PROCEEDINGS

OF THE

Indiana Academy of Science.

1892.

BROOKVILLE, IND.

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OF THE

Indiana Academy of Science,

1892.

O. P. HAY,
C. A. WALDO,
J. M. COULTER, } Editors.

A. W. BUTLER,
C. H. EIGENMANN,
V. F. MARSTERS,
W. A. NOYES,
L. M. UNDERWOOD,
F. M. WEBSTER, } Assistant Editors.

TERRE HAUTE, IND.
PRESS OF MOORE & LANGEN.
1893.

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J. C. ARTHUR.

VICE-PRESIDENT,
W. A. NOYES.

SECRETARY,
AMOS W. BUTLER.

ASSISTANT SECRETARY,
*STANLEY COULTER.
†W. W. NORMAN.

TREASURER,
C. A. WALDO.

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W. W. NORMAN.	C. A. WALDO.	JOHN M. COULTER,
J. P. D. JOHN.	T. C. MENDENHALL,	O. P. HAY,
D. S. JORDAN.	J. L. CAMPBELL.	J. C. BRANNER.

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Ichthyology	CARL. H. EIGENMANN.
Ornithology	AMOS W. BUTLER.
Herpetology	O. P. HAY.
Entomology	F. M. WEBSTER.
Mammalogy	E. R. QUICK.

*Resigned.
†To fill vacancy.

COMMITTEES, 1892–93.

PROGRAMME.

L. M. Underwood, W. A. Noyes.

MEMBERSHIP.

C. H. Eigenmann, P. S. Baker, D. T. McDougal.

NOMINATIONS.

O. P. Hay, H. A. Huston, W. P. Shannon.

AUDITING.

P. S. Baker, W. W. Norman.

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EDITORS.

O. P. Hay, C. A. Waldo, J. M. Coulter.

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J. M. Coulter, J. P. D. John, O. J. Craig,
D. W. Dennis, F. A. Walker.

BIOLOGICAL SURVEY.

L. M. Underwood, A. W. Butler, J. M. Coulter.

DIRECTORS BIOLOGICAL SURVEY.

L. M. Underwood, C. H. Eigenmann, V. F. Marsters.

RELATIONS OF THE ACADEMY TO THE STATE.

C. A. Waldo, J. M. Coulter, A. W. Butler.

OFFICERS OF THE INDIANA ACADEMY OF SCIENCE.

	President.	Secretary.	Asst. Secretary.	Treasurer.
1885–6	David S. Jordan.	Amos W. Butler.	. . . . .	O. P. Jenkins.
1886–7	John M. Coulter.	Amos W. Butler.	. . . . .	O. P. Jenkins.
1887–8	J. P. D. John.	Amos W. Butler.	. . . . .	O. P. Jenkins.
1888–9	John C. Branner.	Amos W. Butler.	. . . . .	O. P. Jenkins.
1889–90	T. C. Mendenhall.	Amos W. Butler.	. . . . .	O. P. Jenkins.
1890–1	O. P. Hay.	Amos W. Butler.	. . . . .	O. P. Jenkins.
1891–2	J. L. Campbell.	Amos W. Butler.	. . . . .	C. A. Waldo.
1892–3	J. C. Arthur.	Amos W. Butler.	Stanley Coulter. W. W. Norman.	C. A. Waldo.

CONSTITUTION.

SECTION 1. This Association shall be called the Indiana Academy of Science.

SEC. 2. The objects of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science.

SEC. 3. Members of this Academy shall consist of three classes, active, non-resident and honorary. Any person engaged in any department of scientific work, or in original research in any department of science, shall be eligible to active membership. Active members may be annual or life members. Annual members may be elected at any meeting of the Academy; they shall sign the constitution, pay an admission fee of two dollars, and thereafter, an annual fee of one dollar. Any person who shall at one time contribute fifty dollars to the funds of this Academy, may be elected a life member of the Academy, free of assessment. Non-resident members may be elected from those who have been active members but who have removed from the state. Honorary members may be elected on account of special prominence in science, on the written recommendation of two members of the Academy. In any case, a three fourths vote of the members present shall elect to membership. Applications for membership in any of the foregoing classes shall be referred to a committee on applications for membership, who shall consider such application and report to the Academy before the election.

SEC. 4. The officers of this Academy shall be chosen by ballot at the annual meeting, and shall hold office one year. They shall consist of a president, a vice president, secretary, assistant secretary, and treasurer, who shall perform the duties usually pertaining to their respective offices, and in addition, with the ex-presidents of the Academy, shall constitute an executive committee. The president shall, at each annual meeting, appoint two members to be a committee which shall prepare the programmes and have charge of the arrangements for all meetings for one year.

SEC. 5. The annual meeting of this Academy shall be held in the city of Indianapolis, within the week following Christmas of each year, unless otherwise ordered by the executive committee. There shall also be a summer meeting at such time and place as may be decided upon by the

executive committee. Other meetings may be called at the discretion of the executive committee.

SEC. 6. This constitution may be altered or amended at any annual meeting by a three-fourths majority of attending members of at least one year's standing. No question of amendment shall be decided on the day of its presentation.

BY-LAWS.

1. On motion, any special department of science shall be assigned to a curator, whose duty it shall be, with the assistance of the other members interested in the same department, to endeavor to advance a knowledge in that particular department. Each curator shall report at such time and place as the Academy shall direct. These reports shall include a brief summary of the progress of the department during the year preceding the presentation of the report.

2. The president shall deliver a public address on the evening of one of the days of the meeting at the expiration of his term of office.

3. No special meeting of the Academy shall be held without a notice of the same having been sent to the address of each member at least fifteen days before such meeting.

4. No bill against the Academy shall be paid without an order signed by the president and countersigned by the secretary.

5. Members who shall allow their dues to remain unpaid for two years, having been annually notified of their arrearage by the treasurer, shall have their names stricken from the roll.

6. Ten members shall constitute a quorum for the transaction of business.

MEMBERS.

HONORARY MEMBER.

Daniel Kirkwood . . . . . Riverside, Cal.

NON-RESIDENT MEMBERS.

John C. Branner . . . . . Palo Alto, Cal.
D. H. Campbell . . . . . Palo Alto, Cal.
B. W. Evermann . . . . . Washington, D. C.
Charles H. Gilbert . . . . . Palo Alto, Cal.
C. W. Green . . . . . Palo Alto, Cal.
C. W. Hargitt . . . . . Syracuse, N. Y.
Edward Hughes . . . . . Palo Alto, Cal.
O. P. Jenkins . . . . . Palo Alto, Cal.
David S. Jordan . . . . . Palo Alto, Cal.
J. S. Kingsley . . . . . Tufts College, Mass.
Alfred Springer . . . . . Cincinnati, Ohio.
Robert B. Warder . . . . . Washington, D. C.

ACTIVE MEMBERS.

J. Alex. Adair . . . . . Hanover.
J. C. Arthur . . . . . Lafayette.
Harry F. Bain . . . . . Iowa City, Iowa.
Philip S. Baker . . . . . Greencastle.
Timothy H. Ball . . . . . Crown Point.
George W. Benton . . . . . Indianapolis.
Alexander Black . . . . . Greencastle.
Willis S. Blatchley . . . . . Terre Haute.
Henry L. Bolley . . . . . Fargo, N. D.
M. A. Brannon . . . . . Ft. Wayne.
W. V. Brown . . . . . Greencastle.
H. L. Bruner . . . . . Irvington.
J. B. Burris . . . . . Cloverdale.
Amos W. Butler . . . . . Brookville.
Noble C. Butler . . . . . Indianapolis.
J. L. Campbell . . . . . Crawfordsville.

J. T. Campbell . . . . . Rockville.
J. Fred Clearwaters . . . . . Greencastle.
John M. Coulter . . . . . Lake Forest, Ill..
Stanley Coulter . . . . . Lafayette.
U. O. Cox . . . . . Mankato. Minn.
M. E. Crowell . . . . . Indianapolis.
Will Cumback . . . . . Greensburg.
George L. Curtiss . . . . . Greencastle.
B. M. Davis . . . . . Irvington.
D. W. Dennis . . . . . Richmond.
Chas. R. Dryer . . . . . Terre Haute.
Joseph Eastman . . . . . Indianapolis.
H. T. Eddy . . . . . Terre Haute.
Carl H. Eigenmann . . . . . Bloomington.
E. S. Elder . . . . . Indianapolis.
Samuel G. Evans . . . . . Evansville.
E. M. Fisher . . . . . Lake Forest, Ill.
Wilbur A. Fisk . . . . . Richmond.
J. J. Flather . . . . . Lafayette.
Robert G. Gillum . . . . . Terre Haute.
U. F. Glick . . . . . Newbern.
Katherine E. Golden . . . . . Lafayette.
Michael Golden . . . . . Lafayette.
C. F. Goodwin . . . . . Brookville.
S. S. Gorby . . . . . Indianapolis.
W. F. M. Goss . . . . . Lafayette.
Vernon Gould . . . . . Rochester.
Thomas Gray . . . . . Terre Haute.
Edwin Stanton Hallett . . . . . Corydon.
A. S. Hathaway . . . . . Terre Haute.
O. P. Hay . . . . . Chicago. Ill.
Wm. Perry Hay . . . . . Irvington.
Franklin W. Hayes . . . . . Indianapolis.
Robert Hessler . . . . . Indianapolis.
W. A. Hester . . . . . Evansville.
T. H. Hibben . . . . . Indianapolis.
Geo. C. Hubbard . . . . . Moore's Hill.
J. W. Hubbard . . . . . Bloomington.

H. A. Huston	Lafayette.
Thomas M. Iden	Irvington.
Alex. Jameson	Indianapolis.
A. E. Jessup	Carmel.
J. P. D. John	Greencastle.
Sylvester Johnson	Irvington.
W. B. Johnson	Franklin.
J. G. Kingsbury	Irvington.
W. H. Kirchner	Terre Haute.
Daniel Layman	Indianapolis.
W. S. Lemen	Indianapolis.
Robert E. Lyons	Bloomington.
Herbert W. McBride	Chicago, Ill.
Robert Wesley McBride	Indianapolis.
D. T. McDougal	Minneapolis, Minn.
F. M. McFarland	Palo Alto, Cal.
J. W. Marsee	Indianapolis.
Vernon F. Marsters	Bloomington.
C. Leo Mees	Terre Haute.
T. C. Mendenhall	Washington, D. C.
Joseph Moore	Richmond.
Warren K. Moorehead	Xenia, Ohio.
David M. Mottier	Bloomington.
J. P. Naylor	Greencastle.
Charles E. Newlin	Indianapolis.
W. W. Norman	Greencastle.
W. A. Noyes	Terre Haute.
J. H. Oliver	Indianapolis.
D. A. Owen	Franklin.
Wallace C. Palmer	Columbia City.
Alfred E. Phillips	Lafayette.
Elwood Pleas	Dunrieth.
E. R. Quick	Brookville.
Ryland Ratliff	Fairmount.
Thomas B. Redding	New Castle.
D. C. Ridgley	North Manchester.
Herman B. Ritter	Indianapolis.
George L. Roberts	Greensburg.

L. J. Rettger . . . . . Terre Haute.
John F. Schnaible . . . . . Lafayette.
J. T. Scovell . . . . . Terre Haute.
C. E. Schafer . . . . . Huntington.
W. P. Shannon . . . . . Greensburg.
G. W. Sloan . . . . . Indianapolis.
Alexander Smith . . . . . Crawfordsville.
W. J. Spillman . . . . . Monmouth, Ore.
Sidney T. Sterling . . . . . Camden.
M. C. Stevens . . . . . Lafayette.
Winthrop E. Stone . . . . . Lafayette.
A. E. Swann . . . . . Indianapolis.
Frank B. Taylor . . . . . Ft. Wayne.
Erastus Test . . . . . Lafayette.
F. C. Test . . . . . Washington, D. C.
Mason B. Thomas . . . . . Crawfordsville.
Wm. M. Thrasher . . . . . Irvington.
A. L. Treadwell . . . . . Oxford, Ohio.
Joseph H. Tudor . . . . . Baltimore, Md.
E. B. Uline . . . . . Lake Forest, Ill.
A. B. Ulrey . . . . . Bloomington.
L. M. Underwood . . . . . Greencastle.
T. C. Van Nuys . . . . . Bloomington.
C. A. Waldo . . . . . Greencastle.
F. A. Walker . . . . . Anderson.
F. M. Webster . . . . . Wooster, Ohio.
M. W. Wells . . . . . Indianapolis.
J. R. Wiest . . . . . Richmond.
H. W. Wiley . . . . . Washington, D. C.
William S. Wood . . . . . Seymour.
A. J. Woolman . . . . . Duluth, Minn.
A. Harvey Young . . . . . Hanover.

Honorary member	1
Non-resident members	12
Active members	121
Total	134

SPRING MEETING.

The spring meeting of the Academy was held at Terre Haute, Ind., May 17, 18 and 19, 1893.

The meeting was called to order by Vice President Noyes, at 3 o'clock p. m., May 17, in the chemical lecture room of Rose Polytechnic Institute.

J. M. Coulter, W. W. Norman and J. T. Scovell were appointed Membership Committee.

L. M. Underwood presented a report from the committee on State Biological Survey, of which he is chairman. The chairman was instructed to appoint two other members to serve on the committee with him and to present plans at this meeting for carrying on the work.

Acting president Noyes announced an excursion for the next day, leaving the Terre Haute House early in the morning, crossing the river, thence to Durkee's Ferry, returning to Terre Haute in time for supper.

In the evening the Academy met in the Normal school. President Arthur presided.

Dr. T. C. Mendenhall spoke of "The Summit of the Continent." Dr. J. M. Coulter spoke on "Forestry."

Later in the evening another meeting was held at the Terre Haute House. Prof. Underwood announced he had requested to serve with him on the committee on Biological Survey, J. M. Coulter and A. W. Butler.

The members then discussed the question of the relation the Academy should sustain to the State.

C. A. Waldo, J. M. Coulter and A. W. Butler were appointed a committee to consider this.

The resignation of Prof. Stanley Coulter, as assistant secretary, was accepted.

A meeting of the Academy was held on the evening of May 18th, at the same place.

The committee on Biological Survey announced that for the present

three directors, one representing Botany, one Zoology and one Palaeontology be appointed. The recommendation was approved. L. M. Underwood, C. H. Eigenmann and V. F. Marsters were appointed such committee.

Instructions were given the Programme Committee regarding arrangements for the winter meeting.

W. W. Norman was elected assistant secretary.

The day was spent along the west side of the Wabash river, above Terre Haute, and was greatly enjoyed. Some of the members continued their investigations the following day.

WINTER MEETING.

INDIANAPOLIS, DEC. 28, 29, 1892.

PRESIDENT'S ADDRESS.

THE INTERDEPENDENCE OF LIBERAL PURSUITS.

J. L. CAMPBELL, CRAWFORDSVILLE.

The crowning group in stone for the new library building in Indianapolis, by Richard W. Bock, of Chicago, is composed of three figures, representing Literature, Science and Art.

The central figure, sixteen feet in height, represents Science, holding in his right hand stretched upward the torch of enlightenment, and in his left a palm, the reward of victory.

In a sitting posture to the right a female figure represents Literature. She holds a book in the left hand resting on the knee, and with uplifted pen in the right hand she is presented at the inspired moment—write.

The third figure, representing Art, is also a woman. She holds a drawing board upon which she is about to produce a design.

This group suggests the topic for discussion, and the subject may be entitled the Interdependence of the Liberal Pursuits, or in the spirit of the times, the need of an intellectual trust, whereby the interests of science, literature and art may be better cared for, and under its fostering care there may be developed higher art, purer literature and nobler science.

The group in stone is a unit, and my plea will be for the unity of these liberal pursuits.

The distinguishing characteristic of our day is devotion to specialties, and this devotion has made us strangers to each other.

A critical examination of the productions in the various departments of literature and science will disclose many defects, which may be traced chiefly to the want of interchange of thought.

The scientific treatises often are defective in style and expression, and the literary works frequently are laughably absurd in their scientific byplays.

The scientific man waves aside with contempt the latest novel, and the novelist returns the compliment by pitying the devotion of the discoverer of an unclassified bug or a fresh compound.

A more generous fellowship is needed for mutual benefit.

This criticism is not intended to be censorious nor unjust; neither is it directed against earnest work in specialties. There can be no valuable results except by loving and exclusive efforts along chosen lines.

It is not asked that the chemist by his compounds should seek for poetry in his crucible: nor that the biologist with his dissecting tools create the life which his search destroys, much less reproduce the higher life of thought, of passion, and of hope, which breathe in the works of the dramatist and in the pages of the writer of fiction.

But outside of our laboratories of books and blowpipes, in our hours of ease, if you please, may not profitable relaxation be found in a better acquaintance with our neighbors.

The poet takes his walks alone that his communion with nature may not be disturbed, but it is possible that he might find valuable assistance in his translation of the "books in brooks" in the "drawing rooms" of the hydraulic engineer.

The geologist no less than the poet may find "sermons in stones," and each may be benefited by contact with the other.

Is it not possible to secure better results by the union of science and literature than are now gotten by their separation and their too narrow circle of fellowship?

Listen to this wail from the Editor's Study in Harper's Magazine for September, 1892, and tell us what does it portend?

"Books are being replaced by newspapers and periodicals. A book shop used to be an intelligent center where readers met not only to keep the run of the thought of the world, but to exchange ideas about it. Few are so now. Book stalls have become shops of notions, of stationery, of newspapers, of artists' materials, of various bric a brac, with an only occasional real book that has attained exceptional notoriety.

"It is no longer profitable to keep a stock of general literature, and many of the brightest and best trained minds now are giving their entire time and energy to the daily and weekly press.

"In its swelling bulk the daily newspaper has become a magazine, and the magazine in a generation that must run as it reads takes the place of the book."

From the scientific side of book making also comes remarkable confessions of weakness. From the testimony of the writers themselves the books of yesterday already have been consigned to the top shelf, where indeed moth and dust do corrupt, but where thieves do not break through

to steal, while the books of to-day will be in the waste basket to-morrow. True, the language used is somewhat different from the above, but the meaning is essentially the same.

The claim is that so rapid are the advances in science that the text book of yesterday is antiquated, or in their illiterate lingo, "not up to the times," and so the butterfly products sport only their brief day and die.

Is it a necessity that books shall have this ephemeral existence? Is this a love that must so soon grow cold; a youth that without years must be old; a life that almost begins with death?

"I paint for immortality" was the inspired utterance of the greatest of artists, and is there to be no second Shakespeare whose writings will be immortal? Is there not an unentered field of research where we may discover the hidden qualities of the few books which endure?

With the confession of weakness and partial failure comes the question of possible increase of strength and more complete success. If there is a balm in Gilead let us seek for it, and if there is a physician anywhere who can cure let us search for him.

And for this purpose let us call a congress of all parties interested for mutual counsel, and, if found practicable, for mutual aid.

If the weakness is real in all departments of thought, and is discovered in all varieties of thought products, let the invitation to this congress of thinkers be general; let the workmen come from every separate shop to the great council chamber; the representatives of art, literature and science of every kind to the symposium of mind.

In this assembly let the historian and the physicist sit together; the biologist and the biographer; the poet and the chemist; the botanist and the linguist. Let the mathematician take counsel with the song writer, and the astronomer and the wanderer in the shoreless realms of fiction discuss the things common to both.

Then the new companionship would beget new inspiration; a better fellowship would lead to a broader culture; "know thyself" would yield to the more generous "know each other," and a fuller answer would be given to the greatest question, "how can men best fulfill their allotted destiny?"

With this liberal view of Intellectual fellowship necessarily would come more liberal methods in the preparatory as well as in the wage earning period of life.

It is not the purpose of this lecture to enter upon the much discussed and never to be settled questions relating to the studies to be selected and

the methods to be pursued in the undergraduate part of preparatory training.

Without dispute broad general culture is the point and the essential requirement.

The deep foundations must be of stone, whatever is to be the superstructure.

My earnest plea is for more room in the elementary period for training in the branches which are extra, or rather pre-professional, and which must be mastered before any one can lay claim to a *liberal* education.

* * * * * * *

If we were permitted to interpret Shakespeare's seven stages of life, his third would conclude with the undergraduate course, while the fourth, who enters as the "lover sighing like furnace with a woful ballad made to his mistress' eyebrow," would mean that devotion to professional study which is more than that of the lover and an attention more exacting than that of the most jealous mistress.

In the preparation for professional life no exclusiveness can be too exclusive, no labor or painstaking within the severest limits can be too exacting.

All that the most ardent advocate for specialties is accepted, and if presented to our great congress of thinkers would be unanimously adopted.

This is the time in life when the student should be lost to the world, when the claims of social life may be ignored, when culture even may be suspended in the eager search for facts.

If the chosen profession be science, the laboratory should be alike shop and parlor: if literature, to quote again from the Editor's Study, books only, "those unfailing faithful companions which stand mute and waiting on the shelves, in whose hearts are preserved the thought, the aspiration, the despair, the love, the heroism, the emotion, the tragedy, the immortal beauty, the bewitching loveliness of the ages."

So oblivious to outer things should be the professional student, that a casual glance at the daily newspaper could scarcely be allowed to keep him informed whether or not he himself has not died.

The usual commencement benediction welcomes the graduate to the great world of letters, but this welcome should be to the retirement and not to the activities of this realm of thought, and the interpretation should be that he has studied to be somebody, now let him learn to do something. A Paul even found it necessary to retire three years into Arabia

for this preparation for the work of directing religious thought for all after ages.

The generous, or rather general qualities of mind and heart, which necessarily have been but little called into activity during the years of professional study, are likely never to be revived, and so the years of active professional life usually are passed within the narrow limits of single professions. Lawyers prefer lawyers, and chemists, chemists. Doctors care only to talk with doctors, and preachers prefer to confine their attentions to the cloth. In the literary professions there is even more exclusiveness, for nothing is so dull and unattractive to writers of this class as the fields of science. Dynamite is greatly preferred by them for the intruder who would try to discuss a dynamo.

The cure for all this is better fellowship.

The Academy of Science purposes at the present session to cultivate this liberalizing of different pursuits within the range of the general purpose of the association. Instead of carrying out our programme by sections as heretofore, our desire is that the members may become interested in the work of others than those in the same specialty. The biologist must listen to the physicist, the chemist to the geologist, the archæologist to the botanist, each for the time being esteeming the work of another better than his own. Thus within the limits of the sciences we are trying the interchange of thought for the better developing of thinking.

If this experiment proves successful may we not hope for a wider association of thinkers in some new organization, which will include all liberal pursuits?

* * * * * * *

The pleasant duty remains to me to extend fraternal greetings to the members of the Indiana Academy of Science.

This Academy is yet young in years, but the success already attained and the recognition secured among associations of kindred character are most gratifying to those of us who have been active members from the beginning. The new names added to our list year by year give cheering assurance of a prosperous future.

We meet this year in the closing days of an epoch of four hundred years of the world's history, dating from the birth of a hemisphere, and from this holiday ending of the old extend our happy new era greeting to the centuries to come.

Next year we will celebrate this fourth century date at the marble city

by the lake. The international exposition of 1893 will epitomize in material form the progress of the world for the centuries, and to no Mecca can the devotee of science turn with more reverent steps.

The interdependence of the liberal pursuits there will have practical illustrations of the most instructive character. The best thought of the centuries will be realized on canvass, in marble, in bronze, in exquisite fabrics, in jewels and ornaments of silver and gold, in the whirr of machinery and the flashes of electricity.

There may we study things, and there may we in profitable intercourse meet men. This will be the academy of science of the world.

PAPERS READ.

ON THE CONSTRUCTION OF A SENSITIVE GALVANOMETER. By BENJ. W. SNOW.

TESTS OF THE TORSIONAL STRENGTH OF A STEEL SHAFT. By THOS. GRAY.

ANALYTICAL AND QUATERNION TREATMENTS OF THE PROBLEM OF SUN AND PLANET. By A. S. HATHAWAY.

INTRODUCTION.

The object of the paper is to show the greater simplicity of quaternions over analytics. For the purpose of comparison, the most condensed analytical treatment possible is adopted. This turns out to be precisely analagous to the quaternion treatment. Three equations, such as $m\,a=a'$, $m\,b=b'$, $m\,c=c'$ are written $m\,(a.\ b.\ c)=(a',\ b',\ c')$. By multiplying these equations by $(x,\ y,\ z)$ is understood the result of multiplying the first by x, the second by y, the third by z, and adding, giving $m\,(a\,x+b\,y+c\,z)=(a'\,x+b'\,y+c'\,z)$. This corresponds to scalar multiplication in quaternions. By forming corresponding determinants with

x, y, z, is understood the set of equations $m \begin{vmatrix} a & b & c \\ x & y & z \end{vmatrix} = \begin{vmatrix} a' & b' & c' \\ x & y & z \end{vmatrix}$ or, in full $m(bz-cy, cx-az, ay-bx)=(b'z-c'y, c'x-a'z, a'y-b'x)$. This corresponds to vector multiplication in quaternions.

The analytical methods thus perfected are, in fact, a sort of degraded and cumbersome quaternion notation in which (a, b, c) stand for $ai+bj+ck$, etc. It involves the necessity of thinking by steps parallel to the axes, and when results are obtained it involves the fitting together of the various steps in order to see what is the actual state of affairs in space. To do this requires considerable practice and grasp of technique, all of which is avoided in quaternions. For example, equations (8) were unnecessary in quaternions, the results desired being sufficiently evident from (7); while even after (8) is derived the technique of equations of the first degree must be at command before the results stated can be seen in the analytical method. The letters m_1, m_2 in (9) and on are not the masses of (1), . . . (5).

EQUATIONS OF MOTION.

(1) $m_1\left(\frac{d^2x_1}{dt^2}, \frac{d^2y_1}{dt^2}, \frac{d^2z_1}{dt^2}\right) = \frac{m_1m_2}{r^3}(x, y, z)$ $\quad m_1\frac{d^2\xi_1}{dt^2} = \frac{m_1m_2}{r^3}\xi$

(2) $m_2\left(\frac{d^2x_2}{dt^2}, \frac{d^2y_2}{dt^2}, \frac{d^2z_2}{dt^2}\right) = -\frac{m_1m_2}{r^3}(x, y, z)$ $\quad m_2\frac{d^2\xi_2}{dt^2} = -\frac{m_1m_2}{r^3}\xi$

where $(x, y, z)=(x_2-x_1, y_2-y_1, z_2-z_1)$ $\quad$ where $\xi=\xi_2-\xi_1$

and $r=(x^2+y^2+z^2)^{\frac{1}{2}}$

Adding (1), (2), also dividing out common m's and subtracting, putting $M=m_1+m_2$, we have:

(3) $\left(m_1\frac{d^2x_1}{dt^2} + m_2\frac{d^2x_2}{dt^2}, \ldots\ldots\right) = (0,0,0)$ $\quad m_1\frac{d^2\xi_1}{dt^2} + m_2\frac{d^2\xi_2}{dt^2} = 0$

(4) $\left(\frac{d^2x}{dt^2}, \frac{d^2y}{dt^2}, \frac{d^2z}{dt^2}\right) = -\frac{M}{r^3}(x, y, z)$ $\quad \frac{d^2\xi}{dt^2} = -\frac{M}{r^3}\xi$

EQUATIONS OF MOTION INTEGRATED.

Integrating (3) twice, we have:

(5) $(m_1x_1+m_2x_2, \ldots\ldots) = (at+b, a't+b', a''t+b'')$ $\quad m_1\xi_1+m_2\xi_2 = at+\xi_0$

Hence, the center of gravity moves in a straight line with uniform speed, viz:

In the direction $a:a':a''$ with speed: $\sqrt{(a^2+a'^2+a''^2):(m_1+m_2)}$.

Form corresponding products of (4) and $\left\{\frac{dx}{dt}, \frac{dy}{dt}, \frac{dz}{dt}\right\}$ add and integrate.

$$(6)\quad \frac{1}{2}\left[\left(\frac{dx}{dt}\right)^2+\left(\frac{dy}{dt}\right)^2+\left(\frac{dz}{dt}\right)^2\right] = \frac{M}{r}-\frac{M}{2a}$$

In the direction α, with speed: $\sqrt{\alpha:M}$.

Multiply (4) by $\dot{r}$ and scalar-integrate:

$$\frac{1}{2}\sqrt{\frac{d\dot{r}^2}{dt}} = \frac{M}{r}-\frac{M}{2a}$$

This is the equation of energy. It shows that the speed of a planet increases when its distance from the sun decreases, and *vice versa*. Also, since $M=m_1+m_2$ is sensibly the same for all planets, therefore the speed of a planet depends only on its distance from the sun and a constant, $2a$, of its orbit (later shown to be its major axis).

Forming corresponding determinants of (4) with (x, y, z) and integrating:

$$(7)\quad \begin{vmatrix} x & y & z \\ \frac{dx}{dt} & \frac{dy}{dt} & \frac{dz}{dt} \\ l & l_1 & l_2 \end{vmatrix} = c\,(l, l_1, l_2)$$

where $l^2+l_1^2+l_2^2=1$ and c is positive.

Multiplying corresponding terms by (x, y, z), and adding, we find:

$$(8)\quad \left(l\,x+l_1\,y+l_2\,z\right)=0;\ \text{similarly,}\quad \left(l\,\frac{dx}{dt}+l_1\,\frac{dy}{dt}+l_2\,\frac{dz}{dt}\right)=0.$$

Multiplying (4) by $\dot{r}$ and integrating the vector part:

$$V\,\dot{r}\,\frac{d\dot{r}}{dt} = c\,\dot{z}$$

where $c\,\dot{z}=c$.

Taking the scalar product by $\dot{r}$ we find

$$S\,\dot{z}\,\dot{r}=0;\ \text{similarly}\quad S\,\dot{z}\,\frac{d\dot{r}}{dt}=0.$$

Equation (7) shows the rate of description of double areas by the radius vector from sun to planet to be constant ($=c$) and that its motion is in a plane perpendicular to $(l:l_1:l_2)=\dot{z}$. The direction of this axis is such that an ordinary screw, when made to advance along it, will rotate in the direction of the description of areas.

Taking the second member of (7) with the first member of (4) and *vice versa*, and forming corresponding determinants and integrating, we have

$$(9)\quad c \begin{vmatrix} l & l_1 & l_2 \\ \frac{dx}{dt} & \frac{dy}{dt} & \frac{dz}{dt} \end{vmatrix} = -\frac{M}{r}(x, y, z) = f(m, m_1, m_2)$$

where $m^2 + m_1^2 + m_2^2 = 1$ and f is positive.

Multiplying (9) by (l, l_1, l_2) and adding, we have $l m + l_1 m_1 + l_2 m_2 = 0$, or (m, m_1, m_2) is in the plane of motion.

Take $(n, n_1, n_2) = \begin{vmatrix} l & l_1 & l_2 \\ m & m_1 & m_2 \end{vmatrix}$ forming the direction cosines of a third axis perpendicular to the two already found.

Form with (l, l_1, l_2) and (9) corresponding determinants, and we have:

$$(10)\quad c \left| \frac{dx}{dt}, \frac{dy}{dt}, \frac{dz}{dt} \right| - \frac{M}{r} \begin{vmatrix} l & l_1 & l_2 \\ x & y & z \end{vmatrix} = f(n, n_1, n_2)$$

This is the hodograph. It is a circle [remembering (8)] of radius $\frac{M}{c}$ and center $\frac{f}{c}(n, n_1, n_2) = \frac{f}{c}\nu$. The radius of this hodograph is one right angle in advance of the radius vector of the planet to which it corresponds.

Transposing the f terms of (9) to the first member, squaring, and using (6), we have:

$$(11)\quad \frac{c^2 M}{a} - f^2 = M^2 \text{ or } a = c^2 M \div (M^2 - f^2).$$

Multiplying (9) into (x, y, z) we have, by adding:

$$(12)\quad c^2 - M r = f(m x + m_1 y + m_2 z).$$

Multiplying the second member of (7) into the first member of (4) and *vice versa* and integrating, we have:

$$c \lambda \frac{d\rho}{dt} - \frac{M}{\rho} \rho^2 = f \rho$$

where $-f\rho = f$.

Taking the scalar product by λ, we find $S \lambda \rho = 0$, or ρ is in the plane of motion.

Take $\nu = \lambda \rho$ forming the rectangular unit vectors λ, ρ, ν.

Multiply (9) by λ and we have:

$$c \frac{d\rho}{dt} - \frac{M}{\rho^2} \lambda \rho^2 = f \nu$$

Multiplying (9) into ρ and taking scalars:

$$c^2 - M \rho = -f S \rho \rho'$$

This, remembering (8), is the equation of the orbit. It is a conic whose focus is the sun, and axis is $(m, m_1, m_2) = \mu$. The eccentricity is $e = \frac{f}{M}$, the semi-parameter, $p = \frac{c^2}{M}$. Hence, the semi-major axis is $c^2 M^{-1} (M^2 - f^2)^{-1}$, or a by (11). The center is $-a e (m, m_1, m_2) = -a e \mu$. We may put the orbit, therefore, in the form:

$$\xi = -a e \mu + \mu a \cos E, \quad \eta = b \sin E. \qquad e < 1.$$

$$\xi = -a e \mu + \mu a \cosh E, \quad \eta = b \sinh E. \qquad e > 1.$$

This substituted in (7) and integrated gives Kepler's equation

$$(13) \qquad \begin{aligned} E - e \sin E &= \frac{c}{a b} (t - t_0) \qquad e < 1. \\ E - e \sinh E &= \frac{c}{a b} (t - t_0) \qquad e > 1. \end{aligned}$$

For analytical treatment see Dr. Dzisbek's Theories of Planetary Motion, pp. 1–13.

NOTES CONCERNING TESTS OF THE PURDUE EXPERIMENTAL LOCOMOTIVE. By WM. F. M. GOSS.

The Purdue experimental Locomotive Plant was installed early in the present year. It has been fully described in a paper read before the American Society of Mechanical Engineers at its San Francisco meeting, and a brief reference to the plan of mounting must serve the present purpose.

The driving wheels of the locomotive rest upon other wheels which are carried by shafts running in fixed bearings. When, as in the process of running, the drivers turn, their supporting wheels are driven by rolling contact. The locomotive as a whole instead of moving forward, remains at rest while the track, that is, the periphery of the supporting wheels, moves rearward. The locomotive draw-bar is connected with a series of scale-beams which constitute a traction dynamometer. Friction brakes on the shafts of the supporting wheels, interpose a resistance to the turning of the latter and, by so doing, supply a load for the locomotive. The whole arrangement is such that while the locomotive is fired in the usual way, it may be run under any load and at any speed, the conditions being similar to those of the track.

In the spring and early summer of the present year nearly a dozen runs were made. All were of a preliminary nature, the whole apparatus being entirely new, and the attendents unskilled in the management of the complicated mounting machinery.

At the beginning of the present school year the work was taken up anew. The object of the present work is, in general, to determine the performance of the engine under conditions varying, first, as to cut-off and, secondly, as to speed. To this end, five series of six tests each have been arranged, all to be run under a constant pulling load of 2500 pounds. This constancy of load makes the mean effective pressure practically constant for all tests, and the power developed dependent upon the speed. The load lacks but little of being equivalent to 10 horse-power for each mile per hour of speed.

All of the tests of the same series are run at the same speed, but each test varies from the others of the series by a change in cut-off. The second series differs from the first, and the third from the second, and so on, only in a change of speed. The first series at 15 miles per hour, and the second at 25 miles per hour, have already been run, and, in carrying them on, all conditions were as perfectly maintained as could be desired. The remaining series will be at 35, 45, and 55 miles per hour respectively. Every test is complete in itself. The observed data include speed, drawbar stress, coal and water consumption, calorimeter determination, draft and temperature in smoke-box, and cylinder performance as obtained by the use of four indicators. All tests are of three hours duration and are run without intermediate stops or change of speed. A comparison of results, first of the tests of each series, and secondly, of tests of the same cut-off in the different series, cannot fail to furnish an analysis of the performance of the locomotive which will be far more complete than anything hitherto attempted.

THE ELECTROSTATIC THEORY OF COHESION AND VAN DER WAAL'S EQUATION. By REGINALD A. FESSENDEN.

QUARTZ SUSPENSIONS. By BENJ. W. SNOW.

A THERMO-REGULATOR FOR ROOMS HEATED BY STEAM. By J. C. ARTHUR.

EXPERIMENTS WITH AND PHENOMENA OF VACUUM TUBES. By R. A. FESSENDEN.

THE ELECTRO-MAGNETIC INERTIA OF A LARGE MAGNET. By THOS. GRAY.

SOME NEW ELECTRICAL APPARATUS. By R. A. FESSENDEN.

ON THE CONSTRUCTION AND USE OF A BOLOMETER. By B. W. SNOW.

ROTARY BLOWERS. By JOHN T. WILKIN.

AN INQUIRY AS TO THE CAUSE OF VARIETY IN ROCK DEPOSITS AS SEEN IN HUDSON RIVER BEDS AT RICHMOND, IND. By JOSEPH MOORE.

Take a depth of our bed rock at this place of, say fifty feet, along the river channel. The variations in the lithological character of the numerous sharply defined layers is very marked and very many times repeated; not more so, however, than in hundreds of other localities throughout the country at the same or at other horizons. Here the well solidified portions are thick-bedded (the layers say a foot thick) while not far below or above they are thin, say one or two inches. These consolidated layers vary in texture and composition, some of them being nearly pure limestone and sufficiently crystalline to take a fair polish. Others are masses mainly of brachiopods, often well preserved and matted together with clay or with lime and iron from a state of solution. Others still are shoals of commingled sand, clay and lime and almost destitute of fossils. Then there are the intercalated beds of clay with sufficient calcium carbonate to effervesce with acids for a little while, but leaving their principal bulk when the solvent has done what it can. These beds of finest grained clay vary in thickness from a very few feet to a few inches and even to the thickness of ordinary paper. Often these clay deposits are entirely destitute of fossils and again they are the hope of the hunter of trilobites and a few other form that may be found therein. All these features are familiar to the observer in various localities.

But the commonness of the phenomena does not make their causes the less desirable to seek. It can hardly be supposed that the ocean varied in

depth so many hundred times as would be necessary to produce all the variations to be read in a thickness of five hundred feet. Pure limestones are made in the deeper waters and fine argillaceous sediments may settle in the deeper or the shallower places.

But there appears to be ample reasons for believing that the sea in which the Hudson River rocks of Indiana and Ohio were deposited had its shore line far away, or in other words, said localities were near the middle of a continental ocean.

How then can we account for such well defined successions of mechanical deposits for so long a period of time? How could these sediments get so far from shore and how could they recur so sharply bounded as they are from the purer limestone and other consolidated ledges? How came it about that there were such numerous alternations of life and death epochs in the same fifty, or five hundred feet? The answer to these questions may be very easy to some geologists. We have not, however, seen them satisfactorily answered. Their solution, whatever it is, will be the opening of a door to other secrets.

THE TRAPS OF REDHEAD, N. B. By V. F. MARSTERS.

EXHIBITION AND EXPLANATION OF A GEOLOGICAL CHART. By ELWOOD P. CUBBERLY.

GLACIAL AND PREGLACIAL EROSION IN VICINITY OF RICHMOND, IND. By JOSEPH MOORE.

Richmond is on Drift, underlaid by upper layers of Lower Silurian known as rocks of the Hudson River Group. These rocks being of the earlier time have been above the sea for ages. Consequently there was plenty of time for them to be much eroded. I shall not in this brief paper specify all the well-marked features of erosion but will allude to a few special examples. There is a buried river channel a few rods west of the present channel of Whitewater. This was reported nearly fifty years ago by Dr. Plummer, of Richmond, but it was not then so well known in its extent and direction as it has since become by means of wells, tile layers and ditches for water and gas mains. Said buried channel is about seventy feet wide where crossed by the national road and its walls are very

nearly vertical. In general direction it lies nearly north and south, approximately parallel to the present channel and is of unknown depth. It is filled with sand, gravel, clay and bowlders, with remains of leaves and sticks here and there. It is believed to have been rather a new channel when filled since the upper edges of its vertical walls were not worn down and rounded. It may have been, and probably this part of it was, eroded during an interglacial period. There is a much narrower channel at a shorter distance on the east side of the present river channel as exposed by the deepening of Main street leading westward from town.

A feature little, if at all, reported in Indiana, so far as the writer has observed, is that of great "pot holes" or "glacial jugs" or "giant kettles."

A few years since Mr. Starr, the proprietor of the gas works, called me over to see one of these where he was excavating in the solid rock for a very large cistern.

In one of the walls was a section of the "jug." It was some ten feet in diameter and about the same depth was exposed, though it extended deeper than the cistern. It was filled with clean sand and gravel beautifully assorted and stratified and near the lowest part exposed were bowlders two feet in diameter finely smoothed and rounded. The walls of this pot hole, which was much the shape of a great jug, were as smooth and polished inside as if the sand and gravel, with the pouring in of a torrent, had been on the whirl for a century. A few years later and about twelve rods from the same place, the city, while cutting into the south wall of Main street near the present river channel in order to widen and straighten the street, struck another jug. This last one was more funnel shaped, but had its sand worn bowlders and smooth sides as in the first.

Though not at the southern limit of glaciers in Indiana we are in the line of a terminal morain as indicated by bowlders and till. These potholes may be the result of the glacier having been stationary or nearly so for a length of time.

As a further phenomenon, lately the matter brought to light by a recent railroad cut, and somewhat in the same connection, may be mentioned a line of masses of Clinton limestone which some have supposed to be outliers in situ. These are about two miles southwest from the central part of Richmond and within five minutes walk of Earlham college.

Recent facts seem to indicate that these masses, jutting out here and there for more than three hundred yards, instead of being outliers and in their original place, are really masses of rock moved on for miles by the

glacier. (It is but a few miles north to where Hudson River rock dips under upper silurian.) Evidences that they are masses of Drift are found in the irregular way in which the rocks lie at all angles, and in the fact that where the lower rock is exposed in the cut the under side is glaciated as if by moving over other rocks.

Relation of Kings county traps to those of Cumberland county, N. S. By V. F. Marsters.

An account of vegetable and mineral substances that fell in a snow storm in LaPorte county, Jan. 8-9, '92. By A. N. Somers.

Some points in the geology of Mt. Orizaba. By J. T. Scovell.

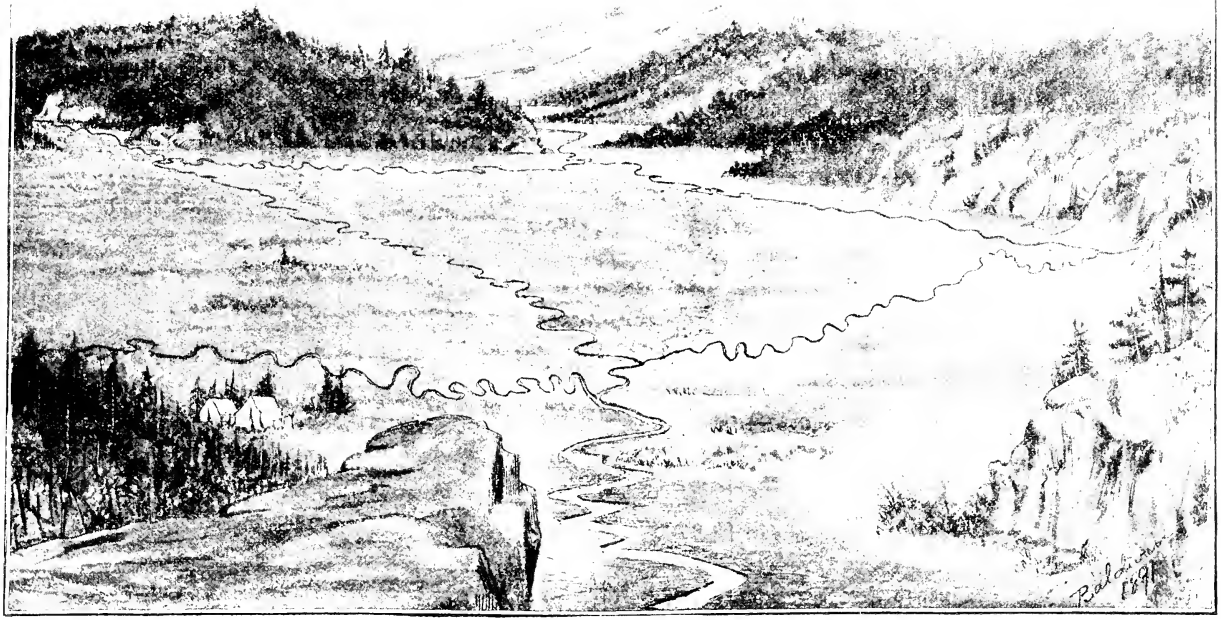
British Columbia glaciers. By C. H. Eigenmann.

An account was given of the ascent of "The Glacier" in the Selkirks in British Columbia. A number of photographs were shown of the foot of the glacier.

Two-ocean pass. By Barton W. Evermann.

[Abstract.]

It was probably in Pliocene times that the great lava-flow occurred in the region now known as the Yellowstone National Park, which covered hundreds of square miles of a large mountain valley with a vast sheet of rhyolite hundreds, perhaps in places, thousands of feet thick. It is certain that such streams and lakes as may have existed there were wiped out of existence, and all terrestrial and aquatic life destroyed. It must have been many long years before this lava became sufficiently cooled to permit the formation of new streams; but a time finally came when the rains,



TWO-OCEAN PASS.

falling upon the gradually cooling rock, were no longer converted into steam and thrown back into the air, only to condense and fall again, but being able to remain in liquid form upon the rock, sought lower levels, and thus new streams began to flow. The rhyolite, obsidian, and trachyte were very hard and eroded slowly, but when the streams reached the edge of the lava-field they encountered rock which was comparatively soft and which wore away rapidly. The result is that every stream leaving the Yellowstone Park has one or more great waterfalls in its course where it leaves the lava-sheet. Notably among these streams are Lewis River, the outlet of Lewis and Shoshone lakes, Yellowstone River, the outlet of Yellowstone Lake, Gardiner, Gibbon, and Firehole rivers, and Lava, Lupin, Glen, Crawfish, Tower and Cascade creeks, all leaving the lava-sheet in beautiful falls, varying from 30 feet to over 300 feet in vertical descent. With scarcely an exception, all these streams and lakes are of the best of pure, clear, cold water, well supplied with insect larvæ, the smaller crustacea, and various other kinds of the smaller animal and plant forms sufficient in amount to support an immense fish-life. But it is a strange and interesting fact that, with the exception of Yellowstone Lake and River, these waters were wholly barren of fish-life. The river and lake just named are well filled with the Rocky Mountain trout (*Salmo mykiss*), and this fact is the more remarkable when it is remembered that the falls in the lower Yellowstone River are 109 and 308 feet, respectively, by far the greatest found in the Park.

The total absence of fish in Lewis and Shoshone lakes and the numerous other small lakes and streams of the Park is certainly due to the various falls in their lower courses which have proved impassable barriers to the ascent of fishes from below; for in every one of these streams just below the falls trout and, in some cases, other species are found in abundance. But to account for the presence of trout in Yellowstone Lake was a matter of no little difficulty. If a fall of 30 to 50 feet in Lewis River has prevented trout from ascending to Lewis and Shoshone lakes, why have not the much greater falls in the Yellowstone proved a barrier to the ascent of trout to Yellowstone Lake? Certainly, no fish can ascend these falls and we must look elsewhere for the explanation.

Many years ago the famous old guide, Jim Bridger, told his incredulous friends that he had found on the divide west of the Upper Yellowstone a creek which flowed in both directions—one end flowing east into the Yellowstone, the other west into Snake River. But as he also told them

about many other strange, and to them impossible things which he had seen, among which were a glass mountain, and a river which ran down hill so fast that the water was made boiling hot, they were not disposed to acknowledge the existence of his "Two-Ocean Creek." Subsequent events, however, showed that the strange stories of Jim Bridger were not without some elements of truth.

Two-Ocean Pass was visited by Capt. Jones in 1873, by Dr. F. V. Hayden in 1878, and by Mr. Arnold Hague in 1884. The observations made by these various explorers seemed to indicate that Two-Ocean Pass is a nearly level meadow, near the center of which is a marsh which, in times of wet weather, becomes a small lake, and that "a portion of the waters from the surrounding mountains accumulate in the marshy meadows and gradually gravitate from either side into two small streams, one of which flows to the northeast, the other to the southwest." (*Hayden.*)

From these reports it began to be suspected that trout, ascending Pacific Creek from Snake River, might in time of high water, pass through the lake in Two-Ocean Pass and descend Atlantic Creek and the Upper Yellowstone to Yellowstone Lake, and thus would the origin of the trout of that lake be explained. Dr. Jordan, who spent some time in the Park in 1889, was impressed with the probable correctness of this explanation, but did not visit Two-Ocean Pass.

In 1891, while carrying on certain investigations in Montana and the Yellowstone Park under the direction of the United States Commissioner of Fish and Fisheries, Colonel Marshall McDonald, I was instructed to visit Two-Ocean Pass and determine definitely the conditions which obtain there.

On August 7, accompanied by Dr. O. P. Jenkins and Mr. Burnside Clapham, we started out from Mammoth Hot Springs with a pack-train of ten pack-horses and eight saddle-horses. Our route led us through all the Geyser Basins of the Park and we reached Two-Ocean Pass August 17, where we remained long enough to make a careful examination. This pass is a high mountain meadow, about 8,200 feet above the sea and situated just south of the Park, in long. 110° 10′, lat. 44° 3′. It is surrounded on all sides by rather high mountains except where the narrow valleys of Atlantic and Pacific creeks open out from it.

Running back among the mountains to the northward are two small cañons, down which come two small streams. On the opposite side is another cañon, down which comes another small stream. The extreme

length of the meadow from east to west is about a mile while the width from north to south is not much less. The larger of the streams coming in from the north is Pacific Creek, and, after winding along the western side of the meadow, turns abruptly westward, leaving through a narrow gorge. Receiving numerous small affluents, Pacific Creek soon becomes a good-sized stream, which finally unites with Buffalo Creek a few miles above where the latter stream flows into Snake River.

Atlantic Creek was found to have two forks entering the Pass. At the north end of the meadow is a small wooded cañon down which flows the North Fork. This stream hugs the border of the flat very closely. The South Fork comes down the cañon on the south side, skirting the brow of the hill a little less closely than does the North Fork. The two coming together near the middle of the eastern border of the meadow form Atlantic Creek which, after a course of a few miles, flows into the Upper Yellowstone. But the remarkable phenomena exhibited here remain to be described.

Each fork of Atlantic Creek, just after entering the meadow, divides as if to flow around an island, but the stream toward the meadow, instead of returning to the portion from which it had parted, continues its westerly course across the meadow. Just before reaching the western border the two streams unite and then pour their combined waters into Pacific Creek; thus are Atlantic and Pacific Creeks united and a continuous water way from the mouth of the Columbia via Two-Ocean Pass to the Gulf of Mexico is established. Two-Ocean Creek is not a myth but a verity, and Jim Bridger is vindicated.

Pacific Creek is a stream of good size long before it enters the pass, and its course through the meadow is in a definite channel, but not so with Atlantic Creek. The west bank of each fork is low and the water is liable to break through anywhere and thus send a part of its water across to Pacific Creek. It is probably true that one or two branches always connect the two creeks under ordinary conditions, and that following heavy rains or when the snows are melting a much greater portion of the water of Atlantic Creek finds its way across the meadow to the other.

Besides the channels already mentioned, there are several more or less distinct ones that were dry at the time of our visit. As already stated, the pass is a nearly level meadow, covered with a heavy growth of grass and many small willows 1 to 3 feet high. While it is somewhat marshy in places it has nothing of the nature of a lake about it. Of course during

wet weather, the small springs at the borders of the meadow would be stronger, but the important facts are that there is no lake or even marsh there and that neither Atlantic nor Pacific Creek has its rise in the meadow. Atlantic Creek, in fact, comes into the pass as two good-sized streams from opposite directions and leaves it by at least four channels, thus making an island of a considerable portion of the meadow. And it is certain that there is, under ordinary circumstances, a continuous waterway through Two-Ocean Pass of such a character as to permit fishes to pass easily and readily from Snake River over to the Yellowstone, or in the opposite direction. Indeed, it is possible, barring certain falls in Snake River, for a fish so inclined to start at the mouth of the Columbia, travel up that great river to its principal tributary, the Snake, thence on through the long, tortuous course of that stream, and, under the shadows of the Grand Tetons, enter the cold waters of Pacific Creek, by which it could journey on up to the very crest of the Great Continental Divide, to *Two-Ocean Pass;* through this pass it may have a choice of two routes to Atlantic Creek in which the down-stream journey is begun. Soon it reaches the Yellowstone down which it continues to Yellowstone Lake, then through the Lower Yellowstone out into the turbid waters of the Missouri; for many hundred miles it may continue down this mighty river before reaching the Father of Waters which will finally carry it to the Gulf of Mexico—a wonderful journey of nearly 6,000 miles, by far the longest possible fresh-water journey in the world.

We found trout in Pacific Creek at every point where we examined it. In Two-Ocean Pass we found trout in each of the streams and in such positions as would have permitted them to pass easily from one side of the divide to the other. We also found trout in Atlantic Creek below the pass and in the Upper Yellowstone where they were abundant.

Thus it is certain that there is no obstruction even in dry weather to prevent the passage of trout from the Snake River to Yellowstone Lake; it is quite evident that trout do pass over in this way; and it is almost absolutely certain that Yellowstone Lake was stocked with trout from the west via Two-Ocean Pass.

GRINNELLIA AMERICANA. By M. A. BRANNON.

Grinnellia Americana is one of the most interesting and beautiful marine plants found along our Atlantic coast. So far as known, it ranges

only from Cape Cod to New Jersey, abounding chiefly in the shore waters of Long Island sound and New York harbor.

This alga attains a length of 50 cm. and a breadth of 10 cm., but this is an unusual size. The ordinary specimen would not exceed 20 cm. in length and 5 cm. in breadth.

This plant attaches itself to the piles of wharves, pieces of decayed wood, and rarely grows on stones and shells. It grows most abundantly 6 to 10 feet below low tide mark. It is a dioecious plant, and also has a non-sexual method of reproduction. The antheridia are small, nearly transparent dots promiscuously distributed in the tissue of the thallus. When liberated, in salt water, the antherozoids are quite active, and while they were not observed fertilizing the female organ, it is safe to affirm that they accomplish a union with the female portion of the plant in the way common to algæ.

The female organ—the cystocarp—is jug shape, with a prominent orifice. The cystocarps are found equally distributed on the surfaces of the thallus which is one cell thick. The interior of the cystocarp is very complicated. It develops from an apical cell. This further testifies that Dr. Schmitz's theory of the origin of the reproductive organs of the red algæ is true—namely, they are terminal growths, or branches of the frond.

Experiments in germinating spores were quite successful. Carpophores were cultivated for several days in salt water. Cell division was rapid and there were young filaments developed containing 16 to 20 cells. The study of spore germination and the development of the young plant is to be continued.

BOTANICAL FIELD WORK IN WESTERN IDAHO. By D. T. MACDOUGAL.

As may be seen by reference to the map, a large proportion of the state of Idaho consists of a triangular mountain mass, with its greatest length from north to south, reaching in places an elevation of 14,000 to 15,000 feet, and including on its eastern border the Bitter Root, Coeur d' Alene and Rocky Mountain ranges.

Botanical explorations have been carried on in the valley of Clark's Fork of the Columbia to the eastward in Montana, in the basin of the

Snake River in southeastern and southern Idaho, to the westward in the Columbian plain in Washington, and in the northern part of Idaho, where the Clark's Fork of the Columbia cuts its way westward through the mountains, but this great central labyrinth is as yet an unknown land to the botanist, nor is he behind his brother zoologist in this matter.

With the purpose of beginning a systematic survey that should finally include this whole region, Messrs. J. H. Sandberg, A. A. Heller and myself, acting under the direction of the Botanical Division of the Department of Agriculture, undertook at the beginning of the last season the exploration of a portion of this territory along the western border of the mountain ranges.

In accordance with this plan, we took the field with a camp outfitted at Lewiston, at the head of navigation of Snake river, in the latter part of April, and worked southward till we struck the Craig Mountains, then swinging around northward, followed the line where the foot hills run down to meet the plain, across the basins of the Clearwater and Palouse rivers, Lake Coeur d' Alene, and Clark's Fork of the Columbia river at its expension into Lake Pend d'Oreille.

This route was chosen because it offered easy access to widely differing areas. To the westward lay the basaltic Columbian plains, with an elevation of 700 to 2,500 feet, with its vegetation made up of plants peculiar to the Pacific coast flora; to the eastward, rising in successive tiers, were the secondary ranges, composed of trachyte, limestone, quartz and granite, reaching an elevation of 7,000 feet, with its wide range of plants comprised in the Rocky Mountain flora.

The difference between these two areas is still further heightened by the peculiarities of the climate. The basaltic plain, during the rainy season, which ends in the latter part of May, supports a dense growth of succulent, broad leaved, rapid growing plants, which mature very early. With the close of the rainy season, the soil dries into dust in a very few days, the earlier growth dies, and is replaced by hardy, coarse, narrow-leaved forms which are capable of enduring the extreme heats of the summer. In the mountains, however, the water supply coming from melting snows and springs is more equable, and we have a greater number of plants which endure throughout the season.

The flora of both regions is characterized by extreme localization. The limits within which a large percentage of the species were collected often comprised no more than a few square yards or a few acres. As examples

may be given Mimulus cardinalis, Castalia Leibergii, Corydalis aurea, Polygonum Kelloggii.

Although the mountain region is very rich in Algæ Lichens Mosses and Hepatics, the conditions for work and character of our outfit made it necessary to confine our attention almost wholly to the Phanerogams and Pteridophytes, although a few lower forms were collected.

In all, ample material of about 1,000 species was brought in, which is fairly representative of the region explored.

THE APPLICATION OF MATHEMATICS IN BOTANY. By KATHERINE E. GOLDEN.

The tendency in the sciences is toward reducing results and conclusions to exactness, as far as possible, and this is as true for botany as for any of the so-called exact sciences. The tendency being toward precision, naturally the use of mathematics is becoming more general in all the sciences, in the solution of problems and the expression of results.

In physiological botany, especially, the use of mathematics is very applicable, for a great many of the principles of physiological phenomena are reducible to the principles of physics and chemistry, which are represented by mathematical formulæ, and when so represented, the conception of the phenomena is simplified, and is divested of much of the mysteriousness that attaches to it, as fundamental principles are often easier of comprehension when reduced to mathema ical formulas. For instance, in studying the absorption of gases by plants, there are so many factors that enter the solution of the problem that the subject is complex to a great degree, but when it is known that the amount of gas dissolved from a mixture is proportional to the relative volume of it in the mixture multiplied by its coefficient of solubility, the quantities of gases that can be dissolved by the cell-sap are known, and a definite basis is obtained from which to start, and to take into consideration other conditions.

To show the estimate that Francis Galton* places on the laws governing the life of plants, in his work on "Natural Inheritance," in trying to arrive at some measurable characteristic by which to determine the reason for the statistical similarity shown in successive generations, he used sweet peas with which to experiment, separating them into groups ac-

*Francis Galton. Natural Inheritance, 1889, pp. 79-82.

cording to size. The experiments were satisfactory, as they gave him the data which he sought, thus enabling him to solve the problem.

That the tendency of botanical work is in the direction of mathematical preciseness is seen in the works of Sachs, Nägeli, Wiesner and many others. Sachs* has worked out cell division in a masterly manner. By means of periclined and anticlined planes he has demonstrated the direction of the cell-divisions in a growing organ, the outline of the organ taking the form of a parabola, a hyperbola, or an ellipse. By this means he has proven that the mode of cell-division depends entirely upon the increase in volume and the configuration of the growing organ, and not upon its physiological or morphological significance. From his work he has formulated two important laws, (1) that the daughter-cells are usually equal to one another in volume, and (2) that the new cell-walls are situated at right angles to those already present.

Previous to Sachs' work it was supposed that it was possible to characterize the true morphological or phylogenetic nature of an organ by the way in which cell-division took place.

Sachs has also studied the growing apex of stems and roots so as to determine the zone of greatest growth. From the tables compiled by him there are certain facts deduced which, when the successive zones are represented by A, N, N − x, the apical zone being A, the zone of greatest growth N, and the last zone of the growing region N − x, are clearly expressed by the formula:

$$A \quad A+1 \quad A+2 \ldots N \quad N+1 \quad N+2 \ldots \quad N-x.$$

The formula indicating the relation of their respective increments.

The following general expression is used by Sachs to express the relative lengths of the different tissues after isolation, where E, C, V, P, stand respectively for epidermis, cortex, vascular tissue and pith:

$$E \quad C \quad V \quad P \quad V \quad C \quad E.$$

The expression also states the relation active tension of the layers, for the greater the compression, the greater will be the length upon isolation.

Nägeli† has demonstrated the movements of bacteria in air and water. He classifies them into groups and applying the general formula for velocity $v = \sqrt{2gh}$, he has deduced the formula $v = \sqrt{\frac{2ghr_1}{r}}$ in which h is

*J. Sachs. Arbeiten des bot. Inst. in Würzburg. 1878. On the Physiology of Plants. 1887, pp. 431-459.

†C. v. Nägeli. Untersuchungen über niedere Pilze aus dem Pflanzenphysiologischen Institut in München. 1882.

the middle vertical diameter of the body, r_1 is the specific gravity of the body, and r the specific gravity of the fluid for the movement in air $v = \sqrt{2gh\frac{(r_1 - r)}{r}}$ for the movement in any liquid.

Wiesner[3] has done a great deal of work in determining the application of the laws for different gases to epidermis with and without openings, at the atmospheric pressure, and pressures above and below that of the atmosphere, and with dead and living, dry and moist membranes. He has made sufficient experiments so that his conclusions, which are expressed by mathematical formulæ in many cases, are general, that is, his formula $\frac{A}{\sqrt{d}}$ in which A represents the absorption coefficient, and d the density of the gas is general for the epidermis, free from stomata, of any plant.

An application of mathematics that one does not often see outside of the statistician's work was made by Dr. Arthur[4] in his work on pear blight. In this there was a set of determinations made as to the succulency of the fruit of the Buffum pear, so as to note the relation between the amount of moisture and the extent of the blight. After the determinations were made, calculations of the probable error in the results were also made, finding the variation in the determinations, and the extreme variation from the mean; using the figures and applying the formula, $= .6745\sqrt{\frac{s}{n-1}}$ in which s is the sum of the squares of the differences between each separate observation and the average of all, and n is the number of observations. This work was done to prove its correctness, as the accuracy of such work had been questioned.

The most general application of graphic mathematics is the rectilinear system of coördinates. This is so simple in the construction of diagrams and so readily understood that a great many people make use of it. Besides, one diagram will show the relation among different sets of data. Take, for example, one of Sachs' diagrams showing plant growth. The abscissæ represents increments of time, the division of the ordinates, the increments in length, the axis of abscissæ represents a certain temperature, and a certain number of the divisions of the ordinates represent a degree a temperature. Then spaces of the diagram are shaded for night. The

[3] J. Wiesner. Versuche über den Ausgleich des Gasdruckes in den Geweben der Pflanzen, 1879. J. Weisner und H. Molisch. Untersuchungen über dis Gasbewegung in der Pflanze, 1889.

[4] J. C. Arthur. 5th Ann. Rep. N. Y. Exp. Sta., 1886, pp. 284-285.

curves of growth and temperature are represented on the same diagram, so that one can easily tell the increment of growth for a given time along with the factors of heat and light. This kind of diagram is especially valuable if the experiment be written in a language that one does not read readily, for the gist of the work can be gotten from the diagram with but little help from the text.

A great deal of mathematical work has been done in phyllotaxy. This work consisted in the first place in imagining a line proceeding from one of the older lateral members, traversing the stem to right or left, so as to include the points of insertion of all the successive lateral members in the order of their age. This line, when projected, horizontally, was called the genetic spiral, but as the line is a helix, its horizontal projection could not be a spiral.

Then in working out the law of the phyllotaxis, a series of fractions were formed, the numerator expressing the number of complete revolutions round the stem, starting from the point of insertion of a lateral organ and extending to the organ directly above it; the denominator expressing the number of joints of insertion of lateral organs passed through. It was discovered that the series of fractions expressing the most common divergences were successive convergents of the continued fraction. $\cfrac{1}{2-\cfrac{1}{1-\cfrac{1}{1-\cfrac{1}{1-}}}}$ etc. and it was supposed that a natural law had been found, but as it is necessary to construct new continued fractions for many of the divergences, this proved fallacious. But as no relation has been found to exist between the method and anything relating to plant life, the method has but little value, except from the mnemonic point of view. Work on this subject was very popular about twenty years ago, as it gave people an opportunity of proving that they knew their mathematics, it being somewhat generally supposed at the time that anyone who could do his mathematics could easily do his other work.

In the latest bulletin* issued from the Ind. Exp. Sta., the subject of which is the relation of number of eyes on the seed tuber to the product, it was found that a relation existed between the eye of the seed tuber and the number of stalks, that is, when the eyes formed an arithmetical series, the number of stalks, per unit of weight, derived from them formed an approximate hyperbolic series. To a scientific person this result means

* J. C. Arthur. Purdue Exp. Sta. Ind., No. 42, 1892.

much, for the results are definite and given in the briefest and yet the most comprehensive manner.

When engineers publish results of experiments, they express the conditions for, and the results of, their experiments by means of mathematical formulæ as much as possible, and the tendency among botanists is to the same practice, for with the great amount of literature that is published annually, the putting the gist of the matter into the most concise and comprehensive form is becoming indispensable.

ON THE FERTILIZATION AND DEVELOPMENT OF THE EMBRYO IN SENECIO AUREUS. By D. M. MOTTIER.

DISTRIBUTION OF THE NORTH AMERICAN CACTACEÆ. By JOHN M. COULTER.

MARCHANTIA POLYMORPHA, NOT A TYPICAL OR REPRESENTATIVE LIVERWORT. By L. M. UNDERWOOD.

HOW A TENDRIL COILS. By D. T. MACDOUGAL.

FORESTRY EXHIBIT OF INDIANA AT THE COLUMBIAN EXPOSITION. By STANLEY COULTER.

NOTES ON CERTAIN PLANTS OF SOUTHWESTERN INDIANA. By JOHN S. WRIGHT.

This report is based upon about two weeks of field work done during the latter part of September, 1892, in the extreme southwestern part of the state, by D. T. MacDougal and J. S. Wright. This region is known as the "pocket" and owing to its peculiar peninsular position has an overlap of a northern and a southern flora.

Notes were made upon the distribution and condition of nearly 200 forms.

Report was made upon a depauperate form of *Rubus ervina* L., found on the Wabash banks.

Among the forest trees special notes were made upon distribution, size, &c., of *Celtis mississippiensis* Bosc.; *Carya olivæformis* Nutt; *Quercus lyrata* Walt.; *Diospyros virginiana* L., and *Taxodium distichum* Richard.

EPIDERMIS AND SPINES OF CACTACEÆ. By E. B. UTLINE.

Before entering upon the revision of Cactaceæ now in preparation under President Coulter's direction at Indiana University, a series of investigations on the minute structure of such material as was then available was made during the winter and spring terms of 1892. It was our purpose not only to learn of the general morphological nature of the family, but also to discover, if possible, any new diagnostic characters that might be of service in the revision. I have therefore selected for presentation only such peculiarities of structure as may prove of most use in specific determination.

Though nearly a year had passed since the collection of the material, it was still green and in good condition, with tissues fresh and distended as in growing specimens—thus making it highly favorable for study. Sixty-five species were examined, represented generically in the following proportions: Mamillaria, 17; Echinocactus, 16; Cereus, 21; Opuntia, 11.

The most striking feature at first sight is the entire absence of true foliage. Naturally, my first inquiry was for some specialized organ or region which should represent, and perform the functions of the missing foliage. The even distribution of stomata and chlorophyll over the entire surface declares the plant itself to be one gigantic and curious leaf so far as function is concerned. However, regarding leaves as devices for increasing surface exposure (expansion of surface formed by the ultimate branching of the fibro-vascular system), I was led to look to the wart-like mamillæ of the genus Mamillaria, and to the tubercles and ribs of Cereus, Echinocactus and certain species of Opuntia as the homologues of leaves. Transverse sections of the tubercles of *Mamillaria macromeris* show fibro-vascular branching similar to that of the leaf,—the chief difference lying in the cylindrical nature of the one as distinct from the flat surface of the other. This conclusion is verified by the position of the flowers and branches, which in nearly all cases proceed from the axils of the tubercles and mamillæ. The genus Opuntia alone is described as having leaves.

The minute, subulate, early deciduous leaves of this genus furnish the nearest approach to true leaves found among our native species.

In all the specimens examined, true epidermal and hypodermal regions occur in sharply defined outline. The cuticular layer is generally thickened and is clearly distinguished from the true epidermal walls. It becomes thinner as it nears the stoma, and is easily traced into the air chamber (?) It completely lines this respiratory cavity, and, as Von Mohl shows, it even sends out open tubes into the adjoining inter-cellular spaces. The range in thickness passes from the very thin, almost imperceptible form seen in *Mamillaria macromeris* to the astonishing thickness of that seen in *Mamillaria* (*Anhalonium*) *prismatica*, where the cuticle is fully ten times the thickness of the true epidermal layer underneath. The stoma in this species communicates with the outer air by a chimney-like canal extending upward and outward through the cuticle. This canal or chimney is beset at three different elevations by sets of four flap like projections which extend out from the wall in such manner as to almost entirely close the orifice. I have failed to find anywhere any mention of these projecting appendages, but conclude that their function is undoubtedly that of accessory guard cells of the *stoma*. They readily expand on application of moisture, which fact in itself is sufficient evidence of their purpose. The outer wall of the true epidermis in this species barely reaches an average development; while the hypodermal region consists of but one layer of moderately thick-walled narrow cells. The only remaining feature of the cuticle worthy of note as a diagnostic character is the undulation of surface, which is displayed in certain species. Prominent elevations occur in *Cereus Greggii*, *Cereus horizonthalonius*, var. *centrospinus*, and in *Echinocactus polycephalus*.

Definitive characters in the true epidermis are not abundant; but, when they do occur, they are distinct and unmistakable. Three species of Opuntia show tangential (?) partitions in the epidermis, breaking it up into two or more rows. *Opuntia phæacantha* has its epidermis thus thrown into eight rows of exceedingly thin-walled cells. A new species of cereus (as yet unpublished) has as high as nine rows of this thin-walled epidermis. Species having two layers are *Echin. polycephalus*, three unnamed species of Cereus from San Louis Potosi, Mex., and a new species of Cereus from Casa Grande, Ariz. The most curious epidermis in the entire collection is that of *Echin longihamatus*. Since there is nothing like it in the entire number observed, it is well deserving of more than passing at-

tention. In other specimens, the epidermal cells when elongated lie in a parallel direction with the line of outer surface. In this case, they are elongated at right angles to the outer surface. Their thread-like walls are contiguous with the cuticle on the outside; while, on the inside, they are bounded by a single hypodermal row. Their only apparent outer wall is the thickened cuticle.

The hypodermal regions seen may be at once divided into two classes. Those of the first and larger class may be characterized as follows: cells irregular, in several layers: walls thick, pitted, collenchymatous. The second class, on the other hand, are thin-walled, regular, and disposed in one layer. Six Mamillariæ and five Cerei will fall under this latter class. The highest number of collenchyma layers is nine, found in *Cereus grandiflora*. The number of rows, shape of cells and relative thickness of walls appear to be constant within the limits of species, and may be of service as determinative characters.

It remains only to mention the calcium oxalate crystals, which are often distributed as constituents of the cell-contents, both in the epidermal and in the hypodermal tissue. These occur in the form of simple, solitary, klino-rhombic crystals, or more frequently in angular, stellate groups. In size, form and position they vary exceedingly, but appear uniform within the limits of the same species. Crystals occurred in every Opuntia and in every Echinocactus examined. In Mamillaria they were frequent, while in Cereus, they were with one exception entirely wanting.

The minute structure of the spines is exasperatingly uniform. The outer, or epidermal cells are usually large and thin-walled, while in the body of the spine the walls are so thick as to entirely close the cell cavities, as is the case in all dense woody tissues. Often there is a gradual transition from one to the other. The important characters are in the outer row of cells. Rough projections partaking of the nature of trichomes, and extending toward the spine tip are common in Cereus and Echinocactus. In Mamillaria the spines are smooth or rarely pubescent, as in *M. pusilla*, *Grahami* and allied forms. Those of the cylindrical and clavate groups of Opuntia are without exception clothed with a semi-transparent, glistening sheath; while those of the flat-jointed Opuntias are naked. Characteristic of Opuntia spines is the conical arrangement of fibers, distinctly seen with the low power objective. Spine fibers of other genera are usually parallel from base to tip, whereas here they are conically arranged with the summits of the cones at the extreme tips and

their bases communicating with the sheath to the rear of the tip and adjacent to it. When the sheath separates from the spine (which happens very early), these ends of the fibers at the base of the cones are slightly lifted from the surface of the spine, forming sharp barbs extending backward on the surface near the tip. This conical barbed structure is likewise common to the sheathless, flat-joint Opuntias, and extends even to the minute and much-dreaded bristles of the same genus. It is this property of conical arrangement that makes the prickly pear group the terror of all who have made its acquaintance.

While many of the characters brought to light in these investigations are artificial as must naturally result in tissues so responsive to environment as epidermal structures, the constancy of character within the same species, together with the requisite variation in features presented by different species, can not but be of service to those engaged in a critical study of the family.

THE GENUS CACTUS. By E. M. FISHER.

The genus *Cactus*, as it stands at present, consists of about 350 species and varieties from North America, of which only twenty-five species and seven varieties have been reported from the United States. All these forms are small, ranging from one-half to three inches in diameter, and are distinguished by their disconnected tubercles.

In this paper it is proposed to consider briefly the history of the genus, and the classification of its species. To give an accurate and satisfactory history of this genus or any of the genera of Cactaceæ is a very difficult thing, because of the meager descriptions and the scarcity of early literature. Taking 1753 (the date of the first edition of Linnæus' "Species Plantarum") as our datum-line, and tracing both backwards and forwards, we reach the following results: In this first edition of the "Species Plantarum," Linnæus published all the Cactaceæ with which he was acquainted under one genus, Cactus, which he subdivided into four groups called *Echinomelocactus* (subrotund), *Cerii* (erect, angular), *Cerii* (creeping with lateral roots), and *Opuntia* (jointed, compressed, proliferous). Previous to this (1737), in the first edition of the Genera Plantarum, Linnæus published *Cactus* as embracing the genus *Cereus* of Jussieu's Acta Gallorum (1719), and *Opuntia* and *Melocactus* of Tournefort's Institutiones (1719). *Melocactus*

of Tournefort, in which we are interested at present, is equal to *Ficoides* or *Ficus* of Commelinus' Hortus Amistel (1697), equal to *Ficoides* or *Ficus* of Plukinet Almag. Botanica (1696), equal to *Echino-melocactus* of Hermannus Hortus Lugdbt. (1687).

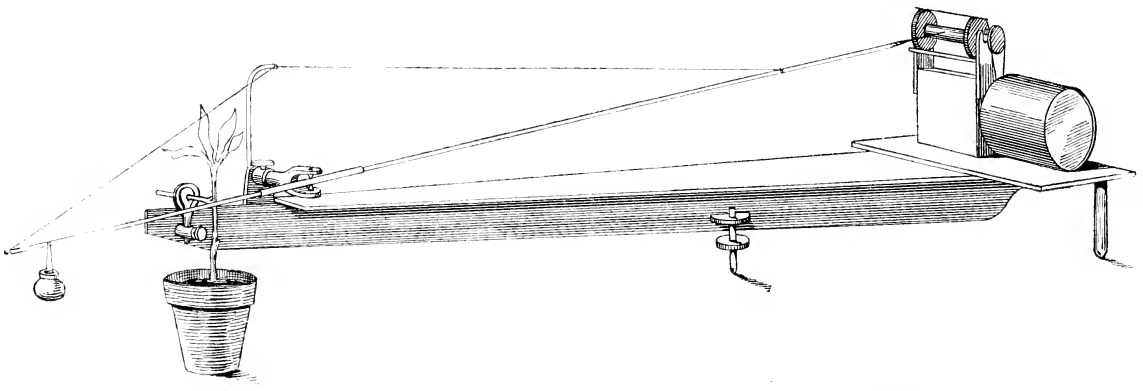
Commencing again with Linnæus (1753), we find that he first described the species *Cactus mamillarius*, which thus seems to stand as the type of the genus. This genus of 28 species was not disturbed until 1812, when Haworth, in his Synopsis Plantarum succulentarum, separated it into five genera, *Mamillaria*, *Echinocactus*, *Melocactus*, *Cereus*, and *Opuntia*, discarding Linnæus' name, *Cactus*. He called *Cactus mamillariis* Linn. *Mamillari simplex* Hawworth, which was the only species of Linnæus that would fall in the new genus *Mamillaria*. At this time (1812), Mamillaria consisted of five species. In 1830 eight species were recognized. This state of affairs was not molested until last year, when Dr. O. Kuntze published his Revisio Genera Plantarum and re-established the Linnæan genus *Cactus*, which thus equals *Mamillaria* Haworth, changing over 300 species of *Mamillaria* to the genus *Cactus*. In summary, we have *Cactus L.*, re-established by O. Kuntze (1891), *Mamillaria* Haworth (1812), *Cactus L.* (1753), *Melocactus* Tourn. (1719) in part, *Ficoides* or *Ficus* Commelinus (1697), *Ficoides* or *Melocactus* Plukinet (1796), *Echino-melocactus* Hermannus (1687).

The revision of the genus *Cactus*, like the other genera of Cactaceæ, is made under great difficulties, because of the lack of types, and insufficient flowering material. Since this is true, and because a specimen is almost useless without flowers, according to the present system of keys, we have attempted with the types at command to revise the genus without using flower characters but by using those parts of the plant which are always present, the tubercles and spines.

SOME CAUSES ACTING PHYSIOLOGICALLY TOWARD THE DESTRUCTION OF TREES IN CITIES. By J. C. ARTHUR.

AN AUXANOMETER FOR THE REGISTRATION OF THE GROWTH OF STEMS IN THICKNESS. By KATHERINE E. GOLDEN.

The main feature of this auxanometer for measuring growth in thickness is a balanced glass arm, supported near one end. The long end has a bristle fastened to it that comes in contact with a blackened glass rod carried round on a brass spool, the spool being revolved by a clock.



THE AUXANOMETER. [Plate loaned by the publishers of the Botanical Gazette.]

The glass arm is supported in a short glass tube that is held between two hardened steel points, the points being adjustable through the arms of a brass *y*. Close behind the steel points is a small fork; this fork, with the glass arm embraces the stem of the plant, the fork permitting an adjustment for large or small stems. These pieces of mechanism are supported by a long wooden beam, that has a beveling near the end supporting the arm. This adjustment is to accommodate plants of varying height.

At the long end of the glass arm, and supported by the beam, is a small wooden platform that in turn supports the revolving spool. The axis of the spool is extended at one end beyond its supports, and carries a grooved pulley, which is connected with a similar grooved pulley attached to the hour hand spindle of the clock by means of a small rubber band. The friction between the rubber and the grooved pulleys, and the uniform tension obtained, precludes slipping.

The way the instrument is used is to place the stem of the plant between the fixed fork and short arm of the glass rod. The distance between the point of contact of the plant and the pivot is $\frac{1}{40}$ of the distance from the blackened glass rod to the pivot, so that any growth of the plant is magnified 40 times on the blackened rod. Thus a growth of $\frac{1}{1000}$ of an inch will be represented by $\frac{1}{25}$ of an inch on the blackened rod.

One of the features of the blackened glass rod is that a permanent record can be obtained by making a print of it on sensitized paper, from which direct measurements can be made.

A STATE BIOLOGICAL SURVEY — A SUGGESTION FOR OUR SPRING MEETING. By L. M. UNDERWOOD.

THE APICAL GROWTH OF THE THALLUS OF FUCUS VESICULOSUS. By D. M. MOTTIER.

SYMBIOSIS IN ORCHIDACEÆ. By M. B. THOMAS.

NOTES ON PEDIASTRUM. W. L. BRAY.

[ABSTRACT.]

Specimens of Pediastrum were kept under cover glass, in moist chamber, for 12 days. In this preparation was observed, in a number of cases, the breaking up and swarming of the contents of a single cell to form new colonies. From a sixteen celled specimen three cells "swarmed," each giving rise to colonies of 32 cells. Inner lamella of mother cell escapes as the enclosing membrane of swarming spores. This membrane increases in size, as did also the spores, while swarming. Spores swarmed with jerky movement about thirty minutes, gradually assuming the symmetrical and permanent position characteristic of the colony, when motion ceased. Protuberances (spines) began to appear on outer circle of cells of new colony in 12 to 20 hours. In one or two cases the enclosing membrane remained 24 hours.

Individual cells of mother colony remained undivided for twelve days, becoming several times the size of their fellows which had swarmed, very turgid and rounded as if growing independently. From another collection one case was observed where contents of a cell broke up into male swarm spores. Not able to be sufficiently observed for more definite statements.

NOTES ON THE GENUS LYTTA. By W. P. SHANNON.

THE GENUS CORALLORHIZA. By M. B. THOMAS.

NOTES ON THE FLORA OF THE CHILHOWEE AND GREAT SMOKY MOUNTAINS. By STANLEY COULTER.

THE NEED OF A LARGE LIBRARY OF REFERENCE IN CRYPTOGAMIC BOTANY IN INDIANA; WHAT THE COLLEGES ARE DOING TO SUPPLY THE DEFICIENCY. By L. M. UNDERWOOD.

BOTANICAL ASSEMBLIES IN THE UNITED STATES ANNOUNCED FOR THE YEAR 1893. By J. C. ARTHUR.

DEVELOPMENT OF OVULE IN ASTER AND SOLIDAGO. By C. W. MARTIN.

THE LILLY HERBARIUM AND ITS WORK. By JOHN S. WRIGHT.

The herbarium, though connected with a pharmaceutical laboratory, does not differ in essential features from that of any college, where the purpose is to do work in systematic botany. While medicinal forms are especially sought for, it is the policy of its supporters to build up a large general plant collection, and to this end collections of plants have been secured from many parts of the world, irrespective of medicinal forms which they might contain. The botanical laboratory maintained in connection with the herbarium is arranged for work in structural botany, with ample equipment for histological work, in the way of microtomes, microscopes and accessories. The laboratory and herbarium have been organized to detect adulterations and substitutions in drugs of botanic origin, and to do research work in botany as it pertains to pharmacy.

NOTES ON ROOT TUBERCLES OF INDIGENOUS AND EXOGENOUS LEGUMES IN VIRGIN SOIL OF THE NORTHWEST. By H. L. BOLLEY.

ADDITIONAL FACTS REGARDING FOREST DISTRIBUTION IN INDIANA. By STANLEY COULTER.

EVIDENCES OF MAN'S EARLY EXISTENCE IN INDIANA, FROM THE OLDEST RIVER GRAVELS ALONG THE WHITEWATER RIVER. By A. W. BUTLER.

ANCIENT EARTHWORKS NEAR ANDERSON, INDIANA By FRANCIS A. WALKER.

Near Anderson, Madison county, Indiana, there is a system of earth works consisting of one large and six smaller ones, the small ones lying south and west of the large one. It is on the south half of Section 16, Township 19 north, Range 8 east, and three miles east southeast of the courthouse.

The principal work is a circular embankment with a ditch on the inside next to the embankment, with an enclosed area, and a small mound in the center of the enclosure. A gateway opens to the south 10 degrees 30 minutes west of the center of the mound, 30 feet in width, as the ditch terminates on each side of it. The work is a true circle 360 feet in diameter and 1,131 feet in circumference, with an area of 2.35 acres. The enclosed part within the ditch is 140 feet in diameter, with an area of .35 of an acre.

The ditch is 60 feet wide, and the embankment at its base 50 feet wide. The entire central area has been filled a depth of 3.2 feet, and the central mound, which is 55 feet in diameter, is 3.75 feet above the central area.

The embankment has an average height of 8.4 feet, with a variance of 3.3 feet, the same not being of uniform height, the highest point being 9.5 feet.

The average depth of the ditch is 6.92 feet, the depth not being uniform, it also varying 3.3 feet, and as compared with the central area is 10.12 feet, with a maximum depth of 11.75 feet. The average distance from the top of the embankment to the bottom of the ditch is 14.96 feet.

Of the smaller works, three are northwest, two southwest and one southeast of the large one. The principal one of these is 195 feet north 70 de-

grees 30 minutes west of the center of the large one. It is oblong and irregular in shape, the center constricted, and has an extreme length from outside to outside of 200 feet, the long diameter being at a bearing of north 56 degrees west.

There is an embankment of irregular height, not to exceed 3 feet, and a ditch within from 1 to 3 feet deep, and a small mound at the west end of the central area. It is 146 feet in diameter from outside to outside at each end of the work, and the constricted part is 142 feet in diameter. The central area is 75 feet at the east end, 85 feet at the west end, and the constricted part only 60 feet in diameter.

Northwest of this work, and 552 feet north 75 degrees 50 minutes west of the center of the large work is a circular mound, without ditch or embankment, 60 feet in diameter and about 18 inches high.

The other mound in this group of three is 64 degrees and 30 minutes west of the center of the large one, irregular in shape and outline and is hard to trace. It is almost contignous to the embankment of the large work, and there now remains but a faint trace of the ditch and embankment.

At a point south 54 degrees 45 minutes west distant 446 feet from the center of the large work is a small one 100 feet in diameter. It is a true circle, with an embankment and ditch within, and a central area of 47 feet in diameter. There is a gateway south 66 degrees 30 minutes east, and from the top of the embankment to the bottom of the ditch it is 2½ feet. This mound is very regular and clearly defined.

South of this one 710 feet south 14 degrees 30 minutes west of the center of the main work is another small work, also 100 feet in diameter. The public road runs through this and has destroyed all but the north embankment, which is about 18 inches from the top of the embankment to the bottom of the ditch within.

Two hundred twenty-five feet south 36 degrees east of the center of the main work is another figure 33 feet in diameter, with gateways at the opposite ends. There is another embankment with a ditch within, and it is about 18 inches from the top of the embankment to the bottom of the ditch.

This group, known throughout the adjoining country as "The Mounds," is on the south bank of White River, on a bluff 75 feet in height. The point of location is the highest in this vicinity, and commands a view of the surrounding country. There is a deep ravine on the west, and one

also east of the works which is about half way between them, the ravines being one quarter of a mile apart. The large work is about 200 feet south of the brink of the river bluff, and one arm of a small ravine north of it comes up close to the west side of the principal work in the group of three. At the base of the bluff and in the east and smaller ravine there are a number of large, bold, running springs of chalybeate water. The bluff is composed of clay, sand and gravel, the sand and gravel being at the base, and out of this the water flows.

"The Mounds," as they are usually called, are in a forest of oak, beech, walnut and ash timber. Some very large trees grew on the embankments; among others, several walnut, which have been cut off. One, four feet in diameter, the stump of which is now gone, grew on the work first described, lying northwest of the large one.

The works still remain covered with a growth of timber in no respects differing from the adjoining forest.

In the bottom of the ditch on the east side of the large work there lies a granite boulder about three feet in diameter, apparently where left when the ditch was being dug.

The river and the ravines on each side afford excellent drainage, and the thick layer of leaves protect the embankment from erosion. The embankments being so heavy, the water that gathers within is not able to force its way through, and no gullies or washes have occurred; in fact, the whole system, especially the large work, is in an excellent state of preservation and seemingly as perfect as when abandoned by the Builders.

About ten years ago, the writer, in company with Dr. Joseph Tingley, then of Asbury University, made an excavation in the center of the mound in the main works. At a depth of about four feet we found a bed of ashes, charcoal, and burned bones, the bones crumbling on exposure to the atmosphere. Dr. Tingley claimed they were not human bones, but of some small animal. We found no stone or any arrangement of the earth in the form of an altar, and the fire seemed to have been there before the mound was built above it. The earth was baked and reddened by the action of the intense heat of the same. Over this the mound was then built as indicated. We dug down about two feet below this stratum, but found no further evidence of fire or any unusual arrangement of earth, nor any evidence that the same had been disturbed, further than in the construction of the central area, which had been filled as before mentioned.

Directly north of the main work on the side of the bluff, about ten feet above low water mark, is an outcropping of hard pan, under which one can enter for a short distance through an opening.

In the neighborhood of the Mounds there is a tradition that there is a cave underneath this hard pan, connected with the works. The writer has not been able to find any one who has any definite knowledge about it, and upon examination of the same himself, this opening seemed to be nothing more than a fox hole in the gravel underneath this outcropping.

These earth works have an excellent location as a pleasure resort. They are located in a forest of about 100 acres. On the north side of this forest flows White River, and on the south is the road leading from Anderson to Muncie. The Big 4 Railroad runs about a quarter of a mile south of the forest, and in the summer time there are frequently excursions from Anderson, Muncie and points along the Big 4.

The real estate on which these works are located belongs to parties who have no knowledge of their worth as pre-historic remains, and who value them solely from a commercial standpoint.

The city of Anderson has extended in this direction about one and one-half miles, and the purchase of this real estate has been in contemplation by parties who proposed converting the same into a pleasure resort, and there is a possibility, as it is located so near the city, of the grounds passing into other hands, the forest being cleared away and changes made in the original outlines, and the value of these works, as pre-historic remains, destroyed.

It is not the object to advance any theory or to speculate upon the purpose of the builders of this system of earth works, but to give data and facts as to their form, size and location, so that should anything occur by which they would be changed or destroyed, these facts might be preserved.

In addition to the measurements above given, drawings, maps and cross sections have been made and photographs taken.

The writer, with Dr. J. M. Coulter and W. S. Ellis, visited these works, and while there, Dr. Coulter suggested that such action be taken, and it was done at his suggestion.

There is a further purpose in this paper that facts may be presented to this body and an interest created, and if these works are found of sufficient importance, steps be taken, looking to their preservation. In their locality, they are looked upon simply as a curiosity, with little thought of

their real worth. A few, however, are manifesting an interest, and are ready to co-operate with this body in anything that may be done, either in the way of securing further facts or preventing their destruction.

ARCHEOLOGY OF TIPPECANOE COUNTY. By O. J. CRAIG.

DESCRIPTION AND ELEVATION OF MOUNT ORIZABA. By J. T. SCOVELL.

THE CLIMATE AND GLACIERS OF MOUNTS ORIZABA AND POPOCATEPETL. By J. T. SCOVELL.

SOME INDIAN CAMPING SITES NEAR BROOKVILLE. By A. W. BUTLER.

REMARKABLE PREHISTORIC RELIC. By E. PLEAS.

THE BRUNS' GROUP OF MOUNDS. By H. M. STOOPS.

THE MOUNDS OF BROOKVILLE TOWNSHIP, FRANKLIN COUNTY, INDIANA. By H. M. STOOPS.

REMARKS ON ARCHEOLOGICAL MAP MAKING. By A. W. BUTLER.

EXPLORATIONS IN WESTERN CANADA. By C. H. EIGENMANN.

[ABSTRACT.]

An account was given of explorations undertaken under the auspices of the British Museum from Winnipeg to the Pacific coast, and from Portland, Ore., eastward. The headwaters of the following rivers were crossed and their fish faunas compared: The Red River of the North, the Saskatchewan, the Columbia, the Fraser, the Missouri. About twenty per cent. of the species collected were new to science. The most interesting of these was a new genus of *Percopsida*, *Columbia* from Oregon. Several species not before taken on the Western slope were obtained. It was noticed that the number of fin rays of Pacific slope fishes was increased over their Atlantic slope relatives, or else some of the rays were modified into spines, as in the case of Columbia and Meda.

NOTES ON THE LOSS OF THE VOMERINE TEETH WITH AGE IN THE MALES OF THE SALAMANDER, DESMOGNATHUS FUSCA. By F. C. TEST.

THE WORK OF THE U. S. FISH COMMISSION STEAMER ALBATROSS IN THE NORTH PACIFIC AND BERING SEA IN 1892. By B. W. EVERMANN.

[ABSTRACT.]

Last winter a treaty was entered into between the governments of the United States and Great Britain, in which it was agreed to leave the various questions in dispute regarding the fur-seal fisheries to a board of arbitration, which will meet at Paris next March.

Very soon after the signing of this treaty, the State Department requested the Commissioner of Fish and Fisheries to undertake the collecting of information regarding the fur-seal of the North Pacific and Bering sea.

It was very soon arranged that the Fish Commission should undertake the work, the U. S. Fish Commission steamer, *Albatross*, then as now, on the Pacific coast, was detailed for the purpose, and it fell to my lot to be sent out as Senior Naturalist of the scientific staff of the *Albatross* to have immediate charge of the proposed investigations.

It was within the scope of the investigations to study the movements

of the seals during their return in the spring to their breeding grounds, to note the position of the herds from day to day, whether the two sexes and the younger seals all traveled together or in separate herds; we were also to determine experimentally the relative effectiveness of the different methods of killing the seal at sea, the percentage of seals lost by each method, the percentage of males, females, or young killed in indiscriminate hunting; a study was also to be made of their food and food-habits; in short, attention was to be paid to everything which would throw any light upon the natural history of this valuable animal.

I joined the *Albatross* at Port Townsend, Washington, March 27, and four days later we steamed through the Straits of Fuca and began our investigations in the North Pacific. At this time it is not proper that the details or results of the work should be given. Suffice it to say that the investigations and studies of seal-life were continued until September, and that during that time the *Albatross* was pretty well over the North Pacific and Bering Sea, and made special visits to a number of points on the mainland of Alaska as well as to numerous islands. Among the places visited may be mentioned Sitka, Prince William Sound, Cook's Inlet, Kadiak, various islands of the Aleutian chain, the Commander Islands only eighty miles off the Asiatic coast, and the Pribilof Islands, where are situated all the breeding grounds of our fur-seal, and where I spent two weeks studying the seals upon the rookeries.

The report upon the entire summer's work of the *Albatross* concerning the seal is now in the hands of the State Department, and cannot now be made public; but while carrying on this work opportunities occurred for making collections in other lines of natural history, and I was, of course, not slow in availing myself of them.

The collection of fishes is quite large, and contains a number of interesting species from Sitka, Unalaska, Atka, Attu and Bering Island.

Among these is a very fine series of the Atka mackerel, *Pleurogrammus monopterygeus*, an important food-fish, hitherto but poorly represented in museums.

An important collection of birds was also made, a part of which collection—the ptarmigan—is treated in another paper.

Several hundred plants were collected, chiefly at Unalaska, the Pribilof Islands, and Sitka.

All these collections are now being studied, and will be reported upon in due time.

EARLY STAGES IN THE DEVELOPMENT OF CYMATOGASTER.* By CARL H. EIGENMANN.

The investigation of which this is an abstract has been conducted with various intermissions since December 1888. I present here simply the result. The proof for any one of the propositions would take up more than the time allotted for all of them. The details with all necessary figures will be published during the year by the U. S. Fish Commission.

A large per cent. of the California fishes bring forth their young alive. The members of one family of these fishes, the *Scorpenidæ*, bring forth many thousands of young in a very immature condition. The members of the other family, the *Embiotocidæ*, bring forth comparatively few young, 3–80, but these are sometimes an inch or two in length and resemble the parent as much as the new born mammal resembles its parent. It is this family which is of great interest and to which I devoted most of my time. After examining many of the species just before and during gestation I selected *Cymatogaster* for a special study, because the peculiarities have become most marked in this species. The results are as follows:

1. Copulation takes place in July. This statement is based on the fact that the testes of the male are very much enlarged at this time and on the fact that the ovaries from now on are filled with spermatozoons. The act of copulation has not been observed.

2. The secondary sexual differences are considerable—among them may be mentioned a small gland or bag on either side of the anal of the male. From it extends a papilla forward to beyond the anterior margin of the fin.

3. The spermatozoa have a long rod-shaped head in place of the globular one usual in fishes.

4. The spermatozoa remain dormant in the ovary till December when they become exceedingly active.

5. The eggs mature and are fertilized between November 1st and February 1st, the largest fishes maturing the eggs earliest, the next in size a little later and the smallest individuals last.

6. Those spermatozoa not utilized in fertilization remain in the ovary for several weeks longer. They are finally eaten by the larvæ when the digestive tract of the latter has been sufficiently developed.

7. During the early stages of gestation the females remain in shallow

* I have hitherto referred to this fish as *Micrometrus*. A re-examination of the literature bearing on the subject proves that this name is not available.

water; males are then rarely seen. Later they become scarce but near the time the young are freed and shortly afterwards they are again found in shallow water.

8. The largest ovarian eggs measure about .3 mm. in diameter. During the process of maturation the egg contents shrink to a diameter of .2 mm. or to less than one-third of its maximum size.

9. The egg of this fish, *Cymatogaster aggregatus*, is 130 times smaller than the normal fish egg which has an average diameter of 1 mm.

10. This small size is largely if not entirely due to the non-formation of deutoplasm.

11. The egg is fertilized while still in the follicle. Some sections show the extrusion of the second polar globule and the presence of the male pronucleus in an egg still surrounded by the cells of the follicle. The latter have begun to degenerate.

12. The development begins after the egg has been freed from the follicle. Eggs with one, two, four, eight and sixteen cells as well as many later stages were found free in the ovary.

13. Neither the developing eggs nor the young are in later stages at any time connected with the parent nor is the position of these in relation to the ovarian structures a fixed one.

14. The duration of gestation is probably five months and the number of young from three to twenty according to the size of the parent. In less than a year after birth the young are with young.

15. The food of the young is supplied by the epithelium of the ovary. The cells enlarge and become clear, when they collapse, their contents are emptied into the lumen of the ovary and the framework of the cells soon follows. When the intestine begins its work the spermatozoa serve as part of the food. The ovary at no time was observed to contain more fluids than the peritoneal cavity. (In other species considerable fluid is sometimes present.) Before the development of the alimentary tract the ovariarn fluid is probably appropriated by a process of intercellular digestion on the part of the epidermal cells.

16. The yolk is a waning structure and can scarcely be taken into consideration in accounting for the growth of early stages.

17. During the whole of gestation respiration is carried on by the osmotic action between the general surface and the closely applied ovarian structures. When the alimentary tract is opened a current is kept flowing through it and aeration is, in all probability, effected by the ali-

mentary tract. In later stages the fins become highly vascular and doubtless serve both for purposes of aeration and food absorption.

18. There is present in the entodermic pole of the developing egg a body the like of which has not been observed in any other egg. It consists of a mass of protoplasm imbedded in the yolk. It is dissolved near the time of the closing of the blastopore. Mr. J. W. Hubbard, one of my students, has connected its history with that of the yolk nucleus which is a conspicuous structure in the ovaries of adult fishes in egg from 20 μ up to maturity. It is a general extrusion from the nucleus of the young ovum and probably represents the histogenetic or somatic portion of the nucleus and this in part at least corresponds to the macronucleus of ciliate infusoria.

19. Before segmentation begins the whole of the germ is separated from the deutoplasm. The first cleavage plane extends entirely through the germ to the yolk before the second cleavage begins.

20. A segmentation cavity is not formed during segmentation but appears later by a separation of the ectoderm and entoderm.

21. The third cleavage plane is not parallel with the first as is usual in fishes, but is semi-equatorial. This has nothing to do with the horizontal cleavage claimed to have been seen by Hoffman and by Brook. It is taken to be a pseudoreversion to primitive methods of segmentation with the reservation that this condition is not perfectly homologous with the third segmentation of the frog or *Branchiostoma*, and would not be had the yolk entirely disappeared.

22. The periblast is formed from a few of the marginal cells. Like the yolk it is a waning structure. Only about 12 cells are ever formed. They take no part whatever in the formation of the embryo. All of them persist as long as a trace of the yolk is left. It, with the final part of the yolk, is absorbed by the blood of the sinus venosus. The liver has nothing to do with its final absorption as Wilson has claimed but simply mechanically encloses the nuclei above and behind.

23. During an early stage of segmentation some of the marginal cells of the blastoderm creep over the yolk till they nearly if not entirely cover it.

24. Before gastrulation the yolk sinks into the mass of the blastoderm the cells of which re-arrange themselves about it and nearly enclose it.

25. The gastrula is finally formed by a process of delamination of en-

toderm from ectoderm and is completely diplastic and symmetrical, the blastofore closing at the entodermic pole of the egg.

26. Before any other organs become evident the sex cells become conspicuous. Their fate I have discussed elsewhere.

27. The earliest stages of the formation of the embryo have not been clearly made out with the material at hand. It is, however, certain that in one of the figures published by me in the "Journal of Morphology," I mistook the tail for the head. The conditions are extremely similar to those found in the mammalian embryos, except that the central cavity is filled with yolk instead of fluid.

28. The mesoderm is formed by a process of delamination from the entoderm. It is formed as two sheets and over the whole of the entoderm exclusive of the axial line.

29. The young fish is freed from its membrane in a very immature condition. It completely encircles the yolk; in fact the head and the tail overlap. It is incapable of motion at this time and indeed the cells which will form the muscles have scarcely become differentiated. The hatching process is due to the growth of the embryo and not to its activity as is usually the case. The fin folds do not appear till much later.

30. Kupffer's vesicle appears very early and is very large. It consists when fully formed of a dome-shaped roof over a large cavity surrounded on the sides by entoderm. It at first rests on the yolk but soon the yolk is forced down and presents a deep impression just beneath the vesicle. Later the vesicle is divided into three distinct cavities. The upper dome-shaped portion persists for some time and probably represents part of the neurenteric canal. The middle portion remains for some time as an enlarged part of the intestine. The lowest portion is the cavity formed in the yolk. It has acquired a roof by the ingrowth of the entoderm cells to form the floor of the intestine. This cavity usually remains for a considerable time.

31. The entoderm at first extends over the entire yolk. It later becomes restricted to a comparatively narrow strip along the axial line.

32. The floor of the alimentary canal is formed by the ingrowth below of the marginal cells of the entoderm. The ingrowth progresses from in front back. A lumen is not formed at once. The lumen is formed in the hind gut and in the gill region at the same time and gives abundant evidence that the alimentary tract is bilateral. The middle anterior part remains a solid mass of cells after the lumen has appeared both in front and behind this tract.

33. The anterior opening of the alimentary canal to the exterior is through the gill slit in larvæ 1 mm. in length, *i. e.* long before the mouth is formed. The first food enters through this gill slit. The food current before the fish can swallow is kept up by a very highly ciliated gullet which extends from behind the gill region to near the hind gut.

34. The mouth does not appear till the larva has increased 3 mm., *i. e.* to a length of about 4 mm., and during all this time the hyobranchial gill slit functions as mouth. There is here found a condition similar to the one supposed by Dohrn to explain the replacement of the annelid mouth by a gill mouth.

35. Just in front of the notochord and near the region of the hyobranchial slit a strand of hypoblast cells extends up from the median portion of the alimentary tract to above the notochord. This strand of hypoblast cells lies in the region where Dohrn supposes the annelid œsophagus to have disappeared.

36. The hind gut soon becomes enormously enlarged and later a large number of long villi are developed.

37. The larvæ retain as an ancestral trait a large yolk sack, the yolk being quite minute. The sack is largely taken up by the large pericardium through which the long tubular heart extends from below and behind, upward and forward.

38. In conclusion: The fish in almost all its stages has become highly specialized. Many stages resemble very closely primitive conditions but the conditions can probably in but few cases be looked upon as a simple reversion. Its development has, on the other hand, become extremely ichthyized and its egg stands at the end of the chain of eggs in which the *Branchiostoma* egg, the *Elasmobranch* egg and the *normal fish* egg form links.

THE CONTEST AGAINST INFECTION. By THEODORE POTTER. Published in The Cincinnati Lancet Clinic, Aug. 6, '92.

SOME STRUCTURAL PECULIARITIES OF PACIFIC SLOPE FISHES. By A. B. ULREY.

THE YOLK NUCLEUS. By J. W. HUBBARD.

PECULIAR DEATH OF AN ORIOLE. By T. B. REDDING.

THE RANGE OF THE CROSSBILL IN THE OHIO VALLEY, WITH NOTES ON THEIR UNUSUAL OCCURRENCE IN SUMMER. By A. W. BUTLER.

In 1838 Dr. Kirtland had not met with the American Crossbill (*Loxia curvirostra minor*) in Ohio and Indiana. Dr. Haymond omitted it from his "Birds of Southeastern Indiana" in 1856. Dr. Wheaton reported it from Ohio in the winter of 1859–60. Evidently it was quite well known to Dr. Haymond in 1869. The winter of 1868–9 they were very abundant in the vicinity of Cincinnati. (Charles Dury.) This was doubtless the case at other places also. The range of the species at this time was supposed to be northern North America, south in the Appalachian mountains into Pennsylvania, extending in winter, irregularly over much of the United States. A letter from Mr. C. E. Aikin, of Salt Lake City, Utah, informs me that this species became very abundant in the city of Chicago in July and August 1869, and remained until late in the fall. They fed greedily upon seeds of sunflowers and were so sluggish that one could approach within a few feet of them so that they fell an easy prey to boys with catapults. In the latter part of August of the same year, he found them common in Lake county, Indiana. He also notes that they were not rare the succeeding year in the vicinity of Chicago. Dr. F. W. Langdon notes the capture of a single specimen from a flock of six or eight at Madisonville, near Cincinnati, O., Nov. 30, 1874. In the winter of 1874–5 Mr. Eugene P.

Bicknell noted these birds were present in the lower Hudson valley, and in April of the latter year found their nest. In the same article is noticed the occurrence of the species about New York City in late spring and early summer; on Long Island in midsummer, and on the Bermudas from March to May. Bull. Nutt. Orn. Club, Vol. V., pp. 7–11.) Mr. E. W. Nelson in his paper on "Birds of Northeastern Illinois," read before the Essex Institute, December 4, 1876, says it was "formerly a common winter resident; now rare." Messrs. Dury and Freeman (Journ. Cin. Soc. Nat. Hist., 1879, p. 4), note its occurrence at Westwood, O., in 1879. Dr. J. M. Wheaton (Bull. Nutt. Orn. Club, 1879, p. 62) gives the following account of the occurrence of the species in Ohio: "On the 18th of June last, Mr. Charles Hinman killed one of these birds out of a flock of eight or ten which visited the coniferous trees in his garden in this city (Columbus). The specimen, which came into my possession by the kindness of Mr. Oliver Davie, was a male, not in full plumage. I have since learned that the Red Crossbill has remained during the season in the vicinity of Cleveland in considerable numbers, and is reported to have nested there." In commenting on this note (Ohio Geol. Survey, Vol. IV., Zoology and Botany, p. 317), Dr. Wheaton says: "I was unable to learn whether its nest had been actually discovered," and adds: "It has been known to nest in Indiana within a few years." I regret very much that I have been unable to get any clue whatever to the authority upon which this statement is made. Prof. A. J. Cook in writing of the Birds of Michigan says of the American Crossbill: "Occasional in summer. Dr. H. A. Atkins took nests of this species at Locke, July 13, 1880." It had previously been reported as breeding in Minnesota. In July and August, 1880, they were noted at Rugby, Tenn. (The Oologist, Vol. V., pp. 78–9; Bull. Nutt. Orn. Club, Vol. VI., pp. 56–7.) Dr. C. Hart Merriam notes it as an "abundant resident" in the Adirondack region. He says it is "rather scarce and irregular in summer, but the commonest bird in winter and early spring. Breeds in February and March while the snow is still four or five feet deep on the level and the temperature below zero (Fahr.). Have taken full fledged young in April." (Bull. Nutt. Orn. Club, Vol. VI., p. 229.)

Mr. C. W. Beckham (Birds of Nelson County, Kentucky; Ky. Geol. Surv., p. 24), says: "A flock of six or eight of these birds appeared here on November 18, 1882 on some pine trees, the first time I had ever observed them. They remained only a day or two, and none were seen until the 17th of March following, when I shot eight out of a flock of about twenty,

in the same place where they had previously been seen. Several flocks were observed about the same time near Bloomfield and Glenville in this county, and excited considerable comment on account of their queer bills. The weather at the time was quite mild, so that their appearance here was probably due to some other cause."

The winter of 1882–3 they were unusually abundant in many localities between the great lakes and the Ohio river. Prof. B. W. Evermann first observed them at Bloomington, Indiana, February 10, 1883. This was the second record for the state. For some time after they were common in Monroe county. March 15, 1883, Mr. E. R. Quick reported having seen a single specimen near Brookville, Indiana. April 2, my attention was attracted to a peculiar crackling sound which came from among the pine trees in my yard at Brookville. Close investigation revealed the fact that the cause was a lot of Crossbills. They were shelling the seeds out of the pine cones and the breaking of the cone scales made the sound which attracted my attention. I observed others were upon the ground feeding upon the seeds of the fallen cones. April 3 I saw six more in my yard. April 4 I saw one in a flock of Pine Finches. April 5 Mr. Quick noted one. Of those observed but one was in the red plumage. Prof. B. W. Evermann saw a few at Delphi, Carroll County, Indiana, the middle of March, 1883. At the same place about twelve were seen December 26, 1884. Mr. J. W. Byrkit informs me that they were very abundant at Michigan City, Ind., in the winter of 1883–4. Miss H. E. Colfax, in her report of the bird noted at the light house, at the same place, gives it January 16, 1884. In the winter of 1883–4 Prof. Evermann reported them very common in Monroe County, Ind. The Ornithologist and Oologist, Vol. VIII., p. 68, contains an account by A. H. Helme of their breeding April 10, 1883, near Miller's Point, L. I. Mr. Robert Ridgway (The Auk. Vol. I., p. 292), notes the probable breeding of the Red Crossbill in central Maryland in May, 1884. Mr. F. C. Brown reported their breeding in Eastern Massachusetts in the summer of 1884 (The Auk., Vol. II., p. 105). In the winter of 1884–5 they were tolerably common in Monroe county, Ind. (W. S. Blatchley, Hoosier Naturalist, 1886, p. 170). The late Mr. C. H. Bollman noted them "quite common," in the same county through March, April and early May 1885. He saw them first March 2, and last observed them May 12. Mr. J. W. Byrkit informed me that he saw the first Crossbills for the year March 24, 1885. He adds: "I am not quite positive but think the Crossbill breeds here (Michigan City), as they make their appearance about this

time and leave for the north about the middle of May." Mr. Charles Dury informed me they were abundant at Michigan City, Ind., one winter, which he thinks was 1885. He also reported Pine Finches and Redpolls from the same locality the same year. Prof. B. W. Evermann reported it from Carroll County, Ind., March 27, 1885. I am indebted to Mr. E. M. Kindle for the information that Mr. Sam Hunter reported a pair of American Crossbills to have bred at Bloomington, Ind. in 1885. Mr. Hunter informed him they nested in a pine tree and that the nest was made exclusively of pine burrs. Mr. R. R. Moffitt informs me that Red Crossbills were taken in Tippecanoe County, Ind., in 1885. He says they nested there. Prof. B. W. Evermann noted them at Camden, Ind., March 27 and April 13, 1885, also a large flock at Burlington, Ind., April 23, 1885.

Mr. Wm. Brester reported its occurrence in the mountains of Western North Carolina in the summer of 1885 (The Auk., Vol. III., p. 107) and says: "Seen only on the Black Mountains where it was numerous in small flocks throughout the balsam forests above 5,000 feet. At Highlands I was told that it regularly appeared in winter about the outskirts of the town." Mr. Charles W. Richmond (The Auk., Vol. V., p. 22), gives upon the authority of Mr. Hugh M. Smith, the information that an adult male American Crossbill, accompanied by a young bird, was seen May 17, 1885, within the District of Columbia. Prof. L. L. Dyche reports the occurrence, in the winter of 1885–6 of the Western Red Crossbill, *Loxia curvirostra stricklandi*, at Lawrence, Emporia, Manhattan and Wakarusa, Kan. They were first observed November 1, 1885, and were last seen January 26, 1886 (The Auk., Vol. III., pp. 258–261). The following winter I was fortunate in securing, through the kindness of Mr. A. O. Garrett, a series of specimens of *Loxia curvirostra minor* from Lawrence, Kan. March 13 and 14, 1887, he obtained four which he sent me, and later he sent me nine others which were taken March 24 and 25. The meeting of the range of these two forms is of considerable interest. Prof. B. W. Evermann reports a crossbill, species not determined, from Bloomington, Ind., February 23, 1886, and another March 8, 1886. The same authority states the late Mr. C. H. Bollman found a few specimens of the Red Crossbill near Bloomington, Ind., July 10, 13 and 14, 1886. Mr. Arthur P. Chadbourn says, in the summer of 1886 it was found in the White Mountains, N. H. (The Auk., Vol. IV., p. 105). Mr. George B. Sennett, in the same volume, p. 242, gives an account of finding this species in

the mountains on the borders of North Carolina and Tennessee in July and August 1886. Mr. Arthur T. Wayne, in the same volume, pp. 287–289, notes their abundance near Yemassee, S. C., in November and December, 1886, and in January and February, 1887. He noted them again in the same vicinity November 20, 1887 (The Auk., Vol. V., p. 115), also during January, 1888 (Ibid, p. 208). Mr. Frank M. Chapman also reports them from Aiken, S. C., November 12, 1887, (Ibid, p. 324). Mr. G. G. Williamson observed them in Monroe County, Ind., January 18 and February 6, 1886. Mr. J. G. Parker reports them from Lake County, Ind., in May, 1887. In the fall of 1887, I again observed them at Brookville, Ind. They came to feed among the pines in my yard. October 29 several were seen and they last appeared November 19. Prof. Walter Faxon and Dr. J. A. Allen give it as common in the White Mountains, N. H., in July 1874, June 1885 and June 1886 (The Auk., Vol. V., p. 152.) Dr. J. A. Allen on the next page of the same number of "The Auk," speaks of a pair of American Crossbills taken at Mandeville, La., March 27, 1888. Prof. B. W. Evermann found them in Vigo County, Indiana in the spring of 1888. They were first seen February 6 and disappeared May 6. Mr. J. O. Snyder found them at Waterloo, Ind., March 13 and 17, 1888. Mr. H. N. McCoy informs me they were quite common in Wayne county, Ind., in the early part of 1888. They were last seen April 5. Mr. G. G. Williamson saw six or eight individuals near Muncie, Ind., April 17, 1888. May 4 he saw three others. Mr. Otho C. Poling notes their occurrence in Adams county, Ill. He gives no account of their occurrence in summer (The Auk., Vol. VII., p. 239). Mr. John A. Balmer, informs me these Crossbills were found in the vicinity of Vincennes, Ind. in the winter of 1888–9. Mr. J. F. Clearwaters told me of the capture of two of these birds in Putnam county, Ind., in the winter of 1888. A flock of American Crossbills was seen by Mr. J. O. Snyder at Waterloo, Ind., April 27, 1889. Mr. Stewart E. White informs me he found them common on Mackinack Island, Mich., August 3 to August 9, 1889. Mr. H. W. McBride wrote me of taking three specimens at Waterloo, Ind., April 2, 1890. February 14, 1891, Mr. Stewart E. White saw six at Grand Rapids, Mich. He next noted the species March 16. He says it is quite rare in that vicinity. Mr. J. F. Clearwaters gave me the following account of their occurrence in Putnam county, Ind.: "On July 27, 1891, Jesse Earll was down beside the old mill pond, where we collect all our water birds, and noticed five birds on the ground, apparently probing in the mud with their bills. As they

rose he shot one which proved to be a male Red Crossbill in breeding plumage. He preserved the skin and still has it. The others were females or young, as he says none of them had any red on them."

Mr. Jonathan Dwight reported the American Crossbill on North Mountain, Penn., in June, 1891. (The Auk. Vol. IX., p. 137.) Dr. B. H. Warren, in his admirable "Report on the Birds of Pennsylvania," p. 228, gives it as breeding in the counties of Clinton, Clearfield, Luzerne, Lycoming and Cameron in that state.

March 1, 1892, Messrs. A. B. Ulrey and E. M. Kindle report seeing six in Monroe county, Ind. Mr. G. G. Williamson noted six near Muncie, Ind., April 16, 1892, and another April 24. Messrs. Charles D. and Lewis A. Test have kindly sent me the following interesting notes from the observations of the spring of 1892. The notes were taken near Lafayette, Ind. March 8, 1892, they saw the first American Crossbill. They were seen on the following succeeding dates: March 11; April 15, 19, 23 and 30; May 1, 3, 6, 8, 18, 20, 21, 27 and 30; June 2, 6, 22, 23, 27 and 30. The birds were seen in pine trees and also in yards and along the road. Search was made for nests but none were found. I am indebted to Mr. Otto Widmann for some valuable notes relating to the American Crossbill in Missouri last winter and spring and summer (1891–2). He says: "I never suspected these cone loving nomads to descend into a country so flat and uninteresting as St. Louis county, Mo., where nature never rears a cone without the help of the gardener. Thousands of young evergreens, especially Norway Spruces, have been planted during the past decade, but old cone-bearing conifers are few and far between. There are on my place, besides a few Norway Spruces, eighteen pine trees about thirty years old. Half of them are Austrian pines, the rest White and Scotch pines. Coniferous trees do not bear fruit every year, but last winter the Austrian pines were full of cones, getting ready to drop the seeds in early spring. Besides the maturing pine seeds our section had another attraction for erratic fruit eaters in the orchards. The apple trees had yielded an enormous crop and the demand not being sufficiently great to gather them in time, thousands of apples were still hanging in the trees when the Crossbills appeared on the scene. It was in the orchard that they made their appearance on November 13—the day after the first 'blizzard' had visited the upper Missouri valley. From this day on, the Crossbills remained in the neighborhood until the end of the month but none were here in December and January—at least I did not notice any until they began to

visit my pine trees in February. They were daily visitors all through March and until the 17th of April. From that day until May 8th none were seen, but from the 8th to the 14th they were again daily callers. After this date they were noticed twice; a party of six on June 5th, and two birds a male and female, in one of my pines on July 21st. I looked for their nest in the tree but, unfortunately it was not there! I think now that I have met with the species on several occasions in former years but did not know them. Frequenters of private gardens they were only seen when on wing or distant tree tops, and evaded identification. With us it is a shy and restless bird, easily alarmed and flying a great distance. Before taking wing and while in the air they are quite noisy with a note closely resembling the parent call of *Progne*; but when feeding in a pine tree the whole troop keeps perfectly silent, and nothing is heard but the noise made by breaking the cone scales. When present in May they are also feeding in elms." Mr. W. S. Blatchley gives me the following notes: "While sitting on the porch of a farm house in Putnam county, Indiana, July 11, 1892, I saw a single Crossbill, *Loxia curvirostra minor*, alight in the top of a pine tree in the yard and begin searching the cones for seeds. I watched it for almost ten minutes and then, that there might be no possibility of mistake in the identification, procured a gun and shot it. It proved to be a young male. On July 15 another young male, *i. e.* a male presumably of the previous year's hatching, was secured from the same tree and kept in confinement for several days, but was finally allowed its liberty."

The American Crossbills have, as has been shown, been noted within the region between the great lakes and the Ohio river in the following winters: 1868–9; 1869–70; 1874–5; 1882–3; 1883–4; 1884–5; 1885–6; 1887–8; 1888–9; 1889–90; 1890–91; 1891–2. From 1882 to 1892 they were only absent one year; 1886–7. In the winters of 1882–3, 1884–5, 1887–8 the area of dispersal was wide and the birds seem to have been generally distributed. Other years as 1868–9, 1869–70, 1883–4, they appeared, or at least were observed, in but few localities but where noted they were abundant.

The results of the inquiries concerning its summer range, particularly with relation to the Ohio valley and the territory adjacent thereto, have been wholly unexpected. Summing up the occurrence in summer and the evidence of its breeding in the region last referred to we note as follows: In the summer of 1869 they were abundant in the vicinity of

Chicago, both in Illinois and Indiana. In the summer of 1878 they were found at Columbus, O., and abundantly at Cleveland, where it was reported to have bred. Dr. Wheaton refers to their having nested in Indiana as a fact well known to him. Dr. H. A. Atkins is said to have taken nests of this species near Locke, Michigan, in 1880. The spring of 1885 they were common at Michigan City, Ind., and Mr. Byrkit thought they might have nested. In the summer of 1885 they were reported to have nested in Tippecanoe county, Ind. The same summer they are reported to have nested at Bloomington, Ind. They were reported from Monroe county, Ind., three different dates in July 1886. They were reported from Putnam county, Ind., in the summers of 1891 and 1892. They remained throughout a part of the summer of 1892 at Lafayette, Ind. They remained even later at Old Orchard, Mo., in 1892.

These notes but serve to bring more clearly to mind the peculiar, erratic character of the bird, of which we have known, to some degree, before. The notes would also seem to indicate that much of our lack of data is due to the scarcity of observers in years past. A few years ago the collection of data regarding almost any species of bird from Indiana, or almost any other state, would have been impossible. It is not improbable, could we begin with the abundance of Crossbills at Cincinnati in 1868–9, with a number of intelligent observers equal to that available now, we could have a collection of observations covering its whole range between the Ohio river and the lakes and perhaps including its movements for almost every year. Those blank years do not necessarily signify that it was wanting in the territory studied, but that for some one of a great many reasons, it was not observed. The erratic distribution of the species applies as well to its summer range as to that in winter. It seems very probable that the species breeds to some extent throughout the Ohio Valley It is true that no specimens representing either the nest or eggs have been, so far as I know, preserved. Yet the evidence presented indicates that the breeding range of the species in the United States is not confined to the coniferous forests of the mountain ranges.

Loxia leucoptera, White-winged Crossbill. This species is not met with in the Ohio valley so often as the last mentioned form. Its range lies farther to the northward. Its distribution within the United States, both in winter and summer, is much less extensive than is that of the American Crossbill. Audubon mentions its breeding in Pennsylvania in summer, but this is probably an exceptional case. Dr. J. M. Wheaton gave

it in his catalogue of Birds of Ohio, in 1861. Mr. Charles Dury found them abundant in the vicinity of Cincinnati, O., in the winter of 1868–9, in company with the last mentioned species. He says, "they were in large flocks containing both species in the proportion of two of the former to one of the latter" (the present) "species." Mr. C. E. Aiken informs me that this species was in company with the American Crossbill when they were so common in the vicinity of Chicago in the summer of 1869. He also noted them in Lake county, Ind., the latter part of August of that year. He says they displayed the same habits as the preceding species. His recollection is that the White winged form was less abundant, a little later in their arrival, and more wary. They remained through the winter. Prof. A. J. Cook informs me that one was killed by Dr. H. A. Atkins, at Locke, Mich., Aug. 9, 1875. A pair of White-winged Crossbills were taken at Fort Wayne, Ind., about 1878. The female is now in the collection of Mr. C. A. Stockbridge of that city. Mr. W. L. Scott notes the occurrence of a flock of White-winged Crossbills near Ottawa, Canada, towards the latter part of June 1882 (The Auk., Vol. I., p. 159). Mr. Fletcher M. Noe notes the occurrence of this species near Indianapolis, Ind., in the early part of 1883. February 6, 1883, Prof. B. W. Evermann shot two males from a flock of fifteen of these birds in a yard at Bloomington, Ind. February 10 he secured a female, and a few days later, two other specimens near the same place. Miss H. E. Colfax reports it from Michigan City, Ind., June 26, 1884. Mr. J. W. Byrkit found both species together in large flocks near Michigan City, Ind., the winter of 1883–4. Mr. Charles Dury reports it from Michigan City, Ind., he thinks in 1885. Faxon and Allen report seeing a few in the White Mountains, N. H., June 1886. (The Auk., Vol. V., p. 152.) Hon. R. Wes McBride has noted it as a winter visitor in DeKalb county, Ind. Dr. C. Hart Merriam gives it as a resident in the Adirondack region but adds, comparing it with the American Crossbill, "not nearly so common as the last." (Bull. Nutt. Orn. Club, Vol. VI., p. 229). Prof. B. W. Evermann informs me that he saw one in his brother's yard at Burlington, Ind. He says, "after watching it for a while I struck it with a stick, killing it." March 16 he saw another specimen of this species at Camden, Ind.

The only instance I know of its occurring in the Ohio valley in summer is that given by the late Mr. C. H. Bollman. He wrote me that he saw eleven on a fir tree in Bloomington, Ind., June 24th, 1886. A few days later he several times noted specimens of the other species.

Everywhere in the Ohio valley this species seems to be quite rare and exceedingly irregular in its occurrence. Mr. E. W. Nelson and Mr. Otto Poling note it as much less common in Illinois than formerly. With the exception of the winter of 1868–9 and the succeeding summer I do not know of its having appeared in any considerable numbers in any of the tier of states just north of the Ohio river.

NOTICE OF A TERRAPIN TO BE RESTORED TO THE FAUNA OF INDIANA. By O. P. HAY.

A MIGRATION OF BIRDS AND ONE OF INSECTS. By T. B. REDDING.

THE SOUTH AMERICAN CAT FISHES BELONGING TO CORNELL UNIVERSITY. By E. M. KINDLE.

[ABSTRACT.]

Some years ago, the late Charles Frederick Hartt made a collection of fishes in South America, which he gave to Cornell University. This collection had never been studied until last spring, when it was sent to Dr. Eigenmann. The cat fishes in it were turned over to me to identify. In the identification of these I have used Dr. and Mrs. Eigenmann's "Revision of the South American Nematognathi." I have also had the use of Dr. Eigenmann's private library, which contains nearly all of the published literature on South American fishes. In the identification of doubtful species I have had the assistance of Dr. Eigenmann.

The collection contains nineteen genera and twenty-seven species, distributed among the three families, Loricariidæ, Siluridæ, and Callichthyidæ, and their sub-families.

Two new species have been found in the collection. One of these belongs to the genus *Hassar*. The name *wilderi* is proposed for it in honor of Prof. Wilder, of Cornell University. It is represented by four specimens from the Tocontins river. The other new species belongs to the genus *Hemiancistrus*, all of whose species are apparently rare. It has been named *longipinnis* in reference to the long dorsal.

The collection is mainly from the Amazon and the LaPlata, and their tributaries. The waters of the Amazon, the LaPlata, and the Orinoco are united through their tributaries, and so far as their fish fauna is concerned form but one river system. The fish fauna of any one of these rivers is therefore very similar to that of the others. The only genus which was considered peculiar to the LaPlata fauna is *Cochliodon*. This genus I find represented in the collection by four specimens from Marajo, near the mouth of the Amazon; so there is now no genus from the LaPlata which is not also found in the Amazon's system. These specimens, which belong to the species *Cochliodon cochliodon*, are of further interest inasmuch as the genus and species has heretofore been known only from the types in the Museum of Vienna.

From the Rio San Francisco there are but four specimens, all of a species common to the mouths of the east coast rivers of Brazil. The rivers of southeast Brazil, which Dr. Eigenmann has shown to have a fish fauna distinct from that of the Amazon to the north and the LaPlata to the south, are not represented in the collection. Lake Titicaca is represented by a single specimen, *Pygidium rivulatum*. This species, with *Rhamdia quelen*, are the only cat fishes found in Lake Titicaca. Both of these are alpine forms characteristic of the mountain streams of the Peruvian Andes.

How the colleges could aid the public schools in teaching biological subjects. By W. W. Norman.

The Ichthyologic features of the Black Hills region.* By B. W. Evermann.

[Abstract.]

Last September I was directed by the U. S. Commissioner of Fish and Fisheries to make certain investigations in Iowa, Nebraska, South Dakota and Wyoming for the purpose of determining the advisability of establishing one or more fish-cultural stations in those states, and if it should be found desirable to establish stations in that region, to determine the most suitable places for their location.

Investigations of this kind require a more or less careful study of the

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physical, chemical and biological features of the streams and lakes of the region under consideration, for these in their various phases are the forces or conditions which constitute the *fish-environment*, and which determine the abundance, condition and distribution of the fish life of each hydrographic basin.

While carrying on these investigations, I spent the greater part of the month of October in and about the Black Hills, and it is to some of the biologic characteristics of that region that I desire to call your attention.

The Black Hills are, as you are aware, an isolated mountain group lying in southwestern South Dakota and eastern Wyoming. These Hills lie wholly within the basin of the Cheyenne River, which is formed by the union of the North and South Forks. The North Fork of the Cheyenne, or the Belle Fourche, as it is usually called, has its rise west of the Hills, flows around them on the north side, and to the eastward joins the South Fork which also rises west of the Hills and sweeps around them to the southward in a wide curve very much like that of the Belle Fourche on the north.

The immediate drainage of the Hills is by means of numerous smaller streams, nearly all of which flow eastward in approximately parallel courses to one or the other of the two Forks, those flowing into the Belle Fourche doing so from the right bank, while those reaching the South Fork flow into it from the left bank. During our stay in this region we made collections of fishes in the following streams: Middle, Sand, Redwater, Crow, Chicken, Spearfish, Whitewood, Beaver, Rapid, Elk, Fall, Warm, Cold, Minnekahta, and Cottonwood creeks, the Belle Fourche and the South Fork of the Cheyenne, and in Montana and Cox's lakes, nearly all of which are well supplied with certain species of fishes. The study of these collections has opened up a number of interesting questions in geographic distribution.

The fish fauna of that portion of the Missouri system lying in and about the Black Hills is peculiarly restricted in its character. The fifteen species contained in this collection,—and no other species has ever been reported from any definite locality of this region,—represent but four families, viz.: two catfishes, four suckers, eight minnows, and one member of the codfish family. Eight of the fifteen species belong to one family, the *Cyprinidæ*. Not a single species of spiny-rayed fish has been found in the streams about the Hills, and it is not likely that any will be found there. Many of the streams in or near the Hills would apparently furn-

ish congenial homes for sunfishes, bass, and even several species of darters. That these are not there must be due to the nature of the lower courses of the streams draining the hills, and that of the Cheyenne, to which they are all tributary. The Cheyenne is ordinarily a shallow stream whose waters are always more or less alkaline and filled with solid matter in suspension from the extremely easily eroded country through which it flows. The lower courses of the streams flowing from the Hills are through the same Cretaceous beds and partake of the same character. Only those species with which the struggle has become most severe will be driven to seek protection and food in the muddy, alkaline streams, and they alone would eventually find their way into the purer, clearer waters above. This, of course, means the soft-rayed, non-rapacious fishes, the suckers and minnows and other mud-loving forms.

The spiny-rayed species are aggressive, extending their attacks to all weaker forms about them, while the soft-rayed species are defensive, and seek protection in retreat. A spiny rayed fish has no occasion to ascend into the muddy, alkaline and uncongenial portions of these streams; the only thing which would cause him to do so would be a quest for food, but he finds it easier and more agreeable to get food of sufficient quantity and quality where he is. Not so with the soft-rayed fish; he must not only search for suitable food, but he must also see that his enemy, the spiny-rayed fish, does not catch him. The attacks of his enemies were probably the first cause impelling him to take refuge in the turbid water. Finding suitable and sufficient food in this new environment, and total relief from the persecutions of his old enemies, he finds the struggle for existence easy, the surroundings in time become bearable and perhaps agreeable, he moves about at will through all parts of the muddy stream and even into the headwaters where, still finding an abundant food supply and none of his old enemies, he is content to make his home.

Before mining began in the Hills in 1875 and 1876, nearly every stream possessed all the natural conditions necessary to make it an excellent trout stream. The waters were clear and cold, not subject to contamination from any source, and suitable food, such as insects and insect larvæ, and the smaller crustacea and mollusca, was undoubtedly found then, as now, in abundance. With the exception of a few streams which are now ruined by mining operations, the creeks of this region are yet excellent for trout.

The explanation for their absence is practically the same as that which

accounts for the absence of spiny-rayed fishes. Land barriers have evidently proved competent to prevent trout getting in from the headwaters of the trout streams to the westward, and the mud and alkali which they encountered in the lower portion of the Yellowstone, the Missouri and the Big Cheyenne have as certainly proved an impassable barrier from that direction. Among the many regions of the United States which possess the necessary natural conditions for trout, the Black Hills district is the only one of any considerable area, if we except portions of the Yellowstone National Park, in which one or more species of *Salmonidæ* are not or have not been indigenous. The absence of trout and all other species of fish from the various lakes and streams of the Yellowstone National Park (*e. g.* Lewis and Shoshone lakes, Gibbon, Firehole and Little Firehole rivers, and Indian, Glen, Nez Percé and Sentinel creeks) is undoubtedly accounted for by the presence of impassable falls where these waters leave the great rhyolite sheet which covers the Park, as shown by the investigations made by Dr. Jordan in 1889. The presence of trout in Yellowstone Lake and tributary streams, notwithstanding the fact that the outlet of Yellowstone lake (Yellowstone River) has two enormous falls which wholly prevent the ascent of fish, is quite evidently due to the most interesting and curious fact that there is a continuous waterway furnishing easy passage for trout from the upper tributaries of Snake River, by way of Two-Ocean Pass, into the upper Yellowstone River. That Yellowstone Lake could have been, and almost certainly was, stocked in this way from the Columbia basin, was demonstrated by the investigations which I made during my visit to Two-Ocean Pass in August, 1891.

The presence of trout in the upper tributaries of the Colorado, Rio Grande, Arkansas, and Platte, whose lower courses are, in some cases at least, not unlike those of the Cheyenne and Missouri, is a matter whose explanation is not without some difficulties. The relationships of the various species or sub-species of *Salmo* found in these different basins are very close and indicate a common origin at no remote date. Whether they are all descended from a form which came up from the Pacific coast or one from the Atlantic cannot be certainly known, though the bulk of the evidence points to the former view. But whatever may have been the fact, it is certain that the headwaters of the Columbia, Colorado, Rio Grande, Arkansas, and Platte have been connected in some way at some time or other, thus permitting the trout to spread into these various basins. That there are no trout in the Cheyenne basin would seem to indicate that

the streams of this system became separated and differentiated as a distinct drainage system earlier than did those of the Platte, Arkansas, Rio Grande, Colorado, or Columbia, or else that they are streams of more recent origin and have never been connected at any time with any of the streams containing trout. Such a history as this for the Cheyenne, together with the shallow, muddy, alkaline character of its lower portion, seems to be a reasonable explanation of the absence of trout from the Black Hills.*

The effect of the peculiar alkali water of the Cheyenne and the lower course of the streams flowing from the Black Hills has been to reduce the fishes to a nearly uniform pale, faded or bleached appearance. Except those found above the alkali water, they are almost wholly without pigment cells of any kind. Perhaps the most extreme case of bleaching is that of the flat-headed minnow, *Platygobio gracilis*, which, of all American fishes, seems to be the one most perfectly adapted to these alkali streams.

The following is a list of the species of fishes obtained in the Black Hills and vicinity:

SILURIDÆ, OR CATFISHES.

1. *Noturus flavus* Rafinesque. Yellow Cat. South Fork of Cheyenne River at Cheyenne Falls, and Belle Fourche River at Belle Fourche.

2. *Ictalurus punctatus* (Raf.) Channel Cat. Middle Creek at Belle Fourche.

CATOSTOMIDÆ, OR SUCKERS.

3. *Carpiodes carpio* (Raf.) Carp Sucker. Found by us only in the Belle Fourche.

4. *Pantosteus jordani* Evermann. This species recently described by me as new (Bull. U. S. Fish Com., XII., Art. 2, 51–56, January 27, 1893,) was found by us in most of the streams of the Black Hills, viz: Whitewood, Spearfish, Crow, Rapid and Hat creeks, and in the Belle Fourche. For full description, see the Bulletin mentioned above.

5. *Catostomus teres sucklii* Girard. Common Western Sucker. Found in Middle, Crow, Chicken, Rapid, Cottonwood and Hat creeks, and in the Belle Fourche.

6. *Moxostoma macrolepidotum duquesnii* (Le Sueur.) The Belle Fourche and South Fork of the Cheyenne, and in Redwater Creek.

*In his paper on "The North American Species of Salmon and Trout," printed in the U. S. Fish Commission Report for 1872-1873, Dr. Suckley, in giving the habitat of *Salmo lewisi* (*S. mykiss*), credits it to the "Black Hills, Nebraska, Dr. Hayden." I have been unable to verify this reference, and I believe it to be an error.

CYPRINIDÆ, OR MINNOWS.

7. *Hybognathus nuchalis placita* Grd. Western Silvery Minnow. Cottonwood, Hat, and Middle creeks, and South Fork of Cheyenne and Belle Fourche rivers.

8. *Pimephales promelas* Raf. Black-headed Minnow. Middle, Rapid, Cottonwood, and Hat creeks.

9. *Notropis deliciosus* (Grd.) Middle, Rapid, Cottonwood, and Hat creeks, and Belle Fourche River.

10. *Rhinichthys dulcis* (Grd.) Western Dace. Whitewood, Chicken, Crow, Rapid, Cottonwood, and Hat Creeks, Cook's Pond, near Spearfish, and Fall River.

11. *Couesius dissimilis* (Grd.) Found only in Rapid Creek.

12. *Platygobio gracilis* (Rich.) Flat-headed Minnow. Middle, Cottonwood, and Hat creeks, and Belle Fourche and South Fork of Cheyenne rivers, in all of which it is abundant.

13. *Semotilus atromaculatus* (Mitch.) Chub. Found only in Chicken, Crow, and Rapid Creeks. These are the most western localities from which this fish has been reported.

14. *Leuciscus neogæus* (Cope.) Found by us only in Cox's Lake and Chicken Creek, near Gammon's ranch, S. D.

GADIDÆ, OR COD-FISHES.

15. *Lota lota maculosa* (Le Sueur.) One specimen obtained at Cheyenne Falls. This is the only fresh water representative of the codfish family.

These fifteen species are, so far as known, the only fishes found native to the Black Hills. It is the intention to continue the investigations in that region during a portion of the coming summer, when it is expected that the exact limits in the range of at least some of these species may be made out. It is especially desirable to determine in what streams the spiny-rayed fishes make their nearest approach to this region.

THE PTARMIGAN OF THE ALEUTIAN ISLANDS. By B. W. EVERMANN.

[ABSTRACT.]

It was my good fortune to spend the six months from March to September, 1892, on board the U. S. Fish Commission steamer *Albatross*, which was engaged during that time investigating the habits, abundance and distribution of the fur-seal in the North Pacific and Bering sea. While

carrying on these investigations we touched at a number of places on the mainland of Alaska, and while cruising along the Aleutian chain of islands we visited most of those which are inhabited.

While the study of the birds of these regions was only an incidental part of my work, nevertheless I had opportunity to make considerable collections at Alexandrovsks and Saldovoi in Cook's Inlet, at Nuchek in Prince William Sound, on Kadiak Island, Unalaska, Amaknak, Atka and Attu islands, also upon Bering Island of the Commander group. Among these is a series of ptarmigan that is of much interest.

The species represented are the following: Willow Ptarmigan (*Lagopus lagopus*) and Rock Ptarmigan (*L. rupestris*) from Kadiak Island, Nelson's Ptarmigan (*L. rupestris nelsoni*) from Amaknak and Unalaska islands, Turner's Ptarmigan (*L. rupestris atkensis*) from Atka Island, and an undescribed species from the island of Attu, the most westerly of the Aleutian chain.

The two species from Kadiak Island were collected April 13 and 14, and are interesting as showing the plumage at that season. The Willow Ptarmigan ranges near the bases of the mountains and among the sparse willow growth of the lower portions of the island. At the time of our visit the snow had melted from considerable areas frequented by this species, while higher up the mountains, where we found the Rock Ptarmigan, and where there is little or no woody vegetation, the snow covering everything completely.

The principle of adaptation to environment was clearly illustrated by these two species. The one whose range was in the region still covered entirely with snow had not yet begun to change from winter to summer plumage, not one of the sixty odd specimens collected showing a single brown feather; the plumage of every one was a solid white. Not so, however, with the Willow Ptarmigan. Their plumage had already begun to change gradually with the slowly melting snow, and in most cases the head and neck had almost completely changed to the summer brown, while brown feathers were scattered here and there through the rest of the plumage.

It is easy to see that it is greatly to the advantage of each of these species to change from winter to summer plumage synchronously with the melting snows; too rapid or premature change as well as change too long delayed would defeat the object of protective coloration.

Specimens of Nelson's Ptarmigan were obtained May 19 and 20, and

others in June. Those obtained in May had changed considerably toward the summer dress, while those taken in June were in complete breeding plumage. On May 24 I spent the day on Atka Island, and secured a dozen good specimens of Turner's Ptarmigan. They were usually found low down, either in the lowest heather or among the tall dead grass of the lowest hills. They were always seen in pairs, and were evidently mated. When flushed the male utters a coarse, gutteral note, not distinguishable by me from that of Nelson's. Most of their crops were empty, but some were filled with leaves of *Empetrum nigrum*. While the higher parts of the island were still covered with snow, the portions where we found the ptarmigan were almost wholly free of snow, and these birds were, as might be expected, in almost complete summer plumage.

The various species of ptarmigan are, as you know, non-migratory, in this respect resembling our native quail of Indiana; and the individuals found upon any particular island are, of course, practically limited to that one island. That ptarmigan are found upon several islands of the Aleutian chain is due either to the fact that the different islands were at one time connected, thus permitting the ptarmigan to spread over the entire area, or else that individual birds now and then found their way to other islands by being carried across by strong winds. Individuals thus carried to a new island remained there, of course, and, adapting themselves to the new conditions, became well established. In time, the new conditions, differing however slightly from those upon the island from which they came, reacted upon these birds and modified them more or less, until finally they became sufficiently differentiated to be easily distinguished from the ptarmigan of any other island. That differentiation of this character does take place is a well known fact to every student of insular faunas, and the ptarmigan of the Alaskan islands afford excellent illustrations of this important principle. The investigations made by Dr. Stejneger and Prof. Ridgway, some years ago, showed that the ptarmigan of Unalaska Island, of Atka Island, and of Bering Island must be regarded as three distinct species, or sub-species.

Unalaska is about 500 miles from Kadiak; Atka is nearly 400 miles further west; Attu is 500 miles west of Atka, and about 300 miles southeast of Nikolski on Bering Island. It will thus be seen that the island of Attu is quite as much isolated as are the others named, and I was therefore very anxious to secure specimens of ptarmigan from that island

if possible. That ptarmigan were to be found upon Attu Island I knew from the report of Mr. L. M. Turner, who visited the island in 1880–81, but who appears not to have collected any specimens.

The *Albatross* anchored in Chichagof harbor, Attu Island, on the evening of May 28, and I spent the next day on shore climbing over the snowy mountain slopes in search of the ptarmigan; and the search was rewarded by our securing five fine specimens, four males and one female. A comparison of these with the specimens which I had from Unalaska and Atka indicated that there are some well marked differences, and that the Attu Ptarmigan is worthy of at least sub-specific rank. Upon returning to Washington I turned the specimens over to the U. S. National Museum, where they have been examined by Doctors Ridgway, Stejneger, and Merriam, all of whom pronounce it a new and well-marked variety.

LOCAL VARIATIONS. By C. H. EIGENMANN.

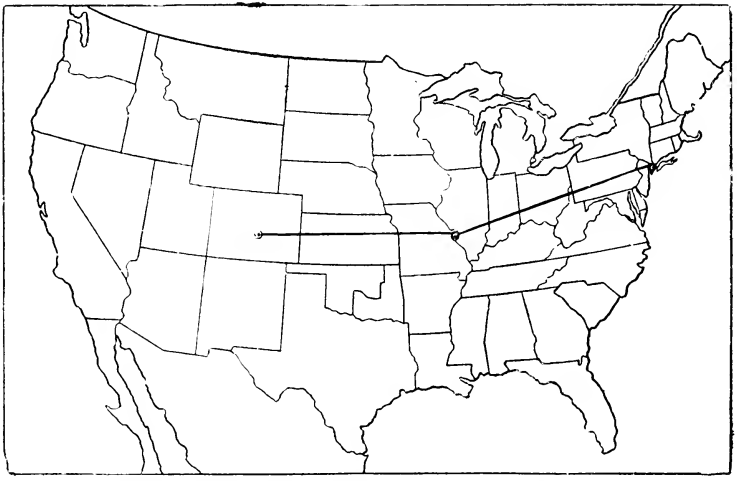
[ABSTRACT.]

A detailed comparison of about 400 specimens of *Leuciscus* from the Columbia basin and the Fraser basin showed that each locality has a variety which in the aggregate was different from the varieties of every other locality. The fin rays were found to decrease with the altitude, and in a general way it was noticed that the variation between the specimens of the same species also decreased with the altitude. These facts were demonstrated by diagrams.

MODERN GEOGRAPHICAL DISTRIBUTION OF INSECTS IN INDIANA. By F. M. WEBSTER.

He who studies geographical distribution is, at the very beginning, brought to understand that the area of any one state, or, indeed, any single country, is far too limited in which to work out his problem, as in the majority of cases the influences which make the presence of a species possible lie, largely, outside the boundaries of such state. The entomology of Indiana is only a fragment of the world's entomology and must be studied in connection with its closely related factors. You will therefore, I hope, pardon me for beginning my subject at a long distance from home and with elements seeming at first to have little to do with Indiana insects.

There are currents of air in the heavens and currents of water in both the oceans and inland streams, and all these have their influence on insect distribution. The influences of the Gulf stream of the Atlantic are far reaching in their effects, as will be further explained, while the corresponding current, sweeping northward along the coast of eastern Asia and south along the west coast of North America, is at present less important in its effects, owing largely, perhaps, to the Rocky Mountains and the Great American Desert. There also seem to be currents of insect migration. These, three in number, may be designated as follows: The



Map indicating, approximately, the natural divide between the northern and southern insect faunas, east of the Rocky Mountains.

Pacific coast, Northwestern and Southwestern. With the first we at present have little to do, as owing, possibly, to the combined influences of the mountains and desert intervening between us and the area directly influenced by it, we see little of the insect fauna of the Pacific coast. To the influence of the Rocky Mountains I attribute the extension of Alaskan forms southward to New Mexico. Whether, with the barriers withdrawn, these trans Pacific and sub-arctic species would drift eastward, is a problem which will likely only be solved when some gigantic system of irrigation

shall cause these desert wastes to cover themselves with vegetation. The other two have an influence on the insect fauna of Indiana which we can as yet but vaguely understand. In a paper on "Some Insect Immigrants in Ohio," read before the Ohio Academy of Science, and, later, published in "Science," Vol. XXII., pp. 57-59, and from which notice the map is extracted, we indicated the dividing line between these two currents of insect migrations in the following terms:

"There are, seemingly, two what we may term gateways through which the majority of species that have come to us from the east, have made entrance into the state of Ohio, and, later, spread out over the northwest. The first, and apparently the most important one of these, being at the extreme northeastern part, adjoining Lake Erie, and which we might term the north gate, and, second, the valley of the Ohio river, from a point where it begins to form the eastern boundary of the state, southward—perhaps to Wheeling, W. Va. Now, there also appear to be two great national avenues or highways which insect migrations follow; progressing more rapidly along either one or the other, but not equally so along both, and often following only one: the more sub-tropical species, whether American or introduced, taking the southern or what I would call the Great Southwestern route, while the sub-arctic, including, besides American, such species as have come to us from England or Europe north of latitude 45° north, take what I would term the Great Northwestern route. The division between these two great thoroughfares will be indicated, approximately, by a line drawn from New York City, latitude 40° 43′ north, to St. Louis, Missouri, latitude 38° 38′ north, thence to Pueblo, Colorado, latitude 38° 17′ north (about), the line of separation trending northward, east of St. Louis, under the influence of the Gulf Stream and the Great Lakes, chiefly the former. Of course it is not to be understood that this line is direct, as it is doubtless more or less irregular, and, from its very nature, to some extent unstable, nor is it to be supposed to form a radical boundary, as some northern forms gradually work their way south of it, and *vice versa*. Yet it will, I think, be found approximately correct."

From the foregoing it will be clearly observed that Indiana is itself but a single factor in the determination of the nature of its insect fauna, and, while the extent of its area covered by a species may be largely a matter of local influences, these are not by any means important factors in determining the exact locality where such species shall first appear within its

borders. This is quite aptly illustrated by *Phytonomus punctatus*, Fab., and *Hylesinus trifolii* Muel.* These entered Ohio first at the extreme northeast corner of the state, and there seems to have been a later introduction by the southeast gateway, the current of the Ohio river carrying them down and landing a colony of each in southeast Indiana and southwest Ohio, thus completely disarranging what had previously seemed very probable, viz: that both of these species would cross northern Ohio and make their first entrance into the state from the northeast. As it is, they will probably not do so, but work to the north and west, the two invasions (a second will probably occur in the northeast) meeting somewhere north of the center, west or southwest of Ft. Wayne. Strange as it may appear, an invasion of foreign or American species starting from Quebec, New England or New York, makes its way westward to the south of the Great Lakes instead of to the north. Therefore, species entering Indiana from Michigan are of rare occurrence. Indeed, I do not know of a single one whose advance can be with certainty traced to such a course. *Aphodius fossor*, Linn., may perhaps be an exception, as it is known to have worked southward to Massachusetts from Canada. It was next found at Detroit, Michigan, and I have seen specimens collected about Chicago, while Prof. Wickham reports it from Iowa, he having found it in 1887. There are, however, at present no good collectors in northern Ohio, and it might have followed the usual route along to the south of Lake Erie.

Invasions have also swept over the state from the west, though not many of these are recorded. *Dorypliora 10-lineata*, Say, an American species, will amply illustrate the fact of there being a current of insect migration from west to east, as well as one taking the reverse course.

For anything we can now see, this system of currents and counter currents may have thus been going on for ages, and it is fruitless to attempt

* NOTE.—Since the above was written, I learn that this species has been reported from northeast Iowa by Mr. Wallace, of Des Moines. Investigation, however, develops the fact that this report is based on an injury to clover, supposed to have been done by this beetle. There is no evidence showing that it has been observed in Iowa. Mr. E. A. Schwarz, of Washington, reports it from Detroit, Michigan, and the report is doubtless correct; therefore, it may now occur in extreme northeast Indiana, in accordance with our previous anticipations. I wish also to call attention to the fact that this insect, in European catalogues, is placed in the genus *Hylastes*, and, so far as known to the writer, has never been considered as belonging elsewhere. If it belongs to this genus in Europe, it should in the United States, since no striking anatomical changes would follow its transportation from that country to this. If our genera are not in conformity with those of the same name in other countries, then why use a preoccupied name? The idea that this species shall be a *Hylesinus* in America and a *Hylastes* in Europe, is sheer nonsense and should be corrected, either in one country or the other.

to show how many of our now thoroughly established species may have been brought to the state in this manner. This much for the insect current of migration that has passed over our great northwestern route.

In regard to the southwestern route, while it may be said to cover a smaller area of the State, it has, probably, brought a less number of species of foreign origin, while of American species, it may have supplied the state fauna with nearly an equal number. Any one who will take the pains to look into the matter will be surprised at the number of southern species that are hovering about in the vicinity of our dividing line, which marks either their approximate northern limit of occurrence, or else their northern limit of normal abundance. Among the Lepidoptera, *Agraulis vanillæ*, Linn., is a good illustration, as it covers almost exactly the southern area and is found in Indiana only in one of the extreme southern counties. *Argynnis diana*, Cram., is probably another example. On the other hand, *Papilio ajax*, Linn., and *P. cresphontes*, Cram., both southern species, have pushed over and far beyond our line of demarkation. Indeed, it seems probable that the former has reached farther north in western New York than it has along the Atlantic. The same might be said of one of the Orthoptera, *Acridium americanum*, Scudd. I have observed this rarely in southern DeKalb county, northern Illinois, and quite abundantly in southern Illinois, and know it to occur sometimes in exceedingly great numbers in southeast Indiana. It pushes far north of our dividing line, but is abundant only near or to the south of it. The following from "Field and Forest," Vol. II., p. 145, Feb., 1877, will prove interesting in this connection:

"Acridium americanum.—Two correspondents, of the Department of Agriculture, writing from Vevay, Indiana, about the middle of last November, reported the visitation in that place of an immense cloud of grasshoppers that literally covered the streets of the town. One of the gentlemen observed, about 5 P. M., dense cumulo stratus clouds in the southwest, gradually overspreading the sky; at 6 o'clock the wind had risen to moderate gusts, and within half an hour a rattling noise was heard against the windows, like that of light hail. On opening the doors, grasshoppers entered in immense numbers, covering the floors, furniture, clothing, &c. The shower continued till 8 o'clock P. M., when the ground was thickly covered, and the boys began to burn them, shoveling them into bonfires. The specimen sent shows the insect to have been the *Acridium americanum*, one of our largest American grasshoppers."

Staymomantis carolina, Burm., is an inhabitant of southern Indiana, and breeds in the extreme southern portion, and, at least, as far north as Jefferson county. I learn that a female was captured in Indianapolis last year. The line given, however, marks its northern limit of usual occurrence. In Coleoptera, *Dynastes tityus*, Linn., is a good example. It is a southern species, occurring from Central America northeast to southern New York. Its northern limit in Indiana is near the line given on the accompanying map. It breeds in the vicinity of Bloomington, and I have seen a specimen taken at Columbus. *Tetracha virginica*, Linn., whose distribution Schaupp gives as "Texas, Louisiana, Florida, Nebraska and Pennsylvania," I have taken at LaFayette.

In Hemiptera, *Murgantia histrionica*, Hahan, whose southern home is Gautemala and Mexico, began its northward march from Texas about 1866, and has now reached northern New Jersey on the east, occurring in southern Ohio, where it appeared about 1889. It has for quite a number of years been observed in southern Illinois, but seems not to have appeared in Indiana until 1899, when it was observed in Perry county. It also occurs commonly over the southern half of Missouri, and, in fact, covering the whole area south of our dividing line, and, as shown, crowding closely up to it in Ohio, Indiana and Illinois, though it is not likely to extend far beyond this in either of these states. Its slow progress and scanty numbers show it to have nearly reached its northern limit. There are two other members of this order of whose local distribution I wish to speak, the origin of both being enveloped in an obscurity altogether too dense to offer any hope of our ever being able to solve the mysteries of their diffusion. I refer to the Chinch bug, *Blissus leucopterus*, Say, and *Cicada septendecim*, Linn.

The Chinch bug was described by Say from a specimen from the east shore of Virginia, though it is now known to have at that time occurred in destructive numbers in Illinois, and at no great distance from New Harmony, Indiana. In fact, Illinois seems to have been the central point of its greatest abundance—the storm center, so to speak. In Indiana, its destructive area may be approximately included by a line drawn from the northwest corner, near Chicago, to New Albany, and its area of occurrence in noticeable numbers by a line drawn from the same point to Ft. Wayne and the eastern border of Ohio. North of this line, especially in the northern row of counties, the insect can only be found by close collecting. I myself spent a half a day in LaGrange county during a season of great

abundance elsewhere, and found but a single specimen, and this of the short-winged form, which occurs also in New York, being variety (c) of Fitch. I have spent a great deal of time and investigation in trying to unravel the mystery of this distribution, but can now give no reason for the almost total absence of the species in the northeastern portion of the state, while they are overabundant in the opposite direction.

While located in Indiana, an opportunity was offered me to study the distribution of three broods of *Cicada septendecim*, Linn., very carefully. These were Brood XXII., 1885; Brood V., 1888; Brood VIII., 1889. The first of these covered the whole area of the state except a narrow strip of country around the southern extremity of Lake Michigan, the outlines being approximately described by a line commencing at the northern boundary of the state, nearly or quite due north of the city of LaPorte, and extending nearly south-southwest, running a short distance east of Westville, on the L., N. A. & C. R. R., and crossing this railway near Wanatah; then sweeping southwest to the western boundary of the state. This brood probably occupied the territory along the Kankakee river, and extending a short distance northward into Lake and Porter counties.

Brood V., 1888, so far as I have been able to learn, covered almost exactly the area not visited by Brood XXII., and was not observed elsewhere in the state.

Brood VIII., I have definitely recorded from the counties of Brown, Clark, Crawford, Daviess, Dearborn, Floyd, Gibson, Harrison, Johnson, Knox, Lawrence, Monroe, Morgan, Orange, Scott, Tippecanoe, Warwick and Washington. In Harrison county, only, were the insects abundant, and in Tippecanoe county the invasion was only known from a single female captured by the young sons of Dr. E. Test. Broods XXII. and V. are both strong ones, while Brood VIII. is apparently very weak, and, owing to the clearing up of the forests and the attacks of the English sparrow, it will not be surprising if it becomes nearly or quite extinct in Indiana during the next century.

Of the Diptera very little is really known. I am quite sure the two species of Simulium, *S. pecuarium*, Riley, and *S. meridionale*, Riley, both inhabit the southwestern portion of the state. How far northward they may occur I am not able to say. The species found in Franklin county I am sure is different, but it may not be a northern form.

I have thus gone over the subject in a general way, without going into a detailed account of a greater number of species than necessary to illus-

trate my points. To have done so would have required a greater knowledge of local distribution of species than we now possess. What is at present especially needed is intelligent, continuous, persistent local collecting, such as is being done by Mr. Evans, of Evansville, Profs. Blatchley, of Terre Haute, and W. P. Shannon, of Greensburg, and Judge McBride and sons, of Elkhart. It is only by long acquaintance with a locality that we become familiar with its fluctuating insect fauna—species that do not occur every year, and when they do appear are present only in scant numbers and over a limited area.

A careful study of species, other than those here given, may throw much light on the problem of general geographical distribution, and our dividing line is supposed to be correct in a general way, as, of course, there can be no such thing as an exact or continuous line of demarkation. This will of necessity be more or less irregular. Again, a species spreads over an area particularly adapted for its occupancy. But, no sooner is this done than the individuals along the frontier begin to adapt themselves to an environment but slightly unfavorable, and, as their adaptation changes, so do they slowly advance outward from the territory originally occupied. A series of to them favorable seasons might occasion the occupation of a wide margin of adjoining country, while a series of unfavorable seasons might sweep this tide of advance back nearly or quite to the place of its origin. But, as the receding tide of the ocean leaves many pools of water in the depressions of rock, so will there be left, in especially favorable nooks, a few of the insects which will retain their hold and form small, local colonies, of perhaps not more than a few individuals, and the offspring of these will meet the investigator long distances from the real habitat of the species. There is scarcely a collector who does not know of one or more small, secluded areas, in his neighborhood, that are rich in varieties, and which he seldom visits without satisfaction, and frequently he is astonished at his success. How long this ebb and flow has been going on, and how many species have been brought to us in this way, are problems we are yet unable to solve. Therefore, these facts have been brought together, and are here presented, not as a finished, or, indeed, as an advanced study, but rather as a primary outline, to be revised and modified as our knowledge of the geographical distribution of our species shall be enlarged by additional study and research.

AN EXTREME CASE OF PARASITISM. By ROBERT HESSLER. Published in American Naturalist.

A PARTIAL LIST OF NEW SPECIES OF PARASITIC HYMENOPTERA REARED IN INDIANA. By F. M. WEBSTER.

In the following list it is my intention to include only such species as were undescribed at the time they were reared by myself during an eight years residence in the State. These have nearly all been since described and, with but few exceptions, from types furnished by my rearings. The object in presenting this matter is to place it in a form convenient for reference by the future investigator, reference in all cases being given to the original description. I have not as yet been able to complete the list of those now described, and still others remain to be described, but I hope to include all or nearly all of them in a future paper:

1. *Bracon agrili* Ashm. From larvæ of *Agrilus fulgens* Lec., burrowing in trunks of maple. La Fayette, April and May. (Proc. U. S. Nat. Mus., 1888, p. 612.)

2. *Bracon diastata* Ashm. From Dipterous leaf miner, *Diastata* n. sp. in corn. La Fayette, June 28, 1886. (Proc. U. S. Nat. Mus., 1888, p. 617.)

3. *Bracon phycidis* Riley, MS. From *Phycis indiginella* Zell. Oxford, July 9, 1884.

4. *Bracon* n. sp. From *Trypeta gibba* Loew, in galls on *Ambrosia artemisiæfolia*. La Fayette, May 3, 1889.

5. *Bracon* n. sp. From larvæ of *Rhyssematus lineaticollis* Say, in seed pods of *Asclepias corymbosa*. La Fayette, March 29, 1889.

Mr. Frederick Blanchard, of Lowell, Mass., in a letter to me, says he has reared *R. lineaticollis* from Asclepius in Massachusetts, and that it is there attacked by a Hymenopterous parasite.

6. *Dimeris rufipes* Ashm. Host unknown. La Fayette.

7. *Rhyssalus loxotenia* Ashm. From *Loxotenia clemensiana* Fern. La Fayette. (Proc. U. S. Nat. Mus., 1888, p. 629.)

8. *Aphidius obscuripes* Ashm. Host unknown. La Fayette. (Proc. U. S. Nat. Mus., 1888, p. 660.)

9. *Aphidius pallidus* Ashm. Host not known. La Fayette. (Proc. U. S. Nat. Mus., 1888, p. 661.)

10. *Lysiphlebus multiarticulatus* Ashm. Host some species of Aphides. La Fayette. (Proc. U. S. Nat. Mus., 1888, p. 664.)

11. *Lysiphlebus ribaphidis* Ashm. From *Aphis ribes* on currant. La Grange county, July 12, 1886. (Proc. U. S. Nat. Mus., 1888, p. 664.)

12. *Lysiphlebus cucurbitaphidis* Ashm. From *Siphonophora cucurbita* Middleton. La Fayette. (Proc. U. S. Nat. Mus., 1888, p. 665.)

13. *Lysiphlebus eragrostaphidis* Ashm. Swept from *Eragrostis*. La Fayette, October 4, 1885. The host is probably *Glyphina eragrostidis* Middleton. (Proc. U. S. Nat. Mus., 1888, p. 665.)

14. *Lysiphlebus mysi* Ashm. From *Mysus ribis* L. La Fayette, See Insect Life, Vol. 3, p. 6. (Proc. U. S. Nat. Mus., 1888, p. 666.)

15. *Lysiphlebus tritici* Ashm. Host *Aphis mali* Fab. La Fayette. October 14, 1888. See Insect Life, Vol. 3, p. 61. (Proc. U. S. Nat. Mus., 1888, p. 668.)

16. *Diaretus americanus* Ashm. From *Siphonophora avenæ* Fabr. Probably Southern Indiana. (Proc. U. S. Nat. Mus., 1888, p. 669.)

17. *Diaretus brunniventris* Ashm. From *Siphonophora avenæ*. Southern Indiana. (Proc. U. S. Nat. Mus., 1888, p. 670.)

18. *Diaretus websteri* Ashm. From *Siphonophora avenæ*. Southern Indiana. (Proc. U. S. Nat. Mus., 1888, p. 669.)

19. *Pachyneuron micans* Howard. From *Siphonophora avenæ* Fab. Goshen. Have also reared it at Wooster, Ohio, from Aphis or grass, probably *Aphis mali* Fab. (Insect Life, 3, p. 246.)

20. *Megaspilus niger* Howard. From *Siphonophora avenæ* Fab. La Fayette. (Insect Life, 3, p. 247.)

21. *Encyrtus websteri* Howard. From *Siphonophora avenæ* Fab. La Fayette. (Insect Life, 3, p. 247.)

22. *Encyrtus clisiocampæ* Ashm. From eggs of *Clisiocampa disstri* Hub. Franklin, Ind. (Ohio Agr'l. Exp. Sta. Bull. 3, Vol. I., Technical Series.)

23. *Herpestomus plutellæ* Ashm. From *Plutella cruciferarum*. La Fayette; also at Columbus, Ohio. (Proc. U. S. Nat. Mus., 1889, p. 396.)

24. *Orthopelma bimaculatum* Ashm. Host not known. La Fayette. (Proc. U. S. Nat. Mus., 1889, p. 416.)

25. *Limnera flavicincta* Ashm. Host not known. La Fayette. (Proc. U. S. Nat. Mus., 1889, p. 436.)

26. *Zela nigriceps* Riley, MS. From *Crambus zeellus* Fern. Cass, Sullivan county, July 11, 1886.

27. *Acoloides saltidis* Howard. From eggs of spider, *Saitis pulex*. The types were reared in Nebraska by Prof. Lawrence Bruner, but specimens

were several years previously reared by me at Oxford, October, 1884. See Insect Life, Vol. 2, p. 359. (Insect Life, 2, p. 269.)

28. *Meraporus brachivorus* Ashm. From *Bruchus exiguus* Horn. La Fayette. (Ohio Agr'l. Exp. Sta. Bull. 3, Vol. I., Technical Series.)

29. *Catolaccus tyloderma* Ashm. From *Tyloderma foveolatum* Say. La Fayette. (Ohio Agr'l. Exp. Sta. Bull. 3, Vol. I., Technical Series.)

30. *Glypta* sp.? From cocoon on red cedar. La Fayette. See Insect Life, Vol. 3, p. 464.

31. *Wesmaelia Rileyi* Ashmead. Although the specimens, six in number, from which the description was drawn, were in the Riley collection and the species named in honor of the possessor, they were reared by me at Oxford, Ind., July 24-August 1, 1884, and sent to the U. S. Department of Agriculture, in whose employ I was at that time. These appeared in a breeding cage in which I was rearing *Toxoptera graminum*, and as there was no other inhabitant of this cage, that species must have been the host. This was the first time the species had been observed. It is not, however, a true Wesmaelid, and represents a rare family not as yet included in our lists. (Proc. U. S. Nat. Mus., 1888, p. 641.)

32. *Pygostolus americanus* Ashmead. (MS.) Reared at LaFayette, Ind., Aug., 1889, from wheat stubble. As this stubble was infested by the Hessian fly and its various parasites, including *Eupelmus allynii* French, and as I also reared from the same lot of stubble, *Acoloides howardii* Ashmead, a spider parasite, *Labes hyphlocyba* Ashmead, *Encyrtus tarsalis* Ashmead, an undetermined species of *Batomus* and a *Homoporus* sp., it is useless to theorize in regard to which of these might have been the host.

33. *Encyrtus tarsalis* Ashmead. (MS.) This was reared with the preceding, and also at LaPorte, Ind.

34. *Encyrtus brunnipennis* Ashmead. (MS.) Reared from wheat stubble from LaPorte, Ind., August, 1889.

35. *Atelopterus tarsalis* Ashmead. Reared at LaFayette, Ind., from *Silvanus surinamensis*, infesting stored grain. This had previously been reared at Washington, D. C., by Mr. Ashmead, from the same insect infesting raisins. (Bull. U. S. Nat. Mus., No. 45, p. 45, 1893.)

36. *Cacus ecanthi* Riley, Nov. Gen., et. sp. Reared from the eggs of *Œcanthus niveus* at LaFayette, Ind. This species is the type of the genus, and the only one whose parasitism is known. (Bull. U. S. Nat. Mus., No. 45., pp. 223-4, 1893.)

Platygaster error Fitch. Reared June 14, 1884, at Oxford, Ind., from

larvæ of *Diplosis tritici*. The original describer was in doubt as to whether this was really a parasite of this species, the wheat midge, or not. Redescribed by Mr. Ashmead from specimens reared by myself as above. (Bull. U. S. Nat. Mus., No. 45, p. 291, 1893.)

A MITE, PROBABLY HYPODERAS COLUMBÆ, PARASITIC IN THE PIGEON. By W. W. NORMAN.

THE LOCUSTIDÆ OF INDIANA. By W. S. BLATCHLEY, Terre Haute, Indiana.

The order of insects known as the *Orthoptera* comprises seven families, three of which are alike in having the posterior femora more or less enlarged for leaping; the three being therefore classed together in a sub-order called the *Saltatoria*, or jumpers.

In the present paper we have to deal with that family of this sub-order known as the *Locustidæ*, which comprises those insects commonly called katydids, green grasshoppers, and stone or camel crickets.

The distinguishing characters of the members of the family *Locustidæ* are the long, slender, tapering, many-jointed antennæ; the almost universal absence of ocelli or simple eyes; the four jointed* tarsi or feet; and the ensiform or falcate ovipositor of the females which is made of four flattened plates; the males having, in many instances, abdominal appendages corresponding to the parts of the ovipositor, which are used as clasping organs. The tegmina or wing covers, when present, slope obliquely downwards, instead of being bent abruptly, as in the *Gryllidæ*: and in most cases the wings are longer than the tegmina.

The stridulating or musical organ of the males is quite similar in structure to that of the male cricket, being found at the base of the overlapping dorsal surface of the tegmina and usually consisting of a transparent membrane, of a more or less rounded form, which is crossed by a prominent curved vein, which on the under side bears a single row of minute file like teeth. In stridulating the wing covers are moved apart and then shuffled together again when these teeth are rubbed over a vein on the

* The members of the genus Daihinia, no one of which occurs in Indiana, have the fore and hind tarsi three-jointed.

upper surface of the other wing cover, producing the familiar, so called "katydid" sound. Each of the different species makes a distinct call or note of its own, and many of them have two calls, one which they use by night and the other by day. Any one who will pay closer attention to these different calls can soon learn to distinguish each species by its note as readily as the ornithologist can recognize different species of birds in the same manner. The ear of these insects, when present, is also similar in structure and position to that of the cricket's, being an oblong or oval cavity covered with a transparent or whitish membrane, and situated near the basal end of the front tibiæ.

The young of *Locustidæ*, like those of the other families of the order, when hatched from the egg resemble the adults in form but are wholly wingless. As they increase in size they moult or shed the skin five times, the wings each time becoming more apparent, until after the fifth moult when they appear fully developed, and the insect is mature, or full grown, never increasing in size thereafter. Throughout their entire lives they are active, greedy feeders, mostly herbivorous in habit; and where present in numbers necessarily do much harm to growing vegetation.

Among the families of Orthoptera the *Locustidæ* take a rank second only to the *Gryllidæ*. The high specialization of the ovipositor of the female and the perfection of structure of the stridulating organ of the male place these two families above all others in the scale of Orthopteron life. That the two are very closely related can be readily seen by any one who will carefully compare them, organ with organ. The *Gryllidæ* are placed first, however, by most entomologists, as the great variety of form of almost any given organ among them, when compared with its relative uniformity of structure among the *Locustidæ*, seems to indicate the higher rank of the former.*

In the number of species in any given locality the *Locustidæ* far outrank the *Gryllidæ*, being excelled in this respect among the other Orthopteron families only by the *Acrididæ* or locusts. In Indiana thirty-nine species of *Locustidæ* are known to occur and are listed in the present paper, specimens of all being in my private collection. This is eleven more than are known in any other state from which lists have been published; McNeill having listed twenty-seven from Illinois; Smith, twenty-eight from New Jersey; Osborne, twenty-four from Iowa, and Fernald sixteen from all New England.

* Scudder, Proc. Bost. Soc. Nat. Hist., XII, 1868, 233.

Undoubtedly other species occur in Indiana, especially in the southern half of the state, but having had to rely almost wholly upon my own collecting, which has been done in Putnam, Vigo, Montgomery, Wabash, Marshall and Fulton counties, the eastern and southern parts of the state are wholly unrepresented in the list. Three persons, Prof. E. E. Slick, of Michigan City; Prof. W. P. Hay, formerly of Irvington, and Mr. W. A. Riley, of Greencastle, have sent me small collections from their respective localities which have aided me much in recording the distribution of certain species.

To Mr. S. H. Scudder, of Cambridge, Mass., I am indebted for the loan of typical specimens of the genus *Cyrtophilus* for comparison; and to Prof. Lawrence Bruner, of Lincoln, Nebraska, for aid in identifying and verifying certain species. Prof. Bruner also furnished me some valuable notes concerning the general distribution of a number of the species, which are incorporated under their respective species in the list below.

The descriptions of such species of *Locustida* as occur in the eastern United States are scattered through many scientific books and papers which are for the most part inaccessible to beginners in entomology. I have thought it best, therefore, to prepare a synopsis of the sub-families and of the genera under each sub-family, which are represented in the state. A short description of each species, with such notes concerning its distribution, food, habits, and comparative abundance, as have been gathered during my collecting, is also given, together with a synonymy of the species, as far as obtainable from the works at hand.

The following is a bibliography of authors and works to which reference is made in this synonymy:

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A SYNOPSIS OF THE SUB FAMILIES OF LOCUSTIDÆ FOUND IN INDIANA.

a. Tegmina and wings present.

b. Prosternal spines absent; vertex rounded or deflexed without spine, tubercle or cone; tegmina always shorter than the wings . . . . . PHANEROPTERINÆ. p. 97

bb. Prosternal spines present; vertex either terminating in a sharp flat spine or produced upwards and forwards in a rounded tubercle or prominent cone.

c. Wing covers leaf like, broadly expanded in the middle, concave within, longer than the wings; vertex terminating in a sharp flat spine . . . PSEUDOPHYLLINÆ. p. 109

cc. Wing covers narrow, not expanded in the middle, often shorter than the wings; vertex terminating in a rounded tubercle or prominent cone . CONOCEPHALINÆ. p. 111

aa. Tegmina and wings absent, or the former rudimentary.

d. Pronotum short, not covering the whole top of the thorax; prosternal spines absent . . STENOPELMATINÆ. p. 140

dd. Pronotum extending back to the abdomen; prosternal spines present . . . . . DECTICIDINÆ. p. 149

LOCUSTIDÆ.

PHANEROPTERINÆ.

The species of this sub-family are among the largest of our Locustidæ, and, with those of the next, are commonly known as "Katydids." The apex of the head is obtuse or rounded, without cone or spine, and the prosternum is unarmed. The wing covers are shorter than the wings, usually expanded in the middle, and of a bright, uniform green color. The wings are folded like a fan and are long and strong, the insects being flyers rather than leapers. The hind limbs, being seldom used except to give themselves an upward impetus at the beginning of flight, while long and slender, are proportionally much smaller in diameter than in the sub-family *Conocephalinæ*, whose members leap rather than fly.

The "Katydids" are the most arboreal of all the Locustidæ, the great majority of them passing their entire lives on shrubs and trees where they feed upon the leaves and tender twigs, and when present in numbers often do excessive injury. The color and form of their wings serve admirably to protect them against their worst foes, the birds; and as they live a solitary life, *i. e.*, do not flock together in numbers as do the green grasshoppers, they are but seldom noticed by man. Their love calls, or songs, however, make the welkin ring at night from mid-August until after heavy frost, and though but one or two of the eight species found in the State make a note in any way resembling the syllables "Katy did, she did," yet all are accredited with this sound by the casual observer, and hence the common name usually given to the members of this sub-family. Their call is seldom made by day for the obvious reason that it might attract the attention of the birds and so lead to the destruction of the songster. As twilight approaches, however, the male of each species begins his peculiar note which is kept up with little or no intermission until the approach of day warns him that his feathered enemies will soon be on the alert, and that silence will be, for a time, the best policy to pursue.

From the other Locustidæ, the Katydids differ widely in their habits of oviposition, the eggs not being deposited in the earth or in twigs, but are usually glued fast in double rows to the outer surface of slender twigs or on the edges of leaves. The eggs of the most common species appear like small flattened hemp seeds, and usually overlap one another in the row in which they are placed. On account of this method of oviposition, the ovipositors of the "Katydids" are broader, more curved, and more obtuse

at the end than in the other sub-families whose members oviposit in the earth or in stems of grass. This sub-family is represented in Indiana, so far as known, by three genera and eight species.

KEY TO GENERA OF PHANEROPTERINÆ.

a. Wing covers of equal breadth throughout; supra-anal plate of male with a long decurved spine which is notched at the end . . . . . I. SCUDDERIA.

aa. Wing covers widest in the middle; supra-anal plate of male not as above.

b. Hind femora but little if any shorter than wing covers; ovipositor well developed, curved gradually upwards . . . . . II. AMBLYCORYPHA.

bb. Hind femora much shorter than wing covers; ovipositor very short, turned abruptly upwards . . . . . III. MICROCENTRUM.

I. SCUDDERIA, Stål (1873).

This genus includes Katydids of medium size, with the wing covers long, narrow, of nearly equal width throughout, and rounded at the ends. The vertex is deflexed, compressed, and hollowed out on either side for the better accomodation of the eyes, which are nearly hemispherical. The hind femora are long and slender, almost equalling the length of the wing covers in some of the species. The ovipositor is short, broad, curved sharply upwards, and has the apical third finely crenate on both margins. The males are readily distinguished from those of other genera by having both anal plates projected into long curved processes; the one from the supra-anal plate curving downwards and notched or forked at the end, that from the sub-anal curving upwards, and likewise notched. The form of these processes, together with that of the notches serve as valuable characters in distinguishing the species. Six species have been described from the United States, four of which occur in Indiana.

a. Length of posterior femora 28 or more mm.[1]

b. Notch of supra-anal spine of male square with a slight median tooth, almost as wide as the middle of the upturned sub-anal spine; the lateral processes slender and compressed.

[1] NOTE.—The measurements in this paper are given in millimeters, an inch being equal to very nearly twenty-five millimeters. The measurements given are, when possible, the average of a number of specimens, and the "length of body" does not include the sexual appendages of male nor the ovipositor of female.

1. SCUDDERIA CURVICAUDA, (DeGeer.)*

"*Locusta curricauda*, DeGeer, Mem., III., 1773, 446, Pl. 38, fig. 3."

Phaneroptera curricauda, Burmeister, Handbuch der Ent., II., 1838, 690.
Scudder, Bost. Journ. Nat. Hist., VII., 1862, 448. (In part.)
Uhler, in Harris' Ins. Inj. to Veg., 1862, 161. (Note.- In part.)

Scudderia curricauda, Brunner, Monogr. der Phanerop., 1878.
Riley, Stand. Nat. Hist., II., 1884, 191.
Comstock, Int. to Ent., I., 1888, 118.
Fernald, Orth. N. Eng., 1888, 22. (In part.)
McNeill, Psyche. VI., 1891, 21. (Song of.)
Scudder, Rep. Ent. Soc. Ont., XXIII., 1892, 68. (Song of.)
Smith, Bull. Ag. Exp. Stat. of N. J., No. 90, 1892, 24.

Phaneroptera septentrionalis, Serville, Hist. Nat. des Orth., 1839., 416.

Tegmina, wings and legs bright grass green; body and face somewhat paler, approaching a whitish in dried specimens. Lateral carinæ of the pronotum with a yellowish line. Posterior femora very slender, armed beneath on inner carina with three or four minute spines.

Measurements: Male—Length of body, 22 mm.; of tegmina, 37.5 mm.; of wings beyond the tegmina, 6 mm.; of posterior femora, 30 mm.; of pronotum, 6.5 mm. Female—Length of body 25 mm.; of posterior femora, 32 mm.; of ovipositor, 7 mm. Width of tegmina, 6.5 mm.

Curricauda is a common insect in the central and southern half of Indiana, but northward seems to be replaced by *S. furculata*. The former is probably less arboreal than any other species of Katydid, as it is often found clinging to the tall, coarse grasses and sedges which grow near the borders of ponds and in damp ravines, and to the coarse weeds along the margins of prairies and meadows. When approached it flies readily in a zigzag, noiseless manner for a long distance to another clump of grass or weeds, or to the lower branches of an oak, a tree in which it delights to dwell.

The eggs are laid in the margins of leaves between the upper and lower epidermis, and are so thin that they are not noticeable except when the leaf is held between one's self and the light. Of the song or note made by the male of *curricauda* McNeill (*loc. cit.*) says: "The note cannot be

*When the author of a species referred it to a different genus from that in which it is now included, his name is put in parenthesis.

supposed to represent more than the first two syllables of the 'Katy did' or 'Katy didn't' of its congeners. It is made but once, and the rasping, jerky sound has been very well represented as *brrwi*."

Curvicauda is a species of wide distribution, occurring throughout the eastern United States, and as far west as the Rocky Mountains. In Central Indiana it reaches maturity about the 25th of July.

bb. Notch of supra-anal spine of male acute and much narrower than the middle of the upcurved sub-anal spine; the lateral processes (at side of notch) broadly rounded with the lower margin thinner.

2. SCUDDERIA FURCULATA, Brunner.

Scudderia furculata, Brunner, Monog. der Phanerop., 1878.
Smith, Cat., Insects found in N. J., 1890, 410.
Id., Bull. Agr. Exp. Stat. of N. J., No. 90, 24, pl. II., Fig. 4.

Somewhat larger than *curvicauda* and closely resembling that species in general appearance, the females of the two being difficult to distinguish except by the measurements; the males readily separated by the different form of the notch of the supra-anal spine. The general color is the same, but the yellow carinal line of the pronotum is less distinct or wholly wanting in *furculata*, and the apical third of wings is usually a transparent reddish brown. The wing covers of the latter are broader and the posterior femora proportionally a little shorter.

Measurements: Male—Length of body, 23 mm.; of tegmina, 37.5 mm., of posterior femora, 30 mm.; of pronotum, 6 mm. Width of tegmina 8 mm. Female—Length of body, 25 mm.; of tegmina, 38 mm; of posterior femora, 33 mm.; of ovipositor, 7 mm. Width of tegmina, 8.5 mm.

According to Brunner[3] *furculata* is usually more southern in its distribution than *curvicauda*, but in Indiana this distribution seems reversed, as the latter is much the more common in Vigo and Putnam counties, while in Marshall and Fulton counties, 150 miles further north, it is very scarce and *furculata* very common. A single male was taken from an oak grove on the border of Lake Maxinkuckee in Marshall county, on August 1st, and on the 26th of the same month it was found in numbers at the same place, and also about the borders of a large tamarack swamp in Fulton county. Its habits of flight and song, as far as noted, are essentially the same as those of *curvicauda*, noted above.

[3] Mss. Notes.

In New Jersey, according to Smith (*loc. cit.*), *furculata* is very common on cranberry bogs, and destroys many of the berries. It will probably be found to occur throughout Indiana near the borders of the larger ponds, lakes and marshes.

aa. Length of posterior femora 22 or 23 mm.

3. SCUDDERIA FURCATA, Brunner. The Fork-tailed Katydid.

Scudderia furcata, Brunner, Monog. der Phanerop., 1878.

Bruner, Bull. Washb. Coll. Lab. Nat. Hist., I., 1885, 127.

McNeill, Psyche, VI., 1891, 21.

Smith, Bull. Agr. Exp. Stat. of N. J., No. 90, 1892, 31.

Phaneroptera curvicauda, Riley, Sixth Rep. St. Ent. Mo., 1874, 164, fig. 51. (Text in part. Not fig. 50.)

This is one of the smallest, and at the same time, our most common species of the genus. The general color is a dark leaf green, the head and pronotum paler; the latter without trace of yellow on its carinæ. The anterior margin of the pronotum is but slightly narrower than the posterior, whereas in the two preceding species the difference in width is plainly perceptible. The notch of the supra-anal spine of the male is deep and rounded, forming a curious fork-like appendage, the lateral processes of which are much swollen.

Measurements: Male—Length of body, 16 mm.; of tegmina, 31 mm.; of posteria femora, 23 mm.; of pronotum, 5 mm. Width of tegmina, 6 mm. Female—Length of body, 20 mm., of tegmina, 30 mm.; of posterior femora, 22 mm.; of ovipositor, 5 mm.

In Central and Southern Indiana the Fork-tailed Katydid is most frequently seen on the low bushes and trees about the margin of thickets and along fence rows, but in the prairie country north it frequents coarse grasses and weeds in company with the preceding species. Its flight is noisless and seemingly without direction, and is not so prolonged as that of *S. curvicauda*. Dr. C. V. Riley (*loc. cit.*) gives the following account of the egg laying habits of *furcata*: "The female stations herself firmly by the middle and hind legs on twigs or leaves contiguous to the one selected to receive the eggs. This leaf is then grasped by the front feet and held in a vertical position, while the edge is slightly gnawed or pared off by the jaws to facilitate the entrance of the point of the ovipositor. When thi

is done the abdomen is curved under and brought forward, and the ovipositor is seized on its convex edge by the mandibles and maxillæ, which, with the aid of the palpi, guide the point to that portion of the leaf prepared to receive it. After gentle, but repeated efforts, the point of the instrument is finally inserted between the tissues of the leaf, and gradually pushed in to more than half its length. As soon as the cavity is formed, the egg is extruded, and passed slowly between the semi-transparent blades of the ovipositor. As the egg leaves the ovipositor the latter is gradually withdrawn, while the egg remains in the leaf, retained in its place, probably, by a viscid fluid that is exuded with it. As many as five of the eggs are sometimes deposited in one row in the same leaf but more often they are single."

This is the most common species of the genus, in the United States, and is quite widely distributed over the country from the Atlantic to the Pacific. In Indiana it has been found in numbers in every county in which collections have been made. The first mature specimens appear about August 5th but it does not become plentiful before the middle of the month.

aaa. Length of posterior femora less than 20 mm.

4. SCUDDERIA ANGUSTIFOLIA (Harris). The Narrow-winged Katydid.

Phaneroptera angustifolia Harris' Ins. Inj. to Veg., 1862, 161, fig. 76.

Scudderia angustifolia, Brunner, Monog. der Phanerop., 1878.

Smith, Cat. Ins. N. J., 1890, 410.

Scudder, Rep. Ent. Soc. Ont. XXIII., 1892. (Note of set to music.)

Phaneroptera curvicauda, Uhler in Harris' Ins. Inj. to Veg., 1862, 161. (Note. In part.)

Scudder, Bost. Journ. Nat Hist., VII., 1862, 448. (In part.)

Id., Am. Nat. II., 1868, 117, (Song of.)

Id., Distrib. Ins. N. Hamp., 1874, 366. (Song of set to music.)

Riley, Sixth Rep. St. Ent. Mo. 1874, 164, fig. 50. (Not text nor fig. 51.)

Scudderia curvicauda Fernald, Orth. N. Eng., 1888, 22. (In part.) (Not *Scudderia curvicauda*), (DeGeer.)

This Katydid occurs in abundance in New England and the Middle Atlantic states, and in the past has been confounded by many writers both with *S. curricauda* and with *S. furcata*. In size, general appearance and structure of anal spines of male it is very similar to *furcata*, but may readily be known by its shorter posterior femora, and by its narrower wing covers.

Measurements: Male—Length of body, 14 mm., of tegmina, 26 mm.; of posterior femora, 19 mm.; of pronotum, 4 mm. Width of tegmina, 5 mm. Female—Length of body, 19 mm.; of tegmina, 25 mm.; of ovipositor, 5.5 mm.

The male of *angustifolia* is our smallest member of the genus. In Indiana it is known only from Fulton county, several specimens of both sexes having been taken on October 7th, from the borders of a peat bog in a tamarack swamp, near Kewanna. This, as far as known, is its first record west of New Jersey. It will probably be found to occur only about the bogs and swamps of the northern half of the State.

Mr. S. H. Scudder, who has studied carefully the songs of many species of Orthoptera and has even set a number of them, including that of *angustifolia*, to music, has given a pleasing account of its song* from which I give the following extract: "It is more noisy by night than by day; and the songs differ considerably at these two times. The day song is given only during sunshine, the other by night and in cloudy weather. I first noticed this while watching one of the little creatures close beside me: as a cloud passed over the sun he suddenly changed his note to one with which I was already familiar, but without knowing to what insect it belonged. At the same time all the individuals around me, whose similar day song I had heard, began to respond with the night cry; the cloud passed away, and the original note was resumed on all sides. Judging that they preferred the night song to that of the day, from their increased stridulation during the former period, I imitated the night song during sunshine, and obtained an immediate response in the same language. The experiment proved that the insects could hear as well as sing. * * * The note by day is *h : r w i* and lasts for one-third of a second. The night song consists of a repetition, ordinarily eight times, of a note which sounds like *t e h w*. It is repeated at the rate of five times in three quarters of a second, making each note half the length of the day note."

*Distribution of Insects in New Hampshire, 1871, 366.

II. AMBLYCORYPHA, Stäl (1873.)

Size medium; wing covers slightly expanded in the middle, regularly rounded at the ends, a little shorter than, or but slightly exceeding, the posterior femora; vertex broad, deflexed but not compressed, without spines; eyes elliptical; stridulating organ of male, brownish, opaque, traversed by a strong green cross vein; ovipositor broad, of medium length, curved gradually upwards from the middle, obtuse or rounded at the end, and with the apical half sharply and strongly serrate on both edges; anal plates of male not prolonged.

Seven species of this genus, which is confined to North America, have been described from the United States. Of these, three have been found in Indiana.

a. Tegmina about 37 mm. in length; exceeding the tip of posterior femora.

5. AMBLYCORYPHA OBLONGIFOLIA, (DeGeer.) The Oblong Leaf-winged Katy-did.

Locusta oblongifolia, DeGeer, "Mem., III., 1873, 445. pl. 38, fig. 2."

*Phyllopter*a *oblongifolia*, Burmeister, Handbuch der Ent., II., 1838, 693.
Harris, Ins. Inj. to Veg., 1862, 159. (Text only.)
Scudder, Bost. Journ. Nat. Hist., VII., 1862, 444.
Id., Distb. Ins. in N. Hamp., 1874, 366.
Id., Am. Encyc. Ed., 1881, VIII., 170. (Text only.)
Rathvon, U. S. Agr. Rep., 1862, 382.
Thomas, Trans. Ill. St. Agr. Soc., V., 1865, 445.

Amblycorypha oblongifolia, Riley, Stand. Nat. Hist., II., 1884, 188.
Bruner, Bull. Washb. Coll. Lab. Nat. Hist., I., 1886, 195.
Comstock, Int. to Entom., I., 1888, 116.
Fernald, Orth. N. Eng., 1888, 21.
McNeill, Psyche, VI., 1891, 21.
Scudder, Rep. Ent. Soc. Ont., XXIII., 1892, 68. (Song of.)

The largest of the three species occurring in the state, measuring about 45 mm. to the end of the wing covers, which are 3.3 times as long as wide. Wings exceeding the wing covers by 6.5 mm. Anterior margin of pronotum much narrower than the posterior, the lateral carinæ sharply defined. Inner, lower carina of posterior femora armed with ten or more rather

strong teeth. General color a bright pea-green, the shrilling organ of male brownish with a heavy green cross vein. The abdomen yellowish or brownish green.

Measurements: Male—Length of body, 21 mm.; of tegmina, 38 mm.; of posterior femora, 30 mm.; of pronotum 6.5 mm. Female—Length of body, 23 mm.; of tegmina, 36 mm., of posterior femora, 31 mm.; of ovipositor, 11.5 mm. Width of tegmina of male, 11.5 mm.

This species is rather common throughout the state from August 1st to October, frequenting the shrubbery along fence rows and the edges of thickets and woods, especially in damp localities; and when flushed, flies with a kind of whirring noise, alighting on fence or the lower branch of tree. I have not distinguished the note made by the male, but McNeill (*loc. cit.*), says that it is a "quick, shuffling sound which resembles "Katy" or "Katydid" very slightly."

aa. Tegmina less than 30 mm. in length; sometimes reaching but not exceeding the tip of posterior femora.

b. Greatest breadth of tegmina contained less than three times in their length; ovipositor strongly curved.

6. AMBLYCORYPHA ROTUNDIFOLIA, (Scudder.) The Round-winged Katydid.

Phylloptera rotundifolia, Scudder, Bost. Jour. Nat. Hist., VII., 1862, 445.

Amblycorypha rotundifolia, Brunner, Monogr. der Phanerop., 1878.

Scudder, Proc. Bost. Soc. Nat. Hist., XIX., 1877, 83.

Id., Am. Encyc., VIII., Ed. 1881, 170. (Fig. only.)

Id., Rep. Ent. Soc. Ont., XXIII., 1892, 68. (Song of.)

Riley, Stand. Nat. Hist., II., 1884, 188, fig. 265.

Comstock, Int. Ent., I., 1888, 116.

Fernald, Orth., N. Eng., 1888, 21.

McNeill, Psyche, VI., 1891, 22.

Phylloptera oblongifolia, Harris, Ins. Inj. to Veg, 1862, fig. 75. (Not text.)

Riley, Sixth Rep. St. Ent. Mo., 1874, 169, fig, 55. (Text in part.)

Length about 32 mm. to end of tegmina, which are proportionally much broader than those of *oblongifolia*. Posterior femora reaching tip of tegmina in male, a little longer in the female; armed on the lower, inner carina with four or five minute teeth. Anterior margin of pronotum, es-

pecially in the female, but little narrower than posterior; the lateral carinæ somewhat rounded. The ovipositor is more curved and more strongly serrate than in either the preceding or the following species. The color is essentially the same as that of *oblongifolia*.

Measurements: Male—Length of body, 19 mm.; of tegmina, 27 mm.; of posterior femora, 25 mm.; of pronotum, 5 mm.; width of tegmina, 10 mm. Female—Length of body, 20 mm.; of tegmina, 27 mm.; of pronotum, 6 mm.; of ovipositor, 10 mm.; width of tegmina, 11 mm.

As far as my observation goes, *rotundifolia* is, by far, the most common member of *Amblycorypha* found in Indiana. It is more of a terrestrial species than the preceding, being often seen on the ground, or on the clumps of tall grass and weeds, which grow in damp ravines. Its flight is comparatively noiseless and less prolonged than that of *oblongifolia*. In Central Indiana it makes its first appearance about the fifth of August. Of its note, Mr. Scudder says: "This insect stridulates both by day and by night, and without variation. The song consists of from two to four notes sounding like *chic-a-che*, repeated rapidly so as to be almost confounded, and when three requiring just one third of a second; the song is repeated at will, generally once in about five seconds, for an indefinite length of time."

bb. Greatest breadth of wing covers contained from $3\frac{1}{4}$ to $3\frac{1}{2}$ times in their length; ovipositor but moderately curved.

7. AMBLYCORYPHA OBLIERI, Brunner. Ohler's Katydid.

Amblycorypha oblieri, Brunner, Monogr. der Phanerop, 1878.
Comstock, Int. to Ent., L., 1888, 116.
Smith, Cat. Ins. of N. Jer., 1890, 409.

Our smallest species of the genus measuring but about 27 mm. to end of tegmina. Posterior femora armed as in *rotundifolia*, slightly exceeding the tegmina in both sexes. Pronotum narrower in front, the anterior half of lateral carinæ rounded, the posterior, rather sharp. The male with longer wings and narrower tegmina than the female. Ovipositor less curved than in either of the other species, the apical half with comparatively strong serrations on both margins. General color, a light, grass green.

Measurements: Male—Length of body, 14 mm.; of tegmina, 23.5 mm.; of hind femora, 20 mm.; of wings beyond tegmina, 5 mm. Female—Length of body, 17.5 mm.; of tegmina 20.5 mm.; of hind femora, 21.5 mm.; of wings beyond tegmina, 3 mm.; of ovipositor, 8.5 mm.

Much less common than either of the preceding, having been noted, as far as known, only in Vigo county, where it frequents the tall sedges and willows bordering the large ponds in the Wabash River bottoms. The young feed upon the leaves of the scarlet oak, *Quercus coccinea*, Wang., and the perfect insect is often found on or beneath this tree. It has been recorded before from New Jersey, Maryland, and the District of Columbia. August 12 and 27th.*

III. Microcentrum, Scudder (1862.)

Size large. Wing covers moderately expanded in the middle, much longer than the posterior femora, and with the outer border sloping off quite sharply, thus causing the tip to be more pointed than in *Amblycorypha* Vertex much as in that genus, slightly furrowed. Eyes broadly oval, very prominent. Hind legs slender and very short, the femora but little more than half as long as the tegmina. Ovipositor very short, bent abruptly upwards, bluntly pointed, and with the apical third finely serrate above. Anal plates of male not prolonged.

"This genus differs from *Amblycorypha*, to which it is most nearly allied, especially by the cut of the wing covers and the shortness of the hind legs and ovipositor."—Scudder.

But one species is known to occur in Indiana.

8. Microcentrum laurifolium, (L.) The Larger Angular-winged Katydid. The Oblique-winged Katydid.

"*Gryllus laurifolius L.*, Syst. Nat. II., 1767, 695, No. 17."

Phylloptera laurifolia, Burmeister, Handb. d. Ent., II., 1838, 693.
Serville, Hist. Nat. des Orth., 1839, 404.

Microcentrum laurifolium, Bruner, Bull. Washb. Coll. Nat. Hist., I., 1885, 127.
Fernald, Orth. N. Eng., 1888, 21.
McNeill, Psyche, VI., 1891, 22.
Smith, Cat. Ins. N. J., 1890, 409.

Microcentrum affiliatum, Scudder. Bost. Jour. Nat. Hist., VII., 1862, 447, fig 5.
Riley, Stand. Nat. Hist., II., 1884, 191.
Comstock, Int. to Ent., I., 1888, 116.

Microcentrus retinervis, Riley, Sixth Rep. Stat. Ent. Mo., 1874, 155, figs. 43–47.

* Unless otherwise stated, the dates given in this paper are those on which the first mature insects have been taken in Central Indiana.

Microcentrum retinervis, Id., Stand. Nat. Hist., II., 1884, 188, fig. 266, (Not *Microcentrum retinervis*, Burm.)

This is the largest species of "Katydid" found in the State, both sexes measuring two inches and more to the end of the wings. The general color is light, grass green, the body yellowish green, lighter beneath. The vertex is quite broad, with its center hollowed out so as to form a shallow pit, which is more prominent in the male. The pronotum is about as broad as long, its anterior margin a little concave and usually possessing a slight median tooth, though this is sometimes obsolete, or is replaced with a shallow notch. The overlapping dorsal surface of the wing covers form a sharp and prominent angle with the lateral portions, whence the common name.

Measurements: Male—Length of body, 25 mm.; of tegmina, 42 mm.; of posterior femora, 22.5 mm.; of pronotum, 6 mm.; width of tegmina, 13 mm. Female—Length of body, 30 mm.; of tegmina 46 mm.; of posterior femora, 24 mm.; of ovipositor, 5 mm.; width of tegmina, 14 mm.

In the country it is this insect which is most commonly called "the Katydid," and the note of *Cyrtophyllus concavus* is usually attributed to it but its true note may be represented "by the syllable '*tic*,' repeated from eight to twenty times at the rate of about four to the second."* It is evidently attracted by light, being often found in the gutters beneath the electric lights in the larger cities and towns. It occurs, probably, throughout the State, but is more common southward and is nowhere found in sufficient numbers to be injurious. The eggs are usually glued in double rows on the sides of slender twigs, which have been previously roughened with the jaws and otherwise prepared for a place of deposit. The two rows are contiguous and the eggs of one alternate with those of the other. Those of the same row overlap about one-fourth of their length. They are of a grayish brown color, long oval in shape, very flat, and measure 5.5x3 mm. They are usually deposited in September, hatch the following May, and the young, in Central Indiana, reach maturity during the first half of August.

The insect whose life history was so well written up by Dr. C. V. Riley, in his Sixth Missouri Report, under the name of *Microcentrus retinervis*, is, in my opinion, the present species, since the measurements of the figures there given correspond exactly with those given above of *laurifolium*. The true *M. retinervis* of Burmeister is found in the eastern United States and

*McNeill, (*loc. cit.*)

probably occurs in Indiana, but has not, as yet, been noted. It is considerably smaller* than *laurifolium*, and with the general color more of a yellowish green.

PSEUDOPHYLLINÆ.

This sub-family is represented in Indiana by the single genus *Cyrtophyllus* the leading characters of which are given below.

IV. CYRTOPHYLLUS, Burmeister (1838).

The members of this genus are at once distinguished from all other Locustidæ by the broad leaf-like form of the tegmina which are longer than the wings, obtuse and rounded at the end, and concave or hollowed within. The vertex extends forward between the eyes in the form of a small flat spine and the prosternum is armed with two sharp spines. Eyes small, globose. The "shrilling" organ of the male is brown in color, with the central portion as transparent as glass, and is set in a strong half oval frame. Ovipositor broad, with the apical half up-curved and denticulate below; apex rather sharply pointed. Sub-anal plate of male produced into a long paddle shaped appendage which is grooved on the upper side.

But two species occur in the United States only one of which is rather common in Indiana.

9. CYRTOPHYLLUS CONCAVUS, (Harris.) The True Katydid. The Broad-winged Katydid.

Pterophylla concava, Harris, Encyclopædia Americana, VIII., 1831, 42.
Platyphyllum concavum, Harris, Ins. Inj. to Veg., 1862, 158, fig. 74.
Walsh, Proc. Ent. Soc. Phil., III., 1864, 233.
Thomas, Trans. Ill. St. Ag. Soc., V., 1865, 445.
Riley, Sixth Rep. St. Ent. Mo., 1874, 167, figs. 52–54.
Cyrtophyllus concavus, Scudder, Bost. Jour. Nat. Hist., VII., 1862, 444.
Id., Encyc. Americ. Ed., 1881, IX., 772, fig.
Id., Rep. Ent. Soc. Ont., XXIII., 1892, 70, fig. 46. (Note of set to music).
Thomas, Trans. Dav. Acad. Nat. Sci., I., 1876, 267.
Packard, Guide to Stud. Ins., 1883, 566, fig. 563.
Riley, Stand. Nat. Hist., II., 1884, 187, fig. 264.

*The measurements given by Burmeister are: length of body, 5-6 of an in.; of tegmina, 1⅛ in.

Comstock, Int. to Ent., I., 1888, 115.
Fernald, Orth., N. Eng., 1888, 20, fig. 10.
McNeill, Psyche, VI., 1891, 24.
Smith, Ins. N. J. 1890, 409.

Platyphyllum perspicillatum, Uhler, in Harris Ins. Inj. to Veg., 1862, 158. (Note.)
Rathvon, U. S. Ag. Rep., 1862, 382, figs. 19, 20. (Not *Cyrtophyllus perspicillatus*, Fab.)

The true Katydid is readily known by the characters of this genus. The wing covers and wings of living specimens are dark green; the body, pronotum and head lighter, with a tendency to turn yellowish when dried Harris says the pronotum is "rough like shagreen, and has somewhat the form of a saddle, being curved downward on each side, and rounded and slightly elevated behind and is marked by two slight transverse furrows." The main veins of the wing cover are very prominent with many reticulating branches, giving that organ much the appearance of a leaf. Posterior femora short, slender, and armed on apical half of lower outer carina with about six small spines. The ovipositor is almost as long as the abdomen, cimeter-shaped, sharp-pointed, and with but slight serrations on the lower edge of apical third. Below the curved anal cerci of the male is a spine, resembling in appearance the cerci, which curves beneath the projecting sub-anal plate.

Measurements: Male—Length of body, 30 mm.; of tegmina, 37 mm.; of posterior femora, 21 mm.; of sub-anal spine, 11 mm. Width of tegmina, 18 mm. Female Length of body, 29 mm.; of tegmina, 36 mm.; of posterior femora, 22 mm.; of ovipositor, 14 mm. Width of tegmina, 16 mm.

The Broad-winged Katydid is found in considerable numbers throughout the State but is much more commonly heard than seen, as it dwells singly or in pairs in the densest foliage which it can find such as the tops of shade trees and the entwining vines of the grape arbor. It is more domestic in its habits than any other species of the "Katydid" group, frequenting, for the most part, the shrubbery of yards and orchards and the trees along fence rows, being seldom, if ever, heard in extensive wooded tracts. Its note is the loudest made by any member of the family, the male having the musical organ larger and better developed than in any other. The call is almost always begun soon after dusk with a single note uttered at intervals of about five seconds for a half dozen or

more times. This preliminary note gives the listener the impression that the musician is tuning his instrument, preparatory to the well known double call which is soon begun and kept up almost continuously from dark till dawn.

Of this call Mr. Scudder, says: "The note, which sounds like *err*, has a shocking lack of melody: the poets who have sung its praises must have heard it at the distance that lends enchantment. In close proximity the sound is excessively rasping and grating, louder and hoarser than I have heard from any other of the Locustarians in America or in Europe, and the Locustarians are the noisiest of all Orthoptera. Since these creatures are abundant wherever they occur, the noise produced by them, on an evening specially favorable to their song, is most discordant. Usually the notes are two in number, rapidly repeated at short intervals. Perhaps nine out of ten will ordinarily give this number; but occasionally a stubborn insect persists in sounding the triple note—('Katy-she-did'); and as Katydids appear desirous of defiantly answering their neighbors in the same measure, the proximity of a treble-voiced songster demoralizes a whole neighborhood, and a curious medley results; notes from some individuals may then be heard all the while, scarcely a moment's time intervening between their stridulations, some nearer, others at a greater distance; so that the air is filled by these noisy troubadours with an indescribably confused and grating clatter."

According to Riley the eggs are thrust, by means of the sharp ovipositor, into crevices and soft substances, and probably, in a state of nature, into the crevices of loose bark, or into the soft stems of woody plants. They are of a dark slate color, about 6.5x2 mm. in size, very flat, pointed at each end, and with the edges beveled off or emarginate. The song has been heard in Putnam county as early as August 5th, and a single female was captured in Lake county on October 15th, so that the species probably exists more than two months in the mature state.

It was to this species that Oliver Wendell Holmes addressed the well known lines:

"I love to hear thine earnest voice
Wherever thou art hid,
Thou testy little dogmatist,
Thou pretty Katydid."

CONOCEPHALINÆ.

Vertex projecting forward and upward in the form of a tubercle or cone, sometimes blunt, sometimes much prolonged. Prosternum toothed

or with two slender spines. Front coxæ (in our genera) with a spine on the outside. Wing covers seldom expanded in the middle, often shorter than the abdomen, and in color either green or brown. Shrilling organ of male well developed, the cross vein prominent, the color light brown, with the central portion transparent (except in the genus *Conocephalus*). The hind legs are usually stout and much thickened at the base as the insects seldom fly, but are active leapers, and very difficult to capture.

The eggs are deposited within the stems or root leaves of grass, the pith of twigs, or sometimes in the turnip-shaped galls so common on certain species of willow. The ovipositor being thus used as a piercer, has in time developed into a slender and sharp pointed instrument which is but little curved and is frequently of excessive length, in some species being over twice as long as the remainder of the body.

To this sub-family belong those slender-bodied green grasshoppers, with long, tapering antennæ which are so common in summer and early autumn in damp meadows and prairies and along the margins of streams, ditches and ponds. They are mostly terrestrial in their habits, but one or two of the larger ones ever being found in trees.

The color of their bodies corresponds closely to that of the stems and leaves of the sedges and grasses among which they dwell, and so protects them from the sight of the few birds which frequent a like locality. Their songs, produced in the same manner as those of their larger cousins, the katydids, are as frequent by day as by night, but are usually soft and low in comparison with those of the former. Their day songs differs from that of the night, and, says Scudder, "It is curious to observe these little creatures suddenly changing from the day to the night song at the mere passing of a cloud and returning to the old note when the sky is clear. By imitating the two songs in the daytime the grasshoppers can be made to represent either at will; at night they have but one note."[3]

Twenty-one species of this sub-family, representing three genera, are known to occur in the state.

KEY TO GENERA OF CONOCEPHALINÆ.

a. Vertex produced forwards into a long sharp cone; stridulating organ of male green and opaque . . V. CONOCEPHALUS.

aa. Vertex terminating in a rounded tubercle which is hollowed out on the sides; stridulating organ of male light brown and partly transparent.

[3] American Naturalist, II., 1868, 116.

b. Prosternal spines very short; ovipositor slender, straight, or very nearly so; insect small . . . . VI. Xiphidium.

bb. Prosternal spines long and slender; ovipositor stout, usually upcurved; insect large . . VII. Orchelimum.

V. Conocephalus, Thunbergh (1815.)

The Cone-headed Grasshoppers.

The members of this genus are readily known by having the vertex prolonged forward and upward into a cone which much exceeds in length the first segment of the antennæ. Face very oblique. Eyes subrotund, rather prominent. Spines of pronotum long and slender. Wing covers long, narrow, rounded at the end, much exceeding the abdomen and slightly exceeding the wings in all our species. The stridulating organ of the male is opaque and of a coarse texture in the left wing cover, but transparent at the center of the right. Hind femora of moderate length, rather slender, the insects often using the wings as locomotors. Ovipositor rather narrow, nearly straight, oftentimes of excessive length; the eggs of those species in which the oviposition has been noted, being deposited between the stem and the root leaves of plants. Anal plates of male not produced; the cerci much swollen, recurved and toothed.

Although these insects are said to be rather common by those writers who have prepared lists of Orthoptera from other States, yet in Central and Western Indiana they are the least abundant of all the *Locustidæ*, five years' collecting having yielded less than twenty specimens. In the northern part of the State, however, they appear to be much more common. Of the habits of the species found in Illinois, McNeill has written: "All the species of Conocephalus seem to possess more intelligence than is usual in Orthoptera, and they are about the most difficult of the order to approach. In escaping they usually slip or fall into the grass instead of jumping or flying; but they seem to fully understand that they are very well protected by their color and form. If approached very cautiously they often remain quite still upon the stem of grass upon which you have surprised them with the usually well founded expectation that you will not be able to distinguish them from the green herbage around. If they think it worth while to make some active movement to escape they will frequently slip around on the other side of the stem and walk down the stem to the ground or off upon another plant. Unlike most Orthoptera they do not use their front legs in holding to the mouth

the thing upon which they feed. Instead of biting they seem to wrench or tear away pieces from the stems or leaves."[1]

The genus is a large one, 101 species being included by Redtenbacher in his monograph. About one dozen are known to occur in the Eastern United States, and four have, up to the present, been taken in Indiana.

a. Cone of vertex slender, about 3.5 mm. in length, and with either the margin or lower face black.

b. A black line on each margin of cone extending from the apex half way or more to base; inner, lower carina of posterior femora with four or five minute spines.

10. CONOCEPHALUS ENSIGER, Harris. The Sword-bearer.

Conocephalus ensiger, Harris, Ins. Inj. to Veg., 1862, 163, fig. 79.
Scudder, Bost. Jour. Nat. Hist., VII., 1862, 449.
Id., Dist. Ins. in New Hamp., 1874, 367. (Note of to music.)
Id., Am. Ency., Ed. 1881, VIII., 170, fig. .
Id., Rep. Ent. Soc. Ont., XXIII., 1892, 72. (Note of to music.)
Thomas, Trans. Ill. St. Agl. Soc., V., 1865, 445.
Smith, Orthop. of Maine, 1868, 145.
Riley, Stand. Nat. Hist., II., 1884, 187, fig. 263.
Comstock, Int. to Ent., I., 1888, 115.
Fernald, Orth. N. Eng., 1888, 22.
Wheeler, Insect Life, II., 1890, 224.
McNeill, Psyche, VI., 1891, 23.
Smith, Ins. of N. Jersey, 1890, 410.
Id., Bull. Ag. Coll. Ex. Stat. N. Jer., No. 90, 1892, 31, pl. II.
Redtenbacher, Monogr. der Conoceph., 1891, 67, 89.
Osborne, Proc. Ia. Acad. Sci., I., 1892, 119.

A slender-bodied species, the general color of which is grass green, the body and face paler: the posterior tibiæ and tip of ovipositor infuscated. Lateral carinæ of pronotum sometimes with a faint yellow line, more plainly visible in the dried specimens. Tegmina very long and slender. Cone of vertex with a small tooth projecting downward from the front of its base. Ovipositor of excessive length, straight, the apex pointed.

[1] Psyche, VI., 23.

Measurements: Male—Length of body, 26 mm.; of tegmina, 42 mm.; of posterior femora, 21 mm. Female—Length of body, 28 mm.; of tegmina 47 mm.; of posterior femora, 23 mm.; of cone of vertex 3.25 mm.; of pronotum, 7.5 mm.; of ovipositor, 31 mm.

This is probably the most widely distributed species occurring in the Eastern United States, having been recorded from Maine to Nebraska. It is the most common one occurring in Northern Indiana, where it frequents the tall rank grasses along ditches and the borders of damp prairies. In Vigo and Putnam counties it is scarce, being replaced by *C. nebrascensis*, Bruner.

The female has been recorded as depositing her eggs between the stem and root leaves of *Andropogon*, a genus of tall, coarse grasses which grow in dry, sandy localities. The young, hatched in May, reach maturity about the 5th of August. Mr. Scudder, who has set the note of the male to music, says of the song: "This insect has but a single song and stridulates only by night, or during cloudy weather. It begins its song as soon as the sky is obscured or the sun is near the horizon. It commences with a note like *b r w*, then pauses an instant and immediately emits a rapid succession of sounds like *c h w i* at the rate of about five per second, and continues them for an unlimited time. Another writer likens its note to the syllable '*ik-ik-ik*,' as if sharpening a saw, enlivening low bushes, and particularly the corn patch, as it seems to especially delight in perching near the top of a cornstalk and there giving forth its rather impulsive song."

bb. Cone of the vertex entirely black beneath; posterior femora armed on both of the lower carinæ with a number of plainly visible spines.

11. CONOCEPHALUS NEBRASCENSIS, Bruner.

Conocephalus nebrascensis, Bruner, Canadian Ent., XXIII., 1891, 72.
McNeill, Psyche, VI., 1891, 23.
Osborne, Proc. Ia. Acad. Sci., I., 1892, 119.
Scudder, Rep. Ent. Soc. Ont., XXIII., 1892, 72.

A heavier bodied and shorter winged species than the preceding. The cone of the vertex projecting upward more strongly and with the apical half more tapering than in *ensiger*; the basal tooth quite prominent. "Anal cerci of male stout, with strong internal hooks. Ovipositor long and slender, lanceolate, a little curved upwards and extending about one-fourth of an inch beyond the closed tegmina."

"General colour bright grass green (rarely a yellowish brown or tan) with narrow, yellowish lines along the lateral carinæ of the pronotum. Posterior tibiæ together with all the feet more or less infuscated."—Bruner.

Measurements: Male—Length of body, 28 mm.; of tegmina, 37 mm.; of pronotum, 8 mm.; of cone of vertex, 3.5 mm.; of posterior femora, 21 mm. Female—Length of body, 33 mm.; of tegmina, 42 mm.; of posterior femora, 23 mm.; of ovipositor, 29 mm.

The above measurements are very nearly the same as those given by Mr. Bruner in the original description of the species, and are the average of a half dozen specimens in my collection. I have one female, however, which is so much larger that at first I was inclined to think it a different species, but the color and structure, except the measurements, agree in every particular with those given above of *nebrascensis*. The following are the measurements of the specimen in question:

Length of body, 36 mm.; of cone, 4.5 mm.; of tegmina, 49 mm.; of posterior femora, 30 mm.; of ovipositor, 39 mm.

This species has not before been recorded east of Illinois, but in Central Indiana it is the most common of the three species occurring there. A number of specimens have been taken in Putnam county by Mr. Riley and in Vigo and Fulton counties by myself. When approached it often attempts to escape by burrowing beneath the fallen grass. It frequents the same localities as *C. ensiger* and is very liable to be mistaken for that species by the casual observer, but may at once be distinguished by the characters given above.

aa. Cone of vertex rather stout, less than 3 mm. in length, devoid of black markings.

c. Lateral carinæ of pronotum with a yellow line; wing covers with irregularly distributed black dots; ovipositor exceeding 25 mm. in length.

12. Conocephalus robustus, Scudder.

Conocephalus robustus, Scudder, Bost. Journ. Nat. Hist., VII., 1862, 449.
Id., Proc. Bost. Soc. Nat. Hist., XI., 1868, 7. (Song of.)
Id., Am. Naturalist, II., 1868, 117. (Song of.)
Id., Distb. Ins. in N. Hamp., 1874, 367. (Song of.)
Id., Rep. Ent. Soc. Ont., XXIII., 1892, 72. (Song of.)

Riley, Stand. Nat. History., II., 1884, 187.
Comstock, Int. to Ent., I., 1888, 115.
Fernald, Orth. N. Eng., 1888, 23.
McNeill, Psyche, VI., 1891, 23.
Smith, Ins. N. Jer., 1890, 410.
Redtenbacher, Monog. der Conoceph., 1891, 89. Pl. III., fig. 36.

A larger and thicker bodied species than either of the preceding; and the wing covers broader. Cone of the vertex more like that of *C. ensiger* but shorter, with the apex more obtuse; the frontal basal spine distinct but blunt. Posterior femora armed beneath on both carinæ with a number of rather weak spines. Wings of male equalling the tegmina in length, in the female a little shorter. Ovipositor shorter than in either of the above species. General color either pea-green or dirty brown* or a mixture of both. The cone rarely with a black spot at apex, its sides often with a narrow yellowish line.

Measurements: Male—Length of body, 30 mm.; of tegmina, 44 mm.; of hind femora, 23 mm.; of pronotum, 8 mm.; of cone, 2 mm. Female—Length of body, 31 mm.; of tegmina, 48 mm.; of hind femora, 26 mm.; of ovipositor, 26 mm.

This species seems to be an inhabitant of sandy districts and occurs only along the Atlantic sea coast and the shores of the Great Lakes. In Indiana it has been noted only in Lake county, where Prof. E. E. Slick found it quite frequently along the shore of Lake Michigan during September and October. Of the specimens sent to me—a half dozen males—he wrote: They were caught off of trees, in the dusk of the evening, as they were singing. They sang ("whetted") continuously for ten minutes or longer while I watched them.

Mr. Scudder thus describes the note as heard in New England: "Robustus is exceedingly noisy and sings equally, and I believe similarly, by day and night. The song resembles that of the harvest fly, *Cicada canicularis*. It often lasts for many minutes, and seems, at a distance, to be quite uniform; on a nearer approach one can hear it swelling and decreasing in volume * * * and it is accompanied by a buzzing sound, quite audible near at hand, which resembles the humming of a bee or the droning of a bagpipe."

C. ensiger is said also to be thus dimorphic in coloration, but all that I have seen from this state are of the green variety.

c. Lateral carinæ of pronotum without trace of yellow; wing covers a bright, grass green, immaculate; ovipositor less than 20 mm. in length.

13. Conocephalus palustris, Blatchley.

Conocephalus palustris, Blatchley, Canad. Ent. XXV., 1893, 89.

A small but comparatively heavy-bodied species, having the cone of the vertex devoid of black markings and without a basal tooth; ovipositor very short and broad; posterior femora armed beneath on both carinæ.

Cone of the vertex short and stout, the tip round, the deflexed front with a dull median carina. Pronotum short, broad, the posterior margin regularly rounded, the lateral carinæ well defined, the entire surface thickly and rather deeply punctate. Tegmina long and rather narrow, regularly rounded to the apex; of a more delicate texture than in either *C. ensiger*, Harris, or *C. robustus*, Scudder. Fore and middle femora with two short spines on the apical third of the lower outer carina. Hind legs short, the tibiæ but little more than half as long as the closed tegmina; the femora with plainly visible spines on both of the inferior carinæ, eight on the outer and six on the inner. Ovipositor a little shorter than the hind tibiæ, broadest at a point about two-thirds the distance from the base, thence tapering regularly to a sharp apex.

General color a very bright grass green. Fastigium tipped with dull yellow, which extends half way down the sides. Labrum and apical segments of all the palpi a rose red tinged with violet. Tarsi somewhat infuscated. Antennæ and apical third of ovipositor reddish-brown.

Measurements: Female—Length of body, 27 mm.; of fastigium in front of eye, 2.75 mm.; of pronotum, 7 mm.; of tegmina, 37 mm.; of hind femora, 20 mm.; of hind tibiæ, 19.5 mm.; of ovipositor, 19 mm.

This handsome species of *Conocephalus* belongs to the same group as *C. robustus* and *C. crepitans*, Scudder, but is smaller and of a more uniform and brighter green than either of those species, besides having shorter legs, ovipositor, etc. It is described from a single female taken October 24, from the fallen grasses on the margins of a large low-land pond in Vigo county. This pond is surrounded on all sides by heavy timber, and its margins have yielded a number of interesting Orthoptera found nowhere else in the county. Among them are *Leptysma marginicollis*, Serv., *Paroxya atlantica*, Scudder, *Anaxiphus pulicarius*, Sauss., *Phylloscirtes pulchellus*, Uhler, and *Xiphidium nigropleurum*, Bruner. The first four mentioned are insects of a southern range, and perhaps *C. palustris* will in time be found to be more common southward.

VI. XIPHIDIUM, Serville (1831).

This genus includes our smallest winged Locustidæ. The vertex projects forward and slightly upward in the form of a rounded tubercle which is hollowed out on the sides for the reception of the basal joint of the antennæ. Face rounded, somewhat oblique. Eyes rather large, sub-globose. Spines of prosternum very short and weak; often mere cone-shaped protuberances. Wing covers narrow, straight, rounded at the end, often varying much in length in the same species, but for the most part shorter than the abdomen. Wings usually a little shorter than the wing covers. Stridulating organ of male well developed, the veins prominent, light brown in color, and with the middle transparent. Hind femora of medium length, stout at base. Ovipositor narrow, straight, or but slightly curved, oftentimes of excessive length. Anal plates of male not prolonged; the cerci usually much swollen, and toothed at base on the inner margin. Eight species are known to occur in the State.

These insects are more variable in color and in the length of wings than those of any other genus of Orthoptera known to me. The variations, however, seem to be abrupt with no intervening forms. There are long-winged and short-winged forms of the same species but none with the wings of medium length; and when a brown form is tinged with green, or *vice versa*, the amount of the different color varies but little. Five of our eight species are thus dimorphic as regards the length of wings, the short-winged individuals, as far as my observation goes, far outnumbering those with the wings fully developed; and at least three of the eight are variable with respect to color.

a. Ovipositor shorter than the body.

b. Ovipositor straight.

c. Wings a little longer than the wing covers; the latter always fully developed.

14. XIPHIDIUM FASCIATUM, (DeGeer.) The Slender Meadow Grasshopper.

Locusta fasciata DeGeer, "Mem., III., 1778, 458, Pl. XL., fig. 4."

Xiphidium fasciatum, Burmeister, Handb. der Ent., II., 1839, 708.

Scudder, Boston Jour. Nat. Hist., VII., 1862, 451.

Id., Distr. of Ins. in N. Hamp., 1874, 368.

Id., Rep. U. S. Ent. Com., II., Appen. II., 1880, 23.

Id., Rep. Ent. Soc. Ont., XXIII., 1892, 75. (Song of.)

Smith, Orthop. of Maine, 1868, 145.

Packard, Guide, Stud. Ins., 1883, 567.
Riley, Stand. Nat. History., II., 1884, 186.
Bruner, Bull. Washb. Coll. Nat. Hist., I., 1885, 128.
Id., Ent. News, III., 1892, 265.
Comstock, Int. to Ent., I., 1888, 114.
Fernald, Orth. N. Eng., 1888, 24.
Smith, Ins. of N. Jer., 1890, 411.
Id., Bull. 90, Ag. Coll. Exp. Stat. N. Jer., 1892, 31, pl. II.
McNeill, Psyche, VI., 1891, 24.
Redtenbacher, Monog. der Conoceph., 1891, 192, pl. IV., fig. 82.
Osborne, Proc. Ia. Acad. Sci., I., 1892, 118.

One of the most slender bodied species belonging to our fauna, and the only one whose wings are never shorter than the body. Posterior femora reaching to or slightly beyond the tip of tegmina in the female, distinctly shorter in the male. Face, sides of pronotum and abdomen, and basal portion of ovipositor green; tegmina and apical third of ovipositor light reddish brown; upper side of abdomen, and stripe on occiput and disk of pronotum darker brown; legs green, brownish on the knees and tarsi.

Measurements: Male Length of body, 13.5 mm.; of tegmina, 17.5 mm.; of hind femora, 11.5 mm.; of pronotum, 3.5 mm. Female—Length of body, 14 mm.; of tegmina, 16 mm.; of hind femora, 13 mm.; of ovipositor, 8 mm.

Abundant everywhere in timothy and clover meadows and especially so about small streams in low ground, blue-grass pastures. One of the first of the Locustidæ to reach maturity, specimens having been taken in Vigo county as early as July 5th. The note of the male is very faint—a kind of *zr-r-r-r* long drawn out.

Fasciatum has, perhaps, the widest distribution of any of our American Locustidæ, its range, according to Redtenbacher, being from British America to Buenos Ayres, S. A.

The *Orchelimum gracile* of Harris, usually quoted as a synonym of *N. fasciatum*, has been shown by Bruner (Ent. News, *loc. cit.*) to be a distinct and valid species.

cc. Wings shorter than the wing covers; the latter variable in length.

15. XIPHIDIUM BREVIPENNE, Scudder.

Xiphidium brevipennis, Scudder, Boston Jour. Nat. Hist., VII., 1862, 451.
Xiphidium brevipenne, Id., Dist. Ins. in N. Hamp., 1874, 368.
Id., Sec. Rep. U. S. Ent. Comm., 1880 Appen., II., 23.
Smith, Orth. of Maine, 1868, 145.
Riley, Stand. Nat. Hist., II., 1884, 186.
Bruner, Bull. Washb. Coll. Lab. Nat. Hist., 1885, I., 128.
Comstock, Int. Ent., I., 1888, 114.
Fernald, Orth. N. Eng., 1888, 24.
Smith, Ins. of N. Jer., 1890. 411.
Id., Bull. 90, Ag. Coll. Exp. Stat. N. Jer., 1892, 31, pl. II.
McNeill, Psyche, VI., 1891, 24.
Redtenbacher, Monog. der Conoceph., 1891, 206, pl. IV., fig. 91.
Osborne, Proc. Ia. Acad. Sci., I., 1892, 119.
Blatchley, Can. Ent., XXIV., 1892, 26.

A little shorter and thicker bodied species than *X. fasciatum*. Posterior femora rather short and stout, unarmed beneath, or rarely with one to four minute spines. Cerci of male swollen, the apex strongly compressed and obtuse, armed below the middle with a rather flat, sharp-pointed tooth.

General color light reddish brown; the face and sides of pronotum usually green; stripe on occiput and disk of pronotum a very dark brown, margined on each side with a narrow yellow line; ovipositor reddish brown throughout.

Measurements: Male—Length of body, 12 mm.; of tegmina, 8 mm.; of posterior femora, 11.5 mm.; of pronotum, 3.5 mm. Female—Length of body, 13 mm.; of tegmina, 7.5 mm.; of posterior femora, 11 mm.; of pronotum, 3 mm.; of ovipositor, 9–10 mm.

This is also an abundant species throughout the State, frequenting the same localities as *fasciatum* and reaching maturity about a fortnight later. Long-winged forms of it occasionally occur, but in Indiana they are very scarce, but one or two having come under my notice. Of the variations in the length of the wing covers of it and allied species Prof. Bruner has well said: "That in the genera *Xiphidium* and *Orchelimum* wing length is

a character not to be relied upon as specific or even varietal difference[6]; " yet Redtenbacher in his Monographie der Conocephaliden has separated a number of his species by this character alone, and I can find no mention in his work of the fact that such a variation exists.

bb. Ovipositor a little curved; tegmina constant in length, covering about two-thirds of the abdomen in the male; shorter in the female.

16. XIPHIDIUM NEMORALE, Scudder.

Xiphidium nemorale, Scudder, Proc. Bost. Soc. Nat. Hist., XVII., 1875, 462.
Id., Entom. Notes, IV., 1875, 65.
Id., Cent. Orth., 1879, 15.
Id., Rep. Ent. Soc. Ont., XXIII., 1892, 75.
McNeill, Psyche, VI., 1891, 24.
Bruner, Can. Ent., XXIII, 1891, 59.

Xiphidium curtipenne, Redtenbacher, Monograph der Conoceph., 1891, 208.

A rather robust species with the general color a dark, greenish brown; tegmina light reddish brown with the front or lower area fuscous. Dorsal stripe of occiput and pronotum not contrasting so strongly with the general color as in the preceding species, margined with a narrow yellow line on each side. All the femora punctate with reddish dots, the tarsi and tip of hind femora dusky. Tegmina with the veins and cross veins unusually prominent giving them a coarse and scabrous look; the tympanum of male stout and elevated. Cerci conical, the apex obtuse, but little compressed. Ovipositor as long as the abdomen, the apical half with a gentle but evident upward curve.

Measurements: Male—Length of body, 14 mm.; of tegmina, 8 mm.; of hind femora, 12 mm.; of pronotum, 3.5 m. Female—Length of body, 15 m.m.; of tegmina, 5.5 mm.; of hind femora, 13 mm.; of ovipositor, 9 mm.

Redtenbacher, in his Monographie, has evidently described this species as new under the name of *curtipenne*. His specimens were from Missouri.

Nemorale is a very common insect in Vigo and Putnam counties but has not as yet, been taken in the northern part of the State. It reaches maturity about August 15th and from then until after heavy frosts may be found in numbers along the borders of dry, upland woods, fence rows, and

[6] Canadian Ent., XXIII, 59.

roadsides where it delights to rest on the low shrubs, blackberry bushes, or coarse weeds usually growing in such localities. On the sunny afternoons of mid-autumn it is especially abundant on the lower parts of the rail and board fences, the male uttering his faint and monotonous love call—a sort of *ch-r-r-r-r—ch-r-r-r-r*, continuously repeated—the female but a short distance away, a motionless, patient, and apparently attentive listener. When in *coitu* the male does not mount the back of the female, but, with his body reversed, is dragged about by her, this being the common practice of all the species of *Xiphidium* and *Orchelimum*. *Nemoralc* has been recorded only from Nebraska, Iowa, and Illinois and seems to be confined to the northern half of the middle United States.

aa. Ovipositor equal to or longer than the body.

d. Length of posterior femora almost equal to that of ovipositor.

e. Body rather stout; the tegmina always covering more than half the abdomen.

f. Abdomen with the dorsal surface light brown, the sides green, or greenish yellow.

17. XIPHIDIUM ENSIFERUM, Scudder.

Xiphidium ensifer, Scudder, Bost. Jour. Nat. Hist., VII., 1862, 451.

Xiphidium ensiforme, Id., Bull. U. S. Geol. and Geog. Surv. Terr., 1876, II., 261.

Xiphidium ensiferum, Id., Sec. Rep. U. S. Ent. Comm., 1880, Appen II., 23.
Riley, Stand. Nat. Hist., II., 1884, 186.
Comstock, Int. to Ent., 1., 1888, 114.
Wheeler, Insect Life, II., 1890, 222. (Oviposition of.)
McNeill, Psyche, VI., 1891, 24.
Redtenbacher, Monog. der Conoceph., 1891, 209.

Very similar in general appearance to *X. brevipenne*, Scudder, and may be only a variety of that species. Typical examples are larger with a much longer ovipositor. The general color is also more of a green than in *brevipenne;* the face, sides of pronotum and abdomen, and the four anterior femora being of that hue. The tegmina and wings are light, reddish brown, as are also the tibiæ and ovipositor; the latter becoming a deeper brown towards the apex. Cerci of male rather stout, with the apical half curved slightly outward and depressed. Ovipositor slender, straight.

Measurements: Male—Length of body, 13.5 mm.; of tegmina, 9 mm.; of hind femora, 13 mm.; of pronotum, 3.5 mm. Female—Length of body, 14.5 mm.; of tegmina, 8.5 mm.; of hind femora, 14 mm.; of ovipositor, 15 mm.

Although found in Indiana wherever collections have been made, this species appears to be less common than either *fasciatum* or *brevipenne*. It differs from them also in the manner of oviposition, as, instead of depositing its eggs in the stems of grasses, it seeks the turnip-shaped galls so common on certain species of *Salix* (willow) and oviposits between their scales. The gall is not formed by the Locustid, but by a Dipterous insect belonging to the family of *Cecidomyidæ*. Although I have never seen the eggs deposited I have on a number of occasions found them within the galls, but did not know to what insect they belonged until Mr. Wheeler published (*loc. cit.*) his excellent account of the oviposition of this species. From that I quote as follows: "On September 8th I observed a female in the act of ovipositon. She was perched with her head turned toward the apex of the gall. Slowly and sedately she thrust her sword-shaped ovipositor down between the leaves, and, after depositing an egg, as slowly withdrew the organ in order to recommence the same operation, after taking a few steps to one side of where she had been at work. She soon observed me and slipped away without completing her task. The number of eggs found in a gall varies considerably. Sometimes but two or three will be found, more frequently from fifty to one hundred. In one small gall I counted one hundred and seventy." The egg is cream colored, very thin, elongate oval in outline, and measures 4x1 mm.[3] The young emerge about the middle of May and reach maturity about August 10th. Long-winged forms of this species are occasionally met with.

On October 21 a pupa was taken which had a white hair worm (*Gordius*) 8½ inches long in its abdomen.

Ensiferum was first described from Illinois, and, as yet, has not been recorded east of the Alleghany Mountains.

ff. Abdomen with the dorsal surface a fuscous brown, the sides shining black.

[3] Mr. B. D. Walsh, in the Proc. Ent. Soc. Phil., III., 1864, 232, recorded the finding, on numerous occasions, of the eggs of an *Orchelimum* in the turnip-shaped galls of *Salix cordata*. Their shape and proportional dimensions, as given by him, differ much from those of *X. ensiferum*, as they were cylindrical, .16 to .17 of an inch long, and seven times as long as wide.

18. XIPHIDIUM NIGROPLEURUM, Bruner. The Black-sided Grasshopper.
Xiphidium nigropleurum, Bruner, Canad. Entom., XXIII., 1891, 58.
Osborne, Proc. Ia. Acad. Sci., I., 1862, 118.
Blatchley, Canad. Ent., XXV., 1893, 90.

A medium sized, rather robust species, easily distinguished from all others of the genus by its peculiar coloration. In Indiana dimorphic forms occur; one having the pronotum, tegmina and legs bright grass green, the other with these parts brownish yellow, the green wholly absent. Both forms have the stripe on the occiput and the sides of the abdomen shining black; the former narrowing in front to the width of the tubercle, and bordered on each side with yellowish white. In the green forms the usual brown stripe on the disk of pronotum is but faintly defined, in the other it is very evident.

"The tegmina are usually abbreviated, reaching only four-fifths of the length of the abdomen, but an occasional specimen is to be found in which the wings are fully developed and then reach to the extremity of the ovipositor in the female. Ovipositor straight, quite broad and heavy. Male cerci of medium length, rather stout, tapering gently toward the apex, and with a strong sub-basal tooth."—Bruner, (*loc. cit.*)

Measurements: Male—Length of body, 14 mm.; of tegmina, 9 mm.; of hind femora, 13.5 mm.; of pronotum, 3.5 mm. Female—Length of body, 15 mm.; of tegmina, 8.5 mm.; of hind femora, 14 mm.; of ovipositor, 16 mm.

In Indiana this handsome insect is known to occur in the two widely separated counties of Fulton and Vigo, but in restricted localities and small numbers, as far as noted, in each. In Fulton county it was found only in a broad, shallow ditch by the side of a railway and near the border of a large tamarack swamp, where it inhabited a space not more than twenty feet square, which contained several dead willow branches, surrounded by a dense growth of sedge and *Polygonum*. Here, on August 26th, four females were taken and on September 24th two males and two females. These were all that were seen, although a careful search was made over a wide area in every direction for others. The most of those secured were taken by clasping the hand about the slender willow branches which were raised a few inches above the ground, on the under side of which the insects took refuge when pursued. A single male taken from the margin of the large pond mentioned under *Conocephalus palustris*, is the only specimen as yet seen in Vigo county. The species has been

noted before only in Iowa and Nebraska, but probably occurs in suitable localities throughout northern Illinois and northwestern Indiana. Of its habits in Nebraska, Bruner has written as follows: "It is quite plentiful among the rank vegetation on low moist ground, and is especially common in wet places where the "cut grass" (*Leersia oryzoides*, Swartz) grows. The supposition is that this grass offers a better place than usual for the deposition of its eggs, which are deposited between the leaves and stems of grass. Grape vines and other creeping plants which form matted clusters that afford shelter from the noonday sun and the bright light of day are favorite haunts of this and other species of our nocturnal grasshoppers and a few of the arboreal crickets."

Since writing the above I have received a pair of this species from Mr. A. P. Morse, Wellesly, Mass., which were labelled "Ithaca, N. Y.," thus extending eastward its known habitat by more than 700 miles.

cc. Body very slender; the tegmina exceedingly short, pad-like, covering only one-third of abdomen.

19. Xiphidium modestum, Bruner.

Xiphidium modestum, Bruner, Can. Ent., XXIII., 1891, 56.

This is the smallest and most slender-bodied Locustid found in the state. It is a dull, reddish brown in color, except the stripe on the occiput and disk of pronotum, which is a dark, chocolate-brown, the two colors being separated by a rather wide yellowish line which in living specimens is very distinct.

The cone of vertex is short and rather narrow. Tegmina, especially those of the female, very short and obtusely rounded. Cerci of male elongate, tapering, a little curved outward and armed with a rather long sub-basal tooth. Ovipositor equalling the body in length, very slender and tapering, with its apical half slightly upcurved.

Measurements: Male—Length of body, 10 mm.; of tegmina, 3 mm.; of hind femora, 9 mm.; of pronotum, 3 mm. Female—Length of body, 11 mm.; of tegmina, 2.5 mm.; of hind femora, 9.5 mm.; of ovipositor, 11 mm.

As yet noted only at one point in the state, namely, the border of a raw prairie near Heckland, Vigo county, where it was found in small numbers on October, 21st. It appears to be less active than any other *Xiphidium*, leaping a shorter distance when disturbed, and frequenting the surface of the ground rather than the stems of the tall prairie grasses among which it makes it home. It will probably be found throughout the prai-

rie region of the state, but has not before been recorded east of the Mississippi river, although it is said by Bruner to be very plentiful in Nebraska, Iowa and Kansas.

dd. Posterior femora much shorter than the ovipositor; the latter of excessive length.

g. The common form with the tegmina very short, less than half the length of the abdomen; the sides of the body green.

20. XIPHIDIUM STRICTUM, Scudder.

Xiphidium strictum, Scudder, Proc. Bost. Soc. Nat. Hist., XVII., 1875, 460.
Id., Entom. Notes, IV., 1875, 63.
Id., Cent. of Orthop., 1879, 13.
Bruner, Bull. Washb. Coll. Lab. Nat. Hist., I., 1885, 128.
McNeill, Psyche, VI., 1891, 24.
Redtenbacher, Monog. der Conoceph., 1891, 205.

This is a species with the body rather slender, of more than average length; constant in color but dimorphic as respects the length of wings, the long winged forms, however, being very scarce. Sides of head and body together with all the femora green. The usual reddish brown stripes on occiput and pronotum narrowly edged with whitish, especially on the fastigium of the vertex. Tegmina reddish brown; in the females exceedingly short and pad like, or well developed and reaching almost to knees; when the former, a little longer than the wings; when the latter, 5 mm. shorter than the wings. In the brachypterous males (the only ones I have seen) the tegmina are somewhat less than half the length of the abdomen. A reddish brown band on dorsal surface of abdomen, darker where it meets the green on sides. Ovipositor pale red, straight, one and a half times the length of the posterior femora. Cerci of male, long, the apical half acuminate, curved slightly inward near the tip.

Measurements: Male—Length of body, 14 mm.; of tegmina, 5.5 mm.; of pronotum, 3.5 mm.; of hind femora, 13.5 mm. Female—Length of body, 17 mm.; of tegmina, short winged form, 3.5 mm.; long winged form, 16 mm.; of hind femora, 15.5 mm.; of ovipositor, 23 mm.

A common species in the prairie country of the western and northern parts of the state, where it frequents, for the most part, dry upland meadows and prairies and reaches maturity about August 5th. An active leaper and tumbler and, like the next species, often striving to escape de-

tection by burrowing beneath fallen weeds and grasses. Its general range is to the west and southwest, it having first been described from Texas, and it has not heretofore been recorded east of Illinois.

gg. The common form with the tegmina covering three-fourths or more of abdomen; sides of body dull, reddish brown.

21. XIPHIDIUM ATTENUATUM, Scudder. The Lance-tailed Grasshopper.

Xiphidium attenuatum, Scudder, Trans. Am. Ent. Soc., II., 1869, 305, (Long winged form.)

Bruner, Canad. Entom., XXIII., 1891, 57.

Id., Entom. News, III., 1892, 265.

Redtenbacher, Monog. der Conoceph., 1891, 191. (Long winged form.)

Xiphidium scudderi, Blatchley, Canad. Entom., XXIV., 1892, 26. (Short winged form.)

? *Xiphidium lanceolatum*, Osborne, Proc. Ia. Acad. Sci., I., 1892, 119.

A medium sized grasshopper with the sides of head and body dull reddish brown. Vertex, disk of pronotum, and tegmina greenish brown in life, the former with the usual dark brown median stripe. Femora greenish brown, very rarely bright green, the tibiæ and tarsi darker. Tegmina and wings either abbreviated or fully developed when the former, covering about three-fourths of the abdomen, when the latter considerably surpassing its tip in both sexes. Antennæ with the basal third reddish, the remainder fuscous, longer than in any other member of the genus belonging to our fauna, measuring 73 mm. in one specimen at hand. Ovipositor also longer than in any other; slender and nearly straight, the apex very acuminate; cerci of male long, broad, with the apical third gently tapering, the basal tooth minute, slender.

Measurements: Male—Length of body, 14 mm.; of pronotum, 3 mm.; of tegmina, short form, 10 mm; of hind femora, 14.5 mm. Female—Length of body, 16 mm.; of tegmina, 9.5 mm.; of hind femora, 15 mm.; of ovipositor, 27—30 mm.

In Indiana the "Lance-tailed Grasshopper" has, up to the present, been recorded only in Vigo county where it is common about the margins of two large ponds in the Wabash river bottoms, but is found nowhere else. The distance between these two ponds is 15 miles and the one to the south is surrounded on all sides with heavy timber. About its margins on September 5th, 1892, mature specimens of *X. attenuatum* were very plentiful

but no young were seen. On the next day the young in all stages were found at the north pond, which lies in an open prairie region, while but one imago was noted. Ten days later the north pond was again visited and many imagoes secured, although the young were still plentiful.

The difference in time of development at the two ponds is probably due to the surrounding forest which shelters the one to the southward, as about its margins occur the four southern species of Orthoptera mentioned above in the notes on *Conocephalus palustris*, not one of which has been found at the north pond.

The males of *attenuatum* are, as far as my experience goes, the most active leapers among the winged Locustidæ, jumping a half a dozen or more times without pause when flushed, and in the net leaping so rapidly from side to side as to prevent capture with the fingers. The females are evidently handicapped in their leaping powers by the excessive length of the ovipositor, and so more often endeavor to escape by burrowing beneath the dense masses of fallen grass and reed stems which are always found in their accustomed haunts.

I find that the length of the ovipositor among the different species of *Xiphidium* is not at all dependent upon the age of the insect. In *attenuatum* it is almost as long after the third, and fully as long after the fourth moult as it is in the imago; while on August 11th a female of *strictum* was taken with no vestige of tegmina in which the ovipositor measured 18 mm. The eggs of *attenuatum*, as the length of the ovipositor indicates, are laid between the stems and leaves of tall, rank grasses.

Only the short winged form of this species has been noted in Indiana, but Prof. Bruner has taken the long winged form in Nebraska, and Mr. Scudder described it from the latter taken in Illinois; though McNeill makes no mention of the species in his list of Orthoptera from that state. Redtenbacher, in his Monographie, has copied Scudder's description and has separated the species from all others of those from America to which it is closely allied, placing it next to *fasciatum*, with which it has little affinity, by virtue of the wing characters alone.

VII. Orchelimum, Serville (1831).

Locustidæ of medium size, but with a short and stout body. Vertex, face and eyes much as in *Xiphidium*. Spines of the prosternum well developed, cylindrical and slender. Antennæ slender and tapering, usually of excessive length. Wing covers narrow, the apical half often much less in width than the basal, exceeding the abdomen in all of our species;

almost always shorter than the wings. Stridulating organ of the male as in *Xiphidium*, but proportionally larger. Ovipositor stout, broad, with the apical half usually upcurved; when straight the apical third tapers rather abruptly on the under side to a fine point. Anal plates and cerci of males as in *Xiphidium*.

Very close to *Xiphidium*, and by some writers united with that genus. Redtenbacher places it as a sub-genus of *Xiphidium*, separating its members from those of *Xiphidium* proper by the same characters as did Serville. As scientists differ in opinion with respect to what characters are necessary to constitute a genus, and as, at the best, it is but an artificial and arbitrary grouping of species for the sake of convenience, I follow Serville, Scudder and Bruner in separating the two, believing that the prime idea of convenience can thus be better subserved.

As seen above, the larger, heavier body, longer prosternal spines, and shorter and broader falcate ovipositor are the chief distinguishing characters of *Orchelimum*. The wing covers are more uniform in length, and the color, while of slightly different shades of brown or green in the same species according to season and habitat, does not run to the extremes of variation as in *Xiphidium*.

The generic name, *Orchelimum*, the literal meaning of which is "I dance in the meadows," is a most appropriate one, for low, moist meadows everywhere swarm with these insects from July to November; and though waltzes and quadrilles are probably not indulged in, yet the music and song, the wooing and love-making which are the natural accompaniments of those amusements, are ever present, and make the short season of mature life of the participants a seemingly happy one.

Nine species of the genus have been taken by the writer within the State, and probably several others occur which have not as yet been discovered.

a. Ovipositor with a very evident curve; its length less than 10 mm.
  b. Face without a median brown stripe.
    c. Posterior femora unarmed beneath.
      d. Tegmina broadest at base; the apical third narrower; body robust.
        e. Tegmina and wings sub-equal in length; size, medium.

22. ORCHELIMUM VULGARE, Harris. The Common Meadow Grasshopper.
Orchelimum vulgare, Harris, Ins. Inj. to Veg., 1862, 162, fig. 77.

Scudder, Bost. Jour. Nat. Hist., VII., 1862, 452.

Id., Proc. Bost. Soc. Nat. Hist., XI., 1868. (Note of set to music.)

Id., Am. Naturalist, II., 1868, 117. (Note of set to music.)

Id., Distrib. Ins. in N. Hamp., 1874, 368. (Note of set to music.)

Id., Rep. Ent. Soc. Ont., XXIII., 1892, 73. (Note of set to music.)

Rathvon, U. S. Agr. Rep., 1862, 382.

Smith, Orthop. Maine, 1868, 145.

Thomas, Geol. Surv. Wyoming, 1870, 269.

Packard, Guide to Stud. Ins., 1883, 567.

Riley, Stand. Nat. Hist., II., 1884, 187.

Bruner, Bull. Washb., Coll. Lab. Nat. Hist., I., 1885, 129.

Comstock, Int. Entom., I., 1888, 114.

Smith, Ins. of N. Jersey, 1890, 411.

Id., Bull. Ag. Coll. Exp. Stat. N. Jer., No. 90, 1892, 5, 22, 31, fig. 13, pl. II.

McNeill, Psyche, VI., 1891, 25.

Osborne, Proc. Ia. Acad. Sci., 1892, 118.

Xiphidium vulgare, Fernald, Orth. N. Eng., 1884, 24.

Xiphidium fasciatum, Thomas, Trans. Ill. St. Agl. Soc., V., 1865, 444. (Not *X. fasciatum*, DeGeer.)

Xiphidium agile, Redtenbacher, Monog. der Conoceph., 1891, 186. (In part.)

A medium sized, robust species, with the general color green or light reddish brown. Face light green or light brown without fuscous marks. The occiput and disk of pronotum with a reddish brown band, widening on the latter, where it is often, especially in the male, bordered on each side with a darker line. The male (as in most of our species) with two short, black dashes on each wing cover, the four forming the angles of an assumed square, enclosing the tympanum. The legs usually pale brown, the tarsi dusky. Pronotum long, its posterior lobe but slightly, if at all, upturned above the plane of the anterior, its hind margin broadly rounded. Tegmina reaching to or very slightly beyond the apex of hind femora, and equalling or very little shorter than the wings. Cerci of male rather

long, the apex bluntly rounded, a little depressed; sub-basal tooth somewhat flattened, with the tip sharp and decurved.

Measurements: Male—Length of body, 18 mm.; of pronotum, 6 mm.; of tegmina, 21 mm.; of hind femora, 18 mm. Female—Length of body, 19 mm.; of pronotum 6.2 mm.; of tegmina, 21 mm.; of hind femora, 18.5 mm.; of ovipositor, 7.5 mm.

Redtenbacher places *vulgare* as a synonym of DeGeer's *Xiphidium agile*, stating as his reason for so doing that Harris and Scudder have separated the two "on account of small differences in the color and size of the wing covers, as well as in the length of the ovipositor." He may be right in thus combining them, but his relative measurements of *X. agile*, as given, do not agree with specimens of undoubted *vulgare* in my possession. Scudder, who has had ample opportunity to compare the two, says (Bost. Journ. Nat. Hist.) that the pronotum is shorter in *agile* than in *vulgare*. Redtenbacher's measurements of this organ, as well as those of the hind femora, are much less than the average measurements given above. Harris, as well as Burmeister, states that the tegmina of *agile* are 2.5 mm. shorter than the wings, while McNeill, in his description of *O. silvaticum*,* says that *agile* has the hind femora armed beneath. Taking all these facts into consideration, though having no typical example of *agile* for comparison, I have concluded not to follow Redtenbacher but to retain for the species at hand the name *vulgare*, by which it is best known to the entomologists of the United States.

This is probably the most abundant member of the family Locustidæ found in Indiana. It begins to reach maturity in the central part of the State about July 20th, and more frequently than any other of our species of *Orchelimum* it is found in upland localities, along fence rows, and in clover and timothy meadows. In early autumn it seems to be very fond of resting on the leaves and stems of the ironweed, *Vernonia fasciculata*, Michx., so common in many blue grass pastures. *Vulgare* seems to be somewhat carnivorous in habit, as on two occasions I have discovered it feeding upon the bodies of small moths which in some way it had managed to capture. The note of the male has been well represented by McNeill as "the familiar *zip-zip-zip-zip-ze-e-e-e-e*—the staccato first part being repeated about four times, usually about twice a second; the *ze-e-e-e* continuing from two or three to twenty or more seconds."

*Psyche, VI., 26.

c. Tegmina distinctly shorter than wings; size large.

23. Orchelimum glaberrimum, (Burmeister.)

Xiphidium glaberrimum, Burmeister, Handb. der Ent., II., 1838, 707.
Fernald, Orth. N. Eng., 1888, 25.
Redtenbacher, Monog. der Conoceph., 1891, 187.

Orchelimum glaberrimum Scudder, Bost. Journ. Nat. Hist., VII., 1862, 453.
Walsh, Proc. Ent. Soc. Phil., III., 1864, 232.
Riley, Stand. Nat. Hist., II., 1884, 186.
Bruner, Bull. Washb. Coll. Lab. Nat. Hist., I., 1885, 128.
Comstock, Int. to Entom., I., 1888, 114.
Smith, Ins. N. Jer., 1890, 410.
McNeil, Psyche, VI., 1891, 25.

Very close to and perhaps only a larger form of *O. vulgare*. The general color is the same, but the brown line on the disk of pronotum is, in the female, more plainly margined with black, while in the male the black dashes at ends of tympanum are larger and more completely enclose that organ. The tegmina of the male exceed the hind femora by about 4 mm., and are exceeded by the wings about the same distance; those of the female are proportionally a little shorter.

Measurements: Male—Length of body, 22.5 mm.; of pronotum, 6 mm.; of tegmina, 25 mm.; of hind femora, 19 mm. Female—Length of body, 23 mm.; of pronotum, 6.5 mm.; of tegmina, 24 mm.; of hind femora, 19 mm.; of ovipositor, 8.5 mm.

Burmeister's original description of this species is very short and not distinctive. It is as follows: "Verticis et pronoti medio fulvo, nigro-marginato; elytris ab alis dimidia linea superatis. Long. corp., 11‴." Burmeister knew but two species from the United States, and this short description was sufficient for him to distinguish these, but of the twenty or more species now known it is difficult to say just which one he had in mind when he wrote the above. Of the specimens referred to this species I have but three examples. One is from Fulton county, the other two from Vigo. They were taken from tall grass growing near the margin of ponds. Nothing distinctive of their habits is known.

dd. Tegmina of equal width throughout; body slender.

24. Orchelimum campestre, Blatchley.

Orchelimum campestre, Blatchley, Canad. Entom., XXV., 1893, 91.

A species of less than medium size, with the wing-covers narrow and of almost equal width throughout, the posterior femora unarmed beneath, and the ovipositor short and narrow.

Cone of the vertex prominent, narrow, rounded at the apex; the sides of the frontal deflexed portion rapidly converging to form a very acute wedge. Wing-covers long, slender, not narrowed in the middle as in *O. vulgare*, *glabrrimum*, etc., tapering slightly on the apical third to a rounded end; their length equalling that of the wings in the male, a little shorter in the female. Posterior femora with the basal half quite stout, the length less than that of the tegmina. Cerci of male slender, cylindrical, somewhat pointed, the apical half curved slightly outwards, the basal tooth short and weak. Ovipositor short, narrow, moderately upcurved, and tapering to a delicate point.

Color.—Tegmina and wings almost uniform transparent olivaceous brown. The usual dark reddish-brown band upon the occiput and disk of pronotum is margined on the latter with two very narrow and darker brown stripes, which extend back to the middle of the posterior lobe of the pronotum. Face, and usually the hind femora, a dirty olive brown; the latter, when dry, with a blackish longitudinal band on the exterior face. In the female the only green on the body is on the lower part of the sides of the pronotum and on the anterior femora. The only male at hand has the posterior femora green, but otherwise is colored like the females. Ovipositor light reddish-brown.

Measurements.—Length of body, male, 17.5 mm.; female, 19 mm.; of pronotum, male, 4.5 mm.; female, 5 mm.; of tegmina, male, 20.5 mm.; female, 24.5 mm.; of antennæ, male, 46 mm.; of posterior femora, male, 17 mm.; female, 17.5 mm.; of ovipositor, 7 mm.

This dull colored grasshopper has been found in small numbers in both Vigo and Fulton counties, in upland prairie meadows, where it frequents the tall grasses, usually in company with *Xiphidium strictum*, Scudder.

It is a smaller and more slender bodied insect than the common *O. vulgare*, Harris, and has a shorter and narrower pronotum and a much smaller ovipositor than that species.

cc. Apical half of posterior femora armed beneath with several small spines.

f. All the tibiæ and tarsi black or dark brown.

25. ORCHELIMUM NIGRIPES, Scudder. The Black-legged Grasshopper.

Orchelimum nigripes, Scudder, Proc. Bost. Soc. Nat. Hist., XVII., 1875, 459.
Id., Entom. Notes, IV., 1875, 62.
Id., Cent. Orthop., 1879, 12.
Id., Rep. Ent. Soc. Ont., XXIII., 1892, 73.
Bruner, Bull, Washb., Coll. Lab. Nat. Hist., I., 1885, 128.
McNeill, Psyche, VI., 1891, 25.
Redtenbacher, Monog. der Conoceph., 1891, 188.
Osborne, Proc. Ia. Acad. Sci., I., 1892, 118.
Blatchley, Canad. Ent., XXV., 1893, 93.

Somewhat smaller than *O. vulgare;* the body moderately robust. Pronotum short, the posterior lobe, especially in the male, rather strongly upturned. Tegmina a little shorter than the wings, surpassing slightly the hind femora. The shrilling organ of the male is unusually large and prominent with strong cross veins, and behind it the tegmina taper rapidly on both margins; their shape and the size of the tympanum causing the male to appear somewhat peculiar and much more robust than it really is. Hind femora armed on apical half of lower outer carina with from one to four small spines. Cerci of male slender, tapering, the apex a little obtuse; the sub-basal tooth long, slender and a little curved. Ovipositor rather long, broadest in the middle, tapering to a delicate point. The males vary much in size. General color green or reddish-brown, the former prevailing in the male, the latter in the female. Occiput and disk of pronotum with the usual brown markings. Front and sides of head, and four front femora, reddish yellow. All the tibiæ and tarsi, together with the apical third of hind femora, black or dark brown; in one specimen at hand the whole body, except the wing-covers and femora, black.

Measurements: Male—Length of body, 18 mm.; of pronotum, 5 mm.; of tegmina, 21 mm.; of hind femora, 16 mm. Female—Length of body, 19 mm.; of tegmina, 22 mm.; of hind femora, 17 mm.; of ovipositor, 9 mm.

A lowland species, which, in Vigo county, is excessively common from August 1st to October 15th, about the river bottom ponds mentioned above, where it frequents the stems and leaves of the different species of *Polygonum*, or smart weed, growing in the shallow water. A few specimens have been taken in Putnam county, and a single male from the margin of a tamarack swamp at Kewanna, Fulton county, so that it probably occurs

in suitable localities throughout the state. It was first described from Texas and has not before been recorded east of Illinois, though it has been taken by myself at Celina, Ohio. It song is much more faint than that of *O. vulgare*, and the *z-e-e-e-e* is much less prolonged.

ff. The tibiæ and tarsi green or reddish-brown.

26. ORCHELIMUM SILVATICUM, McNeill.

Orchelimum silvaticum, McNeill, Psyche, VI., February, 1891, 26.
Scudder, Rep. Ent. Soc. Ont., XXIII., 1892, 73.

? *Xiphidium spinulosum*, Redtenbacher, Monog. der Conoceph., April, 1891, 189.

A somewhat smaller and less robust species than *O. vulgare*, though the proportional measurements of the two are almost the same. The pronotum is shorter, the tegmina more narrow, and in the female the latter are slightly exceeded by the wings; equalling them or a little shorter in the male. The hind femora reach to or slightly beyond the apex of tegmina and are armed on the lower outer carina with three or four minute spines. The general color is the same as that of *vulgare*, but the blackish stripes on the margin of the brown discal stripe of pronotum are more distinct than in that species.

Measurements: Male—Length of body, 17.5 mm.; of pronotum, 4.5 mm.; of tegmina, 16.5 mm.; of hind femora, 15 mm. Female—Length of body, 17.5 mm.; of tegmina, 17 mm.; of hind femora, 15 mm.; of ovipositor, 8 mm.

I am inclined to believe that Redtenbacher's *Xiphidium spinulosum* is this species. The measurements as given by him are somewhat greater, but otherwise the description agrees. McNeill's name, however, has the priority.

In Indiana this species has, up to the present, been taken only in Vigo county, where it frequents the borders of cultivated fields and open woods, reaching maturity about August 20th. "Its stridulation," says McNeill, "is quite distinct from that of *vulgare*. It consists of the same two elements, but the *zip* is repeated many times very rapidly so as to make almost a continuous sound and the *z-e-e-e-e* is comparatively short and very constant, lasting about eight seconds. The first part of the song lasts from three to five seconds."

bb. Face with a dark reddish-brown stripe down the center.

g. Stripe broadly expanded on the lower half of face. Size medium.

27. ORCHELIMUM CONCINNUM, Scudder.

Orchelimum concinnum, Scudder, Bost. Journ. Nat. Hist., VII., 1862, 452.
Riley, Stand. Nat. Hist., II., 1884, 187.
Comstock, Int. to Entom., I., 1888, 115.
Smith, Ins. N. Jer., 1890, 410.
McNeill, Psyche, VI., 1891, 25.
Bruner, Canad. Entom., XXIII., 1891, 71.
Xiphidium concinnum, Fernald, Orth. N. Eng., 1888, 25.
Redtenbacher, Monog. der Conoceph., 1891, 188.

A species of medium size with a body less robust than that of *O. vulgare*. General color brownish-green; the female darker. The reddish-brown dorsal stripe of pronotum and occiput passes over the fastigium and down the face broadening above the labrum to cover the whole lower half of face. The tegmina of male brownish-green, a little shorter than the wings; of the female darker and equal to or a little longer than the wings. Pronotum short. Hind femora rather slender, unarmed beneath. Cerci of male with the apex obtuse, a little compressed, the sub-basal tooth rather slender. Ovipositor less curved than that of *O. vulgare* and with a very sharp point.

Measurements: Male—Length of body, 18 mm.; of pronotum, 5.5 mm.; of tegmina, 21 mm.; of hind femora, 16 mm. Female—Length of body, 19 mm.; of tegmina, 20 mm.; of hind femora, 17 mm.; of ovipositor, 8 mm.

A rare species in Vigo and Putnam counties, and as yet not noted in the northern part of the state. It frequents the weedy and grassy margins of marshes and lowland ponds and reaches maturity about August 15th.

gg. Facial stripe of equal width throughout. Size small.

28. ORCHELIMUM INDIANENSE, Blatchley.

Orchelimum indianense, Blatchley, Canad. Entom., XXV., 1893, 90.

A slender-bodied insect, with a dark median streak down the face, and having the posterior femora unarmed beneath. The cone of the vertex is short, rather narrow, with a rounded apex. The tegmina, narrow, tapering, a little shorter than the wings, and of a delicate, almost gauze-like texture. Posterior femora slender, shorter than the closed tegmina. Anal cerci of male of medium size, longer than the subgenital plate, tapering to a dull point; the basal tooth short, with a broad base and a very sharp point. The ovipositor of female of less than average width and length, the apical half with a gentle upward curve.

Color of dried specimens: Tegmina and wings a transparent whitish, tinged with green on the front or lower longitudinal nerves; the cross nervules of the latter darker. Sides of pronotum and abdomen, and all the femora, light green; the tibiæ and tarsi of a brownish hue. Face yellowish white, with a dark reddish brown stripe the width of the labrum, starting with the mouth and passing upward to the vertex, where it narrows to the width of that organ; then, broadening on the occiput, it passes back to the front border of the pronotum, where it divides into two narrow streaks, which enclose a whitish area and extend a little beyond the posterior transverse suture, where they taper to an end. Subgenital plate of male yellow. Basal third of ovipositor dark brown, the remainder light reddish-brown.

Measurements: Length of body, male, 17 mm.; female, 17.5 mm.; of pronotum, male and female, 4 mm.; of tegmina, male, 21 mm.; female, 19 mm.; of hind femora, male, 14 mm.; female, 15.5 mm.; of ovipositor, 7.5 mm.

This graceful and prettily marked species was found to be quite common among the rank grasses and sedges growing about the margins of a tamarack swamp near Kewanna, Fulton county. It was first taken on August 26th and again on September 24th, when it appeared more plentiful than before. It is the smallest and most slender of the nine species of the genus so far known to occur in the state, and its markings are very distinct from those of any of the others.

aa. Ovipositor straight or nearly so, the under side of apical third tapering rather abruptly to a fine point; its length 10 or more mm.

b. Posterior femora smooth beneath.

29. ORCHELIMUM GLADIATOR, Bruner.

Orchelimum gladiator, Bruner, Canad. Entom., XXIII., 1891, 71.

"In its general structure this species resembles the more robust forms like *O. glaberrimum and O. concinnum*. It differs from these however in having shorter legs and antennæ. The posterior femora are rather slender; the cone of the vertex is short and obtuse, with the extreme tip shallowly sulcate; the hind wings are little if any longer than the tegmina, which do not quite reach the tip of the ovipositor.

"Color, pale transparent grass-green throughout, save the usual markings upon the occiput and disk of pronotum, which are dark brown, on the latter composed of two well defined, narrow, slightly diverging lines.

Antennæ rufous, feet and extreme tip of the ovipositor tinged with rufous.

"Measurements: Female—Length of body, 18 mm.; of antennæ, 35 mm.; of pronotum, 4.75 mm.; of tegmina, 19 mm.; of hind femora, 15.5 mm.; of ovipositor, 10 mm."—Bruner.

A single female of this species was taken in Fulton county, August 26th, 1892, from the borders of the tamarack swamp previously noted. It agrees exactly with Mr. Bruner's description, and therefore I have copied the latter verbatim. He described the species from two females taken from the flowers of a prairie golden rod, *Solidago rigida*, L., at West Point, Neb. The male is not as yet known. The species probably occurs in small numbers in low, damp prairies, but as, aside from the long, straight ovipositor, it bears a somewhat general resemblance to *O. vulgare*, it has heretofore been overlooked, or confounded with that common insect.

hh. Posterior femora armed on the lower outer carina with several small spines.

30. ORCHELIMUM BRUNERI, Blatchley.

Orchelimum bruneri, Blatchley, Canad. Entom., XXV., 1893, 92.

A species of medium size and rather slender body with the posterior femora armed beneath, and the ovipositor very broad, nearly straight and of more than average length.

Cone of the vertex narrow, moderately elevated, rounded at apex. Tegmina long and narrow, a little shorter than the wings. Posterior femora rather stout, the apex, when appressed, not quite reaching the tip of ovipositor; armed beneath on the apical half with three or four small spines. Cerci of male stout, acuminate, with the internal tooth prominent.

Ovipositor very similar to that of *O. gladiator*, Bruner, being very long and stout, nearly straight above, and with the under side of apical third sloping rapidly to the acute apex.

Color of dried specimens.—With the exception of the ovipositor, which is a light reddish-brown, and the usual stripe on occiput and disk of pronotum, the whole body is a pale, transparent brownish-green, the green showing plainly only on the lower half of the side of pronotum and on the meso and metapleura. The reddish-brown dorsal stripe of occiput and pronotum is bordered laterally throughout its *entire* length with a very narrow one of much darker brown. When immersed in alcohol the

reddish-brown stripe fades to a yellowish white, leaving the two lateral ones as prominent dark streaks, widest on the central portion of the frontal disk.

Measurements: Length of body, male, 18 mm.; female, 20.5 mm.; of tegmina, male, 21 mm.; female, 25 mm.; of pronotum, male and female, 4.75 mm.; of hind femora, male, 16 mm.; female, 17 mm.; of ovipositor, 10 mm. Described from two males and four females.

This species, the female of which is at once conspicuous by reason of the shape and size of its ovipositor; has been taken in small numbers only in Vigo county,* where it is found during August and September on the leaves and stems of a tall, broad-leaved knot weed, *Polygonum amphibium*, L., which grows luxuriantly in the shallow waters about the margins of two or three large ponds in the Wabash River bottoms. Several other "green grasshoppers," notably among which are *Xiphidium attenuatum*, Scudder, and *Orchelimum nigripes*, Scudder, frequent this plant in immense numbers. Keeping company with them an occasional specimen of *O. bruneri* is seen, but, being an active leaper, it often escapes amidst the dense foliage of the knot weed before its capture can be effected. Its less robust body and longer, armed posterior femora will readily distinguish this species from *O. gladiator*, the only other one which, to my knowledge, has an ovipositor shaped like that of *bruneri*. The latter is named in honor of Prof. Lawrence Bruner, of Lincoln, Neb., one of the leading authorities on N. A. Orthoptera.

STENOPELMATINÆ.

The Indiana members of this subfamily comprise those insects which are commonly called "stone" or "camel crickets," and, so far as known, belong to the single genus *Ceuthophilus*, which is characterized below.

VIII. CEUTHOPHILUS, Scudder (1862).

Wingless Locustidæ of medium or large size with a thick body and arched back. Head large and oval, bent downwards and backwards between the front legs. Antennæ long, slender, cylindrical and tapering to a fine point. Eyes sub-pyriform, the narrow end downwards, placed close to the basal joint of the antennæ. Maxillary palpi long and slender; the apical joint longest, somewhat curved, split on the under side three-fourths of its length, which is nearly equal to that of the two preceding taken together. Pronotum short, not extending over the meso and meta-notum. Prostern-

*Since the above was written this insect has been found to be very plentiful about the margin of Lost Lake, Marshall county, Ind.

um unarmed. Hind femora thick and heavy, turned inwards at the base, channelled beneath, with the margins of the channels either serrate or spined in the males, seldom armed in the females. Ovipositor well developed, nearly straight, a little upturned at the tip, the inner valves usually strongly serrate on the under side of the apical fourth. Cerci of males long, slender, usually very hairy.

These insects are seldom seen except by the professional collector. They are nocturnal in their habits, and during the day hide beneath stones along the margins of small woodland streams, or beneath logs and chunks in damp woods, in which places seldom less than two, nor more than three or four, are found associated together. Being wingless they make no noise, and, like most other silent creatures, are supposed to be deaf, as no trace of an ear drum is visible.

That they are wellnigh omnivorous in their choice of food, I have determined by keeping them in confinement, when they fed upon meat as well as upon pieces of fruit and vegetables, seemingly preferring the latter. The majority of the species evidently reach maturity and deposit their eggs in the late summer or early autumn, as the full grown insects are more common then, but have been taken as late as December 1st. The eggs, which are supposed to be laid in the earth, usually hatch in April, but some are hatched in autumn and the young live over winter (an anomaly among the Locustidæ?) as I have taken them in January and February, and at this writing, December 24th, have one in confinement which has just passed the second moult.

Several of the species inhabit caves and are usually of much larger size, with longer antennæ and smaller compound eyes than those found above ground.

The males of these insects are quite readily separated by the size, number and relative positions of the spines on the under side of the hind femora, as well as by the degree of curvature of the corresponding tibiæ. The females, having neither the spined posterior femora nor the curved tibiæ, are less readily distinguished by the color and the relative measurements of the different organs. As the two sexes are colored alike and are usually found in close proximity there will be little difficulty in placing the female after determining the male by the keys given below, which mainly pertain to that sex alone.

Seven species have, up to the present, been taken by the writer in Indiana.

a. Hind tibiæ of male with the basal half very distinctly undulated or waved; the hind femora with about 16 small sub-equal spines on each of the lower carinæ.

31. CEUTHOPHILUS MACULATUS, (Say). The Spotted Wingless Grasshopper.

"*Ephippigera maculata*, Say. (Mss.) Harris Cat. Ins. Mass., 1835, 56."

Rhaphidophora maculata, Scudder, Proc. Bost. Soc. Nat. Hist., VIII., 1861, 7, 11, 14.

Id., Encyc. Amer. 1881, VIII., 170.

halangopsis maculata, Harris. Ins. Inj. to Veg. 1862, 155, fig. 73.

Ceuthophilus maculatus, Scudder, Bost. Journ. Nat. Hist., VII., 1862, 434.

Id., Distb. Ins. of N. Hamp., 1874, 366.

Smith, Orth. of Maine, 1868, 145.

Packard, Guide Stud. Ins., 1883, 565.

Riley, Stand. Nat. Hist., II., 1884, 184, fig. 259.

Bruner, Bull. Washb. Col. Lab. Nat. Hist., I., 1885,126.

Fernald, Orth. N. Eng., 1888, 19.

Brunner, Monog. der Stenop. und Gryll., 1888, 307.

Smith, Ins. N. Jers., 1890, 409.

McNeill, Psyche, VI., 1891, 27.

Osborne, Proc. Ia. Acad. Sci., I., 1892, 119.

Raphidophora lapidicola, Scudder, Proc. Bost. Soc. Nat. Hist., VII., 1861, 7. (In part.)

Thomas, Trans. Ill. St. Ag. Soc., V., 1865, 444. (Not *Ceuthophilus lapidicolus*, Burmeister.)

General color: Above, sooty brown with the anterior half of each segment dotted with a number of rather large, more or less confluent, pale spots; below pale brown, unspotted. Antennæ and legs light, reddish brown; the hind femora barred on the outer surface with numerous short lines of darker brown arranged in parallel rows. Anterior femora short, a little longer than pronotum with one or two spines on the, lower, front carina. Hind femora moderately swollen, the inferior sulcus narrow, with each margin armed, in the male, with about 16 rather small, sub-equal spines; in the female, each margin bears a row of numerous minute teeth. Hind tibiæ of male distinctly undulate or waved at base; a little longer than the femora.

Measurements: Male—Length of body, 14 mm.; of pronotum, 4.5 mm.;

of front femora, 6 mm.; of hind femora, 15 mm.; of hind tibiæ, 16 mm.; Female—Length of body, 18 mm.; of pronotum, 6 mm.; of front femora, 6 mm.; of hind femora, 17 mm., of ovipositor, 10 mm.

This insect has a wide range, having been recorded from New England to the Rocky Mountains. In Indiana it is, as far as my observation goes, much less common than some of the other species of the genus, having so far been taken only in Putnam county where, on August 1st, I took several specimens from beneath a log in a deep and damp ravine. It probably occurs sparingly in like situations throughout the state.

aa. Hind tibiæ of male not undulated at base; sometimes with a single, slight curve.

b. Hind femora but little, if any, shorter than the corresponding tibiæ; species living above ground.

c. Upper sides of body each with a broad, dark reddish-brown stripe.

32. CEUTHOPHILUS LATENS, Scudder. The Black-sided Camel Cricket.

Ceuthophilus latens, Scudder, Bost. Journ. Nat. Hist., VII., 1862, 437.
McNeill, Psyche, VI., 1891, 27.

General color, light, reddish brown "with darker streaks upon the hind femora and two broad bands of dark, reddish brown along the whole dorsum, extending half way down the sides, dotted irregularly with brownish yellow spots, most profusely on the abdomen, and separated from one another by a narrow, irregular band of the same color; below yellowish brown; tips of the hind femora dark."

Anterior tibiæ one-third longer than the pronotum, with two spines on the outer lower carina. Middle femora bispined on each carina beneath. Hind femora thick and stout, the inferior sulcus wide and deep, the margins unarmed in the female; in the male with three or four minute spines on the apical third of each carina. Hind tibiæ straight, a little longer than the femora.

Measurements: Male—Length of body, 18 mm.; of pronotum, 5 mm.; of front femora, 6.5 mm.; of hind femora, 14 mm.; of hind tibiæ, 14.5 mm. Female—Length of body, 19 mm.; of hind femora, 14.5 mm.; of hind tibiæ, 15 mm.; of ovipositor, 10 mm.

The above description applies to the species as usually found in the State. I have, however, a pair of specimens taken in Putnam county, which, while agreeing fully with the peculiar coloration and relative measurements of *latens*, differ so markedly in size and in the spination

of the femora that I have more than once been inclined to think them a distinct and undescribed species. They have the middle femora armed beneath with 3 spines on each carina; the hind femora of male with 9 spines on the outer carina, the 4 or 5 middle ones of which are very strong and prominent, the inner carina with 11 small and sub-equal spines. The hind tibiæ with an evident downward curve at base. The hind femora of the female have 5 small spines on the outer and 11 on the inner carina.

Measurements: Male—Length of body, 22 mm.; of pronotum, 6.5 mm.; of front femora, 9 mm.; hind femora, 19 mm.; of hind tibiæ, 21 mm. Female—Length of body, 25 mm.; of pronotum, 7 mm.; of front temora, 9 mm.; of hind femora, 19.5 mm.; of hind tibiæ, 20.5 mm.; of ovipositor, 13 mm.

If, as is most likely, these are only greatly developed forms of *latens*, the spining of the femora of these insects varies greatly with the age, and, unless one has adult specimens, it is not therefore a character of as much specific worth as is usually attributed to it.

C. latens is not an uncommon species in Vigo and Putnam counties. It is most commonly found beneath flat stones near the margins of small streams in upland, hilly localities. It reaches maturity in June or July, probably from specimens hatched in spring, though I have taken the young on two different occasions in February. It has been recorded heretofore only from Illinois and the male is herewith described for the first time, Mr. Scudder's description having been based upon a single female.

cc. Sides of body without a dark, reddish brown stripe.

d. Hind femora of male with the inferior sulcus very deep; the outer carina with about 9 spines of unequal length and not equi-distant.

33. Ceuthophilus uhleri, Scudder.

Ceuthophilus uhleri, Scudder, Bost. Jour. Nat. Hist., VII., 1862, 435.
Riley, Stand. Nat. Hist., II., 1884, 184.
Smith, Ins. N. Jer., 1890, 409.

Ceuthophilus lapidicola, Brunner, Monog. der. Stenopel. und Gryllac, 1888, 307. (Not *C. lapidicolus* Burm.)

General color light reddish brown, the meso and meta-notum usually darker. The pronotum rather thickly and irregularly mottled with paler spots; the other segments with the pale spots for the most part in a

transverse row near the hind margin. The legs yellowish brown, the hind femora with the apex a little dusky above and with three longitudinal, and numerous obliquely transverse, dusky bars on the outer face.

The anterior femora but little longer than the pronotum; the lower, front margin armed with from one to four spines. Hind femora of the male of average width but very stout, the lower, outer carina prominent, the inferior sulcus rather narrow and very deep, the sides meeting at an angle above. The spines of the outer carina are arranged in three sets, the basal set containing 4 equi-distant graduated spines the apical one largest; the middle set contains but a single strong spine equal in size to the one before it and separated from it as well as from the first one of the apical set, by a space almost twice as great as between the members of the basal set; the apical set of 4 small sub-equal spines. The inner carina is armed with about 16 small sub-equal spines. The female has the inner carina also armed in like manner with still smaller spines. Hind tibiæ of male straight, a little longer than the femora.

Measurements: Male—Length of body, 14 mm.; of pronotum, 5.2 mm.; of front femora, 6.2 mm.; of hind femora, 16.5 mm.; of hind tibiæ, 17 mm.

C. Brunner, in his Monographie, has evidently described this species under the name of *C. lapidicola* Burm. At the close of his description he says of *lapidicola*: "Neither the diagnosis of Burmeister nor the description of Scudder are sufficiently exact to recognize the species; for which reason I have designated by this name any new species whatever at hand." In another place he describes under the name *C. uhleri* Scudder, a species having the spines on the outer carina of the hind femora equal in length; whereas Mr. Scudder, in his description of *uhleri* distinctly states that they are "of unequal length, and irregularly arranged."

Specimens of the insect described above were sent to Mr. Scudder, who pronounced my identification correct. In central Indiana *uhleri* is the most common species of *Ceuthophilus*. It is found from July to November beneath rails and logs in rather dry situations. The young have been taken from similar places in December and February, but evidently the larger number of eggs do not hatch until spring.

dd. Hind femora of male with the inferior sulcus shallow; the spines of the outer lower carina sub-equal in size and equi-distant from one another.

c. The sulcus very broad; the spines of the outer carina much larger than those of the inner.

34. CEUTHOPHILUS LATISULCUS, nov. sp.

? *Ceuthophilus uhleri*, Brunner, Monog. der Stenopel. und Gryll., 1888, 308, pl. VII., fig. 33 b.

General color, light brownish or clay yellow, irregularly mottled with fuscous, especially on the pronotum and abdomen; the female somewhat darker. The anterior femora much longer than the pronotum with two sub-equal spines near the apex of the lower front carina. The intermediate femora with three spines on each of the lower carinæ. The hind femora not so broad as in the preceding, the outer lower carina much less prominent; the upper half of the exterior face very scabrous, with small projections. The inferior sulcus very broad and shallow, about twice the breadth and one-half the depth of that of *C. uhleri*; the sides not meeting in an angle as there, but the upper surface of the sulcus flat. The outer carina with 8 sub-equal spines borne at equal distances apart on the apical half; the middle two slightly the larger but much less strong than the corresponding one of *C. uhleri*. The inner carina armed with 20 or more very small teeth. The hind tibiæ with a very slight curve just below the base; a little longer than the corresponding femora.

Measurements: Male—Length of body, 15 mm.; of pronotum, 5.1 m.m.; of front femora, 7 mm.; of hind femora, 17.5 mm.; of hind tibiæ, 18.5 mm.

From *C. uhleri*, which it most resembles, this species may at once be known by the longer anterior femora, the much broader and shallower sulcus of the hind femora, as well as by the difference in size and arrangement of the teeth upon the latter. The adult male is larger with longer hind limbs than that of *uhleri*, though the males of both these species are much more robust when mature than those of *maculatus* and *lapidicolus* which have come under my notice.

C. Brunner, in his Monographie, has described a species of *Ceuthophilus* under the name of *uhleri*, Scudder, which may be the same insect as *latisulcus*. As shown above, however, the name of *uhleri* belongs to the preceding species. Brunner's measurement of his so-called *uhleri*, as well as the number of spines on the femora, differ from those given above.

Latisulcus is described from two males and a female taken in Vigo county, August 25, from beneath a log on a sandy hillside.

ee. The sulcus of average width and depth; the spines of both carinæ small and sub-equal in size.

f. General color clear reddish brown, mottled with paler; each of the carinæ of the hind femora with about 28 crowded minute spines.

35. CEUTHOPHILUS LAPIDICOLUS, (Burmeister.)

Phalangopsis lapidicola, Burmeister, Handb. der Entom. II., 1838, 723.
Raphidophora lapidicola, Scudder, Proc. Bost. Soc. Nat. Hist., VIII., 1861, 7. (In part.)
Ceuthophilus lapidicolus, Id., Bost. Journ. Nat. Hist., VII., 1862, 435.
Riley, Stand. Nat. Hist., II., 1884, 184.
Smith, Ins. N. Jer., 1890, 409.
Osborne, Proc. Ia. Acad. Sci., I., 1892, 119.

Clear reddish-brown, mottled with small pale spots, especially on the abdomen, where the spots have a tendency to arrange themselves in longitudinal rows. The legs paler, the exterior face of the hind femora with the usual darker bars, but not so prominent as in *C. maculatus*. Anterior femora a little longer than pronotum, unarmed beneath. Intermediate femora also unarmed or with a single apical spine on front margin. Hind femora of medium thickness, the inferior sulcus of average width, rather deep; the spines of both carinæ more like the fine teeth of a saw, about 25 in number and crowded on the apical two-thirds of the segment. Hind tibiæ straight, a little shorter than the femora.

Measurements: Male—Length of body, 18 mm.; of pronotum, 5 mm.; of front femora, 6.5 mm.; of hind femora, 18.5 mm.; of hind tibiæ, 16 mm. Female—Length of body, 18.5 mm.; of hind femora, 18 mm.; of ovipositor, 9 mm.

As Brunner has well said it is impossible to distinguish *C. lapidicolus* from Burmeister's description, which was founded upon two female specimens from South Carolina, and undoubtedly many references to it are wrong. If any person is competent to judge as to what *lapidicolus* really is, that person is Mr. Scudder, and I have determined the form described above from specimens bearing that name kindly loaned me by him.

In Indiana, *lapidicolus* is not a common insect, its range probably being more southern. Several specimens have been taken in Putnam county from beneath logs in damp woods.

ff. General color dull yellowish brown, with very numerous paler spots; each of the carinæ of the hind femora with about seven very small and distinct teeth.

36. CEUTHOPHILUS BREVIPES, Scudder.

Ceuthophilus brevipes, Scudder, Bost. Jour. Nat. Hist., VII., 1862, 434.
Smith, Orth. of Maine, 1868, 145.
Fernald, Orth. N. Eng., 1888, 19.

Dull yellowish brown, a little darker on the dorsum of the thorax where there is a narrow median line of clay yellow. Very profusely spotted with dirty white spots, especially on the abdomen, and near the apex of hind femora, where they nearly form an annulation.

Front femora a little longer than the pronotum, with a single spine on lower front carina. Hind femora short and stout; the inferior sulcus of average width and depth; each carina armed with about seven very small teeth. Hind tibiæ straight, of the same length as the femora.

Measurements: Male—Length of body, 14 mm.; of pronotum, 4.5 mm.; of front femora, 5.5 mm.; of hind femora, 12 mm.; of hind tibiæ, 12 mm.

A single male from Vigo county agrees in every respect, except slight differences in measurements, with typical examples from Mr. Scudder's collection. Not before recorded west of New England.

bb. Hind femora distinctly shorter than the corresponding tibiæ; cave inhabiting species.

37. CEUTHOPHILUS STYGIUS (Scudder.)

Raphidophora stygius, Scudder, Proc. Bost. Soc. Nat. Hist., VIII., 1861, 9.
Ceuthophilus stygius, Id., Bost. Jour. Nat. Hist., VII., 1862, 438.
Riley, Stand. Nat. Hist., II., 1884, 184.
Brunner, Monog. der Stenop. und Gryll., 1888, 309.

Pale, reddish-brown, the hind border of each segment with a dark brown band, the pronotum with a similar band on the front margin, and an indistinct, dark median band connecting the two. Face pale with a black dash below each eye, and a shorter median one. Antennæ brownish yellow, paler towards the tip, of excessive length. Front femora, in the specimens at hand, double the length of the pronotum, with three spines on the lower front carina. Middle femora shorter than the anterior with both of the lower carinæ armed with three or four distinct spines. Hind femora rather slender, the lower outer carina prominent; the inferior sulcus narrow and of average depth; both margins armed with num-

erous small spines, those on the outer carina double the size of those on the inner. Hind tibiæ straight, much longer than the corresponding femora.

Measurements: Male—Length of body, 26 mm.; of pronotum, 6 mm.; of front femora, 12 mm.; of antennæ, 100 mm.; of hind femora, 23 mm.; of hind tibiæ, 27 mm. Female—length of body, 23 mm.; of pronotum, 5.5 mm.; of front femora, 11 mm.; of hind femora, 21 mm.; of hind tibiæ, 24 mm.; of ovipositor, 14 mm.

These measurements are much greater than those given by Mr. Scudder, but otherwise the specimens agree with his description in every respect.

Two males and one female of this large and handsome *Ceuthophilus* were taken by Mr. W. P. Hay from a small cave in Crawford county and kindly presented to me. It evidently inhabits only the smaller caves as Mr. Hay saw no specimens in Wyandotte, and Mr. Scudder, in the Proc. Bost. Soc., says of the original types taken in Kentucky: "Though careful search was made in the larger cave, a mile or more in extent, no *Raphidophora* were found, but in the remotest corner of the small cave, a few hundred feet only in extent, in a sort of hollow in the rock, not particularly moist, but having only a sort of cave dampness, the *stygia* was found plentifully these were also found exclusively upon the walls. Even the remotest part of the cave is not so gloomy but that some sunlight penetrates it."

Decticidinæ.

In the western states this sub-family is represented by several genera and a large number of species, but east of the Mississippi River there are but two species of a single genus belonging to it, both of which are found in Indiana.

IX. Thyreonotus, Serville (1839).

These are Locustidæ of large size with the pronotum extending back over the first joint of the abdomen, thus forming a buckler or shield for the back. Face broad, rounded, but slightly oblique. Eyes small, subglobose. Vertex with a blunt decurved projection between the antennæ which is slightly excavated on the sides. Pronotum truncate in front, rounded behind, flattened above, bent abruptly downwards on the sides. Prosternum armed with two short, blunt spines. Tegmina of the females rudimentary, wholly covered by the pronotum; those of the males fairly well developed, extending in our most common species 5 mm. back of the pronotum. The shrilling organ, which is covered by the pronotum, is

circular, and rather large for the size of the tegmina. Wings very rudimentary or wanting. Hind femora long and rather slender, extending, in our species, beyond the abdomen in both sexes, notably so in the males. Ovipositor as long as the body, very stout at the base, straight.

The "Shield-back Grasshoppers," so called on account of the large protective pronotum, are often quite numerous from April 1st to September in dry upland woods and on sloping hillsides with a southern exposure, but are seldom if ever found in damp localities.

On the first warm days of early spring the young begin to emerge and in suitable places for a month or more are among the most common Orthopterons seen. They are much more active during early life than in the mature state when they crawl rather than leap. In captivity they feed as readily upon animal as upon vegetable food, and in the natural state probably feed upon the dead bodies of such small animals as they can find. The earliest hatched reach maturity in Central Indiana about the middle of July, and may then often be found resting on the leaves and stems of low shrubs and weeds, but seldom climb over two or three feet from the ground. The adults are far less numerous than the young, the vast majority of the latter probably falling a prey to the many ground frequenting sparrows and other birds, as they do not hide by day as do the members of the preceding genus.

a. Front margin of pronotum much narrowed, but little more than half as wide as hind margin; the latter broadly rounded.

38. THYREONOTUS PACHYMERUS, (Burmeister.)

Dectieus pachymerus, Burmeister, Handb. der Entom., II., 1838, 712.

Thyreonotus pachymerus, Scudder, Bost. Jour. Nat. Hist., VII., 1862, 453.
Comstock, Int. Ent., I., 1888, 118, fig. 106.
Fernald, Orth. N. Eng., 1888, 26.
Smith, Ins. N. Jer., 1890, 411.
McNeill, Psyche, VI., 1891, 24.
Osborne, Proc. Ia. Acad. Sci., 1892, 119.
Davis, Canad. Entom., XXV., 108 (Song. of).

Color: Male—Grayish or fuscous brown; the sides of pronotum and tegmina black, the former often shining; a narrow, curved yellow line above the posterior lateral angle of pronotum; the exposed dorsal field of tegmina light brown; the femora with numerous minute pale spots. Female—Usually reddish-brown throughout except the yellow line on side of pronotum which is bordered above with a dash of black.

The lateral carinæ of pronotum are much sharper in this species than in the next; the pronotum itself is a little longer, and appears more so than it really is on account of the broadly rounded posterior lobe. The latter has in the female a faint median carina which is absent in *dorsalis*. The hind femora, as well as the ovipositor, are a little shorter than in that species, and the apex of the ovipositor is more bluntly rounded from above.

Measurements: Male—Length of body, 20 mm.; of pronotum, 10 mm.; of hind femora, 16 mm. Female—Length of body, 22 mm.; of pronotum, 9 mm.; of hind femora, 18 mm.; of ovipositor 17 mm.

Pachymerus is, in Indiana, by far the more common of the two species known to occur. So far it has been noted only in Putnam and Vigo counties, but undoubtedly is to be found throughout the State, frequenting the localities mentioned above under the generic description. In a pleasing account of the note and habits of the species, Mr. W. T. Davis says as follows: "Its song much resembles that of *Orchelimum vulgare*, with the preliminary *zip, zip*, omitted. It is a continuous *z-e-e-e*, with an occasional short *ik*, caused by the insect getting its wing covers ready for action after a period of silence. * * * * Starting with raspberries, one kept in captivity had the rest of the fruits in their season, including watermelon, of which he showed marked appreciation. If I offered him a raspberry and then gradually drew it away he would follow in the direction of the departing fruit, and would finally eat it from my hand."

aa. Front margin of pronotum but little narrowed, about three-fourths the width of the hind margin, the latter almost square.

39. THYREONOTUS DORSALIS, (Burmeister.)

Decticus dorsalis, Burmeister, Handb. der Entom., II., 1838, 713.
Thyreonotus dorsalis, Scudder, Bost. Journ. Nat. Hist., VII., 1862, 454.
Id., Distb. Ins. N. Hamp., 1874, 370.
Id., Proc. Bost. Soc. Nat. Hist., XIX., 1877, 83.
Id., Ent. Notes, VI., 1878, 24.
Comstock, Int. Ent., I., 1888, 118.
Fernald, Orth. N. Eng., 1888, 26.
Smith, Ins. N. Jer., 1890, 411.

Color: Female—Dull, yellowish brown; the posterior lobe of pronotum, dorsum of abdomen and ovipositor dark brown. A blackish spot on the face below each eye; the sides of the pronotum with obsolete fuscous markings. The chief structural distinctions between this insect and *Pachymerus* are given above under the latter species.

Measurements: Female—Length of body, 24 mm.; of pronotum, 8.5 mm.; of hind femora, 21 mm.; of ovipositor, 22 mm.

This species is represented in my collection by two females taken in Vigo county, in August, 1891. It has not heretofore been recorded west of the Alleghany Mountains.

The above thirty-nine species comprise all the Locustidæ which, to the present knowledge of the writer, inhabit Indiana. Others undoubtedly occur, especially in the southern half, and throughout the prairie region of the northwestern part, where no collecting has been done. The present paper will, perhaps, aid in the identification of the more common kinds of this much neglected group of insects; but collectors throughout the state should be on the lookout especially for the following twelve species whose known range implies that they are probably inhabitants of Indiana; and when the careful and systematic biological survey of the state, now instituted, has been completed, a number of them will no doubt have been added to our known insect-fauna:

1. *Scudderia pistillata*, Brunner.

   Should be looked for in the northern half of the state. Resembles *furcata*, but has much wider tegmina. Ranges from New Jersey to Nebraska.

2. *Amblycorypha scudderi*, Bruner.

   Resembles *oblongifolia*, but is smaller, with comparatively shorter hind legs, and with apex of ovipositor more strongly serrate. Common in Eastern Nebraska.

3. *Microcentrum retinerris*, (Burmeister.)

   (See under *M. laurifolium*.) Should be found in Southern Indiana.

4. *Cyrtophyllus perspicillatus*, (Fabricius.)

   Has shorter and broader tegmina, more robust legs, and musical organ of male broader than *concavus*. A southern form.

5. *Xiphidium saltans*, Scudder.

   Should be found in the prairie region northwest. Resembles *strictum*, but is smaller, with longer tegmina, and shorter ovipositor. Common in Kansas and Nebraska.

6. *Orchelimum delicatum*, Bruner.

   A more slender and smaller insect than *vulgare*, with a much

shorter (4 mm.) pronotum, and a much longer (11.5 mm.) and straighter ovipositor. To be looked for northward. Nebraska.

7. *Orchelimum volantum*, McNeill.

Described from Henry county, Illinois. Larger than *vulgare*, with much longer tegmina. Posterior femora armed beneath.

8. *Ceuthophilus ensifer*, Packard.

A cave form described from Kentucky.

9. *Ceuthophilus niger*, Scudder.

Allied to *latens*, but wholly black with a reddish tinge. Hind femora short and unusually slender. Described from Illinois.

10. *Ceuthophilus divergens*, Scudder.

Color of *lapidicolus*, but with five, long spines on each side of hind tibiæ, which turn outward at right angles to tibiæ. Nebraska, Iowa.

11. *Hadenœcus cavernarum*, Saussure.

A stone cricket, said by Prof. E. D. Cope to inhabit Wyandotte Cave,* but not included in the list proper, as I have seen no specimens.

12. *Undeopsylla nigra*, Scudder.

A stone cricket, recorded from Iowa, Nebraska and Illinois, and therefore to be looked for in Indiana.

Biological Laboratory, Terre Haute High School, May 10, 1893.

The Blattidæ of Indiana. By W. S. Blatchley, Terre Haute, Ind.

The members of the family *Blattidæ*, commonly known as cockroaches, are classed among the *Orthoptera* by reason of their biting mouth parts, and direct or incomplete metamorphosis. From the other families of that order the *Blattidæ* may be known by their depressed, oval form; their nearly horizontal head, which is bent under and almost concealed by the broad prothorax; their slender legs of equal length and size; their five jointed tarsi; and by the absence of either ovipositor or forcipate appendages at the end of the abdomen.

*Cope, in Reps. Ind. Geol. Surv., IV., 1872. 161, and X., 1878, 493, mentions this species under the name of *Raphidophora subterranea*, Scudder—a synonym of *H. cavernarum*.

The rings of the abdomen overlap each other and are capable of great extension and depression so that these insects seem to be pre-eminently fitted for living in the narrow crevices and cracks which they inhabit. The legs are of peculiar structure in that they are long and more or less flattened, thus enabling the cockroaches to run with surprising swiftness, so that the family has been placed by some writers in a separate sub-order, the *Cursoria*, or runners. The wing covers, or tegmina, are leathery, translucent, and, when well developed, overlap when at rest; while the wings never exceed the tegmina in length, and in some cases are rudimentary or even wanting.

From the other Orthoptera the *Blattida* differ widely in the manner of oviposition, as the eggs are not laid one at a time, but all at once in a peculiar capsule or egg case called an oötheca. These capsules vary in the different species as regards the size, shape, and the number of eggs they contain, but they are all similar in structure. Each one is divided lengthwise by a membraneous partition into two cells. Within each of these cells is a single row of cylindrical pouches, somewhat similar in appearance to those of a cartridge belt, and within each pouch is an egg. The female cockroach often runs about for several days with an oötheca protruding from the abdomen, but finally drops it in a suitable place and from it the young, in time, emerge. While this method of oviposition is the one practiced by all the species of common occurrence in the United States, there seem to be exceptions to it, as Dr. C. V. Riley has recently recorded the fact[*] of an introduced tropical species, *Panchlora viridis*, Burm., being viviparous, the young emerging alive from the body of the parent, and a careful dissection of the latter showing no trace of either eggs or oötheca.

All young cockroaches resemble the parents in form but are wholly wingless, the wings not appearing until after the fifth or last moult. The young are often mistaken for mature individuals by persons who have not made a careful study of the life history of the insects; and those of one or two well known and common forms, have, in the past, even been described or figured as distinct, wingless species by some of the leading entomologists of the country.

To the paleontologist, interested in tracing back the ancestry of insects, the *Blattida* become at once a group of surpassing interest, for the oldest known insect, *Palæoblattina douvillei*, Brong., is a cockroach recently de-

[*] Insect Life, III., August, 1891, 443.

scribed from the Middle Silurian of France. Between seventy and eighty fossil species of the family are known, principally from the Mesozoic formations, but some from all above the Middle Silurian. Mr. S. H. Scudder, of Cambridge, Mass., an eminent authority on insect paleontology, says of the cockroach: "Of no other type of insects can it be said that it occurs at every horizon where insects have been found in any numbers; in no group whatever can the changes wrought by time be so carefully and completely studied as here; none other has furnished more important evidence concerning the phylogeny of insects."

Although abundantly represented in individuals, the number of species of *Blattidæ* inhabiting the Eastern United States is comparatively few, but twelve or thirteen having been recorded. Of these, seven, representing five different genera, are known by the writer to occur in Indiana. Of the seven, five are indigenous or native species, the other two having been introduced from the Old World.

In the present paper is given a synopsis of the genera occurring in the state, together with the accessible synonymy and a brief popular description of each of the species. Such notes as have come to hand during several years of observation, concerning the life history, distribution, and habits of each species, are also added.

A Synopsis of the Genera of Blattidæ Occurring in Indiana.

a. Sub-anal stylets present in the males.

b. Last abdominal sternite of the female divided; length of body more than 22 mm.

c. Supra anal plate either truncate or pointed, and notched or cleft at the end . . . . . I. Periplaneta.

cc. Supra-anal plate rounded, entire at the end . . II. Ischnoptera.

bb. Last abdominal sternite of the female entire; length of body less than 15 mm. . . . . III. Temnopteryx.

aa. Sub-anal stylets absent in the males; last abdominal sternite of the female entire.

d. Body broad, the greatest breadth more than one-half the length; tegmina not reaching the tip of abdomen . . . . . IV. Ectobia.

dd. Body narrow, the greatest breadth about one third the length; tegmina reaching to or beyond the tip of the abdomen . . . . . V. Phyllodromia.

[3]Scudder, Bulletin U. S. Geog. Survey, No. 31, page 103.

I. PERIPLANETA, Burmeister (1838.)

In this genus the sub-anal stylets of the male are well developed; the last abdominal sternite of the female is divided; the supra-anal plate is either truncate, or pointed and notched at the end, and extends farther back than the sub-genital plate; while the abdomen is wider than the front part of the body. All the femora are armed beneath, on each of the carina, with a single row of slender, curved spines, while the tibiæ bear a double row of much longer ones on each of their margins. Two of the largest species occurring in the state belong in this genus.

1. PERIPLANETA ORIENTALIS, (L.) The Oriental Cockroach. The "Black Beetle."

Periplaneta orientalis, Burmeister, Handbuch der Entom., II., 1838, 504.
Riley, Stand. Nat. Hist., II., 1884, 172, fig. 248.
Id., Insect Life, II., March, 1890, 267.
Comstock, Intr. to Ent., I., 1888, 93.
Fernald, Orth. of N. Eng., 1888, 52, fig. 21. *m.*
Hyatt & Arms, Insecta, 1890, 102, pl. 4, figs. 54, 55.

Kakerlac orientalis, Serville, Hist. Nat. des Orthopteres, 1839, 72.

Blatta orientalis, Harris, Ins. Inj. Veg., 1862, 145, fig. 66. *m.*
Rathvon, U. S. Ag. Rep., 1862, 374, figs. 4, 5.

Stylopyga orientalis, Scudder, Bost. Journ. Nat. Hist., VII., 1862, 416.
Glover, U. S. Ag. Rep., 1874, 132, fig. 4.

Female with rudimentary tegmina which do not exceed 5 mm. in length. Male with the tegmina and wings well developed, the former covering three-fourths of the abdomen, the latter almost as long. General color, dark, mahogany brown, the limbs lighter, the pronotum without a yellow margin. The supra-anal plate of the male is truncate; that of the female is rounded with a shallow notch at the end.

Measurements: Male—Length of body, 22.5 mm.; of tegmina, 14 mm.; of pronotum, 6 mm.; width of pronotum, 8 mm. Female—Length of body, 27.5 mm.; greatest width of body, 13 mm.

The eggs of the Oriental cockroach are sixteen in number, and the large horny capsule or oötheca in which they are packed is carried about by the mother for a week or longer when she drops it in a warm and sheltered place. Along one side of the capsule, which resembles in form and color a diminutive seed of the pawpaw, *Asimina triloba*, Duval, is a seam where the two edges are cemented closely together. When the young are hatched they excrete a liquid which dissolves the cement and

enables them to escape without assistance, leaving their infantile receptacle as entire as it was before they quitted it.

The Oriental cockroach, as its name indicates, is a native of Asia, but has been carried from one country to another by shipping. It delights in filth and darkness, and hence in the holds of vessels, the cellars and basements of tenement houses, and in all damp, dirty places it swarms by thousands, undoubtedly doing much good as a scavenger, but infinitely more harm on account of its omnivorous and insatiable appetite. Like most other members of the family it feeds mainly at night, appearing to detest and avoid the light, as one can readily prove by taking a lighted lamp suddenly into its haunts, when a hurried scrambling will take place towards its daylight retreats, and but a few moments will elapse before the last of the busy marauders will have disappeared.

This is probably the most carnivorous of all our Blattidæ, though, like most others, it is fond of starchy food. It is known to feed upon meat, cheese, woolen clothes, and even old leather, and is said to be especially fond of the festive "bed bug," *Acanthia lectularia L.*, which soon disappears from a house infested with the Oriental roach.

In Indiana this species is found in all the larger towns and cities, and is one of the most noisome and disagreeable insects with which certain classes of their inhabitants have to contend.* It seldom occurs in houses in thinly settled localities, and never, as far as my observation goes, beneath the bark of logs and stumps.

2. PERIPLANETA AMERICANA, (L.) The American Cockroach.

Periplaneta americana, Burmeister, Handb. der Entom., II, 1838, 503.
Scudder, Boston Jour. Nat. Hist., VII., 1862, 416.
Riley, Stand. Nat. Hist., II., 1884, 172.
Id., Insect Life, I., 1888, 68; II., 1890, 266.
Fernald. Orth. N. Eng., 1888, 51.

Kakerlac americana, Serville, Hist. Nat. des Orthop, 1839, 68.

Blatta americana, Rathvon, U. S. Ag. Rep., 1862, 375. (In part.)
Packard, Third Rep. U. S. Ent. Comm., 1883, 309, pls. XXV.–XXXV.

From the Oriental roach this species may be readily known by its larger size and its longer tegmina and wings, which, in both sexes, reach beyond the tip of the abdomen. The supra-anal plate is more pointed and the

*For remedies see remarks under *Phyllodromia germanica* or "Croton bug."

notch at the end is narrower and much deeper. The general color is also lighter, being a reddish instead of a mahogany brown, while the pronotum is broadly margined on the sides, and narrowly in front, with yellow which encloses a large bi-lobed brown spot.*

Measurements: Male—Length of body 27 mm.; to tip of wings, 45 mm.; of tegmina, 27.5 mm. Female—Length of body, 30 mm.; greatest width of body, 14 mm.

The American cockroach is, as its specific name indicates, a native of this country; but like *P. orientalis*, it has spread to the four corners of the earth. It is by far the largest species found in the State, but seems to be of rather limited distribution as I know of its occurrence in but two counties, Putnam and Marion. It occurs in numbers in some of the leading hotels of Indianapolis, but usually confines itself to the basement and first floor, and appears to be much more cleanly in its choice of an abiding place than does the closely allied Oriental roach.

II. Ischnoptera, Burmeister (1838.)

Males, with the sub-anal stylets present but minute, and often bent abruptly downward; last abdominal sternite of the female divided; supra-anal plate in both sexes rounded, not notched at the end nor extending as far backwards as the sub-genital. Body narrower and more elongate than in *Periplaneta*, the abdomen not wider than the thorax; in the males, tapering gradually to a rounded point. Legs spined as in *Periplaneta* but the spines not so long and strong as there. Two species occur in Indiana.

3. Ischnoptera pennsylvanica, (DeGeer.) The Pennsylvania Cockroach.

Platamodes pennsylvanica, Scudder, Bost. Jour. Nat. Hist., VII., 1862, 417.
Riley, Stand. Nat. Hist., II., 1884, 172.
Comstock, Intro. Ent., I., 1888, 93.

Blatta pennsylvanica, Thomas, Trans. Ill. St. Agl. Soc., V., 1865, 440.

Ischnoptera pennsylvanica, Packard, Guide, Stud. Ins., 1883, 576.
McNeill, Psyche, VI., 1891, 78.

Ectobia lithophila, Scudder, Bost. Jour. Nat. Hist., VII., 1862, 418.—(juvenile.)

Blatta americana, Rathvon, U. S. Ag. Rep., 1862, 375. (Note and fig. 5 a.)

Tegmina, long and narrow, extending, in both sexes, much beyond the tip of abdomen. Wings as long as tegmina. Disk of pronotum dark brown, margined on sides, and sometimes narrowly in front, with pale

* In this respect it is quite similar to *Ischnoptera pennsylvanica* DeGeer, from which it may be readily distinguished by its much broader body and fissured supra-anal plate.

yellow. Tegmina reddish brown, with the outer basal third rather broadly margined with transparent whitish. Antennæ dusky, reaching back but little beyond the tip of tegmina. Measurements: Male—Length of body, 21 mm.; to tip of tegmina, 27 mm.; of tegmina, 22 mm.; of antennæ, 28 mm.; of pronotum, 5 mm.; width of pronotum, 6 mm. Female—Very nearly the same, the body being a little wider.

This is a native species and is the most common cockroach in the State, being found everywhere beneath the loose bark of logs and old stumps. It is usually seen in the wingless stages, the mature individuals being common only from May to October. The half grown young, described by Scudder, as *Ectobia lithophila*, are of a shining, dark brown color, the dorsal surface of thoracic segments often lighter. As mature specimens are attracted by light, country houses are often badly infested with them; and where food is scarce, the wall paper is sometimes much injured for the sake of the paste beneath. What the hordes of young which dwell under the bark of logs live upon is a question as yet unsettled, but the larvæ of other insects undoubtedly form a portion of their food, as in two instances I have found them feeding upon the dead grubs of a *Tenebrio!* beetle; while living, as well as decaying vegetable matter probably forms the other portion. The mating of the imagoes mostly occurs in late summer and early autumn, the newly hatched young being most abundant from mid September until December. The young in various stages of growth survive the winter in the places mentioned, they being the most common insects noted in the woods at that season. Cold has seemingly but little effect upon them, as they scramble away almost as hurriedly when their protective shelter of bark is removed on a day in mid January with the mercury at zero, as they do in June when it registers a hundred in the shade.

The empty oötheca of this species are very common objects beneath the loose bark of logs and especially beneath the long flakes of the shell bark hickory. They are chestnut brown in color, from 7.5 to 10 mm. in length by 4 mm. in breadth, and are much less flattened than those of *Phyllodromia germanica*, or "Croton bug," described below; while the dorsal or entire edge is slightly curved or bent inwards, after the fashion of a small bean. The young, after hatching, evidently escape in the same manner, as do those of the Oriental cockroach, as no break is visible in the empty capsule.

4. ISCHNOPTERA UNICOLOR, (Scudder.)

Platamodes unicolor, Scudder, Bost. Jour. Nat. Hist., VII., 1862, 417.
Fernald, Orth. New Eng., 1888, 53.

Ischnoptera unicolor, Scudder, Proc. Bost. Soc. Nat. Hist., XIX., 1877, 92.
McNeill, Psyche, VI., 1891, 78.

A much smaller species than the preceding but, like it, having both wings and wing covers exceeding the abdomen. General color a pale shining reddish brown. Head and posterior margin of pronotum darker as is also the apical third of the abdomen beneath. Antennæ slender, tapering, reaching backwards to the end of the wing covers. Length of body, 12 mm.; to tip of tegmina 19 mm.; of tegmina 16 mm.; of pronotum, 3 mm.

A single male of this species was taken from beneath an electric light in Terre Haute, Indiana, on the evening of June 12, 1892. On May 28, 1893, a number of others were secured in low ground from beneath the bark of a red oak stump. They had evidently just reached maturity and were in company with the imagoes and young of *I. pennsylvanica*. On being exposed to view a number of them flew about 50 feet to a clump of May apple stems, down which they ran and endeavored to hide beneath some dead leaves. Nothing farther of its habits is known by the writer but they are presumably the same as those of *I. pennsylvanica*. It has been noted at no other point in Indiana and heretofore has been recorded only from the New England States, Illinois, and Iowa.

III. TEMNOPTERYX, Brunner (1865).

The males of this genus have the sub-anal stylets present, but minute; the last abdominal sternite of the female is broadly rounded and entire; supra-anal plate of both sexes with the apex rounded, entire, equal in length to the sub-genital. Pronotum with its lateral edges roundly deflexed as in *Periplaneta*, rather than flaring outwards as in *Ischnoptera*; much broader in the female than in the male. Body of male rather slender; that of female stouter with the abdomen broader than the thorax.

5. TEMNOPTERYX DEROPELTIFORMIS, Brunner.

Temnopteryx deropeltiformis, Brunner, Nouv. Syst. des Blattaires, 1865, 87.

Tegmina of females rudimentary covering only about one-third of abdomen; those of the males fully developed, surpassing the abdomen by 5 mm. Color a uniform dark mahogany brown except the tibiæ and tarsi of all the legs which are a light reddish brown, the contrast between the two colors in living specimens being very striking.

Measurements: Male—Length of body, 14 mm.; of tegmina, 15.5 mm.; of pronotum, 3.5 mm.; width of pronotum, 4.5 mm. Female—Length of body, 13 mm.; of tegmina, 4 mm.; of pronotum, 4.5 mm.; width of pronotum, 6 mm.

In Indiana this handsome cockroach has been noted only in Vigo county, and there in but one locality, the border of a marsh in a low, sandy woods three miles east of Terre Haute.

A single pair were taken on May 28th, and on June 18th probably a dozen specimens were secured. They were hiding beneath small logs and sticks, and the males when deprived of their shelter flew actively away while the females could but crawl, and that rather sluggishly for a Blattid, towards a new hiding place.

Brunner (*loc. cit.*) recorded it from "Amerique du Nord," and I can find no other note of its occurrence in the United States.

IV. Ectobia, Westwood (1839).

Sub-anal stylets of males wanting; last abdominal sternite of females entire. Supra-anal plates rounded, entire, somewhat carinated above. Abdomen much broader than front portion of body, its greatest breadth contained less than twice in its total length. Tegmina, in both sexes, not reaching tip of abdomen.

6. Ectobia flavo-cincta, Scudder. The Short-winged Cockroach.

Ectobia flavo-cincta, Scudder, Bost. Journ. Nat. Hist., VII., 1862, 418.
Comstock, Intr. to Ent., I., 1888, 93.

Blatta? flavo-cincta, Fernald, Orth. N. Eng., 1888, 51.

This is a short, broad-bodied, native species, in which the tegmina cover only about two-thirds of the abdomen, while the wings are much shorter. The disk of pronotum and dorsal surface of abdomen are dark brown, the tegmina reddish brown. A rather broad yellowish stripe extends from the head along the deflexed lateral border of pronotum and the basal third of tegmina. The sides of the lower half of the face are white, and all the limbs are pale yellow. Antennæ dark brown, a little longer than the body.

Measurements: Length of body, 16 mm.; of tegmina, 9 mm.; of wings, 6.5 mm.; of antennæ, 18 mm.; of pronotum, 5 mm.; width of pronotum, 6.5 mm.; width of abdomen, 9.5 mm.

Mature individuals of this species are not uncommon beneath bark and logs from June to October. Specimens of such are in my collection from Marshall, Putnam, and Vigo counties. I have not, as yet, been able

to distinguish the young from those of *Ischnoptera pennsylvanica*, found in the same localities. A single female with oötheca protruding was taken on September 3, 1892. The oötheca is dark brown and smaller than that of any other species known to me, measuring only 5x4 mm.

Flavo-cincta is a species of northern range, having hitherto been recorded only from New England and the Lake Superior region.

V. PHYLLODROMIA, Serville (1839).

Sub-anal stylets and last abdominal sternites, as in *Ectobia*. Supra-anal plate truncate in the males, suddenly pointed and slightly notched in the females. Body narrow, the greatest breadth contained from two and one-half to three times in the total length. The abdomen not broader than the thorax in either sex, the sides almost parallel in the females; in the male tapering sensibly from the base. The tegmina as long as, or longer than, the abdomen.

7. PHYLLODROMIA GERMANICA, (L.) The Croton Bug. The Water Bug. The German Cockroach.

Blatta germanica, Burmeister. Handbuch der Ent., II., 1838, 497.
Comstock, Int. Ent., I., 1888, 93, fig. 87.
Fernald, Orth. N. Eng., 1888, 50, fig. 20.

Ectobia germanica, Scudder, Bost. Jour. Nat. Hist., VII., 1862, 418.
Glover, U. S. Agl. Rep., 1874, 132, fig. 3.
Riley, Stand. Nat. Hist., II., 171, fig. 247.
Id. Insect Life, I., 1888, 68, 191.

Blatta (Phyllodromia) germanica, Serville, Hist. Nat. des Ortho., 1839, 107.

Phyllodromia germanica, Packard, Guide Stud. Ins., 1883, 576, fig. 569.
Riley, Insect Life, II., 1890, 266, fig. 57 (All stages.)

Ischnoptera birittata, Thomas, Proc. Davenport Acad. Nat. Sci., I., 1876, 250, pl. XXXVI, figs. 1, 2.

This is the smallest of the seven species of Blattidæ which are known to occur in the State. The general color is a light brownish yellow, the females often darker; all the limbs much lighter than the body; the pronotum with two dark brown, longitudinal bands enclosing a yellowish stripe. The tegmina and wings of the male extend to the end of abdomen, those of the female are a little longer. Antennæ dark brown, exceeding slightly the tips of the closed tegmina. The body of the male is longer and narrower than that of the female.

Measurements: Male—Length of body, 13 mm.; of tegmina, 10 mm.;

width of body, 4 mm. Female Length of body, 10 mm.; of tegmina, 11 mm.; of antennæ, 13 mm.

The oötheca of the Croton bug is very light brown, a little over twice as long as broad, 7.5x3.5 mm., with the sides somewhat flattened and the edges parallel. Within it the eggs, thirty-six in number, are arranged in the usual two rows. It is carried about by the mother roach for several days with from half to three-fourths of its length protruding from the abdomen, and when dropped in a favorable place the young, evidently very soon, emerge from it; for in a bottle in which a female with protuding oötheca was placed at eleven o'clock P. M. the young were found to have emerged on the following morning at eight. They were then wholly white, except the lateral edges of the abdomen, where a blackish tinge was evident. By five o'clock in the afternoon of the same day, having meanwhile eaten their fill of moistened wheaten bread, they had become too large for their skins, and had moulted for the first time. They then measured 3 mm. in length, and the head, pronotum, abdomen, and apical half of antennæ were black, while the other two thoracic rings and the basal half of antennæ were a grayish white. The half-grown young are very dark brown, with the first four or five segments bordered with yellow, and with traces of a lighter median stripe.

The "Croton bug," so called because it made its appearance in New York City in numbers about the time the Croton Aqueduct was completed, is a native of Central Europe, but like the Oriental roach, has become cosmopolitan.

It seldom if ever occurs in numbers in the country, but is one of the worst insect pests with which the inhabitants of the larger cities of the United States have to deal. It is the most fecund of all the roaches, and the seasons of mating and hatching of the young are, perhaps, more irregular than in any other species. Adult forms are evidently to be found at all seasons of the year, as I have taken them in December, April and October. It is not so much a lover of filthy surroundings as is the Oriental roach, and hence frequents more often than that species the dwellings of the better class of people. It delights in warm, moist places, and is especially abundant and destructive in buildings which are heated by steam.

As an evidence of its abundance under favorable conditions, I will mention that a single person captured for me over thirty adult specimens and fully half that number of young, in less than ten minutes in the kitchen

of the leading hotel of the city of Terre Haute. Where it once obtains a foothold and the surroundings of temperature and food supply are favorable it is almost impossible to eradicate, as its small flattened form enables it to hide and breed in cracks and crevices which none of the other roaches can enter.

Like many other omnivorous animals, Croton bugs find in wheaten flour a food substance which is rich in nutrition and easily digested, and so they prefer wheat breads and starchy materials to all other foods. On account of this liking they often do much harm to cloth-bound books by gnawing their covers in search of the paste beneath. They also seem to have a peculiar liking for paints of various kinds, and in the office of the U. S. Coast and Geodetic Survey, at Washington, have done much damage by eating off the blue and red paints from the drawings of important maps.* Townend Glover, in the U. S. Ag. Rep. for 1874, states that in his office "They made a raid on a box of water colors where they devoured the cakes of paint, vermilion, cobalt and umber alike; and the only vestiges left were the excrements in the form of small pellets of various colors in the bottom of the box."

In giving a remedy for this, and other species of Blattidæ which frequent houses, I cannot do better than quote from Dr. Riley's excellent article in "Insect Life." He says: "Without condemning other useful measures or remedies like borax, I would repeat that in the free and persistent use of California Buhach, or some other fresh and reliable brand of Pyrethrum or Persian Insect Powder, we have the most satisfactory means of dealing with these roaches.

"Just before nightfall go into the infested rooms and puff into all crevices, under base-boards, into the drawers and cracks of old furniture —in fact wherever there is a crack—and in the morning the floor will be covered with dead and dying or demoralized and paralyzed roaches, which may easily be swept up or otherwise collected and burned.

"With *cleanliness*, and *persistency* in these methods, the pest may be substantially driven out of a house, and should never be allowed to get full possession by immigrants from without."

For no other insects have so many quack remedies been urged and are

* Riley, "Insect Life."

so many newspaper remedies published. Many of them have their good points, but the majority are worthless. In fact, rather than put faith in half of those which have been published, it were better to rely on the recipe which T. A. Janvier gives (in his charming article on "Mexican Superstitions and Folk-lore," published in a recent number of Scribner's Magazine) as current among the Mexicans:

"*To Get Rid of Cockroaches.*—Catch three and put them in a bottle, and so carry them to where two roads cross. Here hold the bottle upside down, and as they fall out repeat aloud three *credos*. Then all the cockroaches in the house from which those three came will go away."

A NOTE ON LOXIA CURVIROSTRA. By W. S. BLATCHLEY.

ON A SIMPLE AIR THERMOMETER FOR USE IN DETERMINING HIGH TEMPERATURES. By W. A. NOYES.

[ABSTRACT.]

The thermometer consists of a bulb of hard glass having a capacity of about 20 cc. and connected with a gas measuring tube by means of a long capillary tube. This tube is protected by means of a double walled iron tube cooled by a stream of running water. The capacity of the bulb having been determined, the amount of air expelled from it when it is introduced into the furnace furnishes the data necessary for calculating, approximately, the temperature. The apparatus was used successfully at 650° C. but for higher temperatures a porcelain bulb would be required.

THE ELECTRICAL OXIDATION OF GLYCERIN. By W. E. STONE AND H. N. MCCOY.

[ABSTRACT.]

The oxidation products of glycerine vary according to the means employed. We have made use of the electric current acting upon dilute solutions of glycerine in the hopes of obtaining glyceric aldehyde. The conditions of dilution, strength of current, temperature and conducting mediums have been varied.

The oxidation is less destructive in neutral or alkaline solutions.

A current of .2 to .5 ampere causes a rise in temperature and the appearance of a yellow color if the solution be alkaline.

Acids and sometimes acroleine are formed.

The oxidized solutions reduce Fehling's solution strongly in the cold and give the fuchsin-sulfurous acid reaction for aldehydes.

To a solution which gave strong reactions for glyceric aldehyde was added enough caustic soda to make a 2 per cent. solution in order to induce polymerisation. After standing some days, a pherylhydrazin compound was obtained, which melted at 200°. This indicated the production of glyceric aldehyde and its polymerisation to glucose.

The product of a second oxidation was polymersed and underwent alcoholic fermentation with yeast.

The electric current, therefore, produces some glyceric aldehyde from glycerine, although the amount is small.

On sulphon-phthaleins. By Walter Jones.

Modification of Grandeau's method of determination of humus in soils, By H. A. Huston and W. F. McBride.

The paper discusses the numerous methods proposed and used for determining the total carbon in the soil and for determining the organic matter and shows that none of these methods are entitled to consideration excepting the process of Grandeau. This method, which consists essentially of removing the bases combined with the humic acid by means of hydrochloric acid, subsequent washing with water and extracting on a filter with ammonia water, is compared with a modification of the method in which the preliminary washing with acid and water is the same but, instead of leaching the soil upon the filter with ammonia water, the soil is transferred to a 500 cc. cylinder, treated with 500 cc. of 4% ammonia, allowed to remain in contact with the ammonia for thirty-six hours, with frequent shaking. During the earlier part of the digestion the cylinder is left upon its side, thus exposing a large amount of surface to the solvent; during the last twelve hours of the digestion the cylinder is placed upright,

thus allowing the soil to settle before an aliquot part is removed for the determination of the humus.

The aliquot part is evaporated to dryness, dried at 100° C., weighed, ignited, weighed again and the loss reckoned as humus. The following points were under discussion:

1st. Comparison of Grandeau's method with this modified method.

2d. Influence of varying the strength of the ammonia used.

3d. Influence of varying the time of digestion.

4th. Is it possible to complete the extraction by Grandeau's method in a reasonable time.

5th. Comparison of differences in duplicates by each method.

6th. Are the amounts of phosphoric acid, potash, etc., found in the ash necessarily associated with the humus, as claimed, or are they to be ascribed to the solvent action of the ammonia and to changes due to the absorptive property of the soils.

Numerous determinations are given upon seven different soils, showing that the modified method gives much higher results than the ordinary process of Grandeau.

Second, In the Grandeau method marked irregularities follow the changes in strength of the ammonia solution. These differences in results bear no relation to the strength of the solution used; they seem to be errors due to the difficulty of securing a complete washing of the soil by the ammonia solution. In the modified method the changes in the strength of the ammonia solution make practically no difference in the amount of the humus extracted, excepting in the case of the peat soil, where 2% ammonia failed to extract all the humus. The results show no considerable increase where the strength is increased above 4%. The ammonia solutions contained 2, 4, 7.3 and 8% of ammonia.

Third, The increase of time has not been fully investigated but the results so far obtained indicate that the time exerts less influence in the modified than in the Grandeau method.

Fourth, With peat, when the Grandeau method is used, considerable material is passing into solution at the end of ten days; with ordinary soils this is not the case, but in the case of the black soil (not peat) the extraction was not complete in a week. On the peat soil the modified method extracted from 10 to 50% more than the Grandeau and on ordinary soil from two to three times as much humus.

Fifth, In comparing a large number of duplicates the modified method

was found to give much more concordant results upon soils high in humus, and upon those low in humus there was a slight improvement over the Grandeau method.

Sixth, The authors see no reason for assuming that the phosphoric acid extracted by the ammonia is in any way associated with the humus, for Mr. Huston has already shown that the phosphoric acid is readily dissolved by ammonia from phosphate of alumina and iron. It is generally considered that there are bases with which the available phosphoric acid in the soil is combined. In the same way we may account for the presence of potash and lime in solution by the ordinary laws which govern the absorption of bases by zeolitic minerals in the soil.

While humates also take part in soil absorption, it is not necessary or even altogether reasonable to consider all the bases removed by ammonia were associated with the humus. In fact, the theory of the process is that the bases associated with the humus had already been removed by means of the hydrochloric acid used in the preliminary washing of the soil.

The paper is in the nature of a preliminary report and the work is still in progress. A complete report of the work will be published later.

THE EXTRACTION OF XYLAN FROM STRAW IN THE MANUFACTURE OF PAPER.

By W. E. STONE AND W. H. TEST.

[ABSTRACT.]

The extraction of substances from straw which on inversion, yield a pentose sugar, has been established. In the process of making straw paper the straw is boiled with a strong solution of quick lime. This liquor, when acidulated and treated with an excess of alcohol throws down a precipitate of pentosans. It seemed, therefore, a good material for the preparation of xylose.

The liquor is yellowish brown in color and alkaline. Specific gravity, 1.215; alkaline equivalent, 2 to 2.5 per cent. calcium oxide. Total residue on evaporation, 3.95 per cent., of which 30.77 per cent. was mineral and 69.23 per cent. organic in nature. Thirty-two liters of the liquor yielded on precipitation with alcohol, 300 grams of xylan. This, on distillation with hydrochloric acid, yielded 45.5 to 47.1 per cent. furfurol. This could not be inverted by methods similar to those practiced by Wohl on inuline. The ordinary method of boiling with 2 per cent.

sulfuric acid was resorted to. Thirty-five grams of crystallized sugar were obtained, which were identified as xylose.

The multirotation of xylose, as observed by Tollens, was confirmed. The initial rotation, five minutes after solution, was 71.65°, which became constant at 18.40° after ten hours.

On the determination of chlorine in natural waters. By W. A. Noyes.

[Abstract.]

American waters, apparently, contain much smaller amounts of chlorine than most natural waters in England. The methods of direct titration with silver nitrate and potassium chromate as advised by Wauklyn and Frankland give too high results, and sometimes two or three times as much chlorine as is actually present, in the case of waters low in chlorine. When 250 cc. of the water were concentrated to about 25 cc. and filtered, the titration with $\frac{1}{100}$ normal silver nitrate, using potassium chromate as an indicator, gave results agreeing with the gravimetric determination within $\frac{1}{10}$ part per million in the case of a water containing but four parts per million of chlorine.

Thiofurfurol and its condensation products. By W. E. Stone and Clinton Dickson.

[Abstract.]

Thiofurfurol is made by the action of hydrogen sulphide on an alcoholic solution of furfuramid. It is characterized by its disagreeable odor. It is a white powder, melting at 117° and containing about 29 per cent. of sulphur, corresponding to the formula $C_5 H_4 OS$. On heating strongly vapors are given off which, on condensation, leave beautiful fibrous crystals, which are not easily acted upon, probably a condensation product. If the thiofurfurol be heated with an excess of fine copper at a temperature below the boiling point of water decomposition takes place. On extracting the mass with ether and evaporating, there remains a tarry mass which yields compact crystals which melt at 149°, contain no sulphur and are probably also a condensation product. The subject will be investigated further.

Determination of valences. By P. S. Baker. Published in DePauw Bulletin.

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