sequence. Worthen's section has a further advantage over later ones in that it goes into sufficient detail and was made by one who had gone over the whole field.

Adjudicating the paleogeographical affinities of the Illinois coal measures according to the standard of the Kansas, Missouri and Iowa sections there appears to be in the several successions a wonderfully close correspondence in general features. This parallelism is well indicated in the subjoined table:

TABLE OF COAL MEASURES TERRANES

Series	Terranes	Kans.	Mo.	Iowa		Illinois
Oklahoman		800	Ab.	Ab.		Ab.
Missourian	Atchison Shales	800	300	300	——— Shales	235
	Forbes Limestone	25	35	25	Effingham Li.	8
	Platte Shales	200	125	150	——— Shales	200
	Plattsmouth Li.	75	50	30	Martinville Li.	30
	Lawrence Shales	300	225	100	——— Shales	100
	Stanton Li.	125	30	20	Livingston Li.	20
	Parkville Shales	100	100	100	——— Shales	75
	Iola Limestones	30	40	Ab.	Li. wanting	Ab.
	Thayer Shales	200	100	75	——— Shales	75
	Bethany Li.	100	75	50	Shoal Limestone	7
Des Moines	Marais des C. Sh.	325	300	250	——— Shales	350
	Henrietta Li.	100	175	100	Mason Li.	100
	Cherokee Shales	400	225	450	——— Shales	200
Arkansan		Ab.	Ab.	Ab.		Ab.

A point of special industrial interest is the fact that more than 95 per cent of the available coal tonnage in the Eastern Interior field is confined to horizons in the Des Moines Series. This is another genetic factor linking it with the Western Interior field where 98 per cent of the coal is also found to be restricted to the same series.

PRE-GLACIAL MOINGONA RIVER.

CHARLES KEYES.

As Iowa's master waterway, the Des Moines river rises beyond the extreme northwest corner of our State, and flows entirely across it to the southeast corner. The name is the oldest term applied by Europeans to any feature of the territory. As such the title is derived from the Moingona Indians whom Jolliet and Marquette, commonly ascribed discoverers of the Mississippi, found in the summer of 1673 located near the river's mouth.

Physiographically the present Des Moines river is made up ot two very distinct parts. The valley in which it flows, between the city of Des Moines and Keokuk, is very much older than that portion above the Capital City. The lower stretch is a broad, flat-bottomed, rock-cut gorge; the upper reach is a deep, V-shaped trench mainly sunk in unconsolidated till deposits. Both parts are post-glacial valleys; the one antedating the Wisconsin ice invasion and the other being subsequent to it. Unlike the upper stretch the lower reach is now engaged mainly in clearing out an old till-filled trough. It is, however, to some evidences of the former existence of an ancient stream, a pre-Glacial Des Moines river, or the Old Moingona river, that attention is here directed.

Possibility of the existence of a pre-Glacial precursor of Iowa's chief waterway has been with me a theme of long standing. The actual location of such a stream first took form more than 30 years ago, when I discovered that there was northeast of Capitol Hill in the city of Des Moines, a deep, drift-filled gorge which cut out the principal coal seams. Although during the period mentioned the subject was not always pursued with uniform vigor because of the fact that sufficient data had not yet accumulated special interest in it was again recently revived by the disclosure in quick succession of numerous facts bearing directly upon the solution of the problem.

When the matter was first broached so long ago as 1882 two circumstances were particularly significant. One was the abandoned drift-filled gorge already mentioned; and the other was a certain "Quaternary Section Eight Miles Southeast of Des Moines"[1] in which tills and gravels were found in such position as to indicate their situation in a valley much older, larger

[1]Proc. Iowa Acad. Sci., Vol. I, pt. ii, p. 30, 1892.

and deeper than the present river valley. In this section the thick till-bed immediately underlying the loess bluff-capping was that afterwards called the Kansan Drift. Discovery at that time of heavy, stratified, orange-colored sands and gravels beneath this Kansan till appears to be the first record of the actual existence of what was subsequently denominated the Aftonian inter-glacial deposits, although of course in the early eighties and nineties of the last century this was not yet suspected. Owing to a then recent land-slide on the bluff a very dark till-layer displayed under the gravels at the base of the section, was thought to be a part of the deposit higher up. Its subsequent reference to the Sub-Aftonian, or Nebraskan, till was the later suggestion of Dr. H. F. Bain[2] after the great complexity of the Glacial Period had become firmly established.

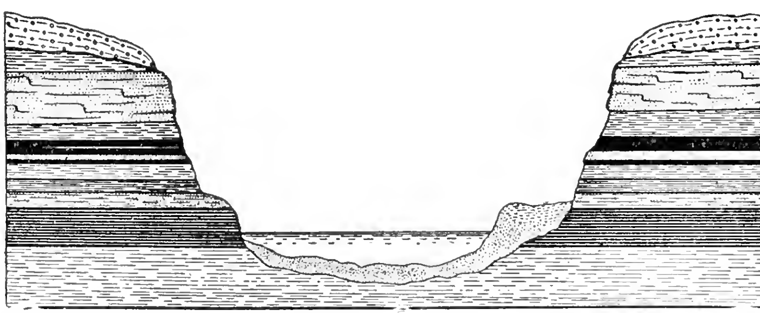


Fig. 175.—Rock gorge of present Des Moines river at Des Moines.

When the personal studies of the glacial deposits of South-eastern Iowa were made in 1887-8, when I was living in that part of the State, investigations extended far beyond the confines of Burlington.[3] The existence of an ancient gigantic, drift-hidden gorge of the Mississippi river was recognized below the mouth of the Skunk river. Soon, however, I found that in this discovery Major G. K. Warren had anticipated me by a full decade.[4] Subsequently by means of deep-well borings the depth of this ancient canyon was reported by Dr. C. H. Gordon[5] to be about 125 feet below low-water level in the present Mississippi river, and six miles wide in place of one mile as at Keokuk at the present time. This was, then the clue to the

[2]Proc. Iowa Acad. Sci., Vol. VII, p. 338, 1897.
[3]American Naturalist, Vol. XXII, pp. 1049-1054, 1888.
[4]Rept. U. S. Army Eng., 1878, Vol. IV, pp. 916-917, 1878.
[5]Iowa Geol. Survey, Vol. III, p. 247, 1895.

magnitude of the Pre-Glacial river work and to a position of this region at a higher level in late Tertiary times.

The relative magnitude of the present Des Moines river and of the Old Moingona river are best displayed perhaps in the city of Des Moines. The present used gorge is scarcely more than half a mile wide and for a part of the way is not more than a quarter of a mile in width, with a firm rock-bottom, (figure 175). The ancient abandoned gorge is more than two miles wide and its bottom is 100 feet beneath the low-water level in the river of today.

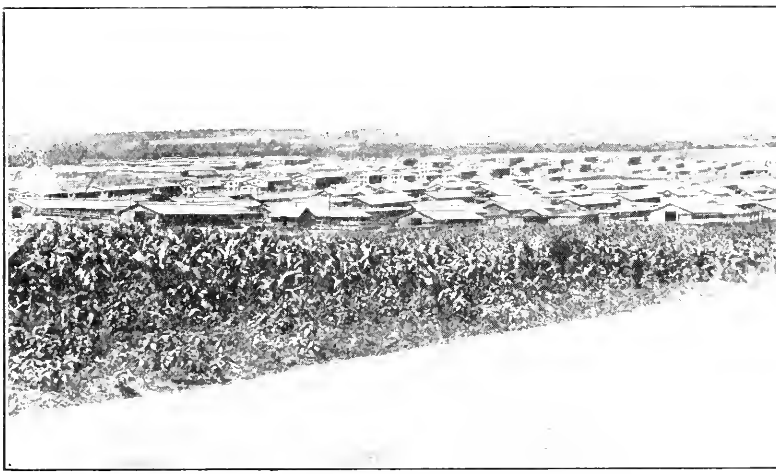


Fig. 175a.—Cantonment of Camp Dodge on Beaver Valley floor, in ancient gorge of old Moingona river. (Photo by Lees.)

Something of a true insight into the character of Iowa's Pre-Glacial drainage is obtained from consideration of the present waterways outside of the drift-mantled area. In Tertiary times the lowest line of the central depression was no doubt occupied by a master-stream much in the same position that it is today. By the rising of the Rocky Mountains the rivers from the west must have been directed eastward down the gentle slope until they reached the Old Mississippi. Their ending with the Missouri river is a later or Glacial consequence. At any rate several of them must have continued directly across Iowa and Missouri. With the advance of the continental ice sheet the northern rivers including the Yellowstone and the Upper Missouri which had long flowed into Hudson Bay must have been blocked in their northern reaches and diverted southward. By the time the ice had melted or retreated the Missouri river had established a permanent course as it exists today, and could not get back to its original path. This is essentially the idea advanced by Prof. J. E. Todd.[6]

The main problem concerning the course of the ancient Moingona river is to establish some intimate connection between the old stream course where it unites with the present Des Moines river valley and some of the Rocky Mountain rivers which still follow their original Tertiary paths. This is accomplished by restoring in fancy the bed-rock surface beneath the drift mantle of the State. In this respect the published data are now very complete. The multitude of well sections published by Prof. W. H. Norton[7] form only a small part of the available information. Especially along the line of the present investigation there is a large supplement of personal records. Comparison and adjustment of these data indicate a pre-Glacial surface of the State that is very much more rugged and broken than that of the present. The old inequalities of relief are now largely smoothed over by the till. Topographically much of the eastern half of the State is evidently not very unlike the driftless area of the extreme northeastern Iowa. The western half of the State is manifestly not nearly so rough.

In western Iowa the relief that existed at the end of Tertiary time and immediately before the first invasion of continental ice presents extreme differences in altitude of between 400 and 500 feet. Over the old elevations the drift is often scarcely a score of feet in thickness. In some of the old depressions and valleys the Glacial drift is 300 to 500 feet thick. The disposition of the low places is such that they lie in long belts and old gorges having relatively steep sides. Some of these primitive troughs are manifestly the paths of extinct streams. The one so well known at Des Moines is now known to extend far beyond that neighborhood. Its narrow belt is traceable northwestward to Sioux City where it intersects the present Missouri Valley. Throughout its entire length the course of this great one-time stream is well defined. Between Des Moines and Sioux City the mean fall is slightly above two feet to the mile—about the same as that of the Des Moines river of today between the Raccoon Fork and its mouth. Curiously enough the depth of the

[6]Science, N. S., Vol. XXXIX, pp. 263-274, 1914.
[7]Iowa Geol. Survey, Vol. XXI, 1912.

Old Moingona channel presents great uniformity. Where the channel traverses the water-shed between the Mississippi and Missouri drainage systems the bottom of this channel is more than 500 feet down. General hypsometric figures are given in the subjoined Table I. The remarkably close agreement of the bed-rock levels as calculated in three distinct and independent ways is presented in Table II.

GENERAL HYPSOMETRIC TABLE.

STATIONS.	Miles between stations	Elevations A. T. of Upland Plain.	Elevations A. T. of Bed Rock	Thickness of Upland Drift	Maximum Thickness of Drift
Des Moines	34	970	675	20	300
Perry	20	975	725	25	250
Jefferson	32	1050	780	30	270
Auburn	28	1250	850	15	400
Schaller	14	1390	890	40	500
Holstein	14	1440	940	50	500
Correctionville	36	1300	960	40	340
Sioux City		1350	1050	30	300

II. TABLE OF GRADIENT VALUES.

STATIONS.	Miles between stations	Well Records of Bed Rock	Interurban Data	Mean Gradient of 2 feet per mile
Des Moines	34	675	675	675
Perry	20	725	745	745
Jefferson	32	780	795	785
Auburn	28	850	845	850
Schaller	14	890	[illegible]	905
Holstein	14	940	920	935
Correctionville	36	960	970	970
Sioux City		1050	1040	1050

There is another deep drift-filled channel which branches off from the one already mentioned at about where the town of Perry stands, and which reaches the Missouri river valley at Onawa. This may be the hypothetical stream which Prof. Todd[7] calls the Old Niobrara river. Whether the present Niobrara

[7]Science, N. S., Vol. XXXIX, p. 263, 1914.

river which now empties into the Missouri river 75 miles above Sioux City formerly flowed through the Onawa channel or formed the Old Moingona stream is something of a moot question. The headwaters of the last mentioned waterway might have been any one of the three important streams rising in the Black Hills—the Cheyenne river, the White river, or the Niobrara river. Of course until the first great ice sheet advanced the Missouri river below the Mandan was non-existant and its headwaters flowed into Hudson Bay as already mentioned. As the continental glacier spread southward it necessarily cut off the discharge of this river and diverted it. As Professor Todd astutely surmises the Missouri waters probably were empounded by the ice until they overflowed the rim of its basin and then emptied into the first eastward flowing stream to the south, at

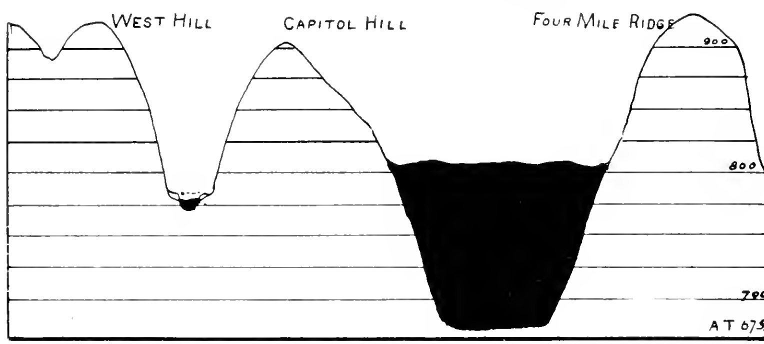


Fig. 176.—Relative magnitudes of present Des Moines River and old Moingona River.

the same time cutting a gorge along the glacier front. This process was repeated until the river had excavated its way to the Kansas river and the ice had covered the lower channels of all of the streams running eastward from the Rocky Mountains.

The excessive thickness of the Glacial till east of Sioux City and along the paths of the two old river valleys under consideration has been long known. Singularly enough Dr. H. F. Bain, who has done considerable work on the Glacial deposits of this portion of the state, mistook the more northerly one of the thickened belts for the terminal moraine of the Iowan Drift Sheet.[8] Later when he came across the thickened belt of the Onawa channel he regarded this as the real southern limit of the Iowan drift.[9] The fact that these thickened belts were not above

[8] Iowa Geol. Survey, Vol. VI, p. 462, 1897.
[9] Iowa Geol. Survey, Vol. VIII, p. 351, 1898.

but below the general bed-rock plain did not seem to suggest to him that they really indicated paths of old rivers. In his misinterpretation originated much of the confusion which long existed concerning the presence of an Iowan drift sheet in the State.

The relative magnitudes of the present Des Moines valley and of the gorge of the Old Moingona river are well represented in

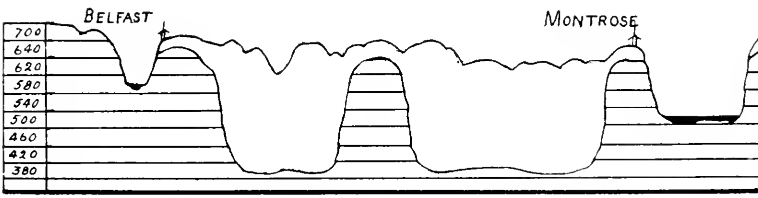


Fig. 177.—Gorges of old Moingona, preglacial Mississippi and present Mississippi River at Keokuk.

cross-section at Des Moines, one mile above the mouth of the Raccoon river (figure 176).

A similar comparison of the old and new Mississippi rivers is represented in cross-section (figure 177) based upon well data and natural exposures around the mouth of the present Des Moines river. The cross-section given by Prof. C. H. Gordon[10] of the old Mississippi gorge at Keokuk exaggerates too much the

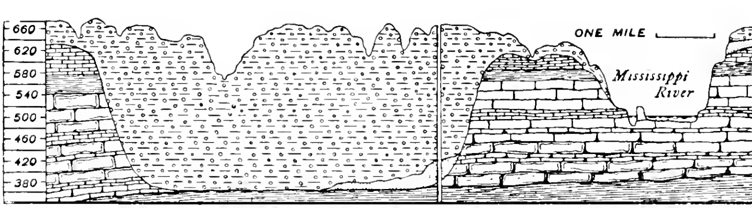


Fig. 178.—Cross section from Sonora to Argyle, at mouth of Old Moingona river, showing old and new gorges of the Mississippi river. (After Gordon).

size of the ancient valley. As represented by this writer the part ascribed to the old Mississippi river embraces both that stream and the old Moingona gorge, thus making the former very much too large. It is quite probable that in pre-Glacial times the old Moingona river was really the more important stream of the two.

[10]Iowa Geol. Survey, Vol. III, p. 248, 1895.

The relations of the present Des Moines valley and the ancient Moingona gorge at Des Moines are shown below (figure 180).

That such a great drift-filled channel is traceable entirely across our state is made largely possible through the results and records obtained by our State Geological Survey. Although its determination appears at first glance a strictly scientific achievement it is not without important economic bearings. Artesian

Fig. 179.—Sketch map of Lee county showing courses of old Mississippi and old Moingona rivers.

waters derived from Glacial gravels doubtless mark the entire course of the ancient valley, as they are already encountered in some parts. Local reservoirs of natural gas occur in the old valley. The gas-wells of Herndon, in Guthrie county, are of this class. Systematic prospecting along the line of the buried valley probably will reveal other similar pockets.

Another point of especial local economic interest is the presence of an immense gravel bed in the old gorge at Des Moines.

This is the source of one of the finest, largest and purest water-supplies for municipal purposes in the entire country. Water works located north of Highland Park and immediately beyond the city limits are competent to furnish water in abundance for a city of 1,000,000 inhabitants.

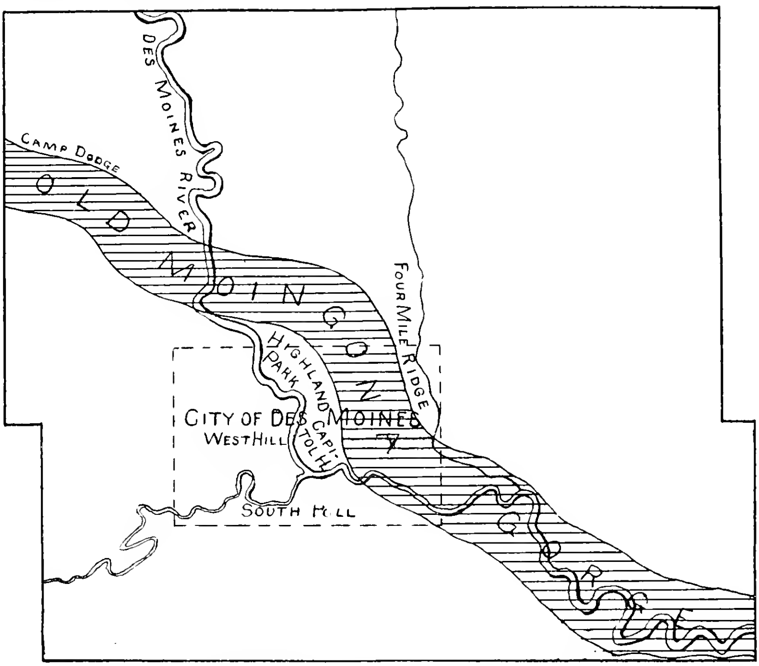


Fig. 180.—Course of old Moingona River across Polk County.

An item of military import is the location of the great cantonment of Camp Dodge in the broad Beaver valley 11 miles northwest of the Capital City. Beaver Creek flows its entire length along the axis of the drift-filled gorge of the old Moingona river. For the special purposes for which this cantonment was established no more ideal location in all the world could be selected.

ALPINE STRUCTURES OF JASPER PARK.

CHARLES KEYES.

(ABSTRACT.)

To those of you who are especially interested in the mechanics of mountain building, and particularly to those of you who are teaching the subject of geology I wish to present a few facts concerning some very remarkable expressions of Alpine structures which with diagrammatic clearness are displayed on this side of the Atlantic. For fan-structures, closely appressed flexures, and overturned folds it is customary to turn to distant Switzerland which cannot usually be visited by the student until long after he has left college. The locality to which I have reference is in the region of Jasper Park, in the northwest part of Alberta. Until recently this district was one of the most inaccessible spots on all the North American continent. Now two lines of railway reach it, traversing the deep valley of the Frasier river and the canyons of the Athabasca river and its chief headwater tributary, the Miette river, which together cut completely across the Cordilleran area, exposing walls 2,000 feet in height. This superb natural cross-section is supplemented by numberless other expanses showing details, afforded by cuttings on either side of the great gorge made by the Canadian Northern and Grand Trunk Pacific railways in establishing their grades. These observations were made mainly during the past two summers.

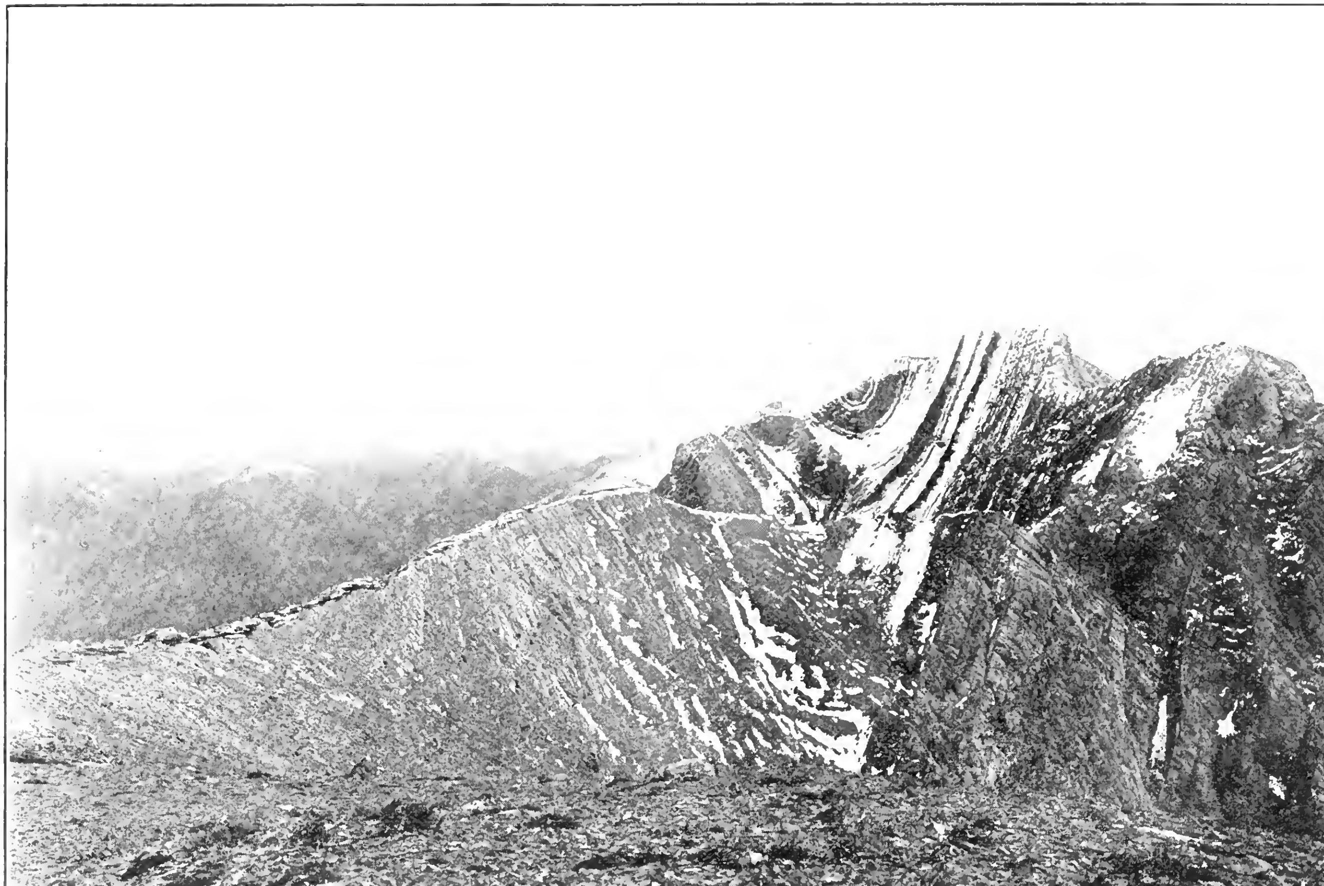
The Cordillera at Jasper Park as in other parts of the mighty chain is characterized by great thrust planes, but unlike in other portions of the uplift there is also sharp flexing on a large scale (see Plate VIII from photograph by D. B. Dowling, of the Canadian Geological Survey). The especially notable feature is the Appalachian or Alpine structure; and the relationships of the various members are presented with far greater perspicacity than anywhere else that I know of throughout the entire extent of the Rocky Mountains, perhaps with greater graphic distinctness than Appalachian structure is exhibited anywhere in the whole world.

Towards the middle line of the mountain system the general uniformity of slant of the strata seems to indicate close-folding of a moderate thickness of beds with consequent numerous repetitions of the same layers, rather than a simple succession of strata of prodigious and unreasonable measurement. Theoretically such a sequence is best explained upon the assumption that there is a great anticlinorium with closely appressed and overturned folds. With this the recent observations seem strictly to accord.

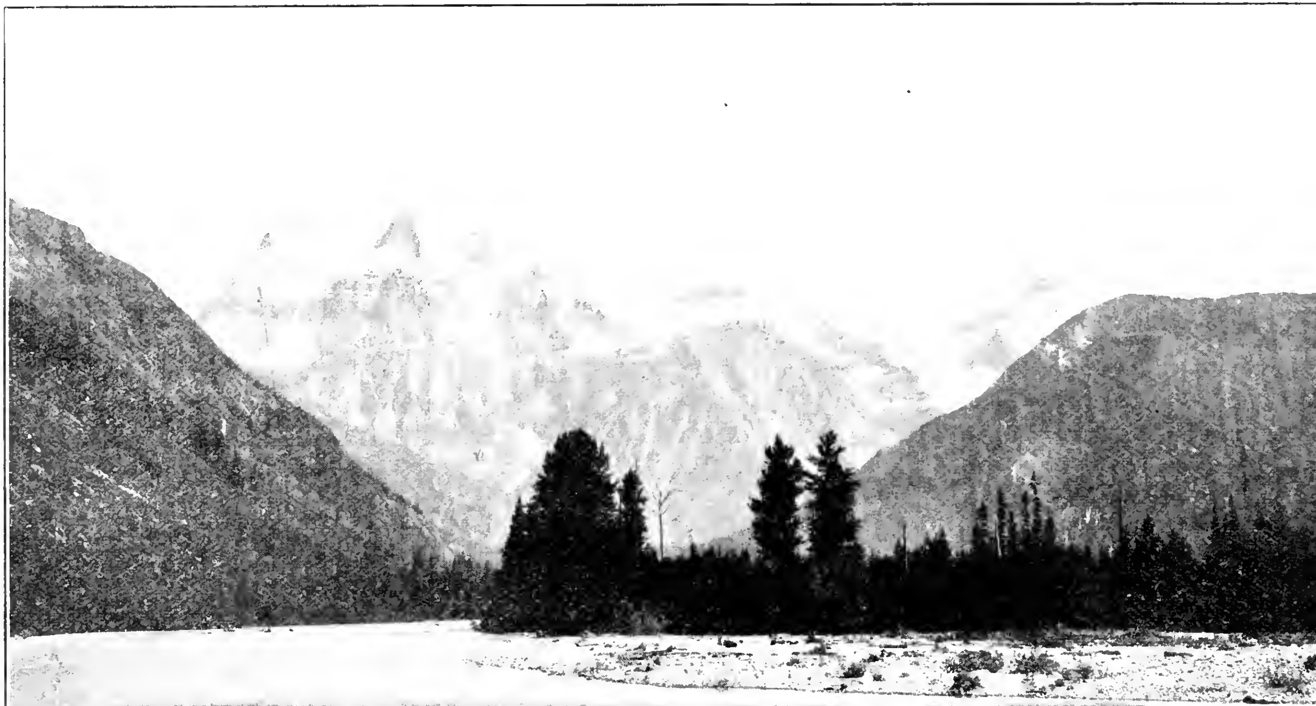
This appressed condition of the folds appears to obtain also on the west side of the axis where the Pre-Cambrian Beltian rocks, reported to be 30,000 feet in thickness, have sub-uniform dips. When the Beltian section along the Canadian Pacific railway, on the west slope of the Selkirk ranges, was inspected several years ago, during the Transcontinental Excursions of the Twelfth International Geological Congress, the divergent slants of the metargillites were thus interpreted. This proving to be the case there is represented in the northern Rockies a fan-structure that compares favorably with that displayed in the Alps made classic by the work of Heim and the other Swiss geologists.

The notably close folding in the northern section of the Rocky cordillera contrasts strongly with the open flexures in the south. In Montana and Idaho, for example, the major folds are so widely separated that distinct mountain uplifts appear to rise out of the plains. In Colorado similar conditions prevail. Where the extreme southern end of the Cordillera plunges beneath the arid plains of the Mexican tableland, in northern New Mexico, the flexing, so gentle as to be reduced to three slight wrinkles, represents the complete anticlinorium.

The stratigraphy of this still virgin region is not without great interest. The Paleozoics are enormously developed. Where in Iowa we measure the thicknesses of the formations in tens or hundreds of feet, in the northern Rockies we calculate them in thousands. Then beneath the Paleozoic strata come tremendous thicknesses of Pre-Cambrian beds. The Proterozoic succession is seemingly perfectly conformable with the Paleozoic sequence, but is separated from the Archeozoic metamorphics by a great unconformity. Both Paleozoic and Archeozoic sections rival in every way the great Paleozoic pile of this region. Of course the few days at my disposal last year and the few days during the past summer are far too short a time to work out anything like a satisfactory scheme.



Sharp flexing in Front Range of Rocky Mountains near Pocahontas, on Athabaska river, Alberta.



Cambric section of Robson Peak, Alberta.

Through the efforts of Dr. C. D. Walcott the Robson Peak section is determined to be undoubtedly Cambric in age. This flat-lying pile of quartzites and shales is 10,000 feet in vertical extent—all exposed in a single section and in full view at one time. (See Plate IX.) Early, Mid and Late Cambric terranes are well represented as is indicated by an abundance of characteristic fossils. West of Robson Peak the metamorphosed shales, limestones and sandstones and the schists in vast thicknesses are mainly Pre-Cambrian in age. East of this point clear to the plains Paleozoics chiefly prevail. Of these the Cambric quartzites are easily recognizable after once seen. They seem to occupy the section for a distance of 50 miles east of Robson Park the width of the belt averaging about 40 miles. The Ordovicic section, if represented at all, must be quite thin, being confined apparently to a relatively small thickness of black shales. Shales of Siluric age seem to be present. The tremendous development of the Devonic limestones at once arrests attention and the characteristic organic forms are often prolific. It is not always an easy matter to separate the Carbonic limestones from those of Devonic age. As indicated by fossils Triassic and Jurassic beds appear to be represented. Cretacic strata, with extensive coal beds are infolded with the Paleozoics.

Since this Athabasca-Fraser river section is more than 100 miles long it may be judged that the thickness of the strata must be very great. No very exact figures are yet available, but something of the enormous thickness may be inferred from the measurements made along the Canadian Pacific railway, 150 miles to the south. There Doctors Daly and Allan give the following; and they are now compared with those of the Iowa section:

		Alberta	Iowa
Mesozoic	Cretacic Jurassic Triassic	4500 feet 1500 feet 3000 feet	800 feet absent absent
Paleozic	Carbonic Devonic Siluric Ordovicic Cambric	6500 feet 7000 feet 2000 feet 8000 feet 19000 feet	2000 feet 350 feet 325 feet 700 feet 1100 feet
Proterozoic	Superi ric Selkirkic Anianic	14000 feet 20000 feet absent	1500 feet absent absent
Archeozoic	Huronic	10000 feet	absent
Azoic	Verennesic	20000 feet	absent

DES MOINES.

PARK SITES ALONG DES MOINES VALLEY.[1]

JAMES H. LEES.

At a time when the establishment of State parks is a prominent subject of discussion among lovers of nature and those who are interested in the conservation and improvement of our resources, both tangible and intangible, it is natural that attention be directed toward the central and chief watercourse of the state in the search for suitable sites for recreation centers. So the question arises as to the possibilities for locating parks, state, district or county, along the valley of Des Moines river. A number of years ago the writer enjoyed the opportunity of making a study of the physical features of Des Moines Valley

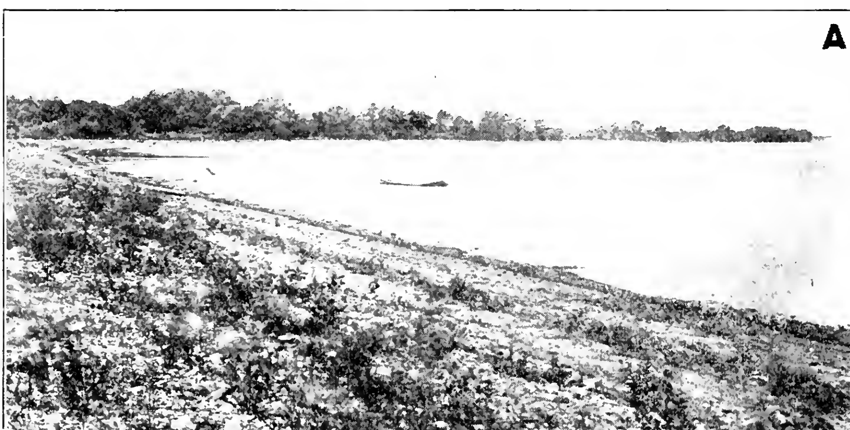


Fig. 181.—Tuttle lake, Emmet county, from the south shore near the outlet.

for the Iowa Geological Survey and from the observations then made the following notes are drawn.

It is evident to one who is at all familiar with the region that there is an abundance of localities along this valley which are well adapted to conversion into parks or which could with some care and effort be transformed into excellent pleasure grounds. The chief question in the matter of locating, perhaps, is that of establishing such parks where they will be conveniently accessible not only to the automobile owner, he can go anywhere, but also to the large group of people, even in our own state, who are less favored in the matter of transportation facilities. How-

[1]Published with permission of the Director of the Iowa Geological Survey.

ever, there are in the vicinity of most of the cities and towns along the river, areas, large or small, which are adapted for park making.

The East Fork of Des Moines river, owing to its character, has fewer potential park sites than has the West Fork. In the first place it is smaller and hence has a narrower, shallower valley, which is nowhere, except in the lower few miles, cut to rock. Then more of the surrounding land is level prairie and does not offer the diversity of landscape which is present along

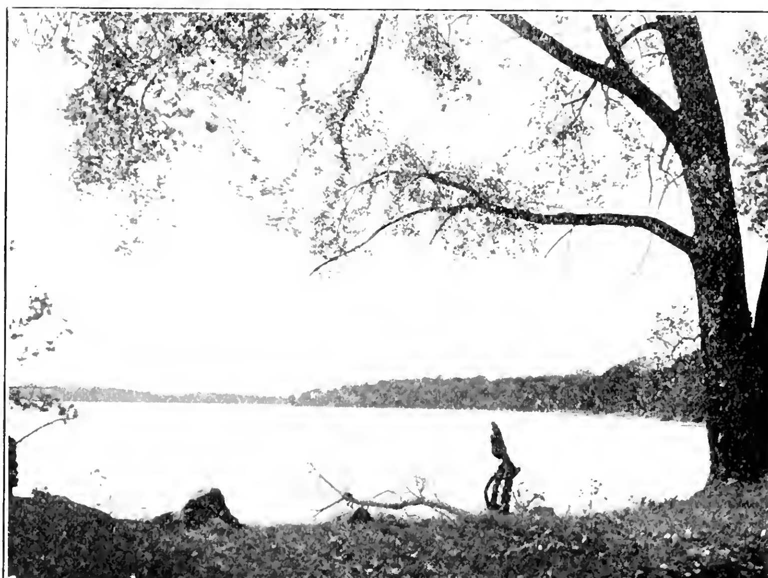


Fig. 182.—Iowa Lake, Emmet county, on the state line.

some parts of the West Fork. Nevertheless there are a number of really picturesque localities which are deserving of mention.

In Minnesota the East Fork is a small stream a few miles in length which flows into Alton lake, known also as The Inlet. This in turn empties by a channel a mile or so long into Tuttle lake, which is crossed by the state line. Tuttle lake covers about four square miles and on the south shore has several attractive areas which while not high above the water are well wooded and make desirable camp and cottage sites. These areas would make an excellent park and should be purchased by the State for public use.

While Iowa lake is not strictly tributary to the Des Moines it is so near by that mention may be made of it here. It also lies on the state line, five miles east of Tuttle lake, and its outlet is to the east toward Blue Earth river. Iowa lake is of interest geologically because it is at the southern end of a series, known as the Chain Lakes, which occupy part of a former river valley of considerable size which seems to have drained southward during pre-glacial or inter-glacial times. Silver lake, the next one to the north, is more popular as a resort,

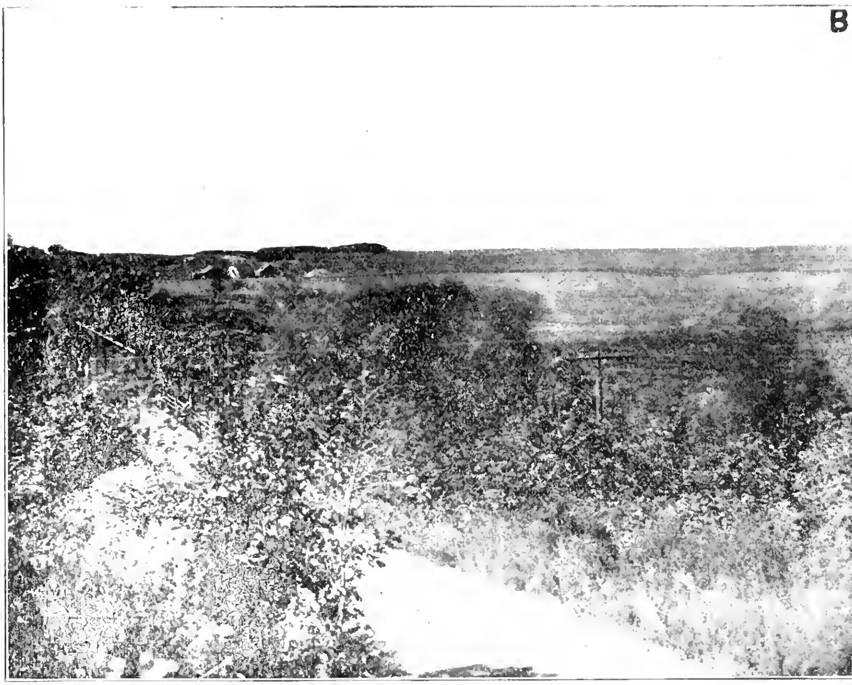


Fig. 183.—The valley of the East Fork at Algona, looking west.

as it is deeper and the banks are higher. However, Iowa lake has a charming shore line and offers a very desirable site for a state park, which should by all means be established at an early date. Iowa has all too few lakes and any which have such natural beauty as Iowa lake should be made available to all. The State Highway Commission in its report on Iowa lakes recommends the buying of park sites at both Tuttle and Iowa lakes.

For a number of miles below Tuttle lake the Des Moines valley is for the most part shallow and its walls are gentle and bare of timber. But east of Burt it unites with an inter-glacial valley known as Union Slough and below this point it is deeper, its walls are steeper, and groves of timber add touches of beauty to its vistas. At and immediately below Algona the east wall is rugged and tree covered and here should be a most desirable park site which now is used only for occasional picnics or for cow pastures. This condition extends all the way to Irvington, five or six miles to the south, so that attractive spots are present in abundance. At Livermore again, steep, timber-covered bluffs, a fairly wide bottom land, and bordering prairie make a very pleasing combination of natural features. Another likely spot

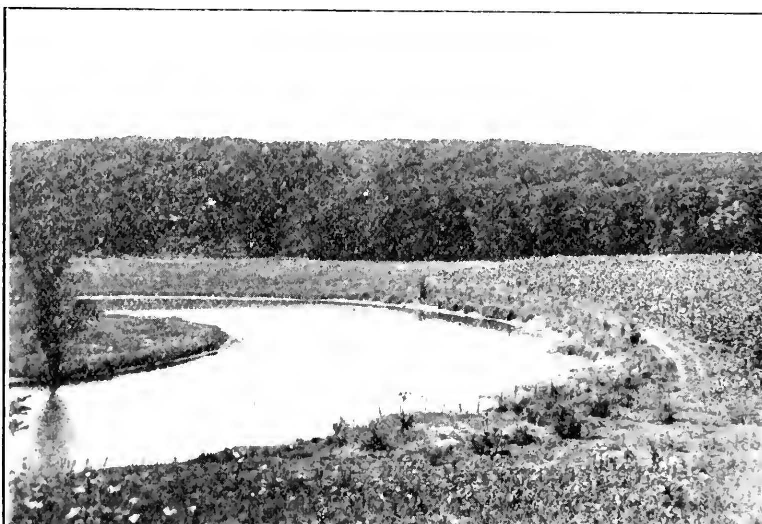


Fig. 184.—The valley of the West Fork just south of Estherville, looking west.

for park purposes is in the vicinity of Dakota, where the forks of the river come together. South of the village a long, high ridge, well timber covered and with fairly steep slopes and flat top, separates the two valleys and would afford a beautiful park location. Some small outcroppings of the bedrock add to the scientific interest of the region.

The West Fork stretches a hundred miles across southwestern Minnesota before it reaches Iowa. Hence it is a fair sized stream in a goodly valley where it crosses the state line. The first locality on the Iowa side which is especially desirable for park purposes, is near Estherville. The east bluff just north of town is fairly steep and well wooded and below town the west wall is quite rugged and is heavily timbered. It seems that along much of its length in Emmet county the west wall of the valley formed the eastern margin of a belt of rough, glacial morainic country. This condition, aided by post-glacial erosion of the valley wall, has made for exceedingly picturesque scenery, which should be preserved for all time. Beyond the distance of a mile or two below town the timber is scattering and for many miles the walls are nearly treeless, except in sheltered spots. In Palo Alto county, too, the belt of rough county leaves the river, hence the valley is shallow and the slopes are gentle. At Emmetsburg, however, Art is assisting Nature in making beauty spots of a long, narrow, rather shallow pool known as Medium lake, around

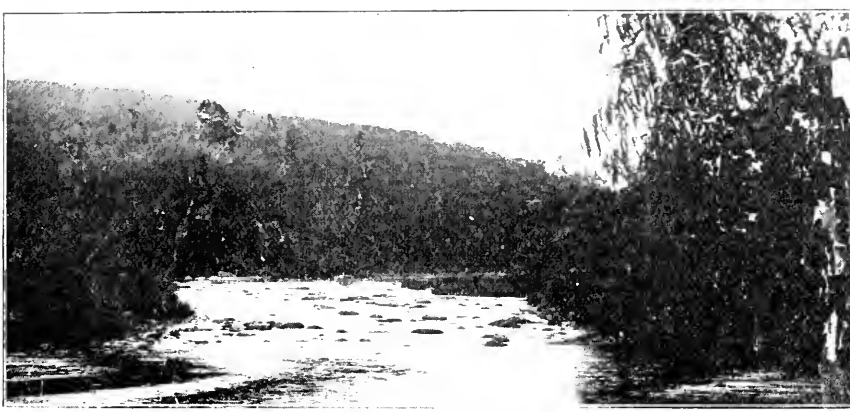


Fig. 185.—The valley of the West Fork at Humboldt.

whose southern end the town has grown. This already is a credit to the foresight of the townspeople and is destined to be of increasing beauty and utility.

Just above Bradgate, at the western edge of Humboldt county, the river, which has been following a post-glacial valley, enters on older, interglacial watercourse. This is deeper and is bounded by steeper walls than the younger valley, hence attractive points and beauty spots are more abundant. Just south of Bradgate the steep bluff is clothed for a mile with a fringe of timber which with care would make a pretty spot and which is easy of access from the town. At Humboldt again the bluff rises sixty or seventy feet above the rocky channel, which reminds one, to use President Macbride's phrase, of "some New England mountain channel, rather than the quiet creeping river of the level prairie." This bluff also is well timbered and makes a most picturesque scene. Just above Humboldt a dam recently constructed has made an artificial lake which will add to the assets of the region. Below Humboldt is the long, narrow ridge between the river forks which already has been mentioned. From the junction of the forks to Fort Dodge, while there is plenty of scenery it is rather far from any town so may be passed by at present. Just above Fort Dodge, however, the east side of the valley affords almost every desideratum for pleasure grounds —steep bluffs, high, level bottom lands, vertical rock scarps, a shelter of timber, an artificial lake behind a high dam, in fact,

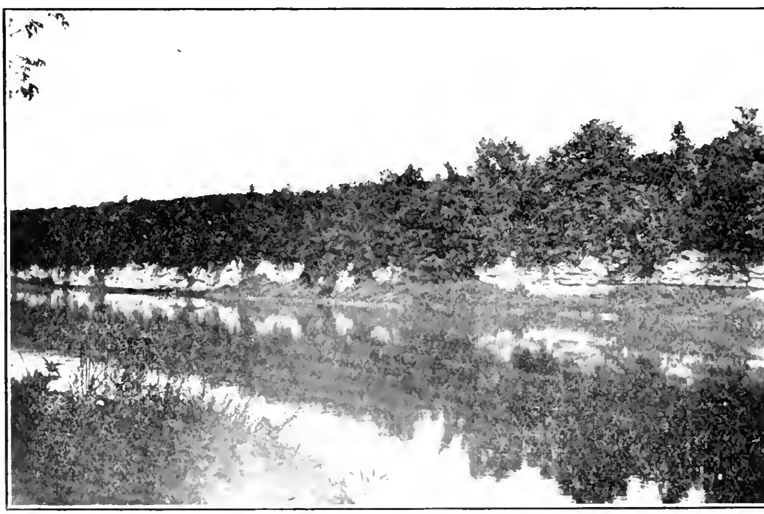


Fig. 186.—Des Moines valley below Fort Dodge.

about all that could be desired. Below Fort Dodge the valley of Two Mile creek, along which the Interurban extends, may be mentioned as a typical valley for this region. The unique deposit of gypsum, for which Fort Dodge is famous, forms cliffs and scarps, and timber fills the little valley through which the singing stream winds its way to the great river. A multitude of similar valleys make spots of local interest and charm and the main valley as well with its alternating wooded slopes and sandstone cliffs forms a picture hard to excel in all the plains country. From Fort Dodge to Boone the river is winding its course through piles of glacial debris which are heaped in ever heightening magnitude to their culmination in the Gary moraine near

Fraser, where they rise two hundred and sixty feet above the stream which flows by their feet. One of the most magnificent stretches of scenery along the river lies between Fraser and Boone, where the Interurban skirts the wall from the river bridge just below Fraser to where it finally reaches the upland above Boone. The winding river flowing between its high walls, here bare and bowlder strewn, there clothed with forest from water's edge to summit, makes a picture which once seen will never be forgotten, whether the picture be tinted with the glorious green of summer or with the glowing and variegated

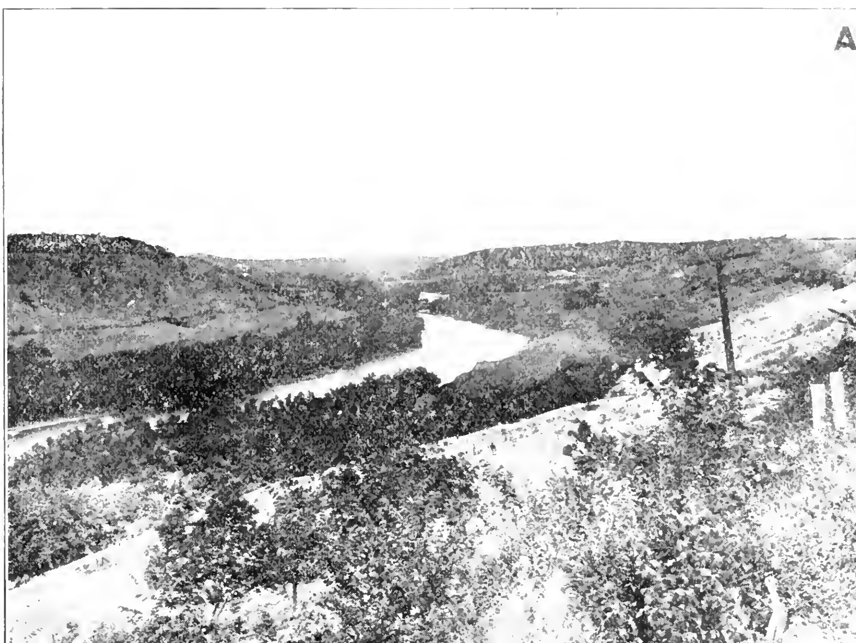


Fig. 187.—Looking up Des Moines valley between Boone and Fraser.

colors of autumn. Some enterprising soul has established a little amusement park in the nook between river and bluff, close to the bridge by which the Interurban crosses the river. This is only a suggestion of the latent possibilities of the region.

The locality known through central Iowa as The Ledges, a few miles below Moingona, in the little valley of Peese creek, offers another opportunity for the locating of a public park of rare charm and attractiveness. The massive sandstone walls, vertical or overhanging, with their fringe of verdure, are in striking contrast with the smooth slopes above Boone, but are equally gratifying to the esthetic sense, and the spot has long enjoyed the favor of campers and pleasure seekers from miles about.

Between Boone and Des Moines the entire stretch of valley is a natural park and it is difficult to choose a locality for preferment. The long narrow ridge which separates Des Moines and Beaver valleys is already in part a national reservation and it would be well to have even more of the river bluff and adjacent bottom lands included, from the point of view of park making, at least. The wide valley of the Beaver, together with

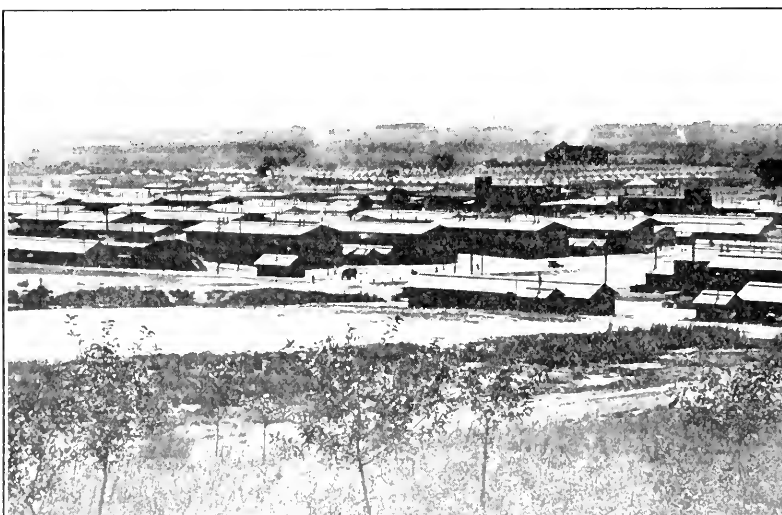


Fig. 188.—Looking west across Beaver valley at Camp Dodge.

the broad river flats opposite its mouth, is of geologic interest from the fact that it represents the original valley of the Des Moines. Another point which is of interest as a geologic phenomenon as well as for its scenic attractiveness is Red Rock bluff, near the village of Red Rock, about thirty miles below Des Moines. The wall of red sandstone which gives its name to the locality rises high above the river and overlooks the broad and fertile valley which separates it from the frowning bluff beyond.

A spot which has always held a fascination for the writer is the south bluff of Des Moines valley directly opposite the State House. A smooth, rounded slope with a few trees and a pic-

The Ledges, Peese creek, Boone county.

turesque old farmstead stands out amid the surrounding timber land like one of Nature's own pleasure grounds and offers a perpetual appeal to "come across."

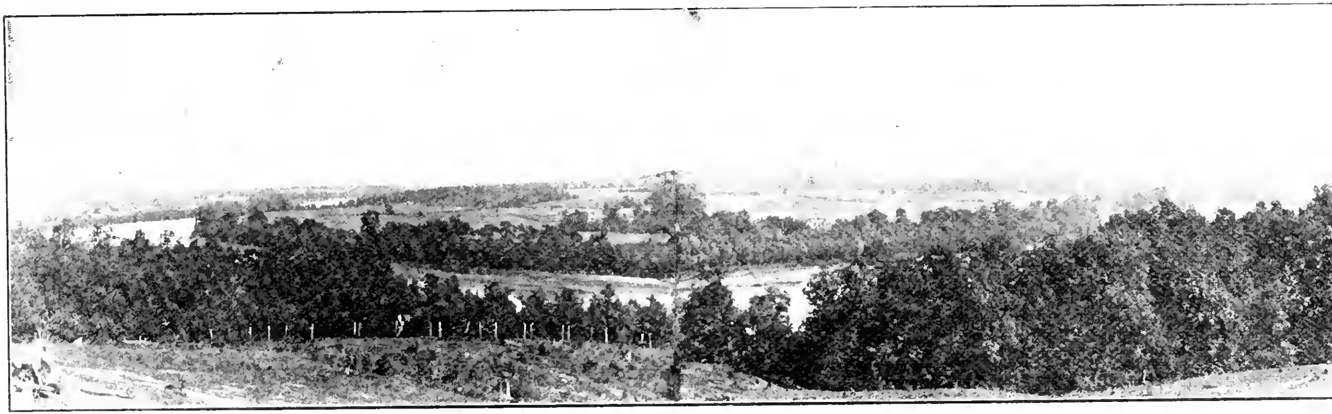
Mention might also be made of three high ridges between Harvey and Tracy which stand like sentinels guarding the broad valley at their feet. They are separated from the uplands behind them by a broad sag which has furnished a natural route for the railways which connect the villages near them. They would afford excellent park sites to the pleasure seekers as well as a continual problem regarding their origin, to the more thoughtfully disposed.

Fig. 189.—Looking south across Des Moines valley from Capitol Hill, Des Moines.

It may seem like reversing the laws of Nature to state that Des Moines valley is not so deep below Des Moines as it is above Boone, but such is the case and this fact, coupled with the greater age of this lower portion, accounts for the longer, gentler slopes and less rugged character of the valley. However, this is partly counteracted by the increased number of outcroppings of resistant bedrock, which afford here and there picturesque scarps and cliffs of pleasing aspect. One of the more notable of these localities is that at Cliffland, between Ottumwa and Eldon. The great vertical wall of sandstone which rises sheer above the flat valley offers with its timber covering a most attractive scene in our land of fields and prairies. Below Eldon the limestones rise high in the hills, and their rugged walls gleaming from out their forest cloak or standing green with the moss of ages make pictures which will hang long on memory's chamber walls. The vicinity of the great "oxbow" in the valley at Keosauqua offers one of the best examples of this type of scene. Near Kilbourn at the upper extremity of the great bend, below Mount Zion, at the lower limb, and at various places around the loop these mural escarpments stand at the valley's margin as centers of natural beauty. Similar conditions prevail in the vicinity of those bits of rare antique, Bentonsport and Bonaparte, which lie between

Fig. 190.—Des Moines valley at Red Rock, Marion county.

Keosauqua and Farmington. These different towns offer another sort of interest in that they were sites of the early attempts by means of locks and dams to improve river navigation. Some of the old lock walls at Keosauqua are yet standing in fairly good repair. Just below Croton another massive cliff rises straight from the river's edge, bearing aloft its crown of foliage and affording the traveler another of those gems of quiet beauty which make this part of the valley so attractive. An old-time ferry will carry the visitor from Croton to Athens on the Missouri side and will add the spice of variety to the perspective of valley and bluff and forest which he may there gain. In the vicinity of Keokuk, too, the city which is built upon a hill, with its beautiful



The Oxbow in Des Moines river, near Keosauqua, Van Buren county. The view is taken from the bluff on the right bank of the stream, nearly two miles west of Keosauqua and looks eastward to Keosauqua on the right and Pittsburg on the left.

outlook over the Des Moines, "the River of the Road," on one side, and over the great Father of Waters on the other, there are abundant localities which would lend themselves delightfully to the dreams and plans of the park maker. Such a spot is that one well named Buena Vista, about three miles west of Keokuk, where the Des Moines mingles its waters with the great flood of the master stream. Here are rocky hills and forest filled valleys

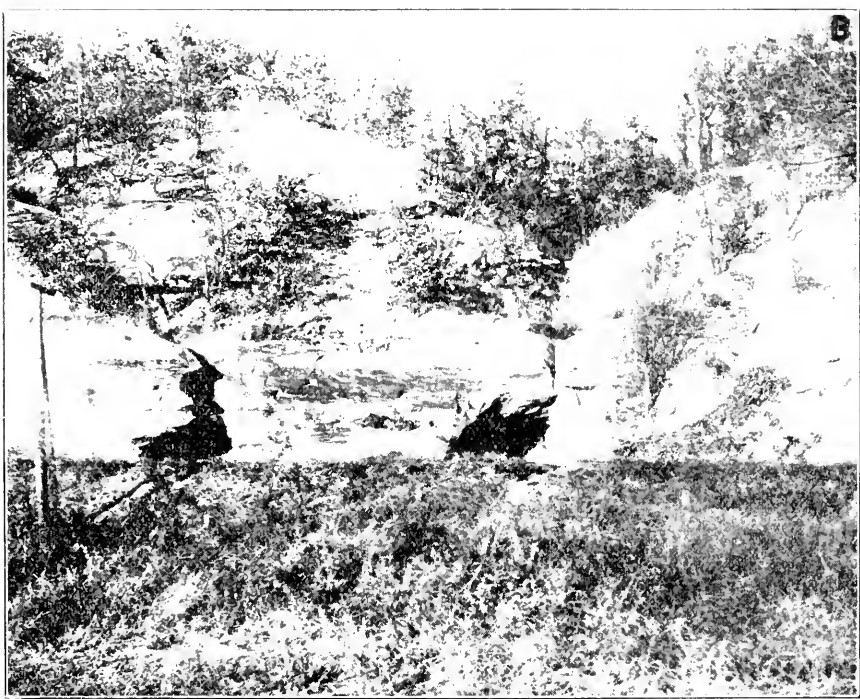


Fig. 191.—The massive wall at Cliffland, below Ottumwa.

and geode-bearing shales to attract the curious, and here too is the east wall of a half buried abandoned gorge of Mississippi river which stretches northward to Burlington and whose width reaches westward to Sand Prairie (Vincennes) and St. Francisville on the Missouri side, eight miles as the crow flies. No rock shows its face in this interval, only sand and clay, which have been fashioned by rains and rushing waters into gullies and miniature gorges, fine examples of the activity of Nature's agencies.

The foregoing sketches will, it is hoped, have demonstrated the truthfulness of the statement made earlier, that Des Moines valley offers abundance of sites for public parks and well merits the attention and interest of all who are concerned, from whatever point of view, in perpetuating the natural beauties of our

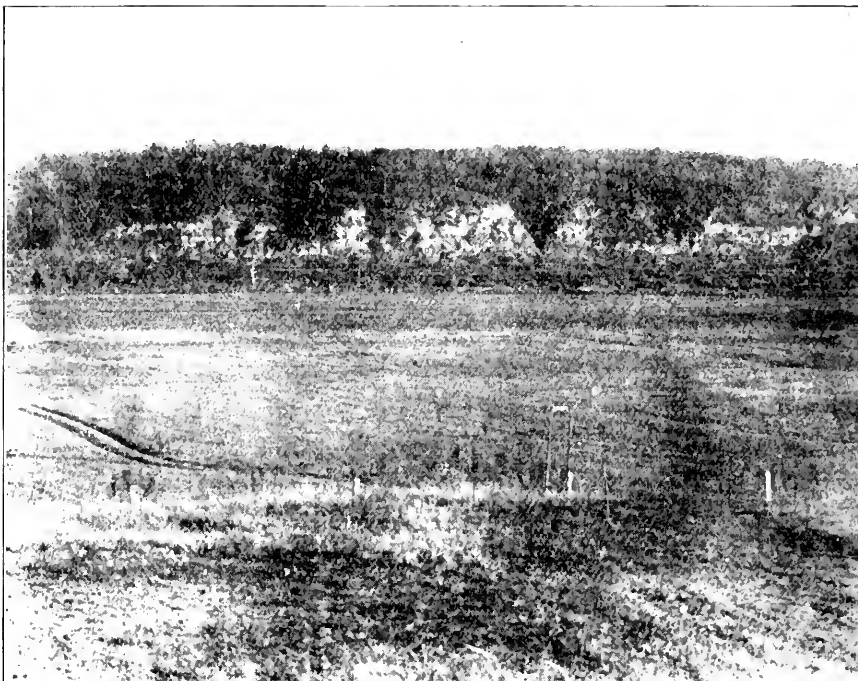


Fig. 192.—The valley wall at Croton, Lee county, from the Missouri side.

state. What is needed is intelligent co-operation among all who have it in their power to see that Iowa remains in deed and in truth what her first citizens called her—Beautiful Land.

Iowa Geological Survey,
Des Moines.

Fig. 193.—Gullies in the filling of the old valley of the Mississippi at Connables, above Keokuk.

SOME FEATURES OF THE FORT DODGE GYPSUM.[1]

JAMES H. LEES.

A New Basal Conglomerate.—During the prosecution of field study of the gypsum for the Iowa Geological Survey the writer found immediately beneath the gypsum in several places a basal conglomerate which has not heretofore been described in reports on the region. The locality where this conglomerate is best developed is in a ravine on the west side of Des Moines river op-

Fig. 194.—Conglomerate beneath gypsum in the ravine opposite Two Mile creek, Webster county. The dark shadow across the middle of the picture divides the gypsum from the conglomerate.

posite Two Mile creek about three miles south of Fort Dodge. The Fort Dodge, Des Moines and Southern railway extends along this ravine and has exposed the conglomerate in some of its cuttings. In the lower part of the ravine the gypsum is seen to lie on the black or dark colored Coal Measures shales. In places the contact is direct while in other places about six inches of clay, evidently residual, intervenes. Perhaps one-half mile up the ravine there is exposed beneath the gypsum a reddish or

[1]Published with permission of the Director of the Iowa Geological Survey.

grayish conglomerate one to two feet thick, figure 194. The pebbles are mostly limestone, fairly well smoothed by attrition, and are rather small, the larger ones being not much over half an inch in diameter. Under the conglomerate lie the shales of the Des Moines stage locally colored red or lighter shades. At other places near by the conglomerate outcrops immediately beneath the drift, figure 195. The gypsum either has been removed by erosion or solution or was not deposited. The significant feature about this conglomerate, however, is its fossil content, and this it

Fig. 195.—The conglomerate which lies immediately under the gypsum in the ravine opposite Two Mile creek, below Fort Dodge. The conglomerate is fossiliferous here.

is which makes it of peculiar value in relation to the gypsum. Professor A. O. Thomas of the Department of Geology of the State University visited the gypsum region with the writer on a later trip and a number of fossils were collected from the conglomerate. Mr. Thomas after studying this collection and comparing it with type forms wrote as follows: "The basal conglomerate fauna is very evidently of Missouri age although I am not ready to say so unequivocally since so many Pennsylvanian forms have a habit of continuing on into the Permian. I have compared the unquestionably identified species with Pennsylvanian and with Permian lists and all point to the former rather than to the latter. Not a trace of anything Mesozoic occurs in the material. Some of the specimens show evidence of wear as from rolling but they do not seem to have been transported far. Here is the list:

Fusulina secalica Say=*F. cylindrica* Fischer.
Zaphrentis (species unidentified).
Stem segments (and plates?) of unknown crinoids.
Rhombopora lepidodendroides Meek.
Productus cf. *longispinus* Sowerby.
Pugnax osagensis (Swallow).
Squamularia perplexa (McChesney).

Fig. 196.—The general even top of the gypsum in the Vincent clay pit, Fort Dodge. Note the channel down the center of the view.

The Rhombopora has suffered from wear so that the characteristic markings, if they were ever present, are rubbed off. There is no question about the Fusulina. I sectioned a few, they are as good specimens as one could wish for."

The nearest known rocks of Missouri age are in Carroll, Crawford and Monona counties. In former times the northward extent undoubtedly was greater. Cretaceous rocks are present only a few miles to the west of Fort Dodge in Calhoun and Pocahontas counties. In spite of the softness of the Cretaceous rocks fossils certainly could be transported as far as the gypsum region and in fact they are found in the drift at considerable distances from the original strata. There are no known strata in northwestern Iowa west of Webster county intermediate in age between the Missouri and the Cretaceous. The presence of Missouri life forms in the conglomerate of the gypsum region proves it to be of post-Missouri age, while the entire absence of fossils of Cretaceous or later age argues strongly for a post-Missouri-pre-Cretaceous age for the conglomerate and for the associated

Fig. 197.—A view from the opposite end of the pit, Vincent pit, showing the uneven surface.

gypsum and the shales and sandstones which in some localities overlie it. The possibility of the Miocene age of these beds, which has recently been advanced,[2] seems to be definitely excluded by the evidence.

Doctor Sidney L. Galpin of the Department of Geology of Iowa State College informs the writer that a similar fossiliferous conglomerate underlies the gypsum beds of Kansas, which are well known to be of Permian age.

[2]Keyes, Chas., Iowa Acad. Sci., Vol. XXI, p. 186. Eng. & Min. Jour., Vol. 100, p. 166, 1915.

The other locality where this conglomerate was found is at the pit of the Vincent Clay Products Company at Shady Oaks station on the Fort Dodge, Des Moines and Southern Railway. This is at the mouth of Two Mile creek on the east bank of Des Moines river directly opposite the ravine in which the previously described outcrops occur. Here the conglomerate is absent from some places while at others it is a foot or a foot and a half thick. It is red and gray and most of the pebbles are less than one-half inch in diameter. Parts of the conglomerate are really a coarse

Fig. 198—The irregular surface of the gypsum buried in drift, Vincent clay pit, Fort Dodge.

sandstone. Fossils were found in streaks and pockets of the coarser materials.

A noteworthy feature in this pit as well as in several others is the fact that the upper few feet of the Coal Measures shales just under the gypsum is highly colored, red, blues, purples and light grays predominating. These lighter colors grade into black below. Whether this lighter coloration is inherent in the shales or is due to the chemical action of the dissolved gypsum as it percolates downward is not clear.

An Irregular Solution Surface on the Gypsum.—The overburden of glacial drift at the Vincent clay pit is removed by hydraulicking. The gypsum, which here has a maximum thickness of about seven feet, is then broken up and removed. In the fall of 1917 quite a large area had been cleared of drift and a remarkably irregular surface of the gypsum was revealed. From its nature it is evident that the irregularity was caused by aqueous solution or erosion rather than by ice erosion. Sinuous winding channels have been cut almost through the gypsum bed as the

Fig. 199.—A detail of the irregular surface in the gypsum. The banding is well shown. Vincent pit.

accompanying views show. What was apparently a larger channel extended almost the entire length of the stripping (see figure 196). Pinnacles and towers and walls of fantastic design have been carved in the solid rock and a most picturesque miniature topography has been formed. Potholes or pothole-like cavities have been dissolved out where we may imagine that the tiny torrents dashed and swirled or the slowly percolating waters of a bygone day seeped among the rocks and clays that formed the surface of that time.

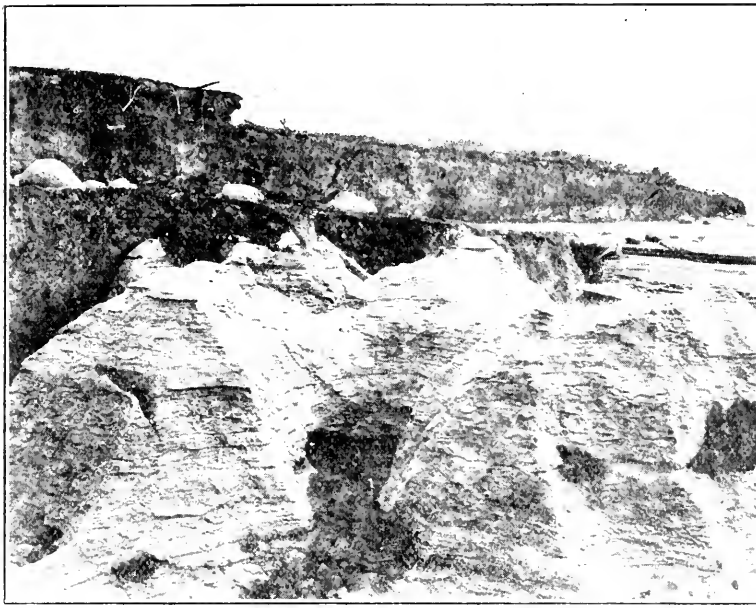


Fig. 200.—A potholelike cavity in the gypsum, Vincent clay pit.

Fig. 201.—Valleys and small erosion channels in the gypsum. Note the small hole at the extreme right. Vincent pit.

There is little evidence to show the age of this solution surface. In some places gray drift fills the hollows in the gypsum while yellow oxidized till extends across hollows and eminences alike, without curving down at any point. In one place an oxidized band bends up over the gypsum mound. There is no indication of slumping or settling of drift into the hollows as the gypsum was dissolved away. If all of the drift here is Wisconsin, as it seems to be, its condition and position would seem to indicate that the solution was accomplished mostly in pre-Wis-

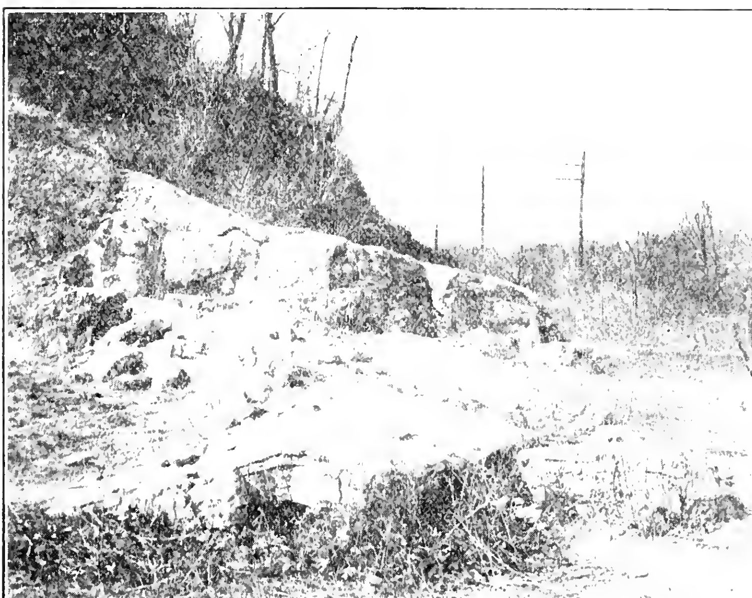


Fig. 202.—Domes in the gypsum on an exposed surface up Two Mile creek. Three feet of red shale overlies the gypsum.

consin (Peorian) time at least, and it might, of course, be earlier than that. The illustrations show that the pebble band and the humus zone extend, for the most part, in uniformly straight lines parallel with the surface of the ground. The fact that this locality is on the upper slope of the valley wall makes escape of the ground water easy and would permit of relatively rapid passage of these waters through and over the rock. This condition might point to a more recent date for the formation of this surface. At the same time similar topographic conditions have prevailed since the valley was formed in post-Kansan (Yarmouth) times, so that similar opportunities for solution have been offered for a long period of time.

Gypsum Domes.—About a mile up Two Mile valley there is an exposure of gypsum just above the track level of the Interurban railway. It is the last exposure to be seen in ascending the valley and it lies at the end of a point between the main valley and a tributary ravine. Evidently the overburden was cleared away in order to obtain the gypsum. About three feet of red sandy shale lies between the drift and the gypsum. Some of the upper

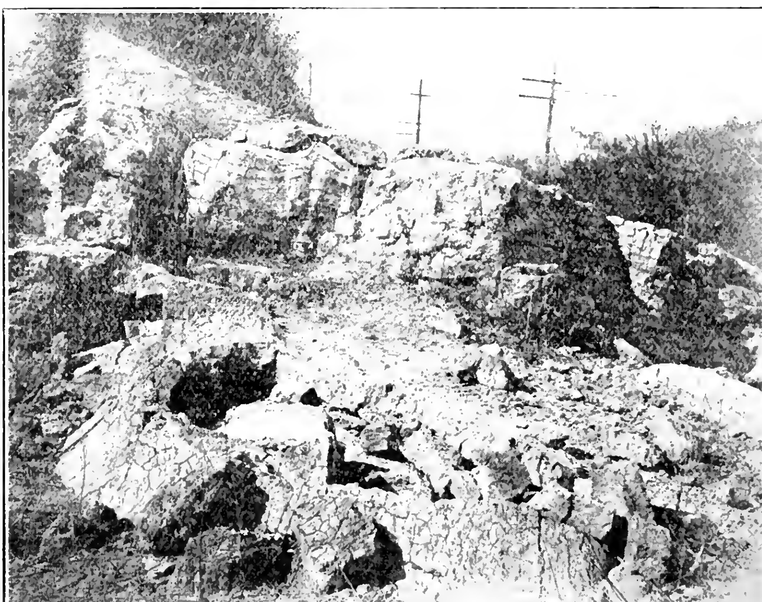


Fig. 203.—Domes and flexures in the gypsum up Two Mile creek valley.

layers of gypsum on the floor of the exposure have been arched up until they have formed a number of hollow domes of circular or elliptical outlines. The walls of these domes are six inches to a foot in thickness and are cracked and checkered in a very irregular manner. The writer has not seen anywhere else the gypsum so weathered as it is at this place. At several places the rocks give forth a hollow sound as one walks over them. Solution channels similar to those seen in the Vincent clay pit are present here also and show the same intricate arrangement as well as revealing the weathering which the gypsum has undergone.

Professor Thomas suggests that the domes have been caused by the crystals of gypsum in the upper layers absorbing an excess of water with a consequent expansion and a heaving up of the layers into domes. In some cases, as is shown in the center background of figures 202 and 203, the expansion has resulted in a buckling of the layers.

As to the age of these phenomena, the first and natural assumption would be that they were very recent, later than the un-

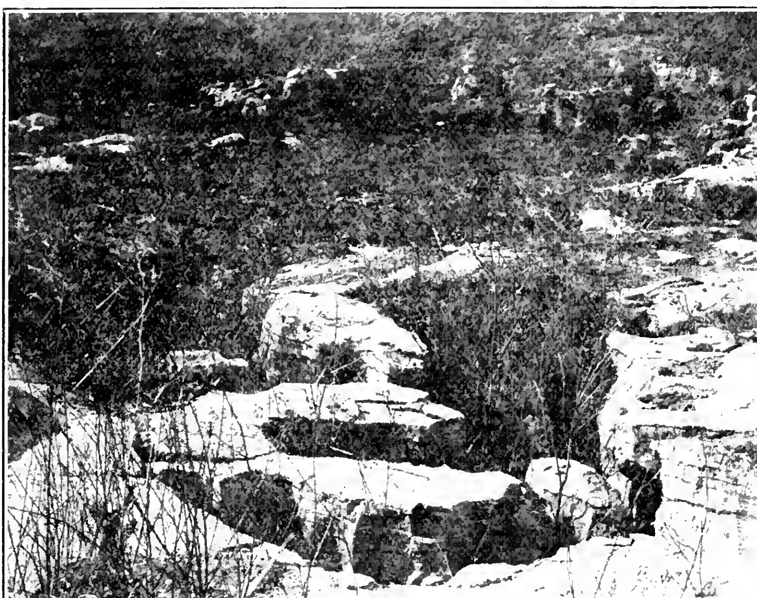


Fig. 204.—Channels of solution in the gypsum in Two Mile creek valley, at the same locality as the last two views.

covering of the beds. This may indeed be the case but the general condition of the beds—their buckling and tilting, their solution channels and extreme weathering—seem to the writer to point rather to a greater age. There are so many possibilities for the time of formation of these features—postglacial, interglacial and preglacial—that it does not seem possible to decide upon any one of them.

IOWA GEOLOGICAL SURVEY,
DES MOINES.

THE STE. GENEVIEVE MARLS NEAR FORT DODGE AND THEIR FAUNA.[1]

JAMES H. LEES AND A. O. THOMAS.

A. The Strata.—In his report on the geology of Webster county[2] F. A. Wilder mentions the presence of a shaly marl rich in fossils, which he includes with the St. Louis limestone. The writers have had the opportunity of examining a number of outcrops of these shaly marls and a study of the fossils collected from them has corroborated the conclusion reached, apparently somewhat tentatively, by Weller and Van Tuyl,[3] that they are Ste. Genevieve in age. Because of this determination it seems worth while to call attention to the character and distribution of these beds and to their contained fossils. Mr. Thomas has studied the fossil content of the beds while Mr. Lees, accompanied to some of the exposures by Mr. Thomas, has examined the different localities where the beds are known to outcrop. With one exception all the outcrops here reported are located within the valley of Lizard creek, west of Fort Dodge.* This exceptional locality is in a ravine which opens into Des Moines valley from the northwest opposite the dam and about one-third mile above the railroad and wagon bridges over the river at the mouth of Lizard creek. The streamlet has cut through the drift, which is rather thin, through the Coal Measures, which are twenty feet or more in thickness, and into the marly beds of the Ste. Genevieve, to a depth of twenty to twenty-five feet. Owing to the unconsolidated nature of most of the beds some of the exposures are somewhat slumped. The Ste. Genevieve beds are exposed for two hundred yards or more along the lower part of the ravine. Just above the mouth of the ravine, the exposure shows two to three feet of a dark red clay, which is overlain by twelve to fifteen inches of a greenish gray clay. Above this lies a streak of rather hard yellow to gray shale, which, a hundred yards upstream, forms an eighteen inch ledge, which makes a small waterfall in the stream. This ledge is in turn overlain by a light gray shale with a yellowish tinge, which has a thickness of about seven feet. This shale is richly fossiliferous, especially in certain streaks, and is the only bed in which any fossils were found. Above it lies a red clay shale having a maximum thickness of ten

[1]Published with permission of the Director of the Iowa Geological Survey.
[2]Iowa Geol. Survey, Vol. XII, pp. 78-83, 1901.
[3]Iowa Acad. Science Vol. XXII, pp. 241-247, 1915.
*For additional localities see addendum at end of this paper.

feet. All of these beds have a starchlike fracture where fresh faces are seen, but crumble to a marly texture on exposure.

In the lower part of the ravine the upper red shale, or marl, is overlain by residual Coal Measures material and drift. Perhaps two hundred yards up the ravine twenty feet of Coal Measures shales are exposed along the hillside. They are gray and fine textured below but near the top contain characteristic ironstones, concretions and coaly streaks and other matter. This upper part is probably largely residual. The beds are exposed for two hundred yards or more up the ravine from their first definite outcrop. There are in places some traces of the bright colors which are so noticeable in the pit of the Fort Dodge Brick and Tile Company across the river.

On the north bank of Lizard creek, about one-fourth mile above the creek mouth, is a long-abandoned pit of the Fort Dodge Clay Works. It shows beneath thirty feet of drift a series of isolated blocks of gypsum about four feet thick. The gypsum lies directly on a black clay shale, fissile and tough, which by digging may be exposed for a thickness of seven feet. Thence there is a gap of six feet, although at this level there are scattered about some ironstone nodules. Below this gap are twenty-five feet of red and yellow and green non-fissile shales with a starchlike fracture. These lie on gray and green shales which have harder fossiliferous limy bands at the top and near the middle. These shales are twenty feet thick and lie on heavy bedded sandstone and limestone ledges which rise ten feet above the water.

The red and green marly shales are exposed at several other places immediately upstream from this old pit, but at most of these localities they seem to be barren of fossils. At the second cutting along the Illinois Central railway west of the river, about half a mile west of the yard limits, there are exposed about twenty feet of gray-green clay shales which have oxidized to yellow and red at the top. Near the middle of the exposure there are one or more streaks of nodular gray limestone which is very fossiliferous, while the body of shale is very sparingly or not at all fossil bearing. This seems to be the exposure described by Doctor Wilder on page 78 of his report. Opposite this cut on the south bank of the creek and below the railroad grade there is a poor exposure of the gray and green shales with the fossiliferous limy bands. Most of the fossils here are brachiopods. Below the level of these shales are red and green shales in alternating layers. No fossils or limestone bands were observed. Under the shales are exposed twelve feet of gray limestone some of which is well bedded while some is fragmental. The whole series of limestone and shales rises fifty feet or more above creek level.

Another outcrop of red and green clay shales occurs about one-fourth mile up the valley from the one just described. Here thirty feet or more of the gray-green shale overlies nodular gray limestone which stands three feet above the water-level. Abundant fossils are present in the shales, but a five foot bed of red clay shale above them is quite barren of life forms.

About four hundred yards above the junction of North and South Lizard creeks, on the east bank of North Lizard, there is an exposure of the gray-green shale which rises twenty-five or thirty feet above the stream. Over this shale lies fifteen to twenty feet of red shale. At several horizons in the gray-green shale there are harder limy bands which contain large numbers of fossil brachiopods. The contact of the red shale with the gray is quite sharp and lies just above a layer of fossiliferous yellow limestone.

The next exposures on this fork, and so far as is known to the writers the last ones, are a group five miles up the valley and in the southeast quarter of section 8, Douglas township, about one-fourth mile below the Minneapolis and St. Louis Railroad bridge, on the north bank of the stream. Here a small tributary ravine has been cut through six feet of yellow and green shale, below this through five feet of red and green shale, beneath which is exposed two feet of gray sandstone or sandy limestone, then five feet of shaly material beneath which in turn two feet of green shale is seen above the stream level. Just down the main valley a few rods is an exposure of ten feet of yellow and brownish red clay shale, under which is six feet of red shale which lies on gray sandstone which rises six feet above the creek The red shales of these exposures are for the most part true clay shales, although some are finely sandy. Lithologically they are the equivalent of the red shales overlying the fossiliferous gray-green marls seen in the abandoned clay pit and elsewhere upstream as far as the exposure just above the forks. None of the beds at this locality yielded any fossils nor were there found any of the nodular limestone bands which are the fossiliferous members of the exposures farther downstream. Black shales, probably Coal Measures, are said to be present in the valley walls. Just where the tributary ravine joins the main valley is an excellent example of how the character of glacial drift may be influenced by the original material. Here a bank twenty feet high is composed of dull reddish drift clay with numerous small pebbles. The red clay was no doubt derived from the red Ste. Genevieve clay shales close by.

The beds seen in these exposures are stated by Wilder on page 103 of his report to belong to the gypsum series. Keyes in his report on the gypsum[4] also referred these beds to the same series. As stated above, however, because of their character and of their association with the massive gray sandstone beneath them this whole assemblage of shales is here placed in the Ste. Genevieve. The underlying sandstone seems to be the same as the St. Louis sandstone which is well exposed near the mouth of the Lizard and at the dam on Des Moines river at Fort Dodge.

In the lower one-half mile of South Lizard valley there are several exposures of the red and green shales. Only one of these, the southernmost, need be described here. This one shows beneath twenty or thirty feet of till a body of red clay shale twelve feet thick. Under it is eight feet of gray sandstone and below this bed a green and red shale extends fifteen feet to water level. Some of the shale near the base of this exposure is finely sandy. All the other outcrops are similar in the character of the beds exposed and it is noteworthy that none of the beds carry any fossils.

An interesting outcrop of St. Louis limestone may be seen at the point of the ridge bounding the west wall of South Lizard valley, and marking the junction of the two branches. Thirty feet of limestone is exposed above water level and shows a steep dip to the east, that is, downstream. One hundred feet upstream there is present ten feet of green sandy marl grading up into gray sandstone and underlying the limestone. Below a gap of six feet there is exposed above the water a two foot bed of limestone. Two hundred yards downstream the red and green clay shales overlie the concretionary upper beds of the St. Louis limestone, just above stream level. Taken together this series of exposures emphasizes the irregularity of the surface of the St. Louis limestone.

B. The fossils of the marls have been known for well over half a century. As early as 1858, Worthen,[5] in his report on the

[4] Iowa Geol. Survey, Vol. III, p. 279.
[5] Geol. of Iowa, vol. I, pt. I, pp. 178, 179, 1858.

Geology of the Des Moines Valley, writes of the rocks "along the bed of Lizard fork, ..." and adds that "the marl bed above contains three or four species of Terebratula, a Spirifer, and the tail of a trilobite." His species of "Terebratula" are no doubt the forms we now know as *Pugnoides ottumwa*, *Composita trinuclea*, and *Girtyella indianensis;* his "Spirifer" is *S. pellaensis.* The Spirifer is the only member of the fauna illustrated and described by Hall in the paleontological part of the report just mentioned.

In 1870, White[6] in discussing the St. Louis limestone says that "the following species are regarded as more characteristic of the formation than any others: *Spirifer keokuk* var. (Hall), *Rhynchonella ottumwa* (White), *Athyris ambigua* (Sowerby) . . . . . . the three . . . . are as common at Fort Dodge as they are in the southeastern part of the state, although the two points are two hundred miles apart." These three species are the same as the "Spirifer" and two of the "species of Terebratula" mentioned by Worthen.

Wilder[7] in the Webster county report says that "this marl is extremely rich in fossils" and he lists the three commonest brachiopods and "Dentalium sp." It is not clear what fossil Doctor Wilder designated as Dentalium,—careful collecting has not yielded a single specimen of this genus of pteropods.

Both White and Wilder followed Hall[8] in assigning the fauna of the marl to the St. Louis limestone. In a recent article in the Proceedings of this Academy Weller and Van Tuyl[9] bring out the fact that geologists working in southeastern Iowa had shown years ago that the upper part of the St. Louis limestone, as then delimited, differed faunally and in many cases lithologically from the greater mass of the formation below. To this upper part Bain[10] gave the name Pella beds because of its typical development at the town of Pella in Marion county; he still regarded the beds as a distinct unit of the St. Louis. In 1890, Ulrich[11] described some bryozoan fossils from the Pella beds at Pella and in the same year Nickles and Bassler[12] referred the beds to the Ste. Genevieve formation on the basis of Ulrich's bryozoa. Later

[6]Rept. on the Geol. Surv. Iowa, vol. I, pp. 221, 222, 1870.
[7]Iowa Geol. Surv., vol. XII, p. 78, 1901.
[8]Geol. Surv. Iowa, vol. I, pt. II, p. 677, 1858.
[9]Loc. cit.
[10]Iowa Geol. Surv., vol. IV, p. 282, 1894.
[11]Geol. Surv. Ill., vol. VIII, pt. ii, pp. 434, 448, 449.
[12]U. S. Geol. Surv., Bull. No. 173, pp. 166, 180.

on Weller[13] called attention to "the correlation of the Pella beds with the Ste. Genevieve" of Illinois and Missouri; in addition, field work by Van Tuyl in southeastern Iowa has shown that the Pella beds are formationally distinct from the subjacent St. Louis. It was first Weller,[14] and later Weller and Van Tuyl,[15] who called specific attention to the existence of Ste. Genevieve (Pella) beds at Fort Dodge although White, quoted above, had recognized nearly fifty years before the faunal similarity of the marl at Fort Dodge and of the St. Louis of southeastern Iowa as the latter formation was then delimited.

The fauna of the marly zone presents some interesting features. It is composed almost entirely of brachiopods, in addition to which are a few bryozoa, fragments of a trilobite, a few thin columnals of a slender crinoid stem, and some inconspicuous attached and burrowing forms. Of the brachiopods, the index species of the Pella beds, *Spirifer pellaensis* Weller and *Pugnoides ottumwa* (White), make up about ninety per cent of the entire assemblage. The next commonest species is *Composita trinuclea* (Hall) while the remaining forms occur rather sparingly. The absence of corals and molluscs and the meager representation of echinoderms and arthropods point, it would seem, to an environment unfavorable to these groups. The shaly nature of the marly beds indicates a muddy and more or less inhospitable sea bottom while the reddish color of much of the formation suggests to many geologists a comparatively arid climate at the time of their deposition. Moreover, the absence of molluscs plus the evidence offered by the brachiopods indicate that the fossiliferous marls at Fort Dodge correspond to the upper faunal zone of the Pella beds of southeastern Iowa as brought out by Weller and Van Tuyl on pages 246 and 247 of the article mentioned above. Their lower zone, characterized by ten or more genera of molluscs, is apparently wanting in the beds representing the northward extension of the Pella seas, at least in the Lizard creek region.

The fossils are beautifully preserved and their most delicate markings may be readily seen with a good hand lens. Freezing and thawing and other agents of weathering have broken and cracked many of the shells which lie exposed at the surface. Disarticulated valves of the larger species are not uncommon.

[13]Jour. Geol., vol. XVII, p. 278, 1909.
[14]Geol. Surv. Ill., Monog. I, p. 341, 1914, also explanation plate XLV.
[15]Loc. cit.

In the descriptions of the brachiopod species, which follow, the main features only are described. Anyone desiring greater detail and complete synonymy is referred to the excellent Monograph on the Mississippian Brachiopoda recently prepared by Doctor Stuart Weller. Page references to this monograph will be cited under each species.

We wish to thank Doctor R. S. Bassler of the United States National Museum for kindly identifying the bryozoa. He finds three species, two of them already described by Ulrich from the Pella beds at Pella and the third is new. The material now at hand is unfortunately too meager for section cutting. Further collecting, it is hoped, will yield more of these interesting forms.

The writers wish also to acknowledge the receipt of a small but comprehensive collection from the marl made by Mr. Charles Rubenstein, a pupil of the Fort Dodge High School and an enthusiastic collector of local fossils.

DESCRIPTION OF THE FOSSILS.

SPONGES.

Clionolithes lizardensis n. sp.
Plate XII, figs. 25, 26.

Fine tubular burrows 0.1 to 0.25 mm. in diameter penetrating the shells of brachiopods, especially those of *Spirifer pellaensis* Weller. The burrows are circular to subcircular in cross section and they ramify the shell structure in all directions. In parts of some shells they are sufficiently numerous to cause partial disintegration in much the same way that modern Cliona destroys the shells of oysters and other bivalves.

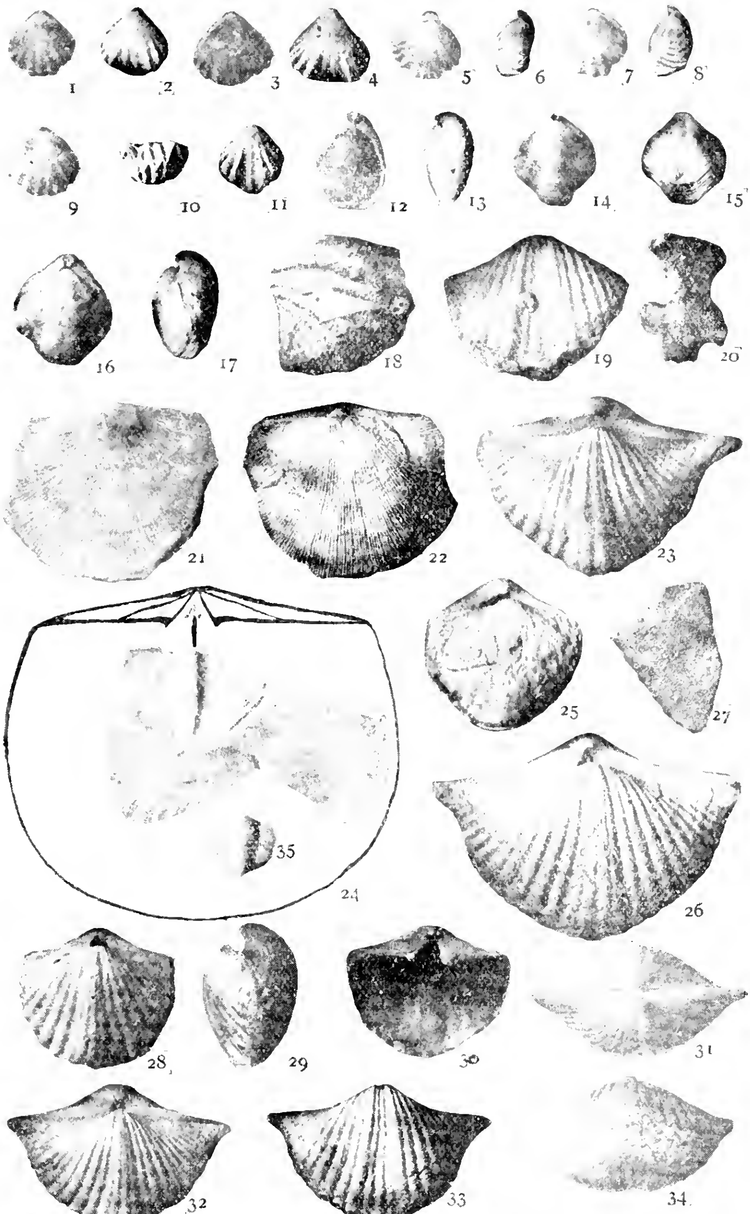
On the surface of the brachiopod shell they appear as minute round holes subequally spaced and not especially crowded in any of the specimens examined. In some shells the outer laminæ of the test have been so undermined that they have crumbled away; on the damaged surfaces the delicate sinuous tunnels and labyrinths may be readily seen.

The generic term Clionolithes was proposed by Clarke[16] for this sort of remains in a very interesting paper on parasitic and dependent forms of life. Doctor Clarke's specimens are from the Devonian of the east. Similar material has been described by

[16]Clarke, J. M., 1908, "The Beginnings of Dependent Life," N. Y. State Educ. Dept., 4th Ann. Rept. Dir. Sci. Div., Adv. sheets, pp. 25-28, plates 8-12.

EXPLANATION OF PLATE XII

	Page
FIGS. 1-11. PUGNOIDES OTTUMWA (WHITE)....................	612
1-2, 3-4. Brachial and pedicle views of two typical specimens.	
5-6, 7-8. Brachial and lateral views of two more examples. 9-10. Brachial and anterior views of another specimen. 11. Pedicle view of an individual with a uniplicate sinus.	
FIGS. 12-13. GIRTYELLA INDIANENSIS (GIRTY)..................	613
Brachial and lateral views of a nearly perfect specimen.	
FIGS. 14-17. COMPOSITA TRINUCLEA (HALL)....................	614
Brachial and pedicle views of two average specimens.	
FIGS. 18-19. SPIRORBIS FORT-DODGENSIS n. sp..................	609
18. The cotype at tip of the paper pointer; note the growth lines. 19. A smoother specimen. The host in each case is *Spirifer pellaensis*. Both specimens enlarged times 3/2.	
FIG. 20. BATOSTOMELLA (sp.)...............................	610
Fragment of a branching zoarium, x3/2.	
FIGS. 21-22, 24 ORTHOTETES KASKASKIENSIS (McCHESNEY)....	611
21-22. Pedicle and brachial views of a nearly complete specimen.	
24. Part of the interior of an unusually large specimen showing the median septum and muscle scars.	
FIGS. 25-26. CLIONOLITHES LIZARDENSIS n. sp..................	605
25. Brachial view of a specimen of *Spirifer pellaensis* partly disintegrated by the borings of this sponge.	
26. Another shell of the same species showing the burrows and several tunnels. Holotypes. Both specimens x3/2.	
FIG. 27. ANISOTRYPA FISTULOSA ULRICH......................	610
A fragment of a zoarium encrusting a piece of brachiopod shell, x3/2.	
FIGS. 23, 28-34. SPIRIFER PELLAENSIS WELLER..................	613
23. Brachial view of a large, long hinged specimen. Note that figure 25 is an example of the rarer short-hinged forms. 28-29. Brachial and lateral views of a "square-shouldered" individual. 30. A separate pedicle valve. 31. Posterior view of a typical shell. 32-34. Brachial, pedicle and anterior views of a very perfect specimen.	
FIG. 35. PHILLIPSIA (sp. undet.)...........................	615
An imperfect pygidium showing some of the features of this genus.	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Thomas[17] from the Devonian of the west and by Price[18] from the Pennsylvanian of West Virginia.

Occurrence.—Ste. Genevieve, Pella beds, near mouth of Lizard creek, Webster county, Iowa.

ECHINODERMS.

Undetermined Crinoids.

Minute fragments of stems not over 1.5 mm. in diameter occur in the clay and in lumps of the marl; they were first noticed in the clay adhering to uncleaned brachiopod shells. The columnals are thin and are rounded pentagonal in transverse section; the lumen is scarcely one-tenth of a millimeter across and the joint faces are marked by fine marginal crenellæ. They are apparently rare.

Spirorbis fort-dodgensis n. sp.

WORMS.

Plate XII, figs. 18, 19.

Tube right-handed, of one and one-half to two and one-half turns, the last volution being much the largest and covering the earlier ones. Diameter of the adult forms from two to two and one-half millimeters, height about one millimeter. Cross section of the volution somewhat oval, mouth slightly upturned, umbilicus small but well marked. Surface marked by sharp conspicuous growth lines which are well separated on the periphery but which are crowded in the umbilical region; there is more or less distinct imbrication of the successive growth increments, each new addition projecting a short distance from within the next older; the younger half-grown tubes are smooth.

These enrolled worm tubes are cemented to the shells of brachiopods, especially to the shells of *Spirifer pellaensis.*

Occurrence.—Ste. Genevieve, Pella beds, along Lizard creek, Webster county, Iowa.

BRYOZOA.

Batostomella interstincta Ulrich.

1890. *Batostomella interstincta* Ulrich, Geol. Surv., Ill., vol. VIII, pt. ii, p. 434, pl. LXXV, figs. 4-4e.

Zoarium forming a thin incrustation spread over the shell of *Spirifer pellaensis;* the incrustation is so thin that the positi n

[17]Bull. Lab. Nat. Hist., State Univ. Iowa, vol. VI, no. 2, pp. 165-166, 1911, plate.

[18]W. Va. Geol. Surv., Raleigh county Rept., part iv, p. 688, pl. xxx fig. 1, 1916.

of the brachiopod ribs is scarcely obscured. At intervals from this spreading base, according to Ulrich, this species throws up "irregularly branched shoots, one mm. or thereabouts in diameter at the basal portion, and somewhat more higher up." These branches are wanting in the specimen at hand but there is some evidence that one or two may have been present but are now broken off.

Zoecial apertures of the encrusting base are from .20 to .25 mm. in diameter when measured along the diagonal rows. Mesopores few; acanthopores common.

One of Doctor Ulrich's figured specimens from Pella encrusts a crinoid stem; on this specimen the bases of the broken branches are prominent, another illustration exhibits one of the branches.

Occurrence.—Ste. Genevieve, Pella beds, on Lizard creek, Webster county, Iowa.

Batostomella (a new species)

Plate XII, fig. 20.

Zoarium branching, main stem (judging from the single fragment at hand) flattened oval to nearly round in cross section, branches more nearly circular than the stem; main stem and branches apparently hollow, wall of the stem about 0.5 mm. thick. Apertures oval, seven or eight in the space of two millimeters; interspaces thick, mesopores few, acanthopores(?) large.

Doctor Bassler labelled this specimen "new species,—in Ulrich collection." The meager amount of material at hand makes it unwise to attempt complete specific description; more specimens, it is hoped, from which tangential and vertical sections may be cut, eventually will be obtained.

Occurrence.—Ste. Genevieve, Pella beds, one-fourth mile above mouth of Lizard creek, Webster county, Iowa.

Anisotrypa fistulosa Ulrich

Plate XII, fig. 27.

1890. *Anisotrypa fistulosa* Ulrich, Geol. Surv. Ill., vol. VIII, pt. ii, p. 448, pl. LXXII, figs. 6-6e.

Zoarium composed of one layer about one millimeter thick coating a fragment of brachiopod shell, presumably that of *Orthotetes kaskaskiensis.* Quoting Doctor Ulrich—"Surface generally smooth, at intervals of three or four mm. with clusters of apertures of larger size than the average, which in rare instances are slightly elevated. A few small cells usually present near the centers of the clusters. Apertures regularly arranged, polygonal, commonly hexagonal, varying in diameter from 0.28 mm. to 0.5 mm., in the clusters, nine or ten of the average size in three mm., separated by comparatively thin partitions. Zoœcial tubes curving gently throughout their length, not quite direct even at the surface of the layers. Walls thin and flexuous below, but towards the surface they become rather abruptly, but only moderately thickened. Lines between walls of adjoining zoœcia sharply marked. Mesopores(?) (small tubes) very rare, only in the groups of large zoœcia. Diaphragms with large perforations, three or four in each tube, quite commonly observed closing their apertures.''

Occurrence.—Ste. Genevieve, Pella beds, Illinois Central railroad cutting, near Fort Dodge, Webster county, Iowa.

BRACHIOPODS.

Orthotetes kaskaskiensis (McChesney)

Plate XII, figs. 21-22, 24.

1914. *Orthotetes kaskaskiensis* Weller, Geol. Surv. Ill., Monog. I, p. 77, pl. VI, figs. 1-14, 15?

Shell of medium to large size, subcircular in outline, broader than long, hinge-line shorter than the greatest width. Cardinal angles rounded. A nearly complete specimen at hand is of the following dimensions: length of pedicle valve 26 mm., length of brachial valve 24.5 mm., greatest width 38 mm., height of cardinal area 4.5 mm., thickness near midlength 5.7 mm.

Pedicle valve flattened concave, greatest concavity near the middle; beak and umbo abruptly elevated, and the whole umbonal region somewhat distorted. Cardinal area flat and sloping backward from the hingeline at a wide angle; each half of the area is divided into two regions by a line originating at its apex and extending diagonally to the cardinal line and terminating at a point midway between the center of the area and the cardinal angle. Pedicle opening higher than wide and closed by a convex deltidium. On the inside of the valve a strong median septum extends forward between the muscle scars.

Brachial valve convex except near the cardinal extremities where it is flat or slightly concave, highest convexity posterior to the middle. Interior unknown.

Surface of both valves marked by radiating costæ which increase by the introduction of new ones between the old or by the division of the older costæ. Growth lines rather coarse, in some eases approaching the character of wrinkles, best developed on the anterior part of the valves. Minute concentric markings may be seen with a lens, especially between the costæ where they have been protected from wear.

Many fragments of this fine species were collected but whole specimens are rare. The best specimen, figures 21 and 22 of the plate, was collected by Charles Rubenstein. Many of the shells exhibit borings of *Clionolithes lizardensis* and in some cases their broken condition is due to the ravages of this little boring sponge.

Occurrence.—Ste. Genevieve, Pella beds, along Lizard creek. Webster county, Iowa.

Pugnoides ottumwa (White)

Plate XII, figs. 1-11.

1914. *Pugnoides ottumwa* Weller, Geol. Surv. Ill., Monog. I, p. 193, pl. XXV, figs. 7-17.

Shell small, five-sided in outline, width and length about equal. Dimensions of an average specimen are: length 12 mm., width 11 mm., thickness 7 mm.

Pedicle valve sharply pointed at the beak, umbo strongly convex, mesial sinus confined to the anterior part of the valve where it is broad and relatively deep; anterior margin sinuous due to the extension of the mesial part of the valve; beak incurved, produced 1 to 1.5 mm. beyond the brachial valve; delthyrium triangular, partly closed; foramen round, terminal, size and position variable when a series of shells is examined; plications simple and limited to the anterior half of the valve, one to three (rarely four or five) in the bottom of the sinus and from three to five on each slope.

Brachial valve more convex than the pedicle; mesial fold confined to the anterior part of the valve and strongly elevated in front; beak incurved beneath that of the pedicle; arrangement of the plications as on the opposite valve.

Surface of both valves smooth except for the plications and a few growth lines near the anterior margins.

This species is very abundant at all the localities where fossils are obtained. It is especially characteristic of the Pella beds and is regarded as their index fossil. It is found also at Ottumwa (whence the specific name), Pella, Oskaloosa, Keosauqua, and elsewhere in southeastern Iowa.

Occurrence.—Ste. Genevieve, Pella beds, along Lizard creek and in the Illinois Central railroad cutting, Webster county, Iowa.

Girtyella indianensis (Girty)

Plate XII, figs. 12-13.

1914. *Girtyella indianensis* Weller, Geol. Surv. Ill., Monog. I, p. 275, pl. XXXIV, figs. 1-24.

Shell small, smooth, elongate, more or less oval to roundly five-sided in outline; front margin truncate. Dimensions of the most perfect specimen found at this locality are: length 15 mm., width 10.5 mm., thickness 7 mm.

Pedicle valve convex, greatest convexity over the umbonal region, mesial sinus shallow and limited to the anterior third of the valve; beak prominent and strongly incurved over that of the brachial valve and terminating in an elongate ovate foramen which opens through the terminal part of the umbo.

Brachial valve less convex than the pedicle, mesial fold ill-defined or wanting, beak curved beneath that of the pedicle.

Surface of both valves smooth except for a few concentric lines of growth. Very fine punctæ which are characteristic of this genus may be readily seen with a lens.

This species is very rare in the Pella beds at Fort Dodge though abundant in corresponding beds in southeastern Iowa. Only two specimens have been obtained. By several geologists this shell has been called *Dielasma turgida* but it has been shown by Girty to differ from that species. From the young specimens of *Composita trinuclea* the young shells of this species may be distinguished by the shape of the foramen and by the fact that the shell structure of *G. indianensis* is always punctate.

Occurrence.—Ste. Genevieve, Pella beds, along Lizard creek, Webster county, Iowa.

Spirifer pellaensis Weller.

Plate XII, figs. 23, 28-34.

1858. *Spirifer keokuk* var. Hall, Geol. Iowa, vol. I, pt. II, p. 677, pl. 24, figs. 4a-d.

1914. *Spirifer pellaensis* Weller, Geol. Surv. Ill., Monog. I, p. 340, pl. XLV, figs. 1-31.

Shell of medium size, in most cases wider than long, greatest width at the hinge-line but in a few cases in front of the hinge-line, cardinal angles extended, rectangular, or in a few cases rounded. An average specimen measures: length 22.5 mm., greatest width at midlength of the shell 28 mm., length of the hinge-line 32 mm., thickness 17 mm.

Pedicle valve convex, beak pointed and strongly incurved; cardinal area sharply defined, curved; pedicle opening triangular, higher than wide. Plications rounded, simple, from nine to thirteen on the lateral slopes; mesial sinus distinct, one strong median plication extends its entire length and on either side is one (rarely two) weaker plication which arises by the division of the first plication of the lateral slope.

Brachial valve convex, beak pointed, short, and scarcely incurving over the narrow area; mesial fold well developed and marked by a prominent median furrow which is flanked on each side by a strong plication, other furrows and plications are the counterparts of those on the opposite valve.

On well preserved specimens fine concentric markings and fine longitudinal lines cover the whole surface, on rubbed or worn shells they may be seen between the plications toward the anterior part of the valves. Lines of growth, densely crowded in some cases, also are present.

Following Hall this species has usually been designated in the Iowa Reports as a variety of *S. keokuk* or simply as *S. keokuk*. It rather closely resembles this species but, as pointed out by Weller, it differs from it "in its smaller size, its more sharply defined and more angular mesial sinus towards the beak, and especially in the narrower and less gibbous umbonal region of the pedicle valve." Some writers have called it *S. littoni* confusing it with that species due perhaps to the fact that Swallow's *S. littoni* had never been illustrated before the appearance of Doctor Weller's Monograph.

Occurrence.—Ste. Genevieve, Pella beds, along Lizard creek and in the Illinois Central railroad cutting, Webster county, Iowa.

Composita trinuclea (Hall)

Plate XII, figs. 14-17.

1858. *Terebratula trinuclea* Hall, Geol. Iowa, vol. I, pt. II, p. 659, pl. 23, figs. 4a-c, 5.

1914. *Composita trinuclea* Weller, Geol. Surv. Ill., Monog. I, p. 486, pl. LXXXI, figs. 16-45.

Shell small, four- or five-sided in outline, length and width about equal, greatest width in front of the middle; an average specimen measures: length 14.5 mm., greatest width 15 mm., thickness 8.8 mm.

Pedicle valve convex, greatest convexity over the posterior half, mesial sinus beginning on the umbo whence it continues as a shallow groove to the anterior third of the valve where it becomes deeper and wider and extends forward in a tongue-shaped point; beak incurved over that of the opposite valve and terminating in a large round foot opening; no cardinal area.

Brachial valve convex, mesial part strongly elevated in front and the elevation set off by a marked depression on each side; a shallow median groove occurs along the summit of the fold in the larger shells; beak curved snugly beneath that of the opposite valve.

Surface of the valves smooth except for crowded concentric lines of growth towards the front margin.

This variable shell has passed under several names in the Iowa Reports. It is doubtless the shell denoted as *Athyris ambigua*, —see reference earlier in this paper. Its usual name, however, has been *Athyris* or *Seminula subquadrata*, each of which is a synonym of the name now recognized.

Occurrence.—Ste. Genevieve, Pella beds, along Lizard creek and in the Illinois Central railroad cutting, Webster county, Iowa.

TRILOBITES.

Phillipsia (species undetermined)

Plate XII, fig. 35.

A single small and imperfect pygidium was collected by Doctor Lees in the marl on North Lizard creek. The margin of the specimen is broken away. The axis is prominent and is distinctly set off from the lateral lobes; thirteen segments are preserved, a number at the distal end being lost. All the segments are sharply defined by narrow, deep sulci. The segments of the lateral lobes are wider than those of the axis, six of the latter being a little wider than five of the former.

Occurrence.—Ste. Genevieve, Pella beds, along north branch of Lizard creek, Webster county, Iowa.

ADDENDUM.

Since the foregoing paper was written an exposure of the Ste. Genevieve marls has been found in the northwest quarter of section 6, Cooper township, in a small ravine on the east side of the river, about five miles above Fort Dodge. Two small outcrops were seen here, one near the mouth of the creek, the other about two hundred feet upstream. The lower exposure shows about two feet of gray nodular concretionary calcareous marl, under which is exposed a few inches of sandy shale. At the upper outcrop there is exposed above water a foot of gray-green, red and varicolored clay shale, similar to those on Lizard creek. A few specimens of *Spirifer pellaensis* Weller and *Pugnoides ottumwa* (White) were found in the clay shale.

Along the west fork of Des Moines river above Humboldt there are several outcrops of brightly colored clay shales which resemble those along Lizard creek although since they are non-fossiliferous the identification must rest on lithological similarities alone, and is not positive.

In the banks of a little brook, just above bridge 355 on the Chicago and North Western railway, about one-half mile east of Rutland, there is exposed two feet of bright red clay shale which is very finely arenaceous and breaks with a coarsely starchlike fracture. It is at the level of the Des Moines flood plain and resembles the red shale below the Minneapolis and St. Louis Railroad bridge over North Lizard in Webster county.

Between Rutland and Bradgate there are exposures of red and blue-gray clay shales as follows: In the bed of the small creek just back of the creamery at Rutland; about a mile above the Rutland bridge, on the south side of the river, rising eight to ten feet above the water; in the south bank of the river in the southeast quarter of section 15; in the northeast quarter of section 23; and just below the Bradgate bridge. It is difficult to determine whether these shales are Ste. Genevieve or Fort Dodge although on account of their clayey nature the former possibility seems the more probable one.

Further examinations of the outcrops near Minneapolis and St. Louis Railroad bridge over North Lizard creek show that the clay shales are exposed in a small gully for at least thirty feet above the stream. This is perhaps two hundred feet below the tributary ravine mentioned on page 601. Along this ravine to the north there are exposed at intervals for nearly one-half mile pink and gray clay shales which rise at least twenty feet above the water. Just north of the east-west road crossing the center of section 8 is a ledge of fine gray sandstone ten feet high. Over it lies ten feet of red sandy shale with some sandstone layers. The relations here seem to be cumulative proof for the theory that these shales belong to the Ste. Genevieve.

CUMULATIVE INDEX, VOLUMES I TO XXV, 1887-1918

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