PROCEEDINGS

OF THE

Biological Society of Washington

VOLUME IX

1894–1895

WASHINGTON:
PRINTED FOR THE SOCIETY.
1894–'95.

COMMITTEE ON PUBLICATIONS

THEODORE GILL, *Chairman*

T. H. BEAN	L. O. HOWARD
F. H. KNOWLTON	T. W. STANTON

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OF THE

BIOLOGICAL SOCIETY OF WASHINGTON

FOR 1894

(ELECTED DECEMBER 30, 1893)

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Delegates to the Joint Commission of Scientific Societies of Washington

Richard Rathbun
C. V. Riley
Lester F. Ward

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* Ex-Presidents of the Society.

LIST OF THE OFFICERS AND COUNCIL

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON

FOR 1895

(ELECTED DECEMBER 29, 1894)

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Vice-Presidents

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PROCEEDINGS
OF THE
BIOLOGICAL SOCIETY OF WASHINGTON.

PROCEEDINGS.

January 13, 1894—220th Meeting.

The President in the chair and twenty-three persons present.

The following communications were presented:

R. T. Hill: A New Fauna from the Cretaceous Formation of Texas.*

Ch. Wardell Stiles: The Teaching of Biology in Colleges.

January 27, 1894—221st Meeting.

The President in the chair and twenty-two persons present.

The following communications were presented:

J. N. Rose: A Botanical Trip to Northwestern Wyoming.

B. T. Galloway: A Rust of Pine Leaves and the Effect of the Parasite on the Host.

Theodore Gill: The Segregation of the Osteophysial Fishes as Fresh Water Forms.†

February 10, 1894—222d Meeting.

The President in the chair and twenty-three persons present.

The following communications were presented:

M. B. Waite: The Treatment of Pear Leaf-Blight.‡

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* Abstract in Am. Journ. Sci., 3d ser., xlvii, 141, Feb., 1894.

† The Early Segregation of Fresh Water Fishes. <Science, NS., I., 678–679, Nov. 22, 1895.

‡ Abstract in Science, March 15, 1895, 305–306. Full paper: Treatment of Pear Leaf-Blight (*Entomosporium maculatum*) in the Orchard. <Journal of Mycology, vii, No. 4, 333–338, pls. xxxii and xxiii, Aug. 15, 1894.

C. Hart Merriam: A Remarkable New Rabbit from Mexico.

Ch. Wardell Stiles: *Distoma westermanni* in the Lungs of a Cat.*

C. V. Riley: The Transmission of Acquired Characters.

February 24, 1894—223d Meeting.

Vice-President B. E. Fernow in the chair and fifteen persons present.

The following communications were presented:

M. B. Waite: The Structure and Method of Opening of the Anthers of the Pomeæ.

B. T. Galloway: The Winter Coloration of Evergreen Leaves.

L. O. Howard: Notes on Spider Bites.

March 10, 1894—224th Meeting.

Ex-President Lester F. Ward in the chair and twenty persons present.

C. H. Townsend: The Ornithology of Cocos Island in its Relation to that of the Galapagos Archipelago.†

B. T. Galloway: A Hexenbesen of *Rubus*.

M. B. Waite: The Hexenbesens of Washington and Vicinity.

Wm. Palmer: Rare Birds taken in the District of Columbia.

Leonhard Stejneger exhibited a specimen of a spade-foot toad (*Spea*) found in sandstone 23 feet below the surface.

March 24, 1894—225th Meeting.

Vice-President Richard Rathbun in the chair and twenty persons present.

The following communications were presented:

Theobald Smith: On the Significance of Variation among Species of Pathogenic Bacteria.

Vernon Bailey: On Some Bones from a Cave in Arizona.

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* Notes on Parasites, 26: *Distoma* (*Mesogonimus*) *westermanni*. Discovery of a parasite of Man, new to the United States. <Johns Hopkins Hospital Bulletin, No. 40, 57–58, figs. 1–4, 1894.

† Birds from Cocos and Malpelo Islands, with notes on Petrels obtained at Sea. <Bull. Mus. Comp. Zoöl., xxvii, No. 3, 121–126, 2 col. pls., July, 1895.

C. D. Walcott: On Some Appendages of the Trilobites,* and On the Occurrence of Fossil Medusæ in the Middle Cambrian Terrane.

April 7, 1894—226 Meeting.

Vice-President Frank Baker in the chair and twenty-five persons present.

Discussion: What is a Living Cell?

April 21, 1894—227th Meeting.

The President in the chair and twenty persons present.

The following communications were presented:

B. T. Galloway: The Effect of Spraying with Fungicides on the Growth of Nursery Stock.†

A. F. Woods: The Calorific Effect of Light upon Plants.

Erwin F. Smith: The Length of Vessels in Higher Plants.‡

Ch. Wardell Stiles: Adult Cestodes of Herbivorous Animals.

May 5, 1894—228th Meeting.

The President in the chair and seventeen persons present.

The following communications were presented:

Lester F. Ward: A Recent Collection of Fossil Cycads from the Potomac Formation of Maryland.§

B. T. Galloway: The Size and Weight of Seed in Relation to the Size and Weight of the Plant.||

May 19, 1894—229th Meeting.

The President in the chair and twenty-three persons present.

The following communications were presented:

C. Hart Merriam: The Dental Armature of Pocket Gophers (*Geomys*).¶

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* Note on some Appendages of the Trilobites. <Proc. Biol. Soc. Wash., vol. ix, 89–97, pl. 1, March 30, 1894.

† Bull No. 7, Div. Veg. Path., U. S. Dept. Agric., Aug., 1894.

‡ Science, NS., I., 77, 1895.

§ Bull. Torrey Bot. Club, xxi, No. 7, 291–299, July 20, 1894.

|| Agricultural Science, vol. 8, 557, 1894.

¶ Monographic Revision of the Pocket Gophers, family Geomyidæ, chap. iii. The Dental Armature. <N. Am. Fauna, No. 8, 69–97, figs. Jan. 31, 1895.

William Palmer: The Nesting Sites of the Blue Gray Gnat-Catcher.

H. J. Webber: The Dissemination of the *Yucca.*

October 20, 1894—230th Meeting.

Ex-President Wm. H. Dall in the chair and fifteen persons present.

The following communications were presented:

A. F. Woods: Some Effects of Spraying Mixtures on the Growth of Plants.*

Ch. Wardell Stiles: Experimental Trichinosis in a New Host.†

Short notes by several members.

November 3, 1894—231st Meeting.

The President in the chair and sixteen persons present.

The following communications were presented:

Theodore Gill: A Remarkable New Bassalian Family of Crabs.‡

Charles T. Simpson: The Geographical Distribution of Land Shells in Jamaica.

M. A. Carleton: Notes on Artificial Infection with Uredospores.

November 17, 1894—232d Meeting.

The President in the chair and fifteen persons present.

The following communications were presented:

Charles L. Pollard: The Genus *Cassia* in America.

Short notes and exhibitions of specimens by various members.

December 1, 1894—233d Meeting.

The President in the chair and thirty-four persons present.

The following communications were presented:

B. T. Galloway: The Physiological Significance of Transpiration of Plants.

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* Proc. Amer. Ass. for the Adv. of Agrl. Science for 1895 (in press).

† Notes on Parasites, 27: Experimental trichinosis in *Spermophilus 13-lineatus.* <Centrallblatt f. Bakt. u. Parasitenkunde, xvi, No. 19, 777–778, 1894. Idem. <The Veterinary Magazine, i, No. 11 (for Nov., 1894), 727–728, Jan., 1895.

‡ A new Bassalian type of Crabs. <Am. Nat., vol. 28, 1043–1045, Dec., 1894.

F. H. Knowlton: The Amount of Water Transpired by Plants.

B. W. Evermann: On the Red Fish of the Idaho Lakes.

December 15, 1894—234th Meeting.

The President in the chair and eighteen persons present.

The following communications were presented:

Charles T. Simpson: The Validity of the Genus *Margaritana*.[*]

C. V. Riley: Some Interesting Results of Injuries to Trees.

Erwin F. Smith: The Last Phase of the Root Tubercle Question.[†]

December 29, 1894—235th Meeting.

(Fifteenth Annual Meeting.)

The President in the chair and fifteen persons present.

The annual reports of the Secretary and Treasurer were presented, and officers for 1895 were elected as follows:

President: Surgeon General George M. Sternberg.

Vice-Presidents: Richard Rathbun, C. D. Walcott, B. E. Fernow, L. O. Howard.

Recording Secretary: M. B. Waite.

Corresponding Secretary: F. A. Lucas.

Treasurer: F. H. Knowlton.

Additional Members of the Council: Wm. H. Ashmead, Tarleton H. Bean, Theobald Smith, Ch. Wardell Stiles, F. W. True.

January 12, 1895—236th Meeting.

The President in the chair and fifty-three persons present.

The evening was devoted to a lecture by

L. H. Bailey: The Plant Individual in the Light of Evolution.[‡]

January 26, 1895—237th Meeting.

The President in the chair and fifteen persons present.

The following communications were presented:

L. O. Howard: A New Cotton Enemy brought over from Mexico.

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[*] Am. Nat., vol. 29, 336–344, April, 1895.

[†] Am. Nat., vol. 29, 898–903, Oct., 1895.

[‡] The Plant Individual in the Light of Evolution. Science, NS., I., 281–292, March 15, 1895.

Theodor Holm: Anatomy of a Leaf-Gall of *Pinus virginiana.*

Lester F. Ward: The Mesozoic Flora of Portugal compared with that of the United States.*

February 9, 1895—238th Meeting.

The President in the chair and thirty persons present.

The following communications were presented:

George M. Sternberg: Explanation of Immunity from Infectious Diseases.†

Theodore Gill: *Pithecanthropus.*‡

February 23, 1895—239th Meeting.

Vice-President B. E. Fernow in the chair and twenty-two persons present.

The following communications were presented:

F. E. L. Beal: The Food Habits of Woodpeckers.§

F. A. Lucas: Some Abnormal Feet of Mammals. ||

M. B. Waite: Notes on the Flora of Washington, D. C., and Vicinity.¶

March 9, 1895—240th Meeting.

The President in the chair and thirty-two persons present.

The following communications were presented:

Ch. Wardell Stiles: A Double-pored Cestode with Occasional Single Pores.**

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*Science, NS., I., 337–346, March 29, 1895.

†Science, NS., I, No. 13, 346–349, March 29, 1895; also incorporated in Part First (Susceptibility and Protective Inoculations) of work entitled *Immunity, Protective Inoculations, and Germ-Therapy*, by Surgeon General George M. Sternberg, U. S. A., 1895.

‡The Nation, lx, 105, Feb. 7, 1895.

§Abstract in Science, March 15, 1895, 304–305; published in full in Preliminary Report on the Food of Woodpeckers, Bull. 7, Division of Ornithology and Mammology, U. S. Dept. Agric., pp. 1–33, August, 1895.

|| Abstract in Science, March 15, 1895, 305.

¶ Ibid., 305-306.

** Notes on Parasites, 36: A double-pored cestode with occasional single pores. <Centralblatt f. Bakt. u. Paras., 1 Abth., Bd. xvii, No. 13–14, 457–459, 1 fig., 1895. (Abstract in Science, March 22, 1895, 334.)

Theodor Holm: The Œdema of Violet Leaves.*

George M. Sternberg: Explanation of Acquired Immunity.†

March 23, 1895—241st Meeting.

The President in the chair and twenty-six persons present.

The following communications were presented:

Charles T. Simpson: The Respective Value of the Shell and Soft Parts in Naiad Classification.‡

F. V. Coville: Remarks on the New Botanical Check List.§

Joseph F. James: Remarks on *Daimonelix* and Allied Fossils.||

Ch. Wardell Stiles: On the Presence of Adult Cestodes in Hogs.¶

April 6, 1895—242d Meeting.

Vice-President L. O. Howard in the chair.

The following communications were presented:

Theodore Gill: On the Torpedoes.**

J. W. Powell: The Classification of the Subject-Matter of Biology.

April 20, 1895—243d Meeting.

Vice-President L. O. Howard in the chair and twenty-nine persons present.

The following communications were presented:

Frank Baker: Some Peculiarities of Lumbar Vertebræ.

Theobald Smith: On Infectious Entero-Hepatitis of Fowls due to Protozoa.††

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* Abstract in Science, March 22, 1895, 334.

† Science, NS., I, No. 13, 346–349, March 29, 1895; also included in *Immunity, Protective Inoculations and Germ-Therapy*, by Surgeon General George M. Sternberg, U. S. A., 1895.

‡ Abstract in Science, April 12, 1895, 418–419.

§ Ibid., 419.

|| Ibid., 420.

¶ Notes on Parasites, 34: On the Presence of adult Cestodes in Hogs. <Veterinary Magazine, 11, 220–222, 1895. Idem. <Centralbl. f. Bakt. u. Parasitenkunde, xvii, No. 7–8, 256–257, 1895.

** Abstract in Science, May 3, 1895, 502–503.

†† An Infectious Disease among Turkeys caused by Protozoa (Infectious Entero-Hepatitis). Bull. No. 8, Bureau of Animal Industry, U. S. Dept. Agric., October, 1895. (Abstract in Science, May 10, 1895, 531.)

G. Brown Goode: The Horizontal and Vertical Distribution of Deep Sea Fishes.[*]

May 4, 1895—244th Meeting.

Vice-President B. E. Fernow in the chair and forty-two persons present.

The following communications were presented:

Charles T. Simpson: The Geographical Distribution of Fresh-Water Mussels.[†]

Erwin F. Smith: The Other Side of the Nomenclature Question.[‡]

May 18, 1895—245th Meeting.

The President in the chair and twenty-eight persons present.

The following communications were presented:

C. Hart Merriam: The Mammals of the Pribilof Islands.[§]

Edgar A. Mearns: The Hares (Genus *Lepus*) of the Mexican Border.[||]

Erwin F. Smith: The Biology of *Bacillus tracheiphilus*.[¶]

Ernest E. Thompson: The Means of Intercommunication among Wolves.

June 1, 1895—246th Meeting.

The President in the chair and seventeen persons present.

The following communications were presented:

C. Hart Merriam: The Short-tailed Shrews of America.[**]

G. Brown Goode: On the Location and Record of Natural Phenomena by a Method of Reference to Geographical Coördinates.

Theodore Gill: On the Relation of the Ancient and Modern Ceratodontidæ.[††]

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[*] Abstract in Science, May 10, 1895, 531–532.

[†] Abstract in Science, May 24, 1895, 586–587.

[‡] The Botanical Club Check List: A Protest (privately printed). Abstract in Science, May 24, 1895, 587–588.

[§] Abstract in Science, June 21, 1895, 698.

[||] Ibid., 698–699.

[¶] Centralb. f. Bakt. u. Parasitenkunde, Allg. vol. I, 364–373, 1895.

[**] Revision of the Shrews of the American Genera *Blarina* and *Notiosorex*. = North Am. Fauna, No. 10, 5–34, pls. 1–3, Dec. 31, 1895.

[††] Science, NS., I, June 28, 1895, 725.

Lester F. Ward: Remarks on the Genus *Caulinites* Brongn., with exhibition of specimens.[*]

October 19, 1895—247th Meeting.

The President in the chair and twenty-six persons present.

The following communications were presented:

S. D. Judd: The Food of the Catbird, Brown Thrasher, and Wrens.

L. O. Howard: An Enemy of the Hellgramite Fly.[†]

W. H. Dall: Exhibition of Remains of the Mammoth.[‡]

Ch. Wardell Stiles: The Rudolph Leuckhart Memorial[§] and The Third International Zoölogical Congress.

C. Hart Merriam: North American Shrews.[||]

November 2, 1895—248th Meeting.

The President in the chair and twenty-four persons present.

The following communications were presented:

F. V. Coville: The Botanical Explorations of Thomas Coulter in Mexico and California.[¶]

William Palmer: Albinistic Birds' Feet.

F. A. Lucas: The Extinct Gigantic Birds of Patagonia.[**]

Theodore Gill: The Belone and Sarginas of Aristotle.[††]

November 16, 1895—249th Meeting.

The President in the chair and thirty-three persons present.

The following communications were presented:

B. W. Evermann: The Fishes of the Missouri River Basin.[‡‡]

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[*] Science, NS., I, June 28, 1895, 725–726.

[†] Abstract in Science, Nov. 8, 1895, 635.

[‡] Ibid., 635-636.

[§] The Rudolph Leuckhart Memorial. <Science, NS., II, 1895, 523–524.

[||] Synopsis of the American Shrews of the genus *Sorex*. <North Am. Fauna, No. 10, 57–98, pls. vii–xii, Dec. 31, 1895.

[¶] Botanical Gazette, xx, 519-531, pl. xxxv, Dec., 1895. Abstract in Science, Nov. 22, 1895, 702–703.

[**] Abstract in Science, Nov. 22, 1895, 703. The Auk, xiii, Jan., 1896, 61–63.

[††] Science, NS., II, 703, Nov. 22, 1895.

[‡‡] Abstract in Science, Dec. 6, 1895, 778. Full paper in press in Rept. Com. of Fish and Fisheries for 1894.

Frank Baker: The Nomenclature of Nerve Cells.*

Edward L. Greene: Some Fundamentals of Nomenclature. †

November 30, 1895—250th Meeting.

The President in the chair and thirty-five persons present.

The following communications were presented:

Edward L. Greene: Some Fundamentals of Nomenclature (continued).‡

Theodor Holm: Contributions to the Flora of the District of Columbia.§

December 14, 1895—251st Meeting.

Hon. Gardiner G. Hubbard, President of Joint Commission, in the chair.||

Annual address of the President, Surgeon General George M Sternberg: The Practical Results of Bacteriological Researches.¶

December 27, 1895—252d Meeting.

(Sixteenth Annual Meeting.)

The President in the chair and nineteen persons present.

The annual reports of the Secretary and Treasurer for the year 1895 were presented, and officers for the year 1896 were elected as follows:

President: Surgeon General George M. Sternberg.

Vice-Presidents: Richard Rathbun, C. D. Walcott, B. E. Fernow, L. O. Howard.

Recording Secretary: M. B. Waite.

Corresponding Secretary: F. A. Lucas.

Treasurer: F. H. Knowlton.

Additional Members of the Council: William H. Ashmead, F. V. Coville, C. S. Pollard, Ch. Wardell Stiles, F. W. True.

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*Abstract in Science, Dec. 6, 1895, 778.

† Science, NS., III, 1, 13-16, Jan. 3, 1896.

‡ Science, NS., III, 1, 13-16, Jan. 3, 1896.

§ Abstract in Science, Jan. 3, 1896, 34-35. To be published in full in next volume Proc. Biol. Soc. Wash.

|| Public meeting in Builders' Exchange Hall under the auspices of the Joint Commission, followed by informal reception, with refreshments. Several hundred people present.

¶ To be published in Popular Science Monthly.

Vol. IX, pp. 1-74 April, 1894

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON

SOCIAL INSECTS FROM PSYCHICAL AND EVOLUTIONAL POINTS OF VIEW.*

BY C. V. RILEY, PH. D.

Prelude.

Friends and Fellow-members:

Custom has ordained that the president of the Biological Society deliver an annual address, and that the public be invited to listen thereto. This custom, likewise followed by some of our sister societies, has certain advantages, but also certain disadvantages. Instead of appealing to members only, or treating, in special and technical way, some subject that intimately concerns them, the speaker finds it incumbent upon him to popularize his subject, and to endeavor to interest alike those who are and those who are not familiar with the science of biology in any of its special branches. It will be my endeavor to accomplish this dual task to-night by omitting the reading of the more technical and detailed portions of this paper, which, though in one sense the most important, may well be printed in smaller type, as a series of notes.

My predecessors have generally dealt with the subjects upon which they were working as specialists, or upon which they were

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*Annual address of the President of the Society, delivered in the hall of Columbian University, January 29, 1894. The address was illustrated with stereopticon views, only a few of which are here reproduced.

known to be authorities. In following this precedent, I am not unmindful of the fact that the science of entomology in its more abstruse and technical phases, however fascinating to the specialist, attracts but little public attention, and that, from among the myriad forms of life which the entomologist includes within the scope of his study, there are comparatively few which interest the intelligent masses or even the general biologist. Among these few are the social insects, and it is my purpose to treat of them to-night and see what light we may draw from them on some of the great questions which now agitate naturalists. By combining the recorded observations and views of others with some that are original and unpublished, I may, perhaps, hope to interest all of you.

Before entering on this main topic, however, it has seemed to me advisable, in view of the character of the audience, to say something of our society and what it undertakes to do. Biology is a word of the century, and was first employed by Lamarck (1801) as a term under which the phenomena of organic nature could be considered; and by Treviranus (1802) to express the science that treats of the philosophy of living nature. Systematic zoology and botany have but incidental bearing on biology; they relate to the framework, the structure, and not to life itself. Not that I undervalue taxonomy in this connection, for, indeed, its value is self-evident; but modern biologists are very generally divided into two camps, viz., those who investigate the different parts and structures of the organism, or who study the processes of growth, and those who study more particularly that phase of the subject which Hæckel called œcology. In the process of differentiation the term is now, perhaps, more correctly applied to the study of the development of the type in the past, and of the individual in the present—not by themselves only, but in their relations to all other forms of life. In other words, it involves the interactions and interrelations of organisms, and deals fundamentally with psychical even more than with structural phenomena, as naturalists use these terms.

The Biological Society was organized for the purpose of considering and discussing the questions involved in the very broadest application of the term biology; in others words, organic nature in any and all of her manifestations. Organized but about two years prior to the death of Charles Darwin, it is not surprising that its members have been very generally imbued with the spirit and interpretations which the illustrious author of "The Origin of Species" gave to the phenomena of life upon our planet. Not that they have been blind followers of the school which believes in the all-sufficiency of natural selection to account for life-phenomena; for a review of the communications and discussions and particularly of the addresses which have been delivered by my predecessors will show that in the search after truth, the ideas of Lamarck and others, who have pregnantly speculated on the philosophy of life, have been duly appreciated. Upon the one great question which, more than any other, has occupied biologists of late years, viz., whether functionally acquired characters are transmitted by heredity, there have been few more able contributions to the subject anywhere published than the papers and addresses of my distinguished predecessor, Prof. Lester F. Ward. Indeed, aside from the reasons already given, the choice of my subject to-night was in no small degree determined by an admission in one of his more recent and yet unpublished communications to the society, to the effect that the characters of neuters among the social insects offer the greatest stumbling block to the theory of the heredity of such acquired characters.

ORGANIZED INSECT SOCIETIES.

The social insects, or those which live in communities, and particularly those of the order Hymenoptera, which possess highly developed social characteristics, have, from the very earliest times, intensely interested the student of insect life. There are insects of other orders which are either social normally or become so by exception and for special purposes. Thus many Lepidopterous larvæ live together when young, but scatter when they grow older. In some cases there would seem to be no particular purpose in the association; in others, as in the common Tent Caterpillars (Clisiocampa spp.) the well-known Fall Webworm of North America (*Hyphantria cunea*) and many similar species of other countries, the association is of a somewhat higher character, as the larvæ build a common web into which they retire at stated periods, and which helps to protect them both from the inclemencies of the weather and from the attacks of birds and other enemies. The highest development of this social trait in the Lepidoptera is found in the small Hyponomeutidae, and in a Mexican butterfly (*Eucheira socialis* Westw.)—the transformations taking place within the nest. The layers of silk in the last-named species are so tough that they have been used as parchment.

In one remarkable case among the Diptera, viz., in Sciara, a genus of small gnats, the larvæ have the habit of banding together in large masses, more or less elongate, all the individuals attached to each other, heads to tails, and the whole mass moving with one impulse and as a unit. They thus move across a road or field, like some huge snake, and are for that reason called "snake-worms," and really give us a very good illustration of how individual units may combine to make a compound whole. Many other insects have the exceptional habit of congregating together in large masses, but in almost every case the congregating is connected with undue multiplication and the desire to migrate to new regions. The habit is well exemplified in our notorious Army Worm, the larvæ of *Leucania unipuncta*, an insect which, over vast stretches of country, occasions great loss to our grain and grass crops by traveling from field to field and leaving devastation in its wake. Instances of this kind might be multiplied; but we do not apply the term social to such temporary associations of individuals, even where they have any specific purpose and are of annual recurrence. Nor do we apply the term social to those insects, of which there are many in different orders, which assemble together during the love or pairing season. The term is strictly confined to those species which permanently live together in colonies, and in which the social habit, with its consequent subdivision of labor, and differentiation of individuals, has become essential to their perpetuity.

Bees.

Living in such well organized communities, exhibiting so much intelligence, and yielding one of the most delicious sweets known, the Honey or Hive Bee has attracted attention from the earliest times, and ever since Aristotle, Virgil and Columella told what was then known of this industrious insect, it has been the subject of investigation. Honey and wax were far more important to man in olden time than they are to us who have so many substitutes for them, and the ancients gave much attention of the practical kind to bees. How very little they knew, however, of their true economy is shown by the prevalence of the belief that bees came from the carcasses of animals. This superstition as to the *Bugonia*, as exemplified in the biblical story of Samson (Judges XIV, 8) continued for twenty centuries and grew out of the resemblance to the Hive bee of *Eristalis tenax*, a Dipterous fly which breeds in putrescent matter. This fact, first clearly recognized by that excellent observer, Réaumur, has been fully established in a recent most interesting paper by Osten Sacken "On the so-called *Bugonia* of the ancients, and its relations to *Eristalis tenax*." (Bullettino della Società Entomologica Italiana, Anno XXV, 1893). In fact the fabulous about bees prevailed till the beginning of the last century, when Maraldi, by the invention of glass hives, gave an impetus to correct observation, and led to the remarkable memoirs of Swammerdam, Réaumur, Schirach and Francis Huber.

The fact that the Hive Bee can be cultivated and controlled with a view to profitable industry, has served to heighten the interest in it, and since the invention in this country, in 1852, of the movable frame hive, by a retired clergyman, the Rev. L. L. Langstroth, progress in apiculture has been rapid and continuous. Of the more important subsequent inventions, many of them made in Europe but perfected in America, may be mentioned the honey-extractor, which, by centrifugal force, throws the honey from the comb, leaving the latter intact and ready to be used again; and the comb foundation, by which sheets of wax are impressed with the bases of the cells and employed to ensure straight and regular combs, to limit drone production and increase the honey product. With the bee-smoker in its modern form, bees are also much more easily controlled and manipulated than formerly. Much has been done, also, in ameliorating the races of bees, both by introducing races from other countries and by the crossing of these. There are some three hundred thousand of our citizens engaged in bee culture, and they add over twenty million dollars annually to the wealth of the country in honey and wax. This amount may be, and in the near future doubtless will be, very largely increased. It is, in fact, difficult to realize what an immense amount of honey is wasted from lack of bees to garner it, and the poet Gray would seem to have had his own ideas on this subject when he wrote the familiar lines.

> "Full many a flower is born to blush unseen,
> And waste its sweetness on the desert air."

The service directly rendered to man by bees, however, in supplying the products mentioned, is but slight as compared with the services indirectly rendered by cross-fertilization of our cultivated plants, and it has been estimated that the annual addition to our wealth by bees in this direction alone, far exceeds that derived from honey and wax. One of the latest discoveries bearing on this subject, very fully enforcing the general principle, was presented to the Society for the first time within the past year by our fellow-member, Mr. M. B. Waite, as a result of his investigations for the Division of Vegetable Pathology in the Department of Agriculture. He has proved that a majority of the more valued varieties of our apples and pears are nearly or wholly sterile when fertilized by pollen of the same variety, or that they bear fruit of an inferior character and very different from that produced when cross-fertilized; further, that were it not for the cross-fertilizing agency of bees, scarcely any of these fruits could be produced in the abundance and perfection in which we now get them, and that to secure the best results and facilitate the work of the bees, it is yet necessary, in the large majority of cases, to mix varieties in the same orchard. Bees were doubtless the earliest embalmers, since they use the propolis to encase and thus prevent the putrefaction of any intruder which is too large for them to drag out of the hive.

There is much, even to-day, in the economy of the Hive Bee that is yet debated among the best informed apiarians, but I will endeavor to give you an epitome of what is absolutely known of its more important habits, structures and functions—the true life-history, so to speak, of the bee. By going somewhat into detail with this species, we may avoid repetition in treating of the other social Hymenoptera, all of which have somewhat similar larvæ and transformations. Let us, in imagination, proceed to an ordinary well-kept apiary. Taking a bee-smoker in one hand—one of the pattern invented by the late M. Quinby of New York—we lift one corner of the hive cover or quilt, and send enough smoke down among the bees to give them to understand that they must submit to our manipulation. Drawing out one of the brood combs, which is rendered easy by the movable frames, thousands of the bees are seen adhering to the surface of the comb. They are mostly workers, but in summer there may be seen numbers of stouter-bodied bees, which are the drones or males. If the bees have not been too much disturbed by the smoke or the removal of the comb, the queen may be seen walking slowly over the surface, surrounded by the workers, who, in deference, recede as she walks along, turning their heads toward her and advancing so as to touch her body with their antennæ. It was long thought that the queen exercises sovereign powers, and Shakespeare voices the popular opinion when, in Henry V, he says:

> "They have a king and officers of sorts."

One of the earliest definitions of a queen bee in Webster's dictionary was, "The sovereign of a swarm of bees." In reality, however, the government of the hive is purely democratic. Each works for the common welfare, and only so long as the individual, whether queen, drone, or worker, is useful to the community, is it spared. With the exception of the drones, the queen is the only bee in the hive having the reproductive organs fully developed, and she is, therefore, the mother of the colony. During the more prolific season she lays two or three eggs in the course of a minute, and often as many as four thousand in twenty-four hours. Three days after deposition of the egg the young larva is hatched. It is the office of the younger workers, known as nurse-bees, to furnish these young larvæ with food, which they are assiduous in doing. In the case of the worker larvæ, five days suffice for full growth, when they nearly fill the cells. As with most other soft-bodied larvæ that are embedded in a semi-liquid nutritious medium, we find provision to prevent contamination of the environmental food with excrementitious matter. The food supply is, in the first place, highly nutritious, and nearly all capable of assimilation. Lest, however, any portion of the waste should enter the food, the larva is, according to Cheshire, rendered incapable of voiding anything during the time of feeding. The arrested development of the digestive system leaves the posterior inflection, which corresponds with the after bowel, unconnected with the middle bowel, and the slight accumulation of waste matter in this latter is cast into the base of the cell at the last molt, and is covered in the bottom of the cell by the lower part of the last cast skin or pellicle, which also serves to line the rest of the cell and leave it clean for the formation of the pupa. Thus, when the young bee emerges, the cell needs but to be brushed out by the workers to be ready to receive another egg or stores of honey and pollen which are to form the winter food.

Just before pupation, or when the larva has acquired full growth, the adult workers cover the cell with a convex lid composed not of wax alone, as in the case of the cappings of honey cells, but of pollen and wax combined. The larva just before pupation strengthens this cap by lining it with silk, which is also slightly attached to the last cast skin. The pupa state lasts some twelve days, and on the twenty-first day from the time the egg was laid, the perfect bee cuts a circular opening in the cell cap and makes its way out. The first care of this young bee is to seek food from an open honey cell, and in the course of two or more days it has acquired sufficient strength and consistence to enable it to begin its labors as a nurse bee, doing for the developing larvæ what was so recently done for it. After a week's time it takes short flights, noting well the location of its hive so as to be able to return to it.

Queens are only bred when a colony is about to swarm, or when an aged or failing queen needs replacing, or where an accident has deprived the hive of her services. If she be removed from the hive during the working season, the bees are thrown into great excitement, shown by the change of the contented hum into one of alarm, by the hurried movements from the combs to the entrance, and by the discontented flight to and from the hive. If all the brood combs are removed the bees become panic-stricken, and give utterance to a peculiar mournful note or distressed wail, quite different from the normal cheerful hum. In time, however, this excitement subsides, as they become satisfied of their loss. If the queen be returned, or a comb containing young larvæ be introduced into the hive, the whole attitude changes. The moment the first bee touches with its antennæ the queen, or a comb, or any point over which she had walked recently, it sets up a loud and cheerful hum, and the occupants of the hive, even those unable to see the comb, immediately catch the sound, and crowd toward the point whence it first proceeded, repeating the jubilant note. If only a comb of larvæ be given them, they still recognize it as a deliverance from the threatened extinction of the colony. In a few hours one of the cells over a larva two or three days old will be enlarged by the partial destruction of the walls of the adjoining cells. This enlarged cell is built outward and downward, and the larva is fed on the so-called royal jelly or bee-milk. The supply of this food is always plentiful, and when a well-developed queen has issued, it is not uncommon to find a quantity of the food, in a partially dried, jelly-like mass, in the bottom of the cell. When, preparatory to swarming, young queens are being reared, the workers have to guard them, even in the cell, from the jealous fury of the reigning queen, and the instinctive rivalry and conflict between queens, accompanied by a peculiar shrill battle-cry, first noticed by the elder Huber, are quite suggestive of similar conflicts between rival queens in human monarchies.

Economy of Hive. Social Organization. Division of Labor.

Each bee, as already stated, labors for the good of the commonwealth of which it is a member. Of them it might well be said:

> "Salus rei publicæ suprema lex."

It is the welfare of the colony which directs the actions of all, and not the will of the queen. Indeed, it would seem that the latter performed her important function—that of supplying the hive with eggs—only when the workers willed it, their own condition of prosperity as regards stores, or their anticipations of the future needs of the colony as regards population, causing them to supply the queen liberally with food rich in nitrogen—a partially digested substance or a gland product, or perhaps a mixture of both, which she alone cannot produce, yet without which any considerable production of eggs is an impossibility. As Evans remarks:

> "The prescient female rears her tender brood
> In strict proportion to the hoarded food."

We must, then, credit the industrious and provident workers with the chief influence in shaping the policy of the hive. They are the *servum pecus*—the living force—of the colony. And to the end that order and efficiency of effort may prevail, they have, we find, a marked division of labor. In the normal condition of the hive the young workers, as already stated, care for the brood—a labor which they take upon themselves within two or three days after issuing from the cell. The glands which secrete a part of the food required by the developing larvæ are active during the earlier part of the life of a worker. Later these nurses become incapable of doing their work well, as the gland system becomes atrophied. When a few days old they take short flights, if the weather favors, but seldom commence gathering stores before they are fifteen days old. Wax production is more essentially a function of the workers in middle life, and it is particularly noticeable that those bees fashioning the wax into combs are principally of this class. Many of those acting as foragers do, however, secrete wax scales, which are doubtless, in the main, utilized. Among the outside workers and hive-defenders some bring honey only on certain trips or for a time; others honey and pollen; others water, and yet others propolis or bee-glue to stop up crevices and glue things fast. Meanwhile some are buzzing their wings at the entrance to ventilate the hive, and others are removing dead bees, dust, or loose fibres of wood from the inside of the hive or from near the entrance, or are guarding this last against intruders, or perhaps driving out the drones when these are no longer needed.

SWARMING.[1]—Perhaps there is no action on the part of the Hive Bee which more distinctly indicates its intelligence and power of communication than the act of swarming. The fact that queen brood is being reared in the hive is the best evidence that the colony is preparing for flight or swarming; but, in addition, it is noticeable that on the day of swarming the whole colony is excited, and in a measure has abandoned ordinary duties. For days previous to the event, scouts have been searching for a favorable hollow or crevice or place in which to house the new colony, and when the time finally comes, which is usually in the hotter part of the day, all the individuals of the hive leave after the peculiar preparatory flight around the hive, known as swarming. The impulse to leave is such that many individuals not yet capable of flight, fall to the ground, and the hive is practically abandoned by all those within it at the time of swarming. Individuals alight on some bough or object near by, with a view primarily to organization and the sending out and return of additional scouts. During this period a cluster will remain more or less in repose, but when once the location for a permanent dwelling has been finally determined upon, the whole mass will leave as with one impulse and fly swiftly and directly to the new home. With the first swarm that the new colony sends out it is the old or fertile queen that goes with the new swarm, but with the after swarms, which issue in about a week, it is a virgin queen that accompanies. The old colony begins again with the few individuals unable to follow the departing swarm, and which have crept back to the old hive, with those which at the time of swarming were busy in the field, and with those which issue from the yet undeveloped brood.

It is a popular mistake to suppose that mating takes place during swarming. If a virgin queen goes with the swarm, she subsequently takes the nuptial flight from her new home. As she flies swiftly and strongly, only the strongest and most vigorous drones are able to mate with her, and there is every opportunity for cross-fertilization with drones from some other colony. It has also been noticed that drones have a way of congregating in some particular spot, as though awaiting their chance of thus mating with the queen.

The more important special Organs.

The different structures and organs of the Hive Bee are most interesting, but I can allude only to a few of the more striking. The tongue is a very complex organ, fitted for obtaining minute quantities of nectar from the flowers that secrete it but sparingly, or to remove the same substance rapidly when found in abundance. The figure of the head and appendages thrown on the screen will illustrate this organ in detail. We have here the mandible, mostly used for cutting and moulding the wax, the maxillæ with their palpi, the labium and labial palpi, and finally the ligula or true tongue with its spoon-like tip. This is extremely flexible, and consists of a rod or central portion, nearly surrounded by a sheath which is covered thickly with hairs, which aid, by capillary attraction, in taking up the liquid food. A lapping motion, when the liquid is abundant, causes the liquid to be lodged among the hairs of the tongue, which can be partially drawn into the mentum, and from this point the maxillæ above and the labial palpi below unite to form a tube around it, which is closed above the extension of the epipharynx, and by alternately arching and depressing the maxillæ, the space enclosed is increased or decreased, thus producing suction and drawing the liquid held on the tongue into the opening of the esophagus.

When drawn from the flowers the nectar is thin and watery and lacks the qualities of the delicious honey into which we find it converted when removed from the cells sealed by the bees. This watery substance is evaporated to the proper consistency in the heat of the hive and by currents of air passing over the surface of the combs before the cells are sealed, these currents being created by bees stationed at the entrance and buzzing incessantly. There has been much discussion among apiarians, as among writers, as to whether the bee gathers or makes honey. Strictly speaking it does both. Formic acid is contained in the blood of the bee and especially in the salivary glands, as recently demonstrated by von Planta of Zurich, and when the gathered nectar, which easily ferments, is regurgitated from the first stomach into the cell, it is combined with sufficient formic acid to change the cane sugar into invert sugar (dextrose and levulose in equal proportions) while the evaporating process just described eliminates the superflous water; so that honey which resists fermentation is essentially a made product.

I would also draw your attention to the wax-producing organs (See Fig. 3a, *a*). If we examine the underside of the abdomen of the worker, the exposed portion of each segment will be seen to be covered with a web of hairs, and by elongating the abdomen, each segment, with the exception of the first and sixth, is seen to bear two shallow, irregularly-shaped plates, one on each side of the median ridge, which is extended as a rim around the whole contour. These pale yellow, smooth plates are in reality wax moulds, the wax glands being under the plates and the secreted wax reaching the surface by osmos through the thin membrane and hardening into a somewhat brittle scale, resembling in appearance a minute, nearly transparent fish scale. The wax is secreted under conditions of great heat, the bee ascending for this purpose to the top of the hive, and the wax producers consuming a large amount of honey.

The next structure of importance to which I would call your attention is the wax pincers (Fig. 1b, *a*, *b*), which is a modified structure of the juncture of the tibia and metatarsus of the posterior legs. With these pincers the wax producer plucks a scale from one of its wax plates, passes it rapidly forward to the mouth, and here makes it plastic and at the same time more or less yellow, by continually manipulating and chewing it between the mandibles. Then the bee sticks it to the under surface of the hive cover or object to which the comb is to be attached. More wax is added, forming a slight ridge, which is chiseled or pressed from each side by workers, using their firm and highly polished maxillæ, and placing themselves so that their range of work will overlap just one-half. As this ridge is built down, forming a sheet—the septum upon which the cells are constructed—the sides of the latter are started simultaneously. In their efforts to make the cells concave at the bottom and so as to fit together at the sides without loss of material, mutual pressure results in straight lines, the sides becoming hexagonal in outline, just as six soap-bubbles resting against a seventh cause the latter to assume a hexagonal form; while the bee starting a cell on the bottom of one already commenced on the other side, naturally takes the apex of the latter as a part of the boundary of its own cell in order that the latter may also be concave. Thus three rhomboidal faces forming the base of one cell, form individually a part of each one of three cells on the opposite side.

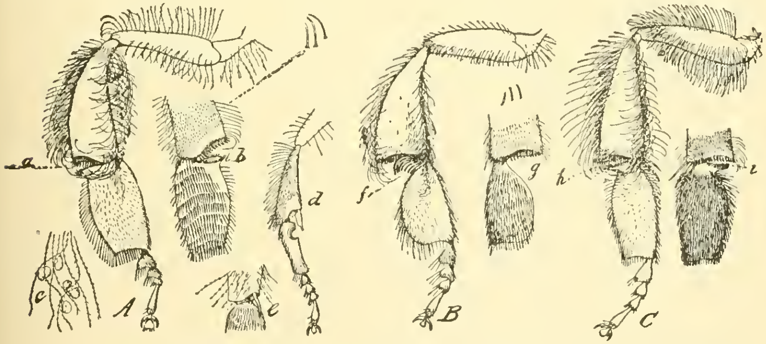

FIG. 1.—MODIFICATIONS OF THE HIND LEGS OF DIFFERENT BEES: A, *Apis*: *a*, wax cutter and outer view of leg; *b*, inner aspect of wax cutter and leg; *c*, compound hairs; *d*, anterior leg, showing antennal scraper. B, *Melipona*: *f*, peculiar group of spines at apex of tibia; *g*, inner aspect of wax cutters and first joint of tarsus. C, *Bombus*: *h*, wax cutter; *i*, inner view of same and first joint of tarsus—all enlarged. (Original.)

Finally I would call your attention to the arrangement of the hairs on the inside and outside of the legs (Fig. 1, A), so well fitted for collecting and holding pollen, and to what is known as the antenna-comb or strigil (Fig. 1, *d*), a structure with which the bee cleanses itself, and especially the antennæ, which are organs of extreme sensibility and need to be kept well cleaned. This structure occurs on the underside of each front leg and is a semi-circular cavity in the upper end of the metatarsus. The cavity is fringed with stiff hairs or spines, forming a comb. The distal or opposing end of the tibia is furnished with a spur, slightly concave on the inner surface and known as the velum When the tibia and metatarsus are bent at right angles, the velum falls over the cavity and forms an almost circular opening just large enough to snugly hold one antenna.

These are the more conspicuous structures, though there are others of minor importance, all indicating remarkable adaptation to special purposes and to the necessities of the bee.

The Hive Bee is but one of many species of its family, and while representing the most highly organized of the social insects, has many cousins and more distant relatives which are equally interesting. The numerous bees, with their diversified habits, have an especial interest, when studied structurally and biologically, as throwing light on the origin and development not only of the higher social habits and intelligences of the true Hive Bee, but also of its structures, so remarkably fitted for their special purposes.

Species of Genus Apis and Variations in Apis mellifica.

The old conception of the Hive Bee, its attributes and structures, was that it exemplifies in a marvelous manner creative wisdom for man's interests. Yet while it represents great perfection of organization and of structure, for particular ends, this perfection is relative and not absolute. Though a number of species of the genus Apis have been characterized by authors, there are but four well defined species so far known, and three of them—*A. dorsata*, *A. indica* and *A. florea* are confined to India and the East Indian and Philippine Islands. The fourth, *Apis mellifica*, or the common Hive Bee, was originally introduced into this country from Europe, and doubtless had its origin in some parts of Asia. It has followed civilized man in his migrations over the globe, and has frequently anteceded him, and, being semi-domesticated, has been more or less influenced by him, as have other domesticated animals. Some ten different types of the species have been characterized by specific names, two of them—viz., *adansoni* Latr. and *unicolor* Latr.—being considered good species by Fredk. Smith, while a still greater number are recognized by local names among apiculturists. These varieties and races show every variation in color through the various shades of black, gray and golden-yellow, as also every variation in disposition, industry, and tendency to swarm, and especially in honey-gathering proclivities. (See Note 1.)

Of the East Indian species only one, *Apis indica*, is cultivated. This bee, which is considerably smaller than our own, building smaller combs composed of smaller cells—36 to the square inch—chooses when wild, a hollow tree or rocky cavity for its home. It is kept to a limited extent by the natives, earthen jars being used for hives, but the yield of honey is small.

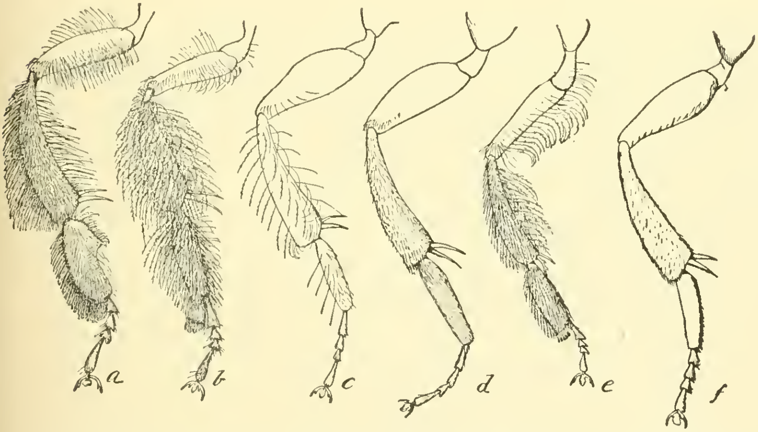

FIG. 2.—MODIFICATIONS OF THE HIND LEGS OF DIFFERENT BEES: *a*, Anthophora; *b*, Melissodes; *c*, Perdita; *d*, Nomada; *e*, Agapostemon; *f*, Nomia—all enlarged. (Original.)

Apis florea, the smallest of the genus, with slender, orange-banded body, builds in the more open country of India, attaching a single tiny comb to the twig of some small shrub. The worker cells are 81 to the square inch of surface, the drone cells 36.

Apis dorsata. the Giant Bee of India, attaches its mammoth combs to the limbs of tall forest trees or to overhanging ledges of rock, generally building a single comb as much as six feet long and two or three feet wide. Great quantities of wax and honey are obtained from this bee by the bee-hunters in India and the islands southeast of Asia. It has not been permanently domesticated; nor is it certain that it can be. The workers of this species are about the size of the queens of *Apis mellifica*, or from seven-eights of an inch to an inch long. The bodies of the bees are slender and wasp-like, and beautifully marked across the abdomen with bright orange bands. (See Note 2.)

While the different species of the genus Apis thus differ in size, coloration, temperament and habit, there is comparatively slight variations in structure; a necessary inference for every zöologist. But if we study the other species of the family Apidæ, we shall find every variation, and obtain a very good idea of how the special organs in Apis may have been evolved and perfected from simpler organs in other genera. This may be illustrated by a few sketches of some of the more important structures, as for instance, the polliniferous organs and the wax producing apparatus. (See Figs. 1, 2 and 3.) The figures already thrown on the screen very well illustrate the fact that the modification of structure and hairy vestiture, which facilitate the collection and transportation of pollen, while exhibited, perhaps, in the greatest perfection in the Hive Bee, is nevertheless an evolution from

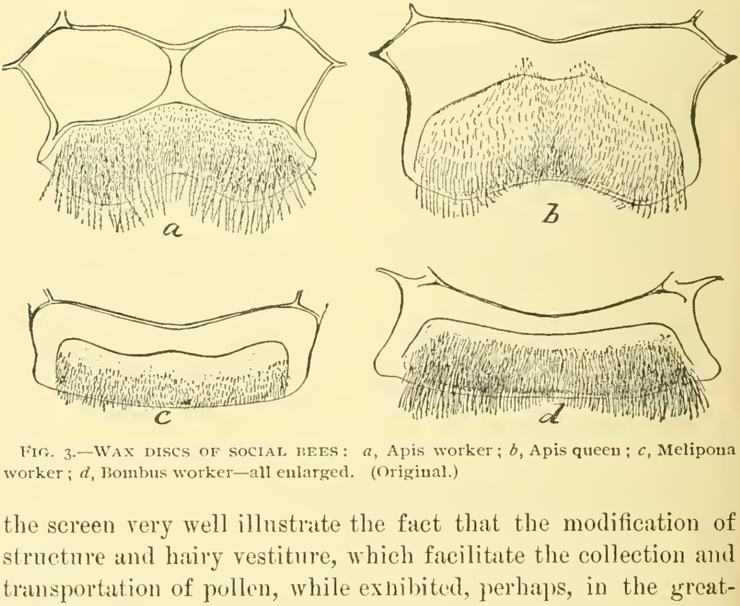

Fig. 3.—Wax discs of social bees: *a*, Apis worker; *b*, Apis queen; *c*, Melipona worker; *d*, Bombus worker—all enlarged. (Original.)

similar structures possessed by other species of social bees, such as the Meliponæ and Bombi, and still more remotely from such as are possessed by the solitary bees. Here again I trust to diagrams, and relegate detailed exposition to a note. (See Note 3 and Figs. 1 and 2.)

In the production of wax the Hive Bee exhibits a lavishness not found in any of the wild bees, not excepting the species of Trigona and Melipona, which approach it most nearly in social economy. As a result we find that the wax-secreting organs of Apis are much larger than in any other wax-producing bees. In Bombus they are greatly reduced and otherwise different in structure, resembling, however, very closely, those obtaining in Melipona and Trigona. In the solitary bees, which produce no wax, these specialized structures are entirely wanting. (See Note 4.) But the most interesting fact is that in the queen bee, in which they are functionless, they are nevertheless present, but more nearly resemble the same structures in Melipona.

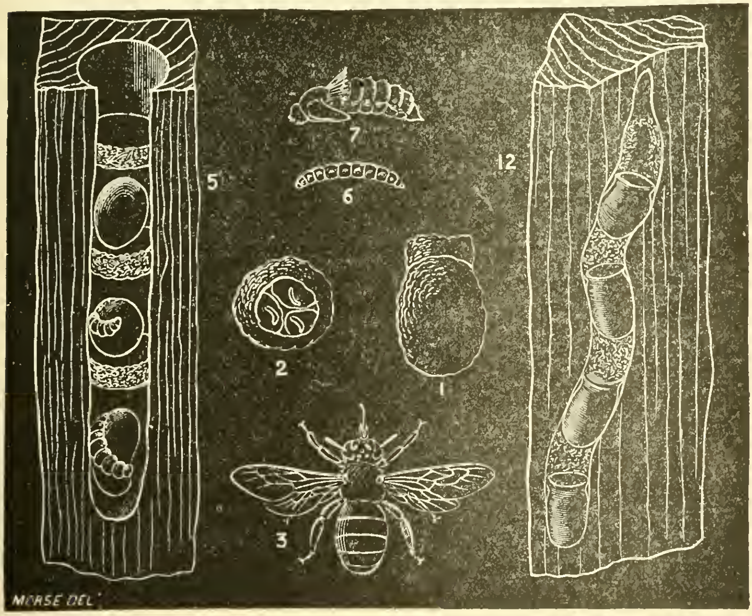

FIG. 4.—ARCHITECTURE OF BEES: 1, cell of bumble-bee; 2, end of same showing eggs; 3, Xylocopa virginica, the carpenter bee; 5, cells of same; 6, larva of bee parsite, *Anthrax sinuosa*; 7, pupa of Anthrax; 12, cells of mason bee, *Osmia lignivora*—natural size. (After Packard.)

The architecture of certain solitary bees is shown in Figs. 4 and 5. These solitary bees, no matter in what situations or of what material they make their cells, generally store them with honey or pollen, and after depositing an egg, cap the cell and leave the young larva to care for itself. The habits of the social Bumble-bee (Bombus) are but a step in advance, as the larvæ are developed in a mass of pollen and honey, in which they form rather imperfect cells. When full grown each spins a silk cocoon which is thickened by a certain amount of wax, which is added by the adult bees. The females labor and several co-operate in the same nest. In the Bottle-bees (Melipona) a still further step is seen, as the cells, of a rather dark, unctuous wax, are formed into regular combs and are somewhat imperfectly hexagonal. They are, however, in single horizontal tiers, separated and supported by intervening pillars, more like the nests of the social wasps, and the cell is sealed after the egg is laid upon the stored food, just as in the case of solitary bees. The honey is stored in separate flask-like cells, and but one queen is allowed to provide eggs.

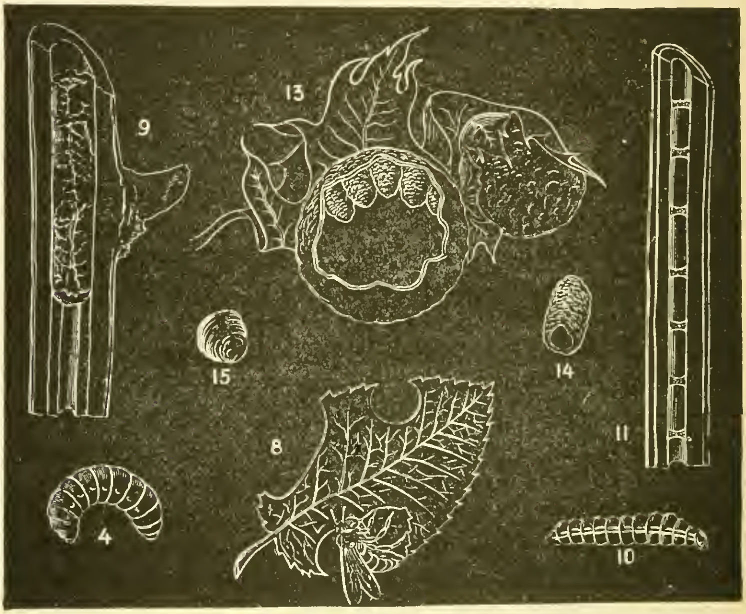

Fig 5.—Architecture of Bees (continued): 4, larva of *Xylocopa*; 8, leaf-cutter bee, *Megachile*; 9, cells of *Megachile* in elder; 10, larva of upholsterer bee, *Ceratina dupla*—enlarged; 11, cells of same in elder, ; 13, cells of *Osmia similima* in deserted oak-gall; 14, earthern cell of same; 15, pollen mass of Osmia—natural size (After Packard.)

SOCIAL WASPS.

The popular conception of these interesting insects is decidedly at variance with their deserts. Wasps are generally considered as thieves, robbers, idlers and vagabonds; as impertinent and inquisitive, invading our homes and devouring anything and everything their fancy craves, as sugar, fruit, meat, wines, etc., and resenting any interference in such a pointed way as to bring pain and rage to the incautious or meddlesome individual who interferes with their operations. The term "waspish," one of the most expressive in the language, very well denotes the popular feeling towards these somewhat maligned insects. Granted that toward other insects they are cruel, and that they courageously resent interference, yet the fact remains that they are seldom, if ever, the original aggressors in the infliction of punishment, except in the capture and appropriation of other insects as food—a course which finds its counterpart in every other carnivorous insect or higher animal, and is justified even by the example of man himself. In their relationship with each other, the wasps are polished and gentle, and never quarrelsome so far as their own species are concerned; and they never turn robbers or marauders of their own kind, as do the more lauded bees, among which we have what are known as the corsair bees, which frequently rob their sisters of the sweets and pollen which they have collected with great pains and indefatigable industry. These robbers even lie in wait, and scheme and plan in bodies for the success of their raids, as do thieves among men. Wasps never resort to such cowardly proceedings, and hence strictly speaking, are not robbers at all; for aside from their own kind the world is their legitimate pray.

The family Vespidæ, to which the wasps and hornets belong, comprises some thousand known species. They closely resemble bees, but differ in possessing more cylindrical bodies with a harder, smoother integument. The wings are longer and folded once longitudinally, and when at rest are laid flat on the body. The antennæ are elbowed, and the jaws are large and powerful. Their eggs are at first nearly spherical, but rapidly become ovoid. Their larvæ, as in the other social Hymenoptera, are legless and helpless grubs, entirely dependent on the adults for food and care. The family comprises two natural groups, viz., the Social

Wasps, having, as with bees and ants, three forms—males, females, and workers or neuters; and the solitary species, in which only females and males occur.

The common Bald-faced Hornet (*Vespa maculata*) is a familiar example of the first-named group. It constructs remarkable nests of various patterns, of a gray, paper-like material, and suspended to the branches of trees and shrubs, or to the rafters of houses. In the second group, on the contrary, the species construct cells or nests, consisting usually of single cells, of sand or mud, in protected situations; store them with insect food for the larvæ, and then abandon them altogether. The former—"natural paper-makers from the beginning of time," as Harris properly styles them—have always done what man, with all his boasted superiority, has only in recent times learned to do; viz., make paper of wood. They resort for this purpose to such woody surfaces as have long been exposed to and bleached by the action of the elements. With their powerful mandibles they tear off minute filaments and chew them into a fine pulp, which they afterward spread into a thin sheet of strong, water-proof paper, out of which they construct their nests. These nests are of two kinds, one made by the true Vespas, as in the case of the Bald-faced Hornet just alluded to. Here the outer covering forms a more or less regular globose body, with a single circular orifice at the bottom, the combs being arranged within this covering in horizontal tiers or stories. In the second category we have the nests of the wasps belonging to the genus Polistes, which are more particularly known by the name of paper wasps. Here the nest has no outer envelope, and is usually limited to a single tier of cells suspended by one or more peduncles or short stems. Thay are usually attached in the open air to the branchs of trees, or are fastened to the underside of the rafters of porches, etc., garrets being favorite places for their construction. Some of the hornets, such as the "yellow-jackets," are found occupying the deserted nests of mice, suspending the tiers of cells from the ceiling and lining the burrow with a layer of woody paper. The burrows are enlarged from time to time as the growth of the colony requires additional space, and in late autumn are often found large enough to fill a bushel measure, containing sometimes from 15,000 to 20,000 cells. In all these cases the tiers of cells are attached to each other or to other supports by strong pillars of the same *papier maché* material, but of darker color and firmer texture.

The combs of these paper wasps and hornets are not double, as in the case of the Hive Bee, and the cells, which are less perfectly hexagonal, have the mouth beneath and are in horizontal instead of vertical layers. They differ from the cells of bees, also, in that they are used solely in the reception of the larvæ and, except in some tropical species,* not for the storage of honey or pollen. The nests of wasps vary greatly in the different species, and find their greatest perfection in the card-making species of Cayenne (*Chartergus nidulans*) the outer covering of which is nearly white and as tough as the stoutest card-board.

The life-history is very interesting. Perfect females or queens and males are produced in the autumn, in cells of large size, and in the case of the hornets proper, these are developed in the lowest and last constructed of the cells. The males and the workers or imperfect females, perish at approach of winter, while some of the fertile females hibernate in sheltered situations. These, in the following spring, originate new colonies, and may be seen about early spring flowers, which they frequent for honey, but more particularly to prey upon other insects attracted to the blossoms. Singly and unaided they originate the new colony, building cell after cell, supplying each with an egg, and persistently bringing home food for the growing young. All these cells in the early season produce neuters or working females only. These, as soon as developed, assist the hibernated mother or queen in the enlargment of the nest and the care of the young. She, after having once started her colony, rarely leaves it, but remains and devotes herself solely to the duty of egg-laying. The workers become by far the most numerous, and by late summer are everywhere found moving actively about in search of food for the home brood. They are less than half the size of the perfect females, and considerably smaller than the males, which are easily distinguished by their more slender bodies and very long antennæ. The males are not mere idlers, as in the case of the bees, but occupy themselves with various labors about the nest, and while the male bee is in the end ruthlessly destroyed

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*St. Fargeau states that he has often, in *Polistes gallica*, found cells filled with honey.

by the indignant workers, the male wasp is respected and protected, and dies a natural death. In the large nests of hornets, the number of males and perfect females produced in the autumn amounts to several hundred, and of these comparatively few females successfully hibernate. Were it otherwise ordained, these insects would become too numerous for the comfort of the rest of the world.

The larvæ are fed from day to day with a prepared liquid food which is disgorged from stomachs of the adults. These prey upon other insects, and also feed upon animal or vegetable matter to which they have access, and are particularly fond of the sweets of fruits, melons, etc., also of sugars and honey, all of which are eaten greedily, and commingled and prepared in the stomach as food for the young. Wasps are not particularly active themselves in the collection of honey from flowers, but are very prone to rob the hives of bees whenever opportunity offers.

We have seen that in the case of the Hive Bee the unfertilized egg, including the egg deposited by the worker bee, invariably produces a drone or male. The experience of English observers, indicates that the reverse of this is true of the social wasps, and that, instead of males being produced from eggs of workers or non-fertilized wasps, other workers similar to the parent are produced. Thus from nests from which the queen wasp is removed quite early in the spring, the generation of workers continues through the season as freely as if the queen were still present to lay eggs, showing that the brood is kept up by the progeny of workers having no access to males, which only appear in the fall. Leuckart has also shown, by careful dissections, that nearly fifty per cent. of the worker generations in the latter part of the summer at least, have fully developed and developing eggs in their ovaries.

It must be noted, however, that the experience of Von Siebold with *Polistes gallica* directly contradicts the observations of English investigators. His experiments carried on in precisely the same way, indicate that, with this species at least, the eggs from the workers produce males. There would, therefore, seem to be no uniformity in this regard among the different species of the family, both arrenotoky and thelytoky occuring among them, and possibly in the same species at different seasons.

In the case of Vespa there is no difficulty in separating the fertilized autumnal queen from the worker generations, the former being considerably larger and presenting even more marked differences from the worker than occur in the similar states of the bee. With Polisites, however, the difference between the fertilized queen and the summer broods of workers is much less marked, and it is more difficult to distinguish them. The abdomen of the true queen of Polistes is somewhat longer and larger than that of the worker, but the variation is so slight that accurate separation is usually impossible, and there is probably less difference between the worker and the fertilized female than obtains with the social bees, the worker being quite capable, in many cases at least, of producing eggs which will develop into other workers, and at the proper season also, doubtless, into males. The distinction between the summer broods and the autumnal females which are fertilized and hibernate, is probably produced by food conditions, as in the case of bees, although accurate observations are wanting.

Just as in the case of bees, the study of the wasp family (Vespidæ) in its different genera and species, reveals every gradation in habit, from the solitary species to the more highly organized or social forms, and these differences in habit are accompanied by differences in structure, so that the origin of the higher or more social forms may be traced through the less specialized.

Many instances might be cited in illustration of the great intelligence of wasps, and especially in proof of their wonderful sense of direction. On the whole they exhibit a rather higher degree of intelligence than do the bees, in the remarkably varied provisions which they make for their young. Their habitations, also, complete in themselves, and built chiefly of extraneous matter not secreted from their own bodies, indicate greater architectural dexterity than is found in the bees.

ANTS.

Few insects have attracted more attention, or have become more renowned than the ants. Considering their comparatively diminutive size, their endless activity, and the wonderful results they accomplish, this is not to wondered at.

Up to the present time some fifteen hundred species of ants have been described, the great majority of the species, as well as the largest and most rapacious, occuring in tropical and semitropical countries. Some two hundred species have already been described from North America, many of which are nearly related to or even identical with those of Europe; while some are cosmopolitan, having been distributed by the agency of man over almost every part of the world. One of the best known of these cosmopolitan forms is the the little Red Ant, *Monomorium pharaonis* Linn., a grievous household pest. Under the tribal term *Heterogyna* Latreille, the ants are divided by the later systematists into four families (by some considered sub-families), namely, the Formicidæ, the Poneridæ, the Dorilidæ and the Myrmicidæ. The first family, Formicidæ, comprises all those species which are destitute of a sting, except in the genus Œcophylla, and are further characterized by having but one node or scale connecting the abdomen with the thorax, and by the habit in the larva of constructing for pupation, a dense, smooth, ovoid, silken cocoon. The remaining families are possessed of a sting, the Poneridæ agreeing with the Formicidæ in the cocoon-forming habit of the larva and in having but a single node or scale connecting the thorax and abdomen, but having an additional, more or less pronounced constriction between the first and second abdominal joints. The Dorilidæ are somewhat aberrant, the female and worker, so far as known, being blind, and nothing being yet known of their larvæ. In the last family, the Myrmicidæ, there are two well-developed, freely mobile nodes between the abdomen and the thorax, and the larvæ are unprotected by any cocoon during pupation. The most interesting and destructive species occur in this family.

Let us glance briefly at some of the species, more according to habit, however, than this classification, and preferably our North American species. Thus they may be considered as Carpenter, Mound-building, Harvesting, Honey, Leaf-cutting, Nest-building and Driving or Foraging ants. (Note 5.)

Ant Economy and Habits.

ANT WARS.—Very many most interesting accounts of the intelligence and battles, and of the curious persistency of ants, especially of the foraging species, are recorded by travellers in tropical countries, and particularly by the late Henry Walter Bates in his "Naturalist on the River Amazons". It is a well established fact that ants, like human beings, do at times declare war against other species, or even against colonies of their own, while with many species there is a form of neuter known as the soldier which seems to be developed for no other purpose than to defend the colony or make war upon some other colony. The soldiers are characterized by an enormous and abnormal enlargement of the head, jaws and mouth-parts. In these wars the greatest pugnacity and courage are exhibited, the contest lasting sometimes for days, and the weaker party ultimately succumbing from sheer exhaustion and decimation.

There is a gradation in the warlike spirit in different species and genera. Thus in Myrmecina and Tetramorium the ants do not fight, but roll up and feign death. Lubbock shows that in *Formica exsecta*, an active but delicate species, the individuals advance in serried masses, and that when fighting with larger species, like *Formica pratensis*, several in unison, attack an individual of the latter, some of them jumping onto the back of the foe and sawing off the head from behind. The species of Lazius, he says, will suffer themselves to be cut to pieces rather than let go when they have once seized an enemy, while *Polyergus rufescens*, the notorious slave-making ant of the Amazons, seizes the head of her enemy by closing the jaws, so as to pierce the brain, thus paralyzing the nervous system; so that a comparatively small force of Polyergus will fearlessly attack much larger armies of the small species and suffer scarcely any loss themselves.

SLAVE-MAKING.—Nor must I pass without brief mention of another fact which has been well observed among ants, namely, that some of the species repeatedly raid the colonies of weaker ants and make slaves of them. In most cases it is a large pale ant which enslaves a small black ant, and this is done either by capturing fully developed workers or more often by carrying home from the weaker colony larvæ and pupæ and allowing these to develop in the formicaries of their masters.

It is most interesting to note, also, that the slave-making habit among ants produces the same demoralizing results for the slave-maker that it does among men. The habit is degrading. Thus, as Lubbock points out, *Polyergus rufescens* has become entirely dependent on its slaves. It has lost the power of building, as also most of its domestic habits. Its impotence away from its slaves has gone so far that even the habit of feeding has been lost, and it will starve in the midst of plenty rather than feed itself.

Such cases as this, of an animal having lost the instinct of feeding, are extremely rare in nature, but the habit here has even affected the structure, for the mandibles of the slave-makers have lost their teeth and are useless except as weapons of war.

BURIAL GROUNDS.—It would seem almost incredible, but there is nevertheless good evidence that some species of ants habitually form burial grounds for the dead. An esteemed friend and reliable observer, Mr. Henry G. Hubbard, informs me that he has carefully studied the habits of a black mound-making ant in Montana, (*Formica subpolita Mayr*), the mounds being made in dry situations in the mountains. There are always burial pits just outside the hill, connected with it by passages; and these burial pits contain generally a double handful of dead ants, with occasional fragments of other insects. They are made in firm, hard soil, and consist of a clean neat chamber, sometimes as large as one's two fists. In moist ground the same species of ant does not seem to use the same method of burial. These facts are all the more interesting as showing how the same species may develop a local habit, as *subopolita* is now considered but a variety or subspecies of the widespread *F. fusca* L.

FOOD-HABITS.—In Note 5, in speaking of the several species, I have recorded in detail some food-habits of our ants. Taken as a whole they are truly omnivorous, feeding upon all sorts of plant and animal matter, storing various kinds of vegetation, and even, as in the case of the leaf-cutter ants, cultivating certain fungus growths for food, but particularly relishing the sweets obtainable from plants and other sources, and more especially from the excrementitious and other secretions of plant-lice and bark-lice.

KEEPING AND RAISING KINE.—There is no work upon ants which does not refer to their well-known habit of guarding and encouraging plant-lice, protecting them from their enemies, and in other ways looking after their welfare. This attitude toward various species of Aphididæ is essentially selfish, as these, when carressed, yield a sweetened liquid which the ants much covet. For this reason the Aphides have been denominated, in popular parlance, the ants' milch-cows. Certain species of plant-lice are frequently attended by particular species of ants, and there is often a remarkable colorational harmony between a particular ant and the Aphidid colony which it cherishes. It is not generally known, however, that the ants do more, and show an exceptional intelligence in carrying the eggs of the plant-lice in autumn into their own formicaries, bringing them together in little heaps and taking every precaution to preserve them through the winter These eggs are carried back in spring to the plant upon which the particular Aphidid is nourished. There are, moreover, a number of other insects which the ants foster in their homes and from which they obtain coveted secretions; so that they may be said to utilize various kinds of cattle.

EARLY STAGES OF ANTS.—The transformations of ants are similar to those of other social Hymenoptera where the young are fed and cared for by the workers or nurses. The eggs are, as a rule, deposited by what may be called queens, i. e., by females more highly fed and developed than the rest, and devoted solely to the propagation of the species. It has also been noted that, in an emergency, where the females have perished, eggs may be deposited by the workers, as in the case of the Hive Bee, and also, as in that case, that these unfertilized eggs produce males only.

FIG. 6.—DEVELOPMENT OF FORMICA RUFA: *a*, larva, lateral; *b*, do., ventral view; *c*, pupa; *d*, cocoon—enlarged, the outlines showing natural size. (After Dalton.)

The eggs are yellowish-white, ovoid or oblong-ovoid, very delicate in texture, and require from two to three weeks, or longer, for hatching, according to seasonal conditions. The larvæ are soft, white, legless grubs, having no eyes and being perfectly helpless. The small head is curved down on the breast and provided with but rudimentary mandibles. There is at first no apparent difference between the larvæ destined to produce the different kinds of individuals, but the growth of those destined to become workers suddenly ceases, whereas that of those destined to become perfect females, continues. As in the case of the larvæ of the bee, the workers are therefore but arrested or undeveloped females, and there is every reason to believe that the ultimate organization is a result of a difference in the kind of food or amount of food supplied by the nurses; so that practically the constitution of the formicary is regulated by the colony itself. The helpless larvæ and pupæ are moved from place to place, and most tenderly cared for by the nurses, which understand the requisite conditions of warmth, fresh air, protection against cold, rain, and other injurious influences, and which feed their young charges with a liquid discharged from the mouth, very much as in the case of the bee.

While the mandibles are used for tearing all sorts of substances, it is the juices of these which are lapped up by the tongue, and which can be regurgitated from a fore-stomach or pouch, in order to feed the young and the queens. These young are, also, arranged by the workers in groups of different sizes and ages, with a view to regulate the amount of food necessary for each stage. The larval life varies very much, so far as observations have been made, as its duration may extend from six or seven weeks to several months, according to the species. Some species even hibernate in the larva state. I have already indicated the differences in habit as to the formation of a cocoon or pupation without a cocoon, in the different families of the group; but a difference is noticeable in this respect, even in the same formicary, as first observed by Latreille. Those which pupate in cocoons are often unable to extricate themselves when mature, and are then tenderly assisted by the workers, who also aid in the unfolding of the wings, and cleansing of the newly-developed ant. (Fig. 6, shows a typical larva, nymph and cocoon).

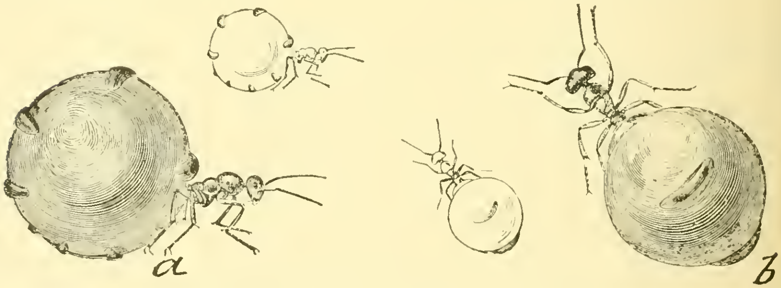


FIG. 7.—HONEY ANTS: *Myrmecocistus mexicanus*; *a*, side view; *b*, from above—enlarged, the outlines showing natural size. (after Lubbock.)

The individuals of the formicary are therefore composed (1) of neuters or workers, which are all females arrested in development; (2) of males; and (3) of fully developed females or queens. All the males and females acquire wings, which are, however, torn off after the marriage flight, and a number of queens are supported in each formicary. In some of the species the workers are uniform in appearance, while in others they exhibit great differences in size and structure. As already stated, the workers or neuters are generally divided into two classes, viz., the ordinary small kind, and a second kind with much larger head and mandibles, and called soldiers. Bates has shown that in the Sauba ant of South America (*Œcodoma cephalotes*) there are two forms of the large-headed neuters, one with hairy and the other with polished head.

LENGTH OF LIFE IN ANTS.—Lubbock's experiments have shown that in some species the mature workers will live from one to six years, and the females even much longer, the life of the males being very ephemeral and lasting but a few days or weeks. He kept a female of *Formica fusca* for thirteen years.

MIGRATIONS.—There are two kinds of ant migrations. The swarming of the sexes takes place usually in the afternoon or toward evening on warm or sultry days, and it is remarkable how very general, over a wide extent of country, the same species will begin to fill the air on some particular day. Species of the genera Lasius, Formica, Tetramorium, and Cremastogaster, particularly, often form dense swarms or clouds, ascending high up into the air. These swarms of ants have sometimes been known to be so dense and persistent that it was impossible, over large areas, to put the foot down without crushing dozens of the insects which have been swept together in vast piles. A case is on record of a large species covering the surface of the water at sea to a depth of six inches, and for a distance of six miles. This congregating in such vast swarms is due to the uniform and simultaneous hatching and development in all the colonies over a large extent of country.

The migrations of the sexes are really love excursions, whereas the migrations of the workers, which take place in vast bodies at times, are a result of undue multiplication, and are intended to improve the condition of the surplus progeny and found new colonies.

MYRMECOPHILÆ.—A most interesting lecture might be devoted to the subject of myrmecophilous insects alone. Ants are as a rule hostile to every other living thing, except such as the plant-lice, which furnish them with desired sweets. They fiercely resent any intrusion into their nests, and often attack and kill their own kind if belonging to another colony. It is therefore remarkable that careful examination of almost any formicary will reveal the presence of a multitude of different insects which appear to live peaceably in the company of the legitimate inhabitants. A mere list of these myrmecophilous insects would be of little interest. The species comprise, first, those which, in the larva and pupa states, live among the ants; secondly, accidental visitors, not confined to ants' nests; and, thirdly, the true myrmecophilous species, i. e., those which in the imago state, and so far as known in the adolescent states also, are exclusively found in ants' nests and depend for their existence on the ants. In some species of the second category we already find a tendency to simulate in color the ant itself, or the surroundings of the formicary; but the true myrmecophilæ, or species of the third class, often mimic in the most remarkable manner the host upon which they depend. Some of these myrmecophilous species are mere scavengers, and feed upon the offal, of an animal or vegetal nature, which is always found abundantly in the nests of ants. They are endured with indifference by the ants, because they are useful in an indirect way, helping in the performance of a duty which would otherwise have to be performed by the ants themselves. Another group is present as marauders, living in the nests for the purpose of stealing and devouring the ants' eggs, larvæ or pupæ, whenever a chance offers. To this group belong the various Histeridæ, a Coleopterous family in which the species are so constructed that it is impossible for the ants to advantageously attack them. In the third group we find species characterized by sweet secretions, from which the ants derive benefit. In some cases, as in the black, clumsy beetles of the genus Cremastochilus, the insects are not absolutely confined to the formicary, though they are always developed there. Frequently in the perfect state they endeavor to escape, and it is curious to note the strategy which the ants employ to prevent the departure of these inquilines or guests from which they obtain the coveted sweet. In such cases, as in the well known genus Claviger, and allied genera, the insects are absolutely dependent on the ants, which take the same tender care of them that they do of their own young, feeding them and keeping them clean, and in every way showing the utmost friendship.

TERMITES OR WHITE ANTS.

The Termites or White Ants have developed, in their higher forms, an organization and a differentation of individuals very similar to those of the true ants; whence the popular name. They are among the oldest insects, as their remains are found in the coal measures of Europe, whereas the true ants do not appear until the Tertiary. Belonging, in fact, to an order which has been very generally looked upon as the lowest or least developed among the Hexapods and as representing most nearly the earlier or primitive insects which appeared upon the globe, the fact that they have acquired a social organization which in so many respects recalls that of the ants, is of great significance, as we shall see when we come to consider the origin and development of these traits. Yet a more intimate acquaintance with the facts concerning the Termites shows us that the development of the social habit and the differentation of forms, have been along different lines from those presented by the social Hymenoptera, and are based upon a different mode of development. In other words, the Termites, belonging to an order which undergoes incomplete metamorphoses—the larva being born in the image of the adult, minus wings—is more or less capable of self-support soon after birth, while in the social Hymenoptera, which undergo a complete metamorphosis, the larva is quite unlike the adult, and entirely helpless during development.

It is only within recent years that the Termites have been carefully studied. The results of these later studies must be relegated to a note. (Note 6). While with most species the colony consists of a king and a queen and of two forms of neuters or workers; yet in the European *Termes lucifugus* as many as fifteen distinct forms have been characterized, but no true queen discovered. In other words, besides the four distinctive classes of individuals which characterize the more highly developed species, we find, sometimes in the same species, but particularly when the different species are considered, every gradation between these different classes.

The fundamental difference between the social Hymenoptera on the one hand, and the Termites on the other, is that in the latter the workers or neuters (including the soldiers) are not undeveloped females, but consist of both sexes, and are in reality arrested or modified larvæ, in which the sexual organs are but imperfectly developed or are completely atrophied. They are recognizable as neuters even after the first larval molt. The common North American species, *Termes flavipes*, is doubtless familiar to most of you. It occurs in vast numbers in rotten or prostrate logs, and frequently invades our houses wherever there is wood in process of decay. The newly-hatched young are very tender and helpless, and move but little, and while in the order Neuroptera the young larva is usually able to care for itself immediately after birth, the newly hatched Termite has become more or less dependent upon the care of the workers, which either feed it with partly digested food from their own mouths, or with their own secretions, or else prepare food for it. The eggs are laid in large numbers by fertile females or supplementary queens, but are carried long distances by the workers into chambers which are generally several feet underground, or else in the heart of otherwise solid trees.

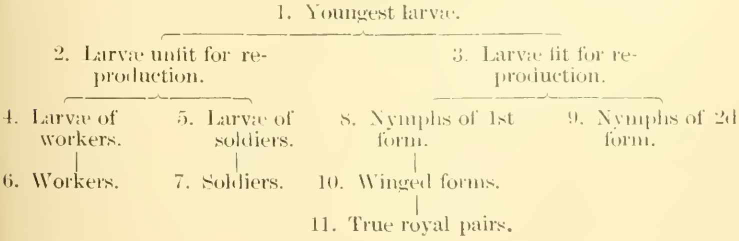
The queen in those species which normally possess one to each colony, becomes helpless as she increases in size and gravity, for she attains to many times the bulk of the ordinary neuters, which are always unwinged. Winged males and females develop from a special brood, and often in such numbers that in spring they swarm until they literally fill the air. They are distinguished from the rest by being more chitinized and darker in color. The great majority of the swarming sexed individuals are doomed to perish, either while on the wing or after falling to the ground, for they are the favorite food of almost all other creatures. But even where not devoured, most of them die without founding new colonies. Swarming is not for the purpose of mating, but it is to be looked upon as an incident in the excessive multiplication of the species, and as a means of inducing cross-fertilization between different colonies.

Upon settling on the ground, the swarming individuals cast off their wings, and if a couple of opposite sex are fortunate enough to enter the outlying burrows of some colony already founded, or to meet a few workers, they are capable of founding a colony themselves. It is only after a female has been duly provided with a place of shelter or cavity that the mating really takes place, from which time forth she becomes more or less stationary and extremely fecund. She becomes, in short, a true queen, and her escort remains with her and has been called a true king; for here again the Termites differ radically from the social Hymenoptera in that coition takes place repeatedly. There are, however, supplemental queens or nymph queens, which seem to be capable of laying eggs, probably parthenogenetically, and which never develop their wings.

The great majority of the neuters are true workers, but a certain proportion of them, about one per cent., are so-called soldiers, having enormously developed heads and powerful jaws, very much as in the true soldier-ants, and fitted for no other purpose than the defence of the colony. Both kinds of neuters are perfectly blind.

The habits and economy of our *Termes flavipes* may be looked upon as typical of the family; but there are species in different parts of the world in which (as in Calotermes) the workers, or (as in Anoplotermes) the soldiers, are absent; others (as in Eutermes) where the soldiers (nasuti) have a bill instead of jaws; others in which the reproductive forms are reduced to the one royal pair; and though the fact has not been absolutely observed, there are probably Termites which produce only males and females, as with ordinary insects, or as in allied families of the Neuroptera. The accompanying diagram will very well illustrate the modes of development and genealogy of the different forms in a typical Termite colony, while some additional sexual forms of less certain character or fixity, have been observed by Grassi in the European *Termes lucifugus*, and called complementary kings and queens. In those colonies which have no true royal pair, their place is taken by supplementary royal pairs. (Note 6.)

Forms in a Termes Colony under normal Conditions.



1. Youngest larvæ.
2. Larvæ unfit for reproduction.
3. Larvæ fit for reproduction.
4. Larvæ of workers.
5. Larvæ of soldiers.
8. Nymphs of 1st form.
9. Nymphs of 2d form.
6. Workers.
7. Soldiers.
10. Winged forms.
11. True royal pairs.

The fecundity of the true queen Termite is something remarkable, and, based on Smeathman's observations on an African species (*Termes bellicosus*) the fact that an egg is produced every second, or some 80,000 a day in the height of the breeding season, has been commonly quoted among writers on the subject. In this species the queen is sealed up in a cell which is as hard as a stone, in the central and most protected part of the termitary, the cell being opened and enlarged from time to time by the workers, and being also perforated by holes which admit the workers to care for and feed her, while preventing the egress of the female and her attendant male escort.

Among the more curious facts connected with these Termites, because of their exceptional nature, is the late development of the internal sexual organs in the reproductive forms and the existence of a single long-lived male—a condition not parelleled among other insects, so far as I am aware. Further, as Dr. Hagen has pointed out, the queen represents a unique instance among insects of actual growth taking place in the imago state; for the intra-segmental ligaments not only expand, but grow with the increasing gravity of the abdomen, the stigmata actually taking part in this growth, though the dorsal abdominal plates remain unaffected.

In the Hive Bee multiplication of colonies takes place by division, but the colonizing swarm carries in itself all the elements necessary for the foundation of a new colony. In the more typical Termites multiplication of colonies also takes place by division, but this is carried out by the neuters and the various adolescent stages, since there is usually but one true queen, which can not be moved. The new colony, therefore, can only obtain a true queen by introducing one of the royal pairs that wander about after they have swarmed and thrown off their wings. That great difficulty attends the establishment of such a royal pair of individuals in a colony is illustrated by the fact that they are rarely discovered among colonies of our commoner species of Termes proper.*

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*From the accounts of authors there is no difficulty in finding the true queen in most of the nest building species of Eutermes in the West Indies, Central and South America; while from Smeathman's famous account of *Termes bellicosus* in Africa, it would seem that the fertile queen is usually present in the colonies. But in the species most studied, viz., *Termes lucifu-*

The Termites thus exhibit a greater variety of resources for the perpetuation of the species, in case of emergency, than even the social Hymenoptera, and they also exhibit a greater variety of individual forms in the same colony. There is also among the different species, and especially among the different genera, a gradation from the simple to the more complex economy. Their habitations also vary from the simple to the more complete.

Calotermes burrows in the branches of trees and requires no specialized cells or chambers. *Termes flavipes* and allied species make extensive excavations in prostrate logs or the beams of houses, and are very destructive to old books, especially in dark and damp situations. The excavations are usually elongate and separated by partitions which are penetrated occasionally so as to connect the whole. The walls are lined with a thin layer of brown excrementitious matter, and some of the chambers are more particularly used to store eggs in, while others are used as nurseries for the young. Subterranean galleries often extend some distance away from the main termitary, and sometimes up under the bark of trees. More rarely they are exposed above ground, when the insects thicken the layer of excrementitious matter.

Eutermes, which is common in the West Indies and in Central and South America, builds exterior nests more or less spherical or conical, generally at the base of trees, but also on the branches or on stone walls. They are often as large as a hogshead, and consist chiefly of excrementitious matter and of collected particles of decayed wood. There are one or more queen cells in the most protected parts of the nest, and other chambers for the eggs and young, while temporary enlargements afford shelter for the winged individuals before swarming. Covered galleries somewhat thicker than an ordinary pencil, and composed of the same material as the nest, but less compact, extend from the main nest to the ground, or up the tallest trees, leading to food supplies.

The constructional faculty is yet more highly developed in the

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gus, the difficulties in procuring a true queen would seem to be very great, and Prof. Grassi, in five years' observations, has never found one. Yet he had no difficulty in obtaining true kings and queens in confinement by establishing little colonies of winged individuals. The same condition of things prevails with our North American *Termes flavipes*, since in my own observations and those of others, no true queen has been met with, and reproduction is carried on, for the most part, by supplementary queens.

hill-making species of the genus Termes, which attain greatest perfection in South Africa. These nests always arise from the ground, and vary according to the species. They are made of finely comminuted wood, mixed with some secretion, or of clay, in which case they become as hard as stone. Long subterranean foraging galleries are extended from these nests.

In South America some species seem merely to excavate subterranean galleries in the soil, while Bates found at Santarem, Brazil, composite nests occupied by different species, which built each its own part of the nest with its own special material.

SOME GENERALIZATIONS.

In the hasty summary which I have thus endeavored to present to you of some of the chief characteristics of social insects, those who are most familiar with the facts can best appreciate how much of interest has been omitted. These insects are attacked by various natural enemies in their own class, and particularly in the case of the bees and wasps, by some of the most abnormal parasites, viz., the Stylopidæ, in which the young larva is extremely active, but the adult female stationary and so degraded that she has lost all members and mouth-parts, and in fact all semblance of an insect, while the adult male is an active, winged creature, of very ephemeral existence. Chapters might be written upon the myrmecophilous and termitophilous insects of various orders, some of which are mere mess-mates, others advantageous associates, while others are unwelcome, but more or less successful intruders on the hospitality of their hosts. This part of the subject must, however, be passed over in order to permit me to close with some generalizations and speculations which the facts already enumerated provoke.

THE SENSES IN INSECTS.

Having thus dealt, in a summary way, with some of the structures and economies of the social insects, let us now consider their psychological manifestations.

Of the five ordinary senses recognized in ourselves and most higher animals, insects have, beyond all doubt, the sense of sight, and there can be as little question that they possess the senses of touch, taste, smell and hearing. Yet, save, perhaps, that of touch, none of these senses, as possessed by insects, can be strictly compared with our own, while there is the best of evidence that insects possess other senses which we do not, and that they have sense organs with which we have none to compare. He who tries to comprehend the mechanism of our own senses—the manner in which the subtler sensations are conveyed to the brain—will realize how little we know thereof after all that has been written. It is not to be wondered at, therefore, that authors should differ as to the nature of many of the sense organs of insects, or that there should be little or no absolute knowledge of the manner in which the senses act upon them. The solution of psychical problems may never, indeed, be obtained, so infinitely minute are the ultimate atoms of matter; and those who have given most attention to the subject must echo the sentiment of Lubbock, that the principle impression which the more recent works on the intelligence and senses of animals leave on the mind, is, that we know very little indeed on the subject. We can but empirically observe

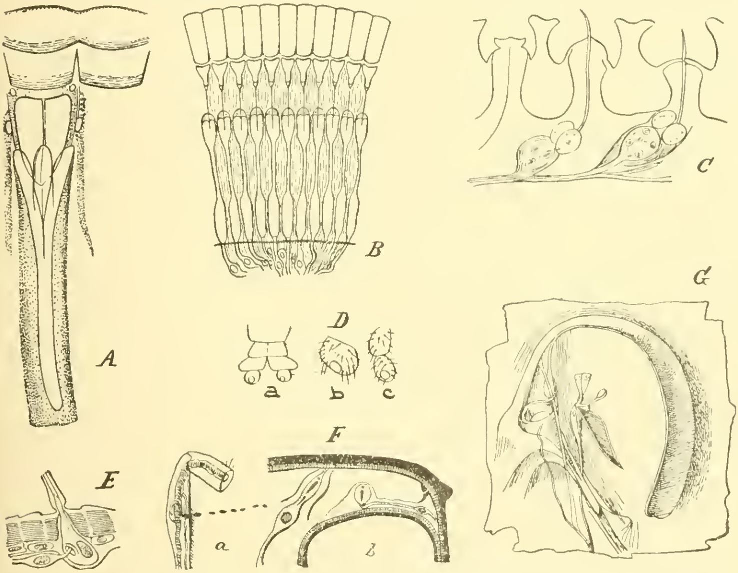

FIG. 8.—SENSORY ORGANS IN INSECTS: *A*, one element of the eye of Cockroach (after Grenacher); *B*, diagrammatic section of compound eye in insect (after Miall & Denny); *C*, organs of smell in Melolontha (after Kraepelin); *D*, *a*, *b*, sense organs of abdominal appendages of Chrysopila, *c*, small pit on terminal joint of palpus in Perla (after Packard); *E*, diagram of sensory ear of insect (after Miall & Denny); *F*, auditory apparatus of Meconema, *a*, fore tibia of this locust, *b*, diagrammatic section through same (after Graber); *G*, auditory apparatus of Calopteuus seen from inner side, showing tympanum, auditory nerve, terminal ganglion, stigma and opening and closing muscle of same, as well as muscle of tympanum membrana (after Graber).—All very greatly enlarged.

and experiment, and draw conclusions from well attested results.

SIGHT.—Taking first the sense of sight, much has been written as to the picture which the compound eye of insects produces upon the brain or upon the nerve centers. Most insects which undergo complete metamorphoses possess in their adolescent states simple eyes or ocelli, and sometimes groups of them of varying size and in varying situations. It is difficult, if not impossible, to demonstrate experimentally their efficiency as organs of sight; the probabilities are that they give but the faintest impressions, but otherwise act as do our own. The fact that they are possessed only by larvæ which are exposed more or less fully to the light, while those larvæ which are endophytous, or otherwise hidden from light, generally lack them, is in itself proof that they perform the ordinary functions of sight, however low in degree. In the imago state the great majority of insects have their simple eyes in addition to the compound eyes. In many cases, however, the former are more or less covered with vestiture, which is another evidence that their function is of a low order, and lends weight to the view that they are useful chiefly for near vision and in dark places. The compound eyes are prominent and adjustable in proportion as they are of service to the species, as witness those of the common House-fly and of the Libellulidæ or Dragon-flies. It is obvious from the structure of these compound eyes that impressions through them must be very different from those received through our own, and, in point of fact, the late experimental researches of Hickson, Plateau, Tocke and Lemmermann, Pankrath, Exner and Viallanes, practically establish the fact that while insects are short-sighted and perceive stationary objects imperfectly, yet their compound eyes are better fitted than the vertebrate eye for apprehending objects set in relief or in motion, and are likewise keenly sensitive to color.

So far as experiments have gone, they show that insects have a keen color sense, though here again their sensations of color are different from those produced upon us. Thus, as Lubbock has shown, ants are very sensitive to the ultra violet rays of the spectrum, which we cannot perceive, though he was led to conclude that to the ant the general aspect of nature is presented in an aspect very different from that in which it appears to us. In reference to bees, the experiments of the same author prove clearly that they have this sense of color highly developed, as indeed might be expected when we consider the part they have played in the development of flowers. While these experiments seem to show that blue is the bees' favorite color, this does not accord with Albert Müller's experience in nature, nor with the general experience of apiarians, who, if asked, would very generally agree that bees show a preference for white flowers.

Touch.—The sense of touch is supposed to reside chiefly in the antennæ or feelers, though it requires but the simplest observation to show that with soft-bodied insects the sense resides in any portion of the body, very much as it does in other animals. In short, this is the one sense which, in its manifestations, may be conceded to resemble our own. Yet it is evidently more specialized in the maxillary and labial palpi and the tongue than in the antennæ, in most insects.

Taste.—Very little can be positively proved as to the sense of taste in insects. Its existence may be confidently predicated from the acute discrimination which most monophagous species exercise in the choice of their food, and its location may be assumed to be the mouth or some of the special trophial organs which have no counterpart among vertebrates. Indeed certain pits in the epipharynx of many mandibulate insects, and, in the ligula and the maxillæ of bees and wasps are conceded, by the authorities, to be gustatory.

Smell.—That insects possess the power of smell is a matter of common observation, and has been experimentally proved. The many experiments of Lubbock upon ants left no doubt in his mind that the sense of smell is highly developed in them. Indeed it is the acuteness of the sense of smell which attracts many insects so unerringly to given objects, and which has led many persons to believe them sharp-sighted. Moreover, the innumerable glands and special organs for secreting odors, furnish the strongest indirect proof of the same fact. Some of these, of which the osmaterium in Papilionid larvæ and the eversible glands in Parorgyia are conspicuous examples, are intended for protection against inimical insects or other animals; while others, possessed by one only of the sexes, are obivously intended to please or attract. A notable development of this kind is seen in the large gland on the hind legs of the males of some species of Hepialus, the gland being a modification of the tibia, and sometimes involving the abortion of the tarsus, as in the European *H. hectus* L. and our own *H. behrensi* Stretch. The possession of odoriferous glands, in other words, implies the possession of olfactory organs. Yet there is among insects no one specialized olfactory organ as among vertebrates; for while there is conclusive proof that this sense rests in the antennæ with many insects, especially among Lepidoptera, there is good evidence that in some Hymenoptera it is localized in an ampulla at the base of the tongue, while Graber gives reasons for believing that in certain Orthoptera (Blattidæ) it is located in the anal cerci, and the palpi.

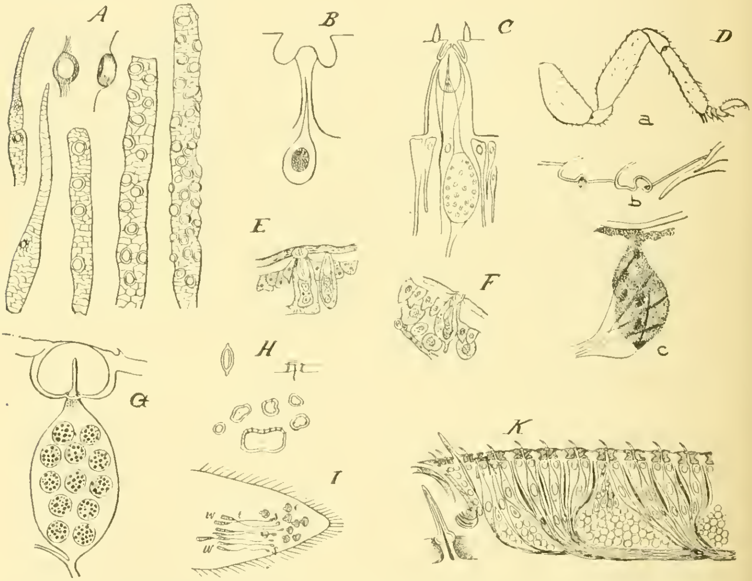

FIG. 9.—SENSORY ORGANS IN INSECTS: *A*, sensory pits on antennæ of young wingless *Aphis persicæ-niger* (after Smith); *B*, organ of smell in May Beetle (after Hauser); *C*, organ of smell in Vespa (after Hauser); *D*, sensory organs of *Termes flavipes*, *a*, tibial auditory organ, *c*, enlargement of same, *b*, sensory pits of tarsus (after Stokes); *E*, organ of taste in maxillæ of *Vespa vulgaris* (after Will); *F*, organ of taste in labium of same insect (after Will); *G*, organ of smell in Caloptenus (after Hauser); *H*, sensory pilose depressions on tibia of Termes (after Stokes); *I*, terminal portion of antennæ of *Myrmica ruginodis*, *c*, cork shaped organs, *s*, outer sac, *t*, tube, *w*, posterior chamber (after Lubbock); *K*, longitudinal section through portion of flagellum of antennæ of worker bee, showing sensory hairs and supposed olfactory organs (after Cheshire).—All very greatly enlarged.

HEARING.—In regard to the sense of hearing the most casual experimentation will show (and general experience confirms it) that most insects, while keenly alive to the slightest movements or vibrations, are for the most part deaf to sounds which affect us. That they have a sense of sound is equally certain, but its range is very different from ours. A sensitive flame arranged for Lubbock by the late Prof. Tyndall, gave no response from ants, and a sensitive microphone arranged for him by Prof. Bell gave record of no other sound than the patter of feet in walking. But the most sensitive tests we can experimentally apply may be, and doubtless are, too gross to adjust themselves to the finer sensibilities of such minute, active and nervous creatures. There can be no question that insects not only produce sounds, but receive the impression of sounds entirely beyond our own range of perception, or as Lubbock puts it, that "we can no more form an idea of than we should have been able to conceive red or green if the human race had been blind. The human ear is sensitive to vibrations reaching at the outside to 38,000 in a second. The sensation of red is produced when 470 millions of millions of vibrations enter the eye in a similar time; but between these two numbers, vibrations produce on us only the sensation of heat. We have no especial organ of sense adapted to them." It is quite certain that ants do make sounds, and the sound-producing organs on

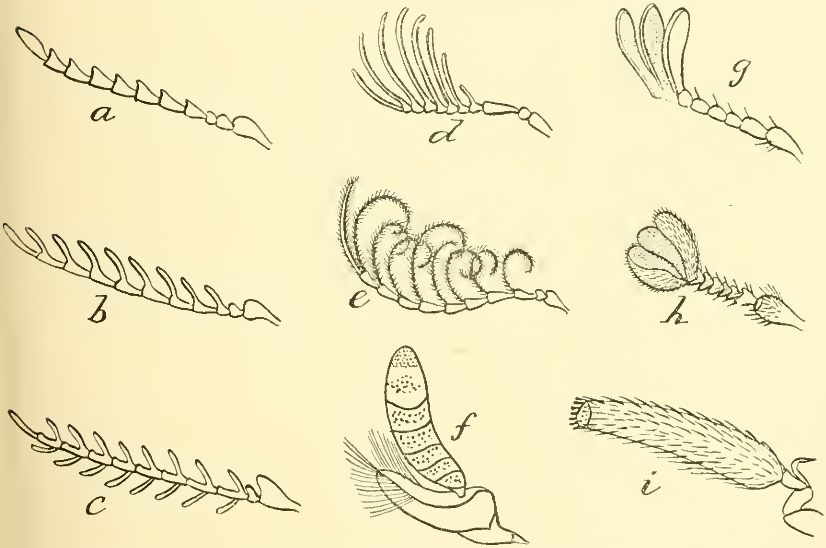

FIG. 10.—SOME ANTENNÆ OF COLEOPTERA : *a*, Ludius ; *b*, Corymbites ; *c*, Prionocyphon ; *d*, Acneus ; *e*, Dendroides ; *f*, Dineutes ; *g*, Lachnosterna ; *h*, Bolbocerus ; *i*, Adranes, (after LeConte and Horn).—All greatly enlarged.

some of the abdominal joints have been carefully described. The fact that so many insects have the power of producing sounds that are even audible to us, is the best evidence that they possess auditory organs. These are, however, never vocal, but are situated upon various parts of the body or upon different members thereof.

SPECIAL SENSES AND SENSE-ORGANS.—While from what has preceded it is somewhat difficult to compare the more obvious senses possessed by insects with our own, except, perhaps, the sense of touch, it is, I repeat, just as obvious to the careful student of insect life that they possess special senses which it is difficult for us to comprehend. The sense of direction, for instance, is very marked in the social Hymenoptera which we have been considerering, and in this respect insects remind us of many of the lower vertebrates which have this sense much more strongly developed than we have. Indeed, they manifest more especially what has been referred to in man as a sixth sense, viz., a certain intuition which is essentially psychical, and which undoubtedly serves and acts to the advantage of the species as fully, perhaps, as any of the other senses. Lubbock demonstrated that an ant will recognize one of its own colony from among the individuals of another colony of the same species, and when we consider that the members of a colony number at times not thousands but hundreds of thousands, this remarkable power will be fully appreciated.

The neuter Termites are blind and can have no sense of light in their internal or subterranean burrowings; yet they will undermine buildings and pulverize various parts of elaborate furniture without once gnawing through to the surface, and those species which use clay will fill up their burrowings to strengthen the supports of structures which might otherwise fall and injure the insects or betray their work. The bat in a lighted

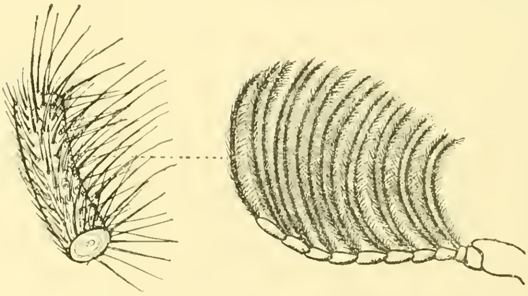

FIG. 11.—Antenna of male Phengodes with portion of ray. —Greatly enlarged. (Original.)

room, though blinded as to sight, will fly in all directions with such swiftness and with such infallible certainty of avoiding concussion or contact, that its *feeling at a distance* is practically incomprehensible to us.

The manner in which anything threatening its welfare thrills and agitates one of these insect communities, and causes every individual to act at once for the common good, has been noted by all observers, and is a good illustration in point. It may be likened to the manner in which the same conditions influence communities of other animals, including man. There are emergencies when intuitive feeling dispossesses reason, and every capable person seems blindly urged to definite action for the protection of the community, regardless of consequence. The war-cry of a nation is an example in point, and violations of otherwise just, but tedious, processes of law, are under certain circumstances deemed justifiable. I shall never forget the emotion that influenced the citizens of Chicago the day following their great fire in 1871. Reason, argument, judgment, were in abeyance. The quicker, intuitive processes prevailed, and to meet lawlessness and the tendency to incendiarism, every right-minded citizen was ready to do vigilant duty, regardless of personal interest, every incendiary being hung to the nearest lamp-post, without ado or delay. It was the universal and deep-seated instinct of self-preservation.

TELEPATHY.—But however difficult it may be to define this intuitive sense which, while apparently combining some of the other senses, has many attributes peculiar to itself, and however difficult it may be for us to analyze the remarkable sense of direction, there can be no doubt that many insects possess the power of communicating at a distance, of which we can form some conception by what is known as telepathy in man. This power would seem to depend neither upon scent nor upon hearing, in the ordinary understanding of these senses, but rather on certain subtle vibrations, as difficult for us to apprehend as is the exact nature of electricity. The fact that man can telegraphically transmit sound almost instantaneously around the globe, and that his very speech may be telephonically transmitted, as quickly as uttered, for thousands of miles, may suggest something of this subtle power, even though it furnish no explanation thereof.

The power of sembling among certain moths, for instance, especially those of the family Bombycidæ, is well known to entomologists, and many remarkable instances are recorded. (Note 7.) I am tempted to put on record, for the first time, an individual experience which very well illustrates this power, as, on a number of occasions when I have narrated it, most persons not familiar with the general facts have deemed it remarkable. In 1863 I obtained from the then Commissioner of Agriculture, Col. Capron, eggs of *Samia cynthia*, the Ailanthus silk worm of Japan, which had been recently introduced by him. I was living on East Madison Street, in Chicago, at the time, a part of the city subsequently swept by the great fire, and since entirely transformed. In the front yard, which (so commonly the case in the old Chicago days) was below the sidewalk, there grew two Ailanthus tress which were the cause of my sending for the aforesaid eggs. I had every reason to believe that there were no other eggs of this species received in any part of the country within hundreds of miles around, It seemed a good opportunity to test this power

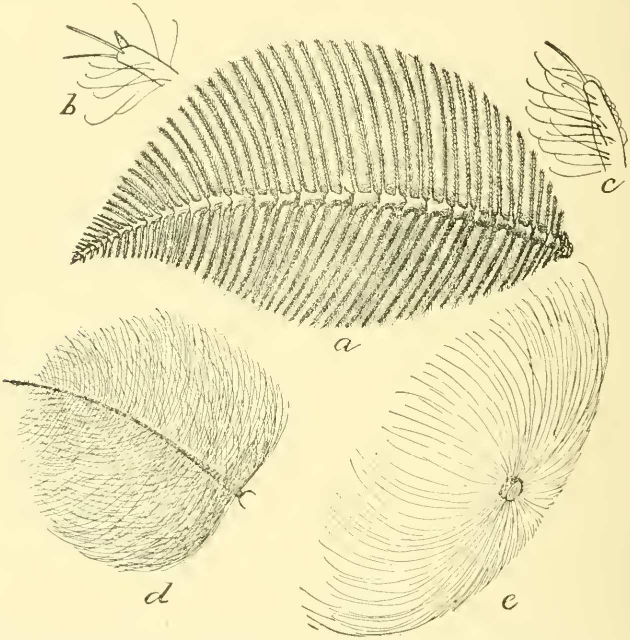

FIG. 12.—SOME ANTENNÆ OF INSECTS: *a*, Telea polyphemus, male, × 3; *b* and *c*, tips of rays of same still more enlarged; *d*, Chironomus × 6; *e*, section of same still more enlarged. (Original.)

of sembling, and after rearing a number of larvæ, I carefully watched for the appearance of the first moths from the cocoons. I kept the first moths separate and confined a virgin female in an improvised wicker cage out of doors on one of the Ailanthus trees. On the same evening I took a male to the old Catholic cemetery on the north side, which is now a part of Lincoln Park, and let him loose, having previously tied a silk thread around the base of the abdomen to insure identification. The distance between the captive female and the released male was at least a mile and a half, and yet the next morning these two individuals were together.

Now in the moths of this family the male antennæ are elaborately pectinate, the pectinations broad and each branch minutely hairy. (See Fig. 12, *a*). These feelers vibrate incessantly, while in the female, in which the feelers are less complex, there is a similar movement connected with an intense vibration of the whole body and of the wings. There is therefore, every reason to believe that the sense is in some way a vibratory sense, as indeed at base is true of all senses, and no one can study the wonderfully diversified structure of the antennæ in insects, especially in males, as very well exemplified in some of the commoner gnats (see Fig. 12, *d*, *e*), without feeling that they have been developed in obedience to, and as a result of, some such subtle and intuitive power as this of telepathy. Every minute ramification of the wonderfully delicate feelers of the male Mosquito, in all probability pulsates in response to the piping sounds which the female is known to produce, and doubtless through considerable distance.

There is every justification for believing that all the subtle cosmic forces involved in the generation and development of the highest, are equally involved in the production and building up of the lowest of organisms, and that the complexing and compounding and specialization of parts have gone on in every possible and conceivable direction according to the species. The highly developed and delicate antennæ in the male Chironomus, for instance, may be likened to an external brain, its ramifying fibers corresponding to the highly complicated processes that ramify from the nerve cells in the internal brains of higher animals, and responding in a somewhat similar way to external impressions. While having no sort of sympathy with the foolish notions that the spiritists proclaim, to edify or terrify the gullible and unscientific, I am just as much out of sympathy with that class of materialistic scientists who refuse to recognize that there may be and are subtle psychical phenomena beyond the reach of present experimental methods. The one class too readily assumes supernatural power to explain abnormal phenomena; the other denies the abnormal because it likewise is past our limited understanding. "Even now," says William Crookes, who speaks with authority, "telegraphing without wires is possible within a radius of a few hundred yards," and, in a most interesting contribution to our present knowledge of vibratory motion and the possibilities of electricity, the same writer remarks:*

> "The discovery of a receiver sensitive to one set of wave lengths and silent to others is even now partially accomplished. The human eye is an instance supplied by nature of one which responds to the narrow range of electro-magnetic impulses between the three ten-millionths of a millimeter and the eight ten-millionths of a millimeter. It is not improbable that other sentient beings have organs of sense which do not respond to some or to any of the rays to which our eyes are sensitive, but are able to appreciate other vibrations to which we are blind. Such beings would practically be living in a different world from our own. Imagine, for instance, what idea we should form of surrounding objects were we endowed with eyes not sensitive to the ordinary rays of light, but sensitive to the vibrations concerned in electric and magnetic phenomena. Glass and crystal would be among the most opaque of bodies. Metals would be more or less transparent, and a telegraph wire through the air would look like a long narrow hole drilled through an impervious solid body. A dynamo in active work would resemble a conflagration, while a permanent magnet would realize the dreams of mediaeval mystics and become an everlasting lamp with no expenditure of energy or consumption of fuel.
>
> In some parts of the human brain may lurk an organ capable of transmitting and receiving other electrical rays of wave lengths hitherto undetected by instrumental means. These may be instrumental in transmitting thought from one brain to another." * * *

INTELLIGENCE IN INSECTS.

Anyone who has closely studied the ways of insects, especially as exemplified in the social species we have been considering, will not doubt that they possess intelligence. They communicate with each other by a language, which, though unspoken, is no less eloquent of all their wishes and desires. They work for the

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* "Some possibilities of electricity." *Fortnightly Review*, March, 1892.

common good; they train a soldier and a police force; they are brave in the defense of the communal interest; they protect and defend their sovereign; they make war and even organize military expeditions; they make slaves and are held in bondage; they encourage and protect other insects which yield them cherished nourishment; they even go so far as to care for the eggs of such, and thus deliberately rear their nectar-giving kine; they cultivate crops; they providently store food for winter use or in anticipation of an inauspicious season; they give expression to satisfaction and pleasure; they exhibit certain baser passions, as jealousy, ill-temper or rage; they even display a certain moral sense, and will help, on occasions, the distressed and threatened of their own kind; they are most assiduous in the care and rearing of their young; they profit by experience; they manifest a pure and simple enjoyment of life by their gambols and playfulness; they are cleanly to a degree which will astonish those who for the first time observe their constant licking and brushing of all parts of the body; they exhibit, in short, most of the sense manifestations displayed by higher animals. It may be ingeniously argued that in all these manifestations they are acting as mere automatons, but the same arguments may be, and have been, urged to explain the actions of man.

So far as experimentation goes, and especially that by Sir John Lubbock, bees are not gifted with the high degree of intelligence with which many writers have credited them, and in this respect do not compare with the higher ants. The Termites are probably the lowest, bees next, wasps next, and ants the highest, in point of intelligence, among social insects. The affection of the bees for their queen, or the deference paid by ants, wasps and Termites to theirs, may be viewed as an instinctive expression of their communal obligation to her, which is at once transferred to another by whom she may be replaced; but our own fealty to our rulers may bear very much the same interpretation. Wasps are more alert and intelligent than bees, and as Lubbock has shown, are measurably susceptible of being tamed. Ants, as we have seen, exhibit a very high degree of intelligence. In fact, the manner in which all these insects work together in harmony, and especially the manner in which certain individuals act as scouts or deliberately set to work to remedy and overcome any exceptional interference with or injury to their habitations, denotes considerable reasoning and reflective power; while the anticipation of the needs of the community—as in the building of queen cells at the proper time by bees and wasps, the varying treatment of the young, and the preparation for swarming by all the social insects—argues an intuitive perception which is as conscious as that which higher animals display in making similar provision for their progeny. This very intuition is the origin of intellect, or, rather, the primary form of intellect. It is, as Ward expresses it, older than reason, and parent of the later faculties of abstraction and reflection. It involves all that we know as sagacity and cunning, displayed by animals for their own good.

But it is to the nature of this intelligence that I would call your attention, since many may question the use of the term in connection with these insects. It has been the fashion in the past to separate man from the rest of the animal world by the nature of his intelligence. The earliest philosophers, instead of beginning with the simpler problems of subjective nature, seem to have been fascinated by the more complex phenomena of objective nature. They built up a fabric of metaphysics which modern methods of induction and modern experimental physiology and psychology have demolished and remodeled. We have had dissertations on the will as something quite independent of the body, and speculations as to the difference between human and divine will.

We must certainly grant to insects the sensations of pleasure and pain, for the worthiest authorities now concede that the least of sentient beings—or animals as contra-distinguished from plants—must possess feeling, however faint. Feeling means either pleasure or pain, the former the inevitable out-growth of experience favorable to the organism, the latter the converse. The former is a sign post on the road to all that is good for the race, the latter a warning of all that is evil; though, paradoxical as it may seem, this is just as necessary to the welfare of the organism. What is evil for the individual may be good for the race. Now all feeling must be conscious, and the different grades of consciousness of feeling, until we reach self-consciousness, involving intellectual processes, are but gradations in the manifestations of one and the same kind of force. Indeed, it is now conceded by advanced thinkers of the biologic school that intellect had its origin in and depends on the senses, and that mind is divisible into feeling and understanding. Most of the acts of these social insects are, it is true, what we call instinctive*; but as I have so often had occasion to express my views and the reasons for them, on the subject of instinct, it is unnecessary to enlarge upon them further than to state that the instinctive acts of insects are often combined, in a greater or less degree, with a low order of conscious reasoning, and that while this is generally of the intuitive kind, it is, on occasions, deliberate and reflecting.

> "If in the insect Reason's twilight ray
> Sheds on the darkling mind a doubtful day,
> Plain is the steady light her Instincts yield,
> To point the road o'er life's unvaried field;
> If few those instincts, to the destined goal,
> With surer course, their straiten'd currents roll."—Evans.

Two beliefs that have very generally prevailed among men up

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*Romanes considers that the instincts of neuter insects are themselves sufficient to refute Lewes' theory of instinct as being lapsed intelligence transmitted through heredity; and he criticises Spencer's views that "the automatic actions of a bee building one of its wax cells answer to outer relations so constantly experienced that they are, as it were, organically remembered." He bases his criticism upon the statement that the bee "begins by performing these actions before it has itself had any individual experience of cell-making and without its parents ever having had any ancestral experience." While this statement represents accepted belief, it follows from what I have already said of the bee that it is essentially untrue. The worker could no more begin to secrete wax and build cells until it had acquired a certain age than could mammals secret the lacteal fluid before a certain age; and during its early life as an adult it had the experience of its older fellows to guide it, were such guidance necessary. The example chosen by Romanes was simply unfortunate. To understand the development of the cell-building instinct, we must consider the stages of its development as illustrated in the varying forms of cells yet existing, from the cruder cells of Bombus on, and remember that each step in the more perfect building has been accompanied by structural modifications, and that the instincts have been accumulated and perfected by heredity *pari passu* with the structures; further that the habit probably became so firmly fixed before the neuters had been differentiated, that it has been transmitted since that time through the queen, though she herself no longer possesses it; further that while instinctive performance is ordinarily inevitable, it yet varies in the amount of its fixity and accuracy and often leads astray or fails; and, finally, that it is often modified by individual experience or reason, or by communal interest or necessity—these truths applying particularly to the social insects, and in a variable degree to all animals.

to within recent years, have been so effectually discarded that they are even renounced by the more advanced theologians. I refer to the belief that organisms were specially created as they now exist, and that man was apart from, and not a part of, the rest of the animal world. It is my judgment that a third equally prevalent notion is essentially false, and will have to be abandoned before we can properly appreciate the psychology of animals. I refer to the notion that the lower animals do not reason, and are incapable of conscious reflection and thought. It would be easy to occupy your time for hours with accounts of their actions which can be explained only upon the views here set forth, and which are utterly at variance with the popular notions and prejudices.

The insects to which I have referred to-night are admitted to be among the more intelligent of their class; but they are only illustrations of an intelligence which is found throughout the other orders, and which impresses us in proportion as we study it and come to realize and recognize it. We can never properly appreciate, nor properly bring ourselves into sympathy with these lower creatures, until we recognize that they are actuated by the same kind of intelligence as we ourselves. There are certain acts which all creatures necessarily perform, as an outgrowth of their organization. These are essentially the instinctive acts, and are, for the most part, inevitable and often unconscious. A great many of the acts of rational men are, in this view, instinctive, and from birth to maturity many of them are prompted solely by the consecutive development of different parts of the organization, and are much less the result of training and teaching than is generally believed. Most of the acts of insects are instinctive and explicable upon this same view, but no one can study them carefully and without bias and not feel that these instinctive and inevitable actions are associated with many others which result from the possession of intelligence—of conscious reasoning and reflective powers. In this view of the case is the whole world truly kin, and is man brought more fully into sympathy with and appreciation of it.

Is it not significant also, that, just as in man, among mammalia, the higher intellectual development and social organization is found correlated with the longest period of dependent infancy; that this helpless infancy has been, in fact, as Fiske has shown, a prime influence in the origin, through family, clan, tribe and state, of organized civilization; so in the insect world we find the same correlation between the highest intelligence and dependent infancy, and are justified in concluding that the latter is, in the social Hymenoptera as in man, in the same way the cause of the high organization, and division of labor so charateristic of them!

HEREDITY: NATURAL SELECTION.

The application of the principle of natural selection to the production of neuter insects, and especially to the production of neuter insects of diversified form, seems, at first sight, impossible. Indeed, we know that Darwin felt that this question of neuter insects was one of the most difficult to deal with in connection with his grand generalization. Weismann, who believes in the all-sufficiency of natural selection, insists, and has within the past year, in his controversies with Herbert Spencer, emphasized his belief, that these neuter insects absolutely preclude the idea of the transmission of acquired characters, and endeavors to explain their occurance by his own peculiar theories as to modification taking place in the germ plasm. I shall certainly not attempt, in the limited time that I may yet hope to hold your attention, to discuss in detail the views held whether by Weismann or his opponents;* but I will venture to show that, while

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*The chief argument in favor of Weismann's theory of heredity is that it is an earnest attempt to establish a basis in observed histologic and embryologic facts. The idea of the continuity or "immortality" (using the word in his own qualified use of it) of the germ plasm is a bold one which gives us at least a conceivable and material basis of reproduction, and is justified, though not absolutely, in the facts referred to and in the history of the Protozoa. One of the chief arguments against it is, in my judgment, that, inasmuch as it precludes the transmission of impressions on the soma, i. e., individually acquired characters, Weismann has, in order to sustain the theory, been led to question and finally to deny the transmissibility of such acquired characters. It is difficult to formulate the later modifications of the original theory without using many Weismannisms, themselves requiring chapters of explanation; but that variation is due to direct effects on the germ plasm by inequalities of nutrition, is, I believe, a correct statement of his latest views. The trouble with all theories of reproduction and heredity based solely on observed microscopic facts, is that the essence, the life principle, the potential factors, must always escape such methods. Wherefore any theory that will hold must cover the psychical as well as the physical facts —the total of well established experience—and this truth was doubtless the social insects offer the most serious obstacles to the acceptance of the theory of natural selection as an all-sufficient theory to explain the phenomena, yet the facts are perfectly explicable upon the general principles that have governed the modification of organisms, among which that of natural selection plays an important, but limited part.

In the economy of the Hive Bee we have seen that all the neuters are structurally alike, and that the different functions which they perform result from inherited tendencies or structural peculiarities developed at different ages. There are some records of abnormal workers, small drones, and slight variations in the amount of arrestation of development; but on the whole the three classes of queen, worker and drone are remarkably well differentiated and fixed. We have seen that the differences in the two former classes result from conditions of food, treatment and environment of the young, and are under the control of the colony. Each fertile egg has the potentiality of developing a fertile queen, and as the neuters, under exceptional conditions, are able to lay eggs which invariably produce drones, the queen, through such drones, must occasionally inherit indirectly from the workers. At bottom, however, the differentiation between the workers and the queen is purely a matter of food and bringing up, or *education*, as the French would more correctly call it. In other words, the ultimate result is decided for each generation in the treatment of the young or the larvæ. The drone results from an unfertilized egg, and as the egg is only fertilized when the tip of the queen's abdomen is pressed into a worker cell, and not when thrust into a drone cell, the production of drones is also under control of the colony.

I have already called attention to the fact that other species

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recognized by Darwin in framing his tentative theory of pangenesis.

Weismann's efforts to derive a physical theory of reproduction and evolution find a paralell in the efforts of those entomological histologists who, starting with the conception that the development of the individual was but an unfolding of structures already nascent in the embryo, expected to find—and even claim to have found—all the structures of the imago represented, *en petit*, in the larva. In truth, however, there is a total re-adjustment of cells, and development *de novo* of organs, with each important change or molt, and the vital force which impels this development, whether of the minutest bodily structure or the subtlest intellectual attribute, is the great mystery beyond explanation.

of bees show gradations in these two kinds of females, and that some species permit more than one queen or fertile female in the colony and would refer for further details, both as to present gradations and variations to the Notes, especially numbers 1, 2, 3, and 4. Natural selection, if it has played any part at all, must have done so chiefly in the manner ingeniously suggested by Darwin himself, namely, not as between individuals, but as between colonies. The tendency to produce arrested females or neuters doubtless became fixed in some ancestral form through social selection, and is kept up by this and colony selection.

In the wasps we have a very different state of things, involving the parthenogenetic production of arrested females and the seasonal production of fully developed forms of both sexes. Here again, the evidence all goes to show that the differences depend for each generation on the environment, food and method of nurture of the larva, the tendency having become fixed in varying degrees in the different species, and only so fixed by being transmitted through the queen or sexually perfect females. So far as natural selection has acted at all, it has acted on the potentiality or inherited tendencies of these females. Very exact information is not yet at hand as to how far the neuters are variable, whether as to condition of the reproductive organs or as to size. But judging merely by mounted specimens which I have examined in various species, it is probable that there is some variation in these respects, though the three classes are quite neatly differentiated, much as in the bees.

When it comes to the ants, the problem is more complicated; but we may safely assume that the different forms have been brought about by the same influences. In a large colony of individuals, where size and character are not fixed by a definite cradle, but where the young larvæ are free and are carried about, nursed and fed by the workers, there would naturally arise greater variations between individuals, and while the kind of nourishment, or the kind of nurture, or the age of the female at the time the ova are produced, or the season of the year, have doubtless all contributed to the variation, and may still independently contribute to it at the present time; yet, whatever the causes of this variation, it has become fixed in certain definite lines that are more or less useful to the species. Whether or not the proportion of the different individuals is under the control of the colony as a whole, by virtue of the treatment of the larva, it will always be difficult to prove, though there is every reason to believe that, as in the bees, there is, to some extent, such control, and that the relative proportions of the different forms will depend upon circumstances. But the fact remains that, in ants, as in bees and wasps, the neuters are but arrested females, and are capable of becoming, under exceptional circumstances, fertile, and that we see in the different species all gradations, not only as to the number of forms of the workers, but as to the number of fertile females that are allowed in the same colony to provide for the continuance of the species. We also find in the same species great variation and gradation in the characters of the different sets which form the community, especially between the different forms of workers, in contrast to what I have remarked as to bees and wasps. This has been recorded not only by writers like Darwin and Lubbock, but by all who have given close attention to the subject; while Ch. Lespès (*Ann. des Sciences Nat.* (4) 20, pp. 241–251) in his "Observations sur les Fourmis Neutres" has shown that all neuters have traces of the female reproductive organs; that these traces vary in the different species; and that where there are two forms of neuters these pass insensibly into each other through intermediate forms. The ants thus furnish us with varying degrees of social organization when the different species are considered, while the different classes in the same species are not as definitely fixed as in the bees or the wasps.

Now it were comparatively easy to account for these neuters among the social Hymenoptera and the different forms and attributes which they present, by putting aside natural selection, as expounded by Darwin, and substituting therefor social selection acting not on generations in time, but on the individual at once by the manner of its bringing up; and surely there would seem to be sufficient justification for this course when we find not only such great physiological and functional, but such profound structural modifications induced by larval environment and nurture, as I have pointed out, especially between the queen and the worker bee.* This has, in fact, been the chief explanation which

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*Mr. Herbert Spencer, in one of his rejoiners to Prof. Weismann, (*Contemporary Review*, December, 1893) refers to a chapter on The Determination of Sex by Prof. Geddes and Mr. Thompson in their "Evolution of Sex," I have offered for the facts, in discussions with friends and before the society, limiting the action of natural selection to colonies as a whole. Few persons who have not had large experience in rearing insects can appreciate the full influence of larval environment and food on the ultimate imago, or the power of larval accomodation to various conditions. All insects in the larva state possess this power, within varying limits, and it is nowhere more marked than in the Aculeate Hymenoptera. I have called attention to it on numerous occasions* when treating of parasitic species, and it is particularly noticeable in the fossorial Hymenoptera and the Meloïdæ. Size, especially, may easily be dimin-

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where they state that "such conditions as deficient or abnormal food" and others "causing preponderances of waste over repair * * * tend to result in the production of males," while "abundant and rich nutrition" and other conditions which "favor constructive processes * * * result in the production of females." He then cites J. H. Fabre's statement that in the nests of *Osmia tricornis* the eggs at the bottom of the cell which are first laid and accompanied by much food, produce females, while those at the top, laid last and accompanied by one-half or one-third the quantity of food, produce males. (Souvenirs Entomologiques, 3ème série, page 328). He further refers to Hüber's observations, that the queen bee only lays eggs of drones when declining nutrition or exhaustion has set in, and that when the workers in bees and wasps lay eggs, these produce drones.

These statements are not entirely justified. I cannot speak positively of Fabre's observations, though I suspect something back of the larval food-supply which has fixed the sex and determined the treatment of the larva. But the queen bee produces drones at any age by the egg passing into the drone cell and not being impregnated in passing the spermotheca. She produces drones only when she is superannuated, because the spermatozoa have become exhausted. In wasps it is just the contrary, the unimpregnated egg producing ordinarily, not a drone or a male, but a female. I have already called attention to the ease with which erroneous conclusions are drawn in this matter of regulating sex by food of larvæ, *ex ovo* (Am. Naturalist, Vol. VII, pp. 513–531, September, 1873) and the evidence would seem to show that the influence is confined to arrestation or modification of the sex without changing it. The subject is, however, most intricate, and further experimental facts are needed. Spencer's conclusion is, nevertheless, generally true, namely: "*that one set of differences in structure and instincts is determined by nutrition before the egg is laid, and a further set of differences in structure and instincts is determined by nutrition after the egg is laid.*"

*See notes on *Tiphia inornata*, Sixth Report on the Insects of Missouri, p. 123, and upon Blister-beetles, First Report U. S. Entomological Commission, pp. 295–302, ished one-half or more, or fully doubled, from the normal, by limiting or increasing the supply of food, as I have proved with Pelopaeus.

But when we come to the facts in the economy of the Termites, this explanation does not hold good to the same degree. Here we find still greater diversity in form than even among ants, under circumstances where control of these forms by the colony itself must be much less, but nevertheless does occur. The young Termite is to a limited extent, and during early life only, provided with food by members of the colony, and from birth is essentially a free moving agent, less dependent on the adults. We have much yet to learn as to the actual facts, which would seem also to vary in different species. Thus in Eutermes Mr. Hubbard believes, but I think wrongfully, that the young feed on nodules, specially prepared, of comminuted and doubtless partly digested material, while Fritz Müller believes that they feed on a fungus mycelium which develops on such prepared substance. The truth with most species seems to be that they are fed on a semi-liquid fluid disgorged from the mouth, whether of the workers or the undeveloped queens; while in some cases they are fed from a secretion from the anus. (See Note 6.) In these respects and in the early helplessness of the larvæ, they closely approximate the social Hymenoptera.

Similar variations to those found in social insects, whether sexual or seasonal, are extremely common among insects which are not social, as is well exemplified by the long category of phytophagic variation, secondary sexual characters, and of dimorphism and heteromorphism among insects. These variations in non-social insects are often equally as marked and as curious, structurally, as they are among social species. They are also, except, perhaps, the secondary sexual characters and the variations which take on the form of mimicry, equally difficult to explain on any view of natural selection that is all-sufficient. On the whole, then, it may safely be said that the production of neuter insects is determined in each generation by the colony itself, in the manner in which the larvæ are fed and reared. In so far as this is true, it is outside the domain of natural selection, and speaks eloquently in favor of the various other causes of variation and modification which have been insisted upon by many of our leading American biologists, and which I have repeatedly urged in my own writings.* The tendency to such production was doubtless developed in the ancestors of the present species, and we may even trace the steps by studying the gradations in existing species.

The facts connected with the social insects which I have considered, present the strongest argument in favor of the heredity of acquired characters and tendencies. Competition has been between colonies rather than individuals, and those colonies which have acquired, through heredity, the habit of producing, through one or more fertile females, the different forms which have proved useful in the social economy, have, in the course of time, survived others in which such tendency was less pronounced. Yet various steps in the process are yet manifest in the different species, and under these circumstances it seems to me foolish to insist that the fixed habit in one species has, *per se*, any especial advantage over the less fixed habit in others which still maintain themselves. I need hardly say to the members of this Society who are familiar with my views as to the causes of variation, that it does not follow in my mind that the different forms of Termites, for instance, that are found in the colonies of some species, are all essential, but that some of the forms may be advantageous, others only partially so, and still others purely fortuitous. The tendency to vary—an inherent property in all organisms—has shown itself among the individuals of these different colonies. These variations have been guided by natural selection among colonies, and by what I have just referred to as social selection among individuals, along certain lines which are most useful. In other cases the variation has accumulated along lines of secondary utility; while in yet others it has gone along lines which are purely fortuitous and still most variable and unfixed—natural selection playing little or no part in these. In species with the less complete social organization, the existing variations will be greatest; while the structures and functions have become most fixed and show least tendency to vary in those species which have become most specialized and perfect in their social economy. It is very questionable, however, whether, in the struggle for existence, this greater specialization and fixity give the species any

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*See more particularly the address before Section F, at the Cleveland (1888) meeting of the A. A. A. S., and the paper before this Society "On the Interrelations of Plants and Insects," Vol. VII, pp. 81–104 (May, 1892).

advantage over another which is more elastic and variable. On the contrary there are many facts which go to show that extreme specialization is a disadvantage and the precursor of decrease and ultimate extinction. So that natural selection, in this light, if limited, as its exponents have limited it, to the production of characters absolutely essential or useful to the species, must play a yet more restricted part in organic variation than even I have allotted to it. Social selection, as here expounded, implies, it is true, a degree of intelligence which has unusually been denied these creatures; but the phenomena are some of them inexplicable upon any other theory, and I have, I hope, already shown how little reason we have for denying them such intelligence.

In a certain way the production of these specialized individuals in a colony of insects may be likened to the production of specialized individuals in a human community. In new countries, like our own, the specialization has not become so marked, but in the older communities of the world, the life of the individual, and especially the early training and environment, produce certain characteristics which permit us to stamp at once the typical sailor, soldier or butcher, the various artisans and the men of various professions. They undergo essential modifications in mind and body. Yet there is no question—or very little—of selection, whether natural or artificial. The tendency to vary in given directions becomes fixed through heredity, since the characteristics of different nationalities in comparison with each other cannot be so well explained upon any other view. Certain types persist, and the same laws which will explain the recurrence and persistence in a promiscuous community of, say, the red-headed type, whether that of atavism or any other be adduced, will undoubtedly apply to the persistency of types in the social insects. That no material or mosaic theory of heredity yet propounded is satisfactory, as accounting for the facts, does not affect the question, and that natural selection, as expounded by Weismann and the ultra-Darwinians, fails to explain the phenomena, is the very best evidence that too much is claimed for the theory.

INVERTEBRATE VS. VERTEBRATE.

I used to be fond of speculating as to the possibilities of the articulate type as exemplified in the ant, in comparison with the vertebrate type as exemplified in man, had the former continued its development so as to approximate, say, the eagle in bodily size and man in brain development. That the Arthropod type could attain to such dimensions is evidenced in the Eurypterus or water scorpion which prevailed in early geologic times, and attained a length of six feet; while a modern Japanese crab (*Megachilus kampferi*) has a spread of ten or twelve feet, and is a formidable creature.

For very much the same selfish reasons that begot most of our earlier notions as to man's origin and place, it has been assumed that he represents the perfection of the animal organization, the highest expression of an all-wise Creator. Following this same idea, our own world, it has been reasoned, is the only one peopled. Now it has never seemed to me that there was any justification for the assumption that existing forms of plants or animals must of necessity have assumed the physical or mental characteristics which belong to them, considering the myriad forms which have preceded us and gone, or the many which are yet with us, but fast going. Remembering, also, that the race is not always to the swift, nor the battle to the strong, there would seem to be no valid reason why, on some other sphere, under like, or even under unlike conditions, life may not have taken on other distinctive types or attained developments inconceivable to us; or, for that matter, why it might not have been differently manifested upon our own little earth.

Place the directing enginery of the human brain in a body with a hard, external skeleton, which should at once be a defensive armor against exterior attack, a protection to all the vital organs, and yet allow free play to every possible movement; with a breathing system that is multiple, and therefore less liable to get out of order than where it is concentrated in one place; with six or more legs; extremities variously differentiated, so as to enable one pair of them to perform the functions of our hands, while other pairs possessed greater prehensile, tactile or other specialized powers; with powerful primary and with supplemental jaws; with all the senses and sense organs we possess and others added; with simple and compound or telescopic eyes combined in the same individual; with a venomous, offensive and defensive weapon; with a social organization in which working, fighting and reproductive elements are well differentiated and yet under control; with the power of aërial flight developed when wanted; with a reproductive system that permits of great prolificacy and yet avoids all the dangers of placental birth; with the power of temporarily suspending the active life functions when necessary; and, finally, with the power of such renewal of both the softer and harder tissues of the body as ecdysis involves—and you have in fancy a creature which would easily make the earth and all the fullness thereof its own.

The great industry exhibited by social insects has been a favorite topic wherewith to point a moral to the sluggard; but I venture to suggest that their economies, if they do not point other morals, are extremely suggestive to man. With all their other traits, so comparable to those characteristic of human society, they will hardly be charged with the possession or practice of any theology; yet we may look in vain, among all the nations of the earth, unless, indeed, among the similarly unblessed aborigines of Borneo and some other lands, for greater self-sacrifice or courage in defending the common weal; for greater loyalty to the sovereign head of the community, not made by divine right, but practically chosen by the commoners; for greater attention or care in the education of the helpless young, or for more harmonious or friendly action between the individuals that form the community. Without form or ceremony they have developed an altruism which with us is believed to exemplify the highest phase of civilization.

Nor am I quite sure that they have not solved the social problem in a way that, so far as the good of the community as well as the individual is concerned, has marked advantages over the many varied attempts in the same direction by mankind in different parts of the world. If a large proportion of the units of both sexes which go to make up human society could be so brought up and trained that the sexual instincts remained permanently arrested and undeveloped, while along with this arrestation in this particular there went an increasing intellectual development and energy, to be expended in profitable industry, what a large share of vice and misery in human society might be avoided, and what a large amount of increased happiness among the multitude might thus be secured, since in the end, intellectual and bodily activities, freed as far as possible from all baser passions, bring us the highest happiness that we can realize!

APPENDIX.

Note 1.—The principal Races of Apis mellifica.

The common form of this species, known as the Brown, the Black or the *German* bee, is the best-known. It is found throughout northern Europe, and as far south as central Austria, central Switzerland, and southern France to the Italian frontier. It also occurs in Portugal and Spain, and extends into Siberia, and, during later centuries, has been introduced into North and South America, many of the Pacific islands, and into Australia.

Its chief merits are that it has a moderate swarming propensity and is an excellent comb-builder and honey gatherer, and accommodates itself to the greatest extremes of climate. Its disadvantages, as compared with some other varieties, are a disposition to rob, to attack persons who approach the hive and to be somewhat less industrious. The general color is a dull brown, lighter on the thorax, the queens nearly black.

The *Heath* and *Brabant* bees, sub-varieties, occuring in the heath districts of northern Germany, are much given to swarming, a habit which has become fixed by the stimulative feeding in spring practised by the bee-keepers there for at least two hundred years.

The *Italian* or *Ligurian* bee, originally confined to Italy, Sicily, Sardinia, the southern Tyrol, and southern Switzerland, has now been introduced into most countries where the common black bee occurs. It is gentler in disposition, but not so good a comb-builder and, with a more tender constitution, does not thrive in extreme northern climates.

The color of the Italians is in general much brighter, and the first three segments of the abdomen are golden-yellow on their dorsal surfaces. Its qualities and its color have become fairly well fixed by artificial selection which there is every reason to believe has been practised in Italy for some two thousand years. Both Virgil and Columella evidently refer to it, the former (Georgics IV, 98) speaking of two kinds of bees, the better of which he describes as having shining bodies, variegated like drops of gold. The tendency to vary under domestication at the present time would indicate that the the race is a composite one, and Mr. Frank Benton informs me that by crossing the Egyptian, the Palestine or the Syrian with the common brown German race, workers are produced in a few generations that can scarcely be distinguished from Italians; a fact which as regards the Egyptains, was ascertained by the Berlin Acclimatization Society which, some 30 years ago, experimented with the honey bees native to Egypt, and which Mr. Benton has since confirmed by tests with the other two races (Palestine and Syrian). He finds also, that the Syrian tpye leads, when crossed with the common brown race, most commonly to the Italian type, a fact which is significant when we remember that the Phœnicians—ancient inhabitants of Syria—established colonies in southern Italy at a very early date. We can hardly realize to-day the importance that was attached to the production of honey and wax in Egypt and the surrounding countries in those days, until we remember the uses to which these articles were put in connection with the religious rites of the people, and especially the embalming of the dead, as well as the relative importance of honey in those early days in the absence of the many other sweets which we possess. In the United States the Italian race, by selection since its introduction a third of a century ago,* has undergone more rapid modification than any of the other races, though

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*See a paper by the author on "What the Department of Agriculture has done for Apiculture." Proc. North American Bee Keepers' Association, 1893.

greater efforts, proportionately, have been made with these—another fact which would indicate that the Italian type is less fixed than some of the oriental races.

The *Carniolan* race is confined to Carniola, Austria, and the adjoining provinces, and is a local type developed by some centuries of peculiar treatment with little intermixture of outside blood. This race is somewhat larger than the others, exceedingly robust, the distinctive color-mark being light gray varying to steel blue, the abdominal segments being all edged with pubescence of this color and the thorax thickly set with the same. The race is characterized by great prolificacy, which can be traced to the constant stimulative feeding early in the season, and by a very mild disposition, a result which would seem to be due to the frequent manipulation of the hives, migratory bee-keeping having been practised for centuries in Carniola.

The *Cecropian*, *Attic*, or *Hymettus* bees of Greece, on the other hand, though similar to the Carnioian race in markings, are exceedingly irritable, as a result, doubtless, of their being very little manipulated or interferred with.

The *Tunisian* bees are found in Tripoli, Tunis, and Algeria, where they are extensively cultivated by the natives. The type is uniformly dark in color. The queens are very prolific and when preparing to swarm 200 to 300 queen-cells are often constructed, instead of only 8 to 10 as is usual with the ordinary race. The workers are small, very active, irritable and vindictive. Because of this and the fact that they do not winter well, in consequence of prolonging the brood season, their introduction has been very limited.

The *Egyptians*, or the bees found all over northeastern Africa, and which for several thousand years have been extensively cultivated in Egypt, possess very marked characteristics as regards color, form and habits, and have been regarded by many as worthy of specific rank, having been described by Latreille as *Apis fasciata*. The workers are small-bodied, slender, covered with a dense, light gray pubescence, and the abdominal segments are edged on their dorsal surfaces with a lemon-yellow color, giving with the gray pubescense a banded effect. They do not withstand our winters and are easily angered by manipulation, not being amenable to smoke like European bees. The queens are prolific and when the colonies are made queenless great numbers of workers commence depositing eggs at once.

The *Palestines* and *Syrians* possess many of the qualities and characteristics of Egyptians; yet the queens, workers and drones are readily distinguishable from those of the latter, being less yellow and larger bodied, especially the Syrians. They are marked varieties, more fixed than the Italian, and evidently forming, with other eastern Mediterranean bees, an Oriental group having allied characteristics and of which the Egyptian is the extreme type.

The *Caucasian* and *Smyrnian* races vary more than the other Oriental races. In specimens from Smyrna the light yellow coloration of the abdominal segments noted farther south is found to be replaced by a darker yellow and the light gray pubescence by a less dense and darker gray, often brownish, pubescence. Queens, workers and drones are larger bodied and variations in temper and habit may also be noted.

The *Cyprian* race, having been isolated for a long period, is, as might be expected, a very fixed one—the most thoroughly so of any race of bees yet brought to this country, and transmits its peculiar markings and characteristics through many generations of crosses with any other known type. In general it resembles the race found on the adjacent mainland, whence it was probably brought by the early Phœnicians who colonized Cyprus. Very characteristic markings of this variety are the bright yellow lunule which the postscutellum shows and the bright yellow of the ventral surface of the abdomen clear to the tip. The conditions under which this race has been established have resulted in the survival of a hardy, active race, capable of procuring a living and storing a surplus where others could barely subsist.

The literature refers almost entirely to the older countries of Europe and the East. Some modification has doubtless taken place in the tropical parts of America but the subject has not yet been sufficiently studied in those countries.

Note 2.—The Species of Apis with their Varieties.

(1) *Apis mellifica*, L. as indicated in Note 1, is found in all the countries of Europe, and extends over the whole of Asia Minor into the Syrian Desert and south into Arabia. It occupies all the islands of the Mediterranean and has spread through all the northern countries of Africa southward into the Desert of Sahara. South Africa has one or two varieties belonging to the species, while the representatives of the genus found in Senegal and the Congo country doubtless belong to this species, as do those of Madagascar. It has been permanently introduced into Australia, Tasmania, New Zealand and many of the islands of the Pacific ocean. Whether the honey bees reported from northern India belong to this species or not, has not been definitely ascertained. It is also more than probable that the honey bee of China, described under the name of *Apis sinensis*, is but a variety of this species. In North and South America it is evidently introduced, and has spread into some of the adjacent islands. There is a difference of opinion as to whether the honey bee native to Egypt, which Latreille describes as *Apis fasciata*, should have specific rank or be regarded as a variety of *mellifica*. While Frederick Smith, who was one of our best authorities, was inclined to attribute to it specific value, the fact that it interbreeds with *mellifica*, producing fertile offspring, would rather confirm the opposite view. Respecting the honey bees of Tasmania, Senegal, the Congo and Madagascar, our information is insufficient to permit us to say whether they are specifically distinct or not, and the same may be said of the Hazara, Bhootan, and Bushar bees of northern India and other more or less distinct types found in Japan.

(2) *Apis indica* Fabr. The extent of territory occupied by this small East Indian bee is not definitely known, although it has been definitely reported from northern and southern India, Ceylon, Farther India and Java. *Apis nigrocincta*; *A. socialis*, Latr.; *A. delesserti* Guer.; *A. perrottetii* Guér. and *A. peronii* Latr. are probably only varieties of *A. indica*.

(3) *Apis florea* Fabr. This, the smallest bee of India, is found generally in southern India and Ceylon, and there are indications, that it is common to other portions of the East Indies. *Apis lobata* described by F. Smith in his first catalogue, is dropped from the second edition.

(4) *Apis dorsata* Fabr.
=*nigripennis* Latr.
=*bicolor* Klug.
=*testacea*.

It is somewhat questionable whether the names here given as synonymous are such, or names of true varieties of *dorsata*. *A. dorsata*, known as the Giant East Indian Bee, is found in British India, Ceylon, Farther India and the Dutch East Indies.

(5) *Apis zonata* Guérin. Found in the Philippine Islands and Celebes. Mr. F. Smith enumerated this as worthy of specific rank, when he revised his catalogue in 1876. He referred to its greater size and difference in form of the metatarsus compared with that of *A. dorsata*. But Gerstaecker asserted in 1865 that this difference in structure of the metatarsus does not exist—is "purely imaginary".

Mr. Frank Benton, to whom I am under obligations for valuable information on this subject, has kindly prepared for me the following table as indicating his own ideas of the grouping of the species of Apis, and the known varieties of these.

The Species of Apis with their Varieties.

Apis mellifica* *Linn.*

Race.—Common Brown, Black, or German.—Hab.: Central, northern and northwestern Europe; introduced into N. and S. America, Australia, New Zealand and Pacific Islands.
  Sub-var.—Heath.—Hab.: Heath districts of North Germany.
  Sub-var.—Brabant or Small Holland.—Hab.: Brabant (Holland and Belgium).
Race.—Carniolan.—Hab.: Carniola, Carinthia (Aus.). A distinct var.
  Sub-var.—Hungarian.—Hab.: Northwestern Hungary.
Race.—Dalmatian.—Hab.: Dalmatia (Austria).
Race.—Herzegovinian.—Hab.: Herzegovina (Austria).
Race.—Cecropian, Attic or Hymettus.—Hab.: Greece and the adjacent islands.
Var.—*ligustica* Spin., Ligurian or Italian.—Hab.: Italy and adjacent islands. S. Switzerland, and S. Tyrol; introduced into other parts of Europe, N. and S. America, Australia and New Zealand.
Var.—†*rufescens*—Hab.:—Tasmania (acc'd to M. Girard).
Var.—†*nigritarum* St. Farg.—Hab.: Congo (Africa).
Var.—†**adansoni* Latr.—Hab.: Senegal (Africa).
Var.—*scutellata* St. Farg.—Hab.: South Africa.
Var.—*caffra* St. Farg.—Hab.: South Africa.
Race.—Tunisian.—Hab.: Tunis, Algeria.
  Sub-var.—Minorcan.—Hab.: Balearic Islands (Spain).
Var.—†**unicolor* Latr.—Hab.: Madagascar; intr. into islands of Bourbon and Mauritius.
Race.—Smyrnian.—Hab.: Asia Minor.
Race.—Caucasian.—Hab.: Caucasus.
Race.—Cyprian.—Hab.: Island of Cyprus. A very distinct var.
Race.—Syrian.—Hab.: Syria, northward from Mr. Carmel.
Race.—Palestine.—Hab.: Palestine.
Var.—*fasciata* Latr.—Hab.: Egypt.

Apis sp.

Race.—Hazara.—Hab.: Hazara District, Punjab (India).
Var.—**sinensis*.—Chinese bee.—Hab.: China.
  =*cerana* Fabr.
Race.—Bushar.—Hab.: Bushar District, Punjab (India).
Race.—Japanese
  1. "Grayish yellow bee."
  2. "Bee with yellow spots." Hab.: Prov. Sinano.
  3. "Small brown bee."—Hab.: Hikigoie (Satsuma)
Race.—Boohtan.—Hab.: Boohtan (India).

It is very probable that further investigation of this group will bring four of its varieties under *A. mellifica*, and the last one under *A. indica*.

Apis

**indica* Fabr., Small East Indian bee.—Hab.: British and Dutch East Indies.
  =*socialis* Latr.—Hab.: Bengal.
  =*delesserti* Guér.—Hab.: Pondicherry.
  =*perrottetii* Guér.—Hab.: India.
  =*peronii* Lat..—Hab.; India.
Var. (?)—**nigrocincta*.—Hab.: "Celebes, Borneo, etc." (acc'd to F. Smith.

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*Regarded by Frederick Smith as good species.

†Not positively known that they will interbreed with *Apis mellifica*. All others named under *A. mellifica* will do so.

Apis
**florea* Fabr.—Hab.: India, Ceylon, Borneo.
=*lobata* Smith.—Hab.: India.

Apis
**dorsata* Fabr.—Hab.: British India, Ceylon, Farther India, Dutch East Indies.
=*bicolor* Klug.
Var.—*nigripennis* Latr.—Hab.: Bengal.
Var.—*testacea* Smith.—Hab.: Timor.

Apis
**zonata* Guér.—Hab.: Philippine Islands, Celebes.
This may prove but a variety of *A. dorsata.*

Note 3.—Polliniferous Organs in Bees.

The modification of structure and hairy vestiture (see Fig. 2) to facilitate the collection and transportation of pollen is, perhaps, exhibited in its most perfect development in the Hive Bee. That these peculiarities have been evolved from those possessed by less specialized species of social bees, represented by existing Meliponae and Bombi, and still more remotely from those of solitary bees, will not be questioned by those who study the steps in the process as exemplified in modern species.

The pollen of flowers is variously collected by different bees, and different parts of the body are specially developed for this purpose. But in the Hive Bee the specialized polliniferous apparatus is limited to the posterior legs, and in these to the tibia and the basal joint of the tarsus, so that the development of these parts only need be traced.

In the case of the tibia the first thing to be noted is the entire absence of the tibial spurs, which are present in all Hymenoptera except the genus Apis, and its near allies Melipona and Trigona. The tibia and first tarsal joint are greatly broadened and more or less concave exteriorly, and the latter is extraordinarily enlarged, so that it is nearly equal in size to the tibia. The outer surface of this modified tarsal joint is not remarkable and has no specific function, but the inner surface is divided into transverse rows of stiff spines or combs, reddish in color, the rows slightly overlapping and elevated at a slight angle from the surface of the joint. The function of this series of combs is to collect the pollen grains which become entanled in the feathery hairs of the thorax of the insect, and an examination will almost invariably discover more or less of the grains of pollen in these combs. During the collecting of honey and pollen the bee is constantly passing the face of this tarsal joint over its abdomen, removing the pollen grains from time to time, and emptying the load of pollen into the pollen-basket proper or corbiculum, on the outer face of the tibia. This, as noted, is concave, with a smooth, almost hairless exterior surface, provided at the sides with several rows of long curved hairs, which arch over either side, forming a veritable basket in which the pollen may be securely packed. As soon as the collecting combs of the tarsus are filled, the bee draws them across the strong, curved hairs of the corbicula, the right tarsus emptying into the left corbiculum and *vice versa*, until both are filled. These baskets or masses of pollen are emptied by means of the single strong tibial spine on each of the middle pair of legs, the spine being thrust beneath the load of pollen and used as a pry to loosen and remove it.

A very remarkable peculiarity of the posterior legs, but having no connection with the polliniferous apparatus, is seen at the union of tibia and first tarsal joint. These are articulated at the extreme anterior angles in such a manner that the broadened apex of one and the base of the other, work together as a sort of nippers or pincers. The tibia is armed on the inner margin with a strong, uniform row of short spines extending two-thirds of the way across. This apparatus is employed by the bees in removing the wax scales from the abdomen.

Examination of these parts in other species of Apis fails to indicate any particular modification or deviation in structure from *mellifica*. In *Apis indica* no differences whatever can be discovered; in *A. dorsata* the leg is somewhat more hairy and a few hairs occur on the outer surface of the tibia. In *A. florea* the smallest species known, the spines on the apex of the tibia are somewhat shorter and stouter and the hairs forming the corbiculum are somewhat less regular in length and arrangement.

This statement of the structure of these parts in the species of Apis will enable us to compare intelligently the similar parts in those genera most nearly allied to them, tracing the variation through these to the more widely divergent forms. The genera Melipona and Trigona include bees which are closest to Apis in general structure and habits, and agree also in the absence of the tibial spines of the posterior legs. We find, as might be inferred, a very close correspondence in the polliniferous apparatus, which, in all essential details, is practically the same as in Apis. The pollen-collecting combs on the inner surface of the first tarsal joint are absent, or rather their place is supplied by a uniform clothing of short stiff spines which are not arranged transversely in rows, as in Apis, but serve the same purpose. This joint also differs in shape from that in Apis, by being suddenly narrowed or excavated toward the base so that the nippers noted in the former genus for the removal of the wax are practically wanting, although the row of stiff spines at the apex of the tibia is still present, but somewhat reduced. A very peculiar tuft of strong, curved spines occurs, in the two genera mentioned, at the anterior outer angle of the tibia. This has no counterpart in any other bees and its function is problematical.

In the case of Bombus, the lowest of the social bees, there is at once a greater divergence from Apis and at the same time a resemblence to it in certain features of the hind legs and polliniferous apparatus. The tibial spines are very strongly and prominently developed, allying this genus to the solitary bees and other Hymenoptera, but the general structure of the tibia and first tarsal joint is practically identical with that of Apis, and the tarsal joint in this particular does not present the divergence which was noted in the case of the genera Melipona and Trigona, but has the broadly truncated basal margin forming the lower blade of the nippers, even more strongly developed than in Apis. The pollen-collecting spines on the inner face of the tarsal joint are uniformly distributed over the surface, practically as in the two genera last mentioned (Melipona and Trigona). The bordering hairs of the corbiculum are somewhat stronger and more abundant, but in all essential details the structure is identical with the same in Apis.

The solitary bees of the genus Anthophora, which is somewhat nearer Apis than any other, present distinct traces of the specialized polliniferous apparatus of this last. The enlargement of the tibia and of the first tarsal joint is quite marked, and the corbiculum is imperfectly indicated by the longer growth of hairs on the edge of the tibia, the face of the latter being also covered with shorter hairs. The brush or pollen comb on the inner surface of the tarsal joint is practically the same as in Bombus. The small row of spines at the apex of the tibia are entirely wanting, and the nippers at the junction of the tibia and metatarsus are not particularly noticeable; in fact this structure is not seen in any except the social bees which alone produce and use wax in their economy. The genus Melissodes presents a distinctly wider divergence from Apis, in that the hairy vestiture on the outer surface of the tibia and metatarsus is equally long and dense over the entire surface, showing little if any approach to the corbiculum, which, as we have seen in Anthophora, begins with the shortening of the hairs on the outer face of the tibia. In other particulars the bees of this genus are similar to Anthophora, and in both genera the pollen collected is carried interspersed among the hairs of the tibia and tarsus, being doubtless emptied or combed into them from the brush of the inner surface of the first tarsal joint, and probably removed again by the same brush in storing it in their larval cells.

Going still lower in the scale of bees, we find in Perdita a yet wider divergence from Apis in the absence of any particular dilation of the tibia and metatarsus, the posterior legs being similar to the anterior members, simple in structure, and armed with long, scattered, feathered hairs, which are generally distributed over all their surface and which entangle more or less of the pollen grains. The brush of the inner surface of the metatarsus is still present, and in fact occurs in all Apidae and Andrenidae. The genus Nomada is still less specialized, in that the legs are simple, not dilated and also practically hairless; or rather the hairs are short and simple and have no pollen-collecting capacity. In this genus the brush of the metatarsus can hardly have any other use than to keep the body of the insect clean, as these bees are pseudo-parasitic or inquilinous and do not collect or store pollen. It is a mere modification of the normal or original structure and doubtless a degeneration due to the semi-parasitic habit.

From the above review of the modification of the posterior legs as polliniferous organs in various genera of the family Apidae, it will be seen that there are first developed on the leg, hairs which are feathery and which will entangle the grains of pollen. The next step in the development is an increase in the abundance of this hairy vestiture, and a further advance occurs in the widening of the tibia and first tarsal joint, to give a greater surface for the pollen-collecting, plumose hairs. This reaches its maxium in the genus Melissodes in which the external hairs of both the tibia and the metatarsus are very long and dense and the feathering very decided. The next step toward the condition found in Apis is exhibited in Anthophora, and consists in the partial disappearance and shortening of the hairs on the outer face of the tibia and metatarsus, by which means an imperfect corbiculum is formed, foreshadowing the more complex structure of the social bees, in which it becomes quite well developed in Bombus and perfectly so in Trigona, Melipona, and Apis. In Anthophora a further modification is noted in that the hairs of the legs are practically simple and unfeathered as in the higher social bees.

In the other family of bees, the Andrenidae, we have a similar condition of things, the variation in the pollen-collecting character of the posterior legs ranging from Agapostemon to Prosopis, and showing the same gradations noted in the Apidae from Melissodes to Nomada.

The reader interested in studying how the mouth-parts and the legs have been modified in the bees by their honey and pollen gathering habits, cannot do better than consult Hermann Müllers' works* on the subject. There is almost an unbroken chain of these characters, from the highly developed bees to such as are hardly distinguishable from the fossorial wasps.

NOTE 4.—Wax-producing organs.

In all the wax-producing bees the specialized discs (see Fig. 3) on which the wax is deposited when secreted by the true glands beneath, occur on the basal half of the second to the fifth ventral segments of the abdomen, the overlapping half of each segment covering and protecting the disc of the succeeding segment. With the Hive Bee these discs are compound and two in number on each segment. They are broad, ovate, pale yellow in color, smooth, delicate and transparent, and are surrounded by a narrow thickening of the chitine of the sclerite and separated by an unmodified medio-ventral septum. This specialized structure occurs only in the workers. The queen, however, has a sub-obsolete, undivided area on the same five abdominal segments, and which in structure bears a striking resemblance to the similar area in the workers of the lower forms of social bees. The wax discs of Melipona and Trigona are practically identical, and are narrow, extending entirely across the base of the segment, not being broken, as in Apis, with a dividing septum, and also extending laterally

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*The Fertilisation of Flowers, by Prof. Hermann Müller. Translated and edited by D'Arcy W. Thompson, B. A., London, 1883.

nearly to the apex of the sclerite as in the case of the fertile female in Apis. In Bombus the structure is almost identically the same as in Melipona.

NOTE 5.—Ant Economy.

Considering the large number of species of ants, a book would be required to treat of them in detail, and volumes have been written. In this note I shall only treat of a few of the better known, to supplement the mere summary in the body of the address The most interesting of our North American species which I have had an opportunity of studying are the mound-building species of the East, the leaf-cutting species of Florida and Texas, and the honey ants of Colorado. With the aid of Mr. Th. Pergande, who has been assiduous in his studies of the family, and is perhaps our best-informed myrmecologist, I have brought together a number of notes on the habits of our North American species of Carpenter Ants and others; but they are excluded as the least important in connection with the text, and with a view of duly limiting the pages.

MOUND-BUILDING ANTS.—In this category may be classed by far the larger number of our better-known ants. The term is, however, particularly applicable to the species of the genus Formica. These ants are very much more active and industrious and typical of the family, than are the carpenter ants. Our own species inhabit, by preference, pine woods. They are pugnacious and valiant, and whenever their mound is disturbed, however slightly, will speedily cover the whole surface in one surging mass, spreading over the mound and attacking in their fury any living creature within reach. They are in fact so fierce and fearless that even man does well to avoid their mounds; for the bite is quite severe, and when multiplied indefinitely is unbearable.

The Fallow ant (*Formica exsectoides* Forel), one of our best known species and a close ally of *F. exsecta* of Europe, builds large mounds of earth, more or less mixed with other materials, especially small sticks and dried leaves of pine. These will measure all the way from two to eight feet in diameter at the base, and may be from one to three feet high. They are more or less regular and conical, full of galleries, with larger or smaller chambers which communicate with a general system of subterranean cells or cavities, which are used as store-rooms, nurseries for the young, parlors for the queens, and other purposes. The purpose of the superstructure in most mound-building ants appears to be for aëration, for the more rapid development of the larvæ, and, apparantly, to facilitate social intercouse between the individuals when not engaged in actual work. Except for the extraneous matter which gives it firmness, all the material of the mound is brought up from beneath the surface, and the inhabitants are incessantly at work, night and day, in constructing, altering and repairing. Very large colonies are often connected by secondary hills. I once had a good opportunity of studying these mounds around Ithaca, N. Y., and Dr. H. C. McCook has published a most interesting and detailed account of his observations upon this ant in the Trans. American Entomological Society for 1877, Vol. VI, page 253, and also in *The American Naturalist* for July, 1878, Vol. XII, pp. 431–445. It is particularly common in the Alleganies. There are three forms of workers, viz. major, minor and dwarf. His interesting observations will well repay reading.

It is in these mound-building ants that we find the true economy of the division of labor. While large numbers are ceaselessly building and mining, so as to keep the formicary in good condition, repairing or increasing its size, so as to accommodate the growing numbers, others are busily engaged in scouring the surrounding country for food, both for themselves, for the multitude of those who stay at home, and for the young. In these expeditions they never hesitate to attack any other insect that may be in their way, no matter how much larger than themselves, and what they lack in power individually they make up in numbers. Still others again are running over the trees and shrubs and other plants, searching for plant-lice, from which they gather the sweet rejectamenta, gorging themselves frequently to such an extent that they return home with difficulty. This honey is used chiefly for feeding the larvae.

HONEY ANTS.—There is really but one Honey Ant, strictly speaking, viz, *Myrmecocystus melliger* Llave (*M. mexicanus* Westm.), in North America, and this ranges from Mexico to Colorado. Other species occur in other parts of the world, with somewhat similar habits, and one is especially mentioned by Lubbock from Australia (*Camponotus inflatus* Lubb.) which has undergone precisely the same modifications, though belonging to a distinct genus, a most interesting fact, since it shows that the modification has arisen independently. The honey collected and stored by these ants has little value commercially, first, because of its rather poor quality; secondly, because of its small quantity—barely more than half a pint to each colony—obtainable; and, thirdly, because of the difficulty of colonizing or in any way commercially manipulating the ants. The insect must be crushed to obtain the honey. Yet it is sought for by the Mexican Indians, and used to a considerable extent. The formicaries are little truncated cones from two to three inches high, and usually less than a foot in diameter. They have a tubular channel, a few inches in diameter, leading from the central opening to the interior, to a depth of six inches or more below the general surface. Here are often found one or more dome-like vaults or honey-chambers, about an inch deep by about three inches in width. Hanging from the roughened roof of these chambers may, at any time, be found numbers of the honey-bearers, with immensely swollen abdomens and looking, when congregated, like a series of small grapes or large currants, with the same translucency which these possess. These individuals have little capacity for movement, and indeed move but little. They are but living receptacles of the sweets which are gathered by the real workers, and the food-supply of the rest of the colony is only drawn from these stationary honey reserves, or animated honey pots, as Lubbock calls them, when necessity requires. The modifications are confined to the abdominal portion of the digestive organs. The honey is gathered from a little Cynipid oak-gall which I have described as *Cynips quercus-mellaria* and which abounds on a small scrubby oak (*Quercus undulata*) frequent in those regions. The ants always work at night, making their way in long strings to the nearest gall-bearing tree, the branches of which they carefully search for the young and succulent galls which secrete a small globule of a clear saccharine liquid. The gathered liquid is then, upon the return to the formicary, emptied into the mouths of those individuals which serve as honey stores.

LEAF-CUTTING ANTS.—These are represented almost solely by the genus Atta, which abounds in tropical and sub-tropical countries, where the species are dreaded by planters because of their great destructiveness to cultivated plants and trees. These ants have been denominated agricultural ants, and recent observations have confirmed the explanation originally urged by Belt, that the leaves are cut into pieces and gathered into small heaps, as a nidus for the cultivation of a fungus (Rozites) the mycelium form of some mushroom, so that they may be said to have anticipated man in this kind of culture. The only two species belonging to the genus so far observed in this country, are *Atta fervens* Say, and *Atta tardigrada* Buckley. The former is our commonest species, occurring in Texas. Its formicaries are often twenty feet in diameter and several feet high, with numerous smaller moundlets scattered over the surface. They have a crater-like depression in the top, with a central opening running down into the formicary, sometimes to a very great depth. Each formicary contains immense numbers of individuals, and during the day appears to be empty and deserted. After dark, however, the entrances are opened, first by smaller workers who remove the particles of sand and earth, then by individuals of larger form who aid in removing the refuse. When the way has been sufficiently cleared, the inmates pour forth, both workers and soldiers, and march to some plant or other near by. They are generally seen in double column, one column ascending the plant and cutting off the leaves, and the other returning loaded to the nest. Great intelligence is shown by this ant in its foraging expeditions. The cut leaves, either whole or in circular pieces, are usually thrown on the ground by those who ascend the tree, while others below receive and bear the fodder home. Each piece of leaf is grasped by the jaws, and, with a quick motion of the head, thrown back over the head and thorax in such manner that it lodges edgewise in a deep furrow and between two spines which characterize the head, so as to cover the insect more or less and offer little or no obstacle to its progress. Very long underground tunnels are sometimes excavated from the main formicary to some shrub or tree so as to facilitate access thereto. The stories told by southern planters of the ravages of this insect seem almost incredible, but I have myself witnessed the utter denudation of a large tree in a single night, in which case all the forces of the formicary seemed to be concentrated on a single object.

Atta tardigrada is found east of the Mississippi River, occurring throughout the gulf States from Florida to Texas. In Florida what is evidently this species builds rather large cells from two to four inches in diameter in fine white sand, the walls very firm and smooth. In some instances the walls are said to be lined with a kind of curtain composed of particles of different colored sands brought up from a lower stratum and interwoven with fine white threads, by which is doubtless meant shreds of the refuse vegetation collected—a kind of spongy mass, manufactured from the vegetation and somewhat resembling the comb made by certain bees. This spongy mass contains small irregular pockets, apparently designed for the reception of the young, and in this we have the nearest tendency in ants to the building of cells which is so common in some of the other social Hymenoptera. This species prefers the fine needle-like leaves of tender pine seedlings, and a row, marching in single file, each carrying a piece of one of these needles, suggests a file of soldiers armed with rifles.

Atta mexicana Sm. abounds in the temperate regions of Mexico, its formicaries being twenty or more feet in diameter, and a funnel is said to extend through its center to facilitate drainage, which would seem to be necessary in a country subject to very heavy rains. The damage done by this species, especially to coffee plantations, is said to be very great.

Atta cephalotes L. is dreaded in Brazil because of its destructiveness to vegetation and of its tendency to enter houses and carry off the mandioca meal. Its formicaries often reach a diameter of more than 100 feet.

NEST-BUILDING ANTS.—Though we have in the United States no species which constructs nests similar to those of wasps, yet such are known to occur in other parts of the world, especially in tropical and sub-tropical countries. The genera Polyrhacis, Dolichoderus and Cremastogaster imitate wasps in the construction of their nests.

Some of the Brazilian species of Cremastogaster construct more or less globular, black nests, about the size of a human head, fastened between the branches of trees, large numbers of which may often be noticed among the mangrove bushes bordering the shores of the ocean, and frequently so low down as to be but a few inches above high tide. Similar nests are common in the West Indies, and look very much like young nests of Eutermes.

The nest of *Cremastogaster arboreus* Sm., found at Port Natal, Africa, is very large, measuring about fifteen inches in length, by nine inches in diameter. It is always built around a branch, resembles in texture and appearance the nest of our common paper wasp, *Vespa maculata*, and contains thousands of the insects. (See Smith, Cat., Hym. Ins. Brit. Mus. Pt. VI, pl. XIV.

We see the beginnings of the nest-building habit in some of our North American species, especially in *Cremastogaster lineolata* Say, which builds coverings over colonies of Aphides, the coverings composed of minute particles of vegetable and earthy matter firmly glued together; or else makes a more or less conspicuous loose nest by massing together the exuviæ of the Aphides and portions of dead leaves, generally around some twig or branch. (See *Practical Entomologist*, Vol. II, No. 3, Dec. 1866, p. 41.) In this case the object is doubtless to prevent the robbing of the coveted sweets by other nectar loving species; while the more elaborate nests of the tropics are for self protection and social economy, the nearest approach to these in N. A. being made by a Florida ant (*Cremastogaster læviuscula* Mayr) which makes large brown chambered nests in long grass, recalling somewhat in color and character those of Eutermes.

Note 6.—Termite Economy.

True royal Pairs.—There are many recondite phenomena connected with the life-history of the Termites that yet remain unexplained. But all the species annually produce large numbers of male and female adults, i. e., winged individuals which are capable, normally, of reproducing. These are recognizable after the first moult by the larger thoracic segments, which bear the first indication of wing-pads. During flight or swarming, and the subsequent walks on the ground, no real union of the sexes has so far been observed. In fact the reproductive organs are at this period not fully developed, and it is not until a pair have succeeded in establishing themselves amid a certain number of workers that the sexual organs become functional. The wings are thrown off and at this stage these individuals are known as true royal pairs, the wing stumps showing in contradistinction to the wing-pads of the larva and pupa, while their darker color otherwise distinguishes them. They are long-lived, coition taking place repeatedly. The male increases but little in size, but the abdomen of the female increases enormously with increasing fecundity.

Supplementary Kings and Queens.—The absence of a true royal pair by no means impairs the vitality and prosperity of a Termite colony; for a certain number of individuals are met with which, in the absence of the true queen may become sexually mature. the female laying fertile eggs, from which, in due course of time, all the forms composing the colony are developed. The true nature of these secondary or supplemantary males and females was first fully recognized by Fritz Müller, and their development is explained as follows:

At first indistinguishable from the larvæ of individuals which produce winged specimens, they are, in the nymph or pupa state, thicker and clumsier. The internal sexual organs are more strongly developed, and they have short wing-pads placed sideways instead of long and broad wing-pads as in the nymphs which produce the true kings and queens. In short, they undergo one moult less, and, as a consequence, do not acquire wings or swarm. They acquire sexual maturity later in the season than the winged individuals, from which they are always distinguished in maturity by the possession of wing-pads instead of the wing stumps. They are also lighter in color, the males having smaller eyes, and the females a broader thorax, whereas in the true royal individuals there is no difference in this respect. They are not as long-lived, either, as the royal pair, the males dying within a few months and the females probably not surviving more than a year.

It will be seen from the above stated facts that if through the death of a queen, or in the absence of a queen, a colony has not been able to secure another royal pair from the swarming individuals "nymph-like males and females, safely kept in the nest" step in as substitutes and save the colony from becoming extinct. Furthermore it has been observed that if, in very small and fragmentary colonies, the supplementary males and females should be absent, the colony may yet be perpetuated by the substitution of larva-like males and females, which have been called complementary kings and queens.

A remarkable observation made by Fritz Müller deserves mention here. He found in a Eutermes colony, in the passages of what appeared at first to be a true royal cell, not less than 31 supplementary females and among them a single true king, i. e., with distinct wing-stumps. "Instead of a royal palace" he says, "in which the king lived in chaste matrimony with his equal consort, I had a harem before my eyes in which a sultan satisfied himself with numerous coquettes." This observation would seem to indicate that, in the economy of the Termite colony, a true king and queen may not only be replaced by supplementary kings and queens, but that this substitution may take place for both sexes at the same time, or for each sex separately.

I would observe, in this connection, that during the swarming season many species of true ants forcibly detain some of the winged males and females and prevent their leaving the formicary by biting off their wings, and that the pairs thus forcibly detained supply the colony with eggs. A similar condition may prevail among the Termites, and if so, would throw light on some of the facts which have been observed.

INFLUENCE OF FOOD AND TREATMENT.—The effect of food and treatment has less, perhaps, to do with the differentiation of individuals among termites than among the bees, wasps or ants.

All Termite larvæ are supposed to partake of the same kind of food, as to the nature of which there is conflict of opinion, due doubtless to the varying habits in the different species. From my own observations on Termes and Eutermes, I am inclined to believe that, as in the Social Hymenoptera, the food and treatment of the young larva, during the first stage more particularly, have much to do in determining the development or suppression of the sexual organs, and, as a consequence, in determining the character of the full grown individual. The eggs are, first of all, brought together in special parts of the termitary, and it is quite probable that the workers exercise some judgment and discrimination in the grouping, as has been proved to be the case with Hymenoptera, with a view to future larval treatment. Judging from the delicacy of their mouth-parts and of the general integument, the young are at first more or less dependent upon either the forethought or the direct action of the adults, and I cannot resist the conclusion that the infancy of the termites is dependent, as it is in the Social Hymenoptera, if not to the same extent; for they have soon perished where I have hatched them away from adults, and have developed where the adults had access to them. But further exact observations, which, in the nature of the case, it is difficult to make, are needed before definite conclusions can be drawn. Fritz Müller believes that the young feed on a fungus which develops on the walls of the cells, a peculiar white fungus being not uncommon in such situations, though I have more often found nothing of the sort where the young were abundant.

Mr. Hubbard found many small hard bodies among the eggs of *Eutermes rippertii* which were recognized as the sclerotium of a fungus by Prof. F. G. Farlow, and other observers have referred to the presence of fungi in Termite nests. Mr. Hubbard also records the feeding of the young upon hard and tough rounded masses found in the nests of the above-named species. They could not do so, however, without the assistance of the nasuti or workers to soften these nodules, for their mouthparts are too feeble, while the nodules are of very irregular occurrence and in some nests not present at all. Where the young are crowding, the material of the nest is moister than elsewhere and their chief food must be a liquid regurgitated from the mouth, by the workers or by the partly developed sexed individuals, just as in the social Hymenoptera, and either taken directly or from the moistened substance of the cavities. Indeed, though Mr. P. H. Dudley in some interesting observations on Eutermes on the Isthmus of Panama (Journal N. Y. Micros. Soc. V. p. 62, April, 1889) describes the nasuti as being able to fire an "offensive glutinous shot, which puts an antagonist twice his size *hors de combat*." I have never been able to confirm this statement. The nasuti have seemed to me defenseless and I suspect that the liquid so readily secreted from the tip of the nose is chiefly designed for nourishment. That comminuted, decayed wood, as well as the faeces are also used for food has been shown by Grassi and others, while the tendency to feed freely upon one another is matter of common record, and indeed all the dead and dying are devoured.*

In Calotermes the excrement consists of dry and hard sub-ovoid particles which accumulate in the burrows, so that the faeces are not used here whether as food or to line the burrows. Consequently the young must depend entirely on liquid from the mouths of the females. The food is, however, from what has gone before, sufficiently varied in those species which exhibit the greatest number of colony forms, to justify the belief, here set forth, that it has much to do in the development of those forms.

It is, however, definitely known that differentiation of the sexes takes place at an early period, and can be recognized by anatomical and external characters in the larva, immediately after the first moult. Freshly hatched larvæ appear to be sexually undifferentiated, although it is probable, as suggested by Newman in 1853 and Hagen in 1855, that this is simply because the differences are too minute to be observed. Sex is doubtless determined in the egg, but the different forms of either sex are, in all probability, due to food and treatment in the first larval stage, and to an innate tendency confirmed by heredity. The mode of treatment of the mother, in insects generally, may influence the sex of the offspring; but there is no evidence to show that the sex can be altered when the egg has once passed. Fecundity varies in individuals of any community, and a certain number are always sterile. In the social insects this condition is simply controlled to the advantage of the species, and the tendency, associated with various other modifications, has been emphasized by heredity. Prof. B. Grassi (Bull. Mensuel Acad. Gioenia, 1889; Entom. Nachrichten, 1889) has offered a rather curious explanation of the origin of the sex in Termites. He finds in the cœcum of the young larvæ, as well as in the fully developed workers and soldiers, an abundance of protozoon parasites. With each moult these parasites disappear, but immediately commence to reappear, and the cœcum is inflated in a sac which presses on the sexual organs so that the development of the latter is prevented, the protozoons not appearing, after the first moult, in those individuals which are to become truly sexual, or at least in only the smallest quantities. He bases this view upon the examination of many hundreds of individuals, but the probabilities are that the presence of the protozoons has no essential part in the result, as he offers no explanation as to why they are absent or less numerous in the one case than in the other.

COMPOSITION OF THE TERMES COLONY.—Remembering that in Termes the adolescent stages actively participate in the work and composition of the colony, and accepting the nomenclature most recently used by the latest and best observers, the forms already indicated in the diagram on p. 33 may be enumerated as occurring in the species of the genus Termes, as exemplified by the commoner European and American species:

Prof. Grassi has enumerated some three additional forms, but this confusing complexity of forms really occurs only among those which are reproductive and they never all occur at one and the same time, while some of them only occur under certain peculiar conditions.

The youngest larvæ, i. e., the indistinguishable freshly hatched larvæ of all forms (No. 1) are very small, in no species attaining 2 mm. in length. They are delicate, feebly chitinized creatures, blind, the thoracic segments not specialized, and with short 9-to 10-jointed antennæ. After the first moult the differentiation into neuters and sexed individuals becomes appreciable, not only in the beginnings of the development of the sexual organs, but in the increase in the number of antennal joints. The larvæ and sub-

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*By placing a small quantity of arsenic or calomel mixed with sugar in their burrows or nests, the termites will greedily devour the mixture, and by means of the poisoned individuals being fed on as fast as they perish, the whole colony will in time be destroyed.

sequent stages of the neuters remain eyeless and the thoracic segments are very little altered, since they develop no wings. But after the second moult a further differentiation takes place between the larvæ of the ordinary workers and soldiers, those of the former being recognized by the small head, smaller mandibles, large maxillæ and labium, while those of the latter have a much larger head, very prominent mandibles, variously modified according to species, and much smaller maxillæ and labial parts. In the perfect workers and soldiers these differences are still more strongly marked, and both forms may at once be distinguished from other larvæ by the darker color and the shining and harder integuments.

A peculiar form of neuter, occurring in Eutermes, the so-called nasuti, remained a puzzle for a long time. In this form the head is pear-shaped and prolonged anteriorly into a tube or nose which possesses a channel leading backward into the head. The nasuti have the power of secreting a viscid liquid from the tip of this nose. The mandibles are not prolonged and are unfitted for biting, while the lower mouth-parts are but little better developed than in the common soldiers. Dr. Hagen in the Appendix to his famous monograph of the Termes, recognized this form as a soldier form, characteristic of the genus Eutermes, which replaces the large-headed and mandibulate soldiers of the other genera. Mr. Hubbard, however, records having found in one colony of *Eutermes rippertii* in Jamaica a few of these nasuti among the soldiers (Boston Soc. Nat. Hist., 1877, pp. 270–2). It is believed, and I think justly, by Fritz Müller that when found in colonies of other Termites having mandibulate soldiers, these nasuti are mere inquilines or intruders, and the opposite view is justifiable, that when the mandibulate soldier is found among the nasuti, it also is an intruder.*

Acknowledgment.

Figures 1, 2, 3, 8, 9, 10 and 11. are made from illustrations belonging to the Department of Agriculture, and are used by the kind permission of Chas. R. Dabney, Jr., Assistant Secretary of Agriculture.

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*Since this address was written, I have had an opportunity of studying Eutermes in the West Indies, *E. morio*, at St. Thomas, St. Kitts, Monserrat, Dominica, Martinique, St. Lucia and Barbados, and both it and *E. rippertii* in Jamaica. The nasuti are here the smallest individuals in the colony and also somewhat the darkest. They have no power of biting, and no organ of offense, as the liquid exuded from the tip of the nose has no pungent property. They may, therefore, be handled with perfect impunity Of some forty nests examined none have furnished a mandibulate soldier. The nasuti, though having no weapon of offense (so far at least as man is concerned) are nevertheless active guards, and undoubtedly take the place of the soldiers in Termes proper. They crowd around the queen, when the colony is disturbed, and rush to the outside and about the borders of any breakage or hole made in the nest or the tunnels thereto. They throw up the head and play the antennæ and palpi in a comically threatening way, considering their inoffensiveness, and they watch around the borders on the inside of such breakage while the workers run up rapidly now and again to deposit the soft excrement which is to mend the gap, and of which the tunnels and nests are for the most part formed. Eggs and young larvæ are frequently borne on the nose and on the feelers of these nasuti; but I have not yet satisfied myself that they are thus purposely carried, and are not accidentally stuck by the exuding liquid, the latter view comporting best with most of the cases. But that these nasuti perform some function in the economy of the colony other than that of soldiery defence, is rendered almost certain by their relatively large numbers compared with the real soldiers in Termes, for they are generally as numerous as the mandibulate workers and sometimes as numerous as all the other individuals together. While the liquid from the nose may be used in cementing the walls of the tunnels, I am inclined to believe that it is of more importance in furnishing the first pabulum of the young.

Eutermes rippertii differs little from *E. morio* in habit except that the hard, paler nodules generally found in its older nests do not occur in those of the latter. But the most interesting experience, which is born out by the observations of Mr Dudley on the species in Panama, is that I have found as many as nine queens in one nest and often three or four. In fact there is every variation, even in independent nests which apparently have no accessory mother-nest, from those without queen to those with one up to nine (or more according to Dudley), while in one nest I found scores of true royal pairs in which the queens had undergone no material enlargement. I have also found either no male or sometimes two and once three males associated with a single queen. Ordinarily, however, there is but a pair, i. e., one queen and her escort.

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PROCEEDINGS

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FOSSIL CYCADEAN TRUNKS OF NORTH AMERICA, WITH A REVISION OF THE GENUS CYCADEOIDEA BUCKLAND.

BY LESTER F. WARD.

The recent discovery of a large number of fossil cycadean trunks in the Cretaceous rim of the Black Hills, has furnished a new stimulus to the study of these forms in America. Such objects have been found at no less than six distinct North American localities. The oldest and best known forms are those first mentioned by Tyson from the Lower Cretaceous of Maryland. Dr. Emmons found one such in the Trias of North Carolina, and Sir Wm. Dawson another in the Trias of Prince Edward Island. All the rest, with one exception, are from Cretaceous strata, the age probably not widely differing from that of the Maryland specimens. These are from the Trinity division of the Comanche group in Southern Kansas, and from two localities among the foot-hills outside of the Red Beds of the Black Hills region in South Dakota. The exception to this is the *Cycadeoidea mirabilis* (Lx.) Solms (*Zamiostrobus mirabilis* Lx.), found on the surface of the ground by Dr. F. V. Hayden, near Golden, Colorado, within the Laramie, or Post-Laramie terrane. This locality is at the foot of the Front Range, and it would have been very easy for an erratic block to be borne down the mountain side and lodged in the valley where this was found. As is well known, older formations are encountered on ascending the eastern slope of the Rocky Mountains, and Cretaceous and Jurassic strata undoubtedly crop out immediately above this locality.

Early in the spring of 1893, the National Museum obtained possession of a collection of six fine cycadean trunks from parties residing at Hot Springs, South Dakota, who had collected them at that vicinity.* One of these specimens measures thirty-one inches in height and twenty-four in greatest diameter, and weighs nine hundred pounds; the others are comparatively smaller, the smallest of all not exceeding a foot in height. Most of them are considerably flattened, but one or two are nearly circular in cross section. One of them exhibits a number of lateral branches, and in most cases the apex is depressed, forming the "crows nests" so characteristic of the specimens from the Isle of Portland, Dorsetshire, England.

In the Geology of the Black Hills, prepared by Professors Newton and Jenney, from their survey of 1875, and published at Washington in 1880, none of the Cretaceous strata below the Dakota group of Meek and Hayden, are recognized; and while I presumed from the general history of this class of vegetation that these remains came out of the Triassic Red Beds, or the overlying Jurassic, I was still so greatly interested to ascertain their true source that early in September last I made an expedition to the region, and in coöperation with Professor Jenney discovered the locality and made further collections, including one very much branching and very large trunk and many interesting fragments. All the remains of this class that have been thus far found in the southern part of the Black Hills, occur in the area mapped as Dakota group by Professor Newton, and, although no cycadean vegetation had yet been found amidst the extensive collections from the Dakota group of Kansas, Nebraska, and other more eastern localities, we were at first disposed to accept this as proof of their occurrence at that horizon in this region. But the great improbability of this assumption led us to make a careful examination of the series that had been thus classed by Professor Newton. The result was that we came to the conclusion that the Dakota group of Newton is much more extensive than the No. 1 of Meek and Hayden, and while the upper portion of it cer-

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*See Science, Vol. XXI, New York, June 30, 1893, p. 355.

tainly belongs to the true Dakota, the lower portion very probably extends to near the base of the Cretaceous. The evidence upon which these conclusions rest will soon be published, and it need only be added that the cycadean trunks belong to this lower portion though not very near the base and may not differ greatly in age from those found in Southern Kansas and Maryland.

At another part of the Black Hills region, within the foothills on the Eastern side, some six or eight miles north of Rapid City, and between that place and Piedmont, and also probably in the Cretaceous area, two other specimens have been found and are now at the State School of Mines at Rapid City. The whereabouts of these specimens was not known at the time that I visited that section, but since my return Professor Jenney, appointed at about that time Dean of the Faculty of the State School of Mines, has discovered them there and has furnished me the data for the brief description given below, together with rough drawings, and measurements, From him I learn that in 1877, Mr. J. M. Leedy, then of Rapid City, now residing in Florida, found these specimens at the place stated, that they remained at his ranch for some time, were then placed on exhibition at a fair held at Library Hall, and not being supposed to have any value, were subsequently thrown out into a vacant lot, where they remained until removed to the School of Mines. These forms are much more cylindrical than those found in the southern section, and seem without doubt to constitute a new species. I have therefore named this species *Cycadeoidea Jenneyana,* in commemoration of Professor Jenney's great services to the people of that section as well as to science in general.

I have not seen Professor Cragin's specimens from Southern Kansas, and he unfortunately did not figure them, but he stated in his description that they very closely resemble the Maryland specimens, of which he had obtained a photograph and had learned some particulars as to size. While he thought these two forms were specifically identical, it is probably best to let them remain as distinct species for the present.

All of our American forms appear to belong to the genus Cycadeoidea of Buckland. None of the taller, more slender, palm-like, or branching trunks, belonging to the Old World genera Bucklandia and Cylindropodium, have yet been discovered this side of the Atlantic. The genera Fittonia, Yatesia, and

Platylepis, in which the leaf-bases are persistent, seem also to be absent. I have therefore made a careful revision of the genus Cycadeoidea condensing into it the Bolbopodium and Clathropodium of Saporta, and also referring to it all the species of Bennettites of Carruthers. The greater part of all this had already been done by the recent researches of Count Solms-Laubach, and it only remained to pick up a few of the outlying forms that did not come within the purview of his studies. If his results are accepted at all there is no logical stopping-place short of the embodiment of all these forms under the genus Cycadeoidea. It is of course possible that future exhaustive study, especially from the standpoint of internal structure, may result in the subdivision of this genus into several. But at present the tendency is toward consolidation, and a great uniformity is found in both the external and internal characteristics of the extinct Cycadaceæ.

In a much more extended paper, which is now in preparation, I hope to bring out the special characteristics of our American forms and to compare them with those of the Old World. Sections are now being made of some of the specimens from the Black Hills, and it is proposed to illustrate the internal structure of these specimens as fully as possible. Prof. F. H. Knowlton has consented to superintend the work of section cutting and to prepare the part of this paper relating to internal structure. Thus far we are in possession only of the Black Hills material and the single specimen of *C. mirabilis* described by Lesquereux in his Tertiary Flora. This specimen was loaned several years ago to count Solms who made sections of it and prepared several slides, duplicates of which he sent back with the specimen. I also have a somewhat careful description of what he found, not only in letters received from him, but also in his memoir on the fossil cycads of Italy. Should other material come into our hands it will also be treated from the same standpoint.

I have endeavored in all cases to conform strictly to the law of priority now so rigidly enforced in all departments of natural history. I have been careful to give dates, so that the reasons for the deviations from the more current designations may be clear. If I have made any mistakes in this respect I shall be very thankful to receive corrections before the final paper is completed, this being one of the objects of this preliminary one.

REVISION OF THE GENUS CYCADEOIDEA BUCKLAND.

Genus Cycadeoidea Buckland.

1827. Cycadeoidea Buckland, Proc. Geol. Soc, Lond., Vol. 1, No. 8, pp. 80-81 (Session of June 6, 1827).
1828. Cycadeoidea Buckland, Trans. Geol. Soc. Lond., 2 Ser., Vol. II, pp. 375-401, pl. xlvi–xlix.

This genus seems to be the ultimate destiny of all cycadean trunks of dwarf bulb-like or conical form, deciduous leaf stalks and rhombic leaf scars. Count Solms-Laubach has already referred many of the species of Bennettites and Clathropodium to it, and the Marquis Saporta admits that one species of Bolbopodium belongs to the same genus as *C. pygmæa.* The fact alone that fruit has been found in one species (*C. Gibsoni*) seems insufficient ground for retaining the genus Bennettites. The only other name that has any claim to retention for this group is *Mantellia* of Brongniart, but his publication of it at the same date with Buckland's Cycadeoidea was a *nomen nudum*, and had moreover been used for an animal fossil. It is therefore generally given up. Brongniart himself conceded this, but wrote *Cycadoidea* on grounds of euphony. Even this cannot be allowed by the now more and more strictly enforced rules of nomenclature, and *Cycadeoidea* must stand as originally written by Buckland.

Cycadeoidea megalophylla Buckland.

1827. Cycadeoidea megalophylla Buckland, Proc. Geol. Soc. Lond., Vol. I, No. 8, p. 80.
1828. Trans. Geol. Soc. Lond., 2d Ser., Vol., II, pp. 397–401, pl. xlvii, figs. 1–4; pl. xlviii, figs. 1–3.
1828. Mantellia nidiformis Brongn., Prodrome, pp. 96, 199.
1837. Mantellia megalophylla (Buckl.) Bronn, Lethaea Geognostica, p. 227, pl. xv, fig. 2.
1837. Cycadites megalophyllus Buckland, Geology and Mineralogy, etc., Vol. I, p. 497; Vol. II, p. 98; pl. lx, figs. 1, 2.
1838. Zamites megalophyllus (Buckl.) Presl, in Sternberg's Versuch, etc., Vol. II, Hefte 7 and 8, p. 196.
1842. Encephlartos Bucklandii Miquel, Monogr. Cycad., p. 60.
1849. Echinostipes nidiformis (Brongn.) Pomel, Matériaux, etc., p. 16.
1874. Clathropodium megalophyllum (Buckl.) Saporta, Pl. Jurass., Vol II, p. 285, pl. lxxvi, fig. 1.

Purbeck beds, Isle of Portland, Dorsetshire, England.

Cycadeoidea microphylla Buckland.

1827. Cycadeoidea microphylla Buckland, Proc. Geol. Soc. Lond., Vol. I, p. 81.
1828. Trans. Geol. Soc. Lond., 2d Ser., Vol. II, pp. 398–401, pl. xlix, figs. 1, 2.
1834. Strobilites Bucklandii L. & H., Foss. Fl. Gt. Brit., Vol. II, p. 133, pl. cxxix.
1837. Mantellia microphylla (Buckl.) Bronn, Lethaea Geognostica, p. 227.
1837. Cycadites microphyllus Buckland, Geology and Mineralogy, etc., Vol. I, pp. 497, 498; Vol. II, pp. 98, 99, 100, pl. lxi, figs. 1–3; pl. lxii, figs. 2, 3.
1838. Zamites microphyllus (Buckl.) Presl, in Sternberg's Versuch, etc., Vol. II, Hefte 7 and 8, p. 196.
1849. Echinostipes microphyllus (Buckl.) Pomel, Matériaux, etc., p 16.
1874. Clathropodium microphyllum (Buckl.) Sap., Pl. Jurass., Vol. II, p. 284.

Purbeck beds, Isle of Portland, Dorsetshire, England. Morris gives as locality for *Strobilites Bucklandii*, not stated by Lindley and Hutton, the Upper Greensand of Wiltshire, and Presl says that the species is also found in the Lower Lias of Lyme Regis.

Cycadeoidea pygmæa L. & H.

1835. Cycadeoidea pygmaea L. & H., Foss. Fl. Gt. Brit., Vol. II, p. 175, pl. cxliii.
1841. Zamites pygmaeus (L. & H.) Morris, Ann. and Mag. Nat. Hist., Vol. VII, p. 116.
1849. Echinostipes pygmaeus (L. & H.) Pomel, Matériaux, etc., p. 17.
1870. Mantellia pygmaea (L. & H.) Carruthers, Trans. Linn. Soc. Lond., Vol. XXVI, p. 703.

Lower Lias of Lyme Regis, England. Pomel thought he recognized the species in his material from France, but this may have been *C. Pictaviensis.*

Cycadeoidea Saxbyana (R. Brown) Morris.

1851. Cycadites Saxbyanus R. Brown, Proc. Linn. Soc. Lond., Vol. II, p., 130.
1854. Cycadeoidea Saxbyana (R. Brown) Morris, Cat. Brit. Foss., 2d ed., p. 7.
1867. Bennettites Saxbyi Carruthers, Brit. Assoc. Rep., 37th Meeting, Pt. II, p. 80.
1870. Bennettites Saxbyanus (R. Brown) Carruthers, Trans. Linn. Soc. Lond., Vol. XXVI, pp. 681, 698, 706, pl. lvii, figs. 1–8.

Wealden of Brook Point, Isle of Wight, England.

Cycadeoidea Gibsoni Carruthers sp.

1867. Bennettites Gibsoni Carr., Brit. Assoc. Rep., 37th meeting, Pt. II, p. 80.
1870. Bennettites Gibsonianus Carr., Trans. Linn. Soc. Lond., Vol. XXVI, pp. 681, 700, pl. lviii, figs. 1-5; pl. lix, figs. 1-9; pl. lx. figs. 1-12.

Lower Greensand of Luccomb Chine, Isle of Wight, England.

Cycadeoidea Portlandica (Carr.) Solms.

1870. Bennettites Portlandicus Carr., Trans. Linn. Soc. Lond., Vol. XXVI, pp. 681, 700, 707, pl. lxi, figs. 1-5.
1892. Cycadeoidea Portlandica (Carr.) Solms, Mem. Accad. Sci. Ist. Bologna, Ser. V, Tom. II, p. 187.

Lower Purbeck beds, Isle of Portland, England.

Cycadeoidea maxima (Carr.) Solms.

1870. Bennettites maximus Carruthers, Trans. Linn. Soc. Lond., Vol. XXVI, pp. 681, 699.
1892. Cycadeoidea maxima (Carr.) Solms, Mem. Accad. Sci. Ist. Bologna, Ser. V, Tom. II, p. 187.

Wealden of Shanklin, Isle of Wight, England.

Cycadeoidea Carruthersi.

1870. Mantellia intermedia Carruthers, Trans. Linn. Soc. Lond., Vol. XXVI, pp. 681, 702, 708, pl. lxiii, figs. 4, 5.
1874. Cycadeoidea intermedia (Carr.) Schimp. (non Ranzani), Paléontologie Végétale, Vol. III, p. 556.

Lower Purbeck beds, Isle of Portland, England.

The name *C. intermedia* being preoccupied by Ranzani in 1836 (see below) it was necessary to change it.

Cycadeoidea Peachii (Carr.) Solms.

1867. Bennettites Peachii Carruthers, Brit. Assoc. Rep., 37th meeting, Pt. II, p. 80.
1870. Bennettites Peachianus Carruthers, Trans. Linn. Soc. Lond., Vol. XXVI, pp. 681, 700, 707, pl. lxii, figs. 1, 2.
1892. Cycadeoidea Peachii (Carr.) Solms, Mem. Accad. Sci. Ist. Bologna, Ser. V, Tom. II, p. 187.

Coral Rag of Helmsdale, Sutherlandshire, Scotland.

Cycadeoidea inclusa (Carr.) Schimper.

1870. Mantellia inclusa Carruthers, Trans. Linn. Soc. Lond., Vol. XXVI, pp. 681, 703, 708, pl. lxiii, figs. 2, 3.
1874. Cycadeoidea inclusa (Carr.) Schimper, Paléontologie Végétale, Vol. III, p. 556.

Lower Cretaceous of Potton, Cambridgeshire, England.

Cycadeoidea Bucklandi Corda sp.

1845. Zamites Bucklandi Corda, Beitr. z. Flora der Vorwelt, pp. 38, 120, pl. xvii, figs. 1–10.

Locality and formation unknown. Corda says that the specimen probably came from England. It resembles *C. Saxbyana*.

Cycadeoidea Morieri Renault sp.

1887. Clathropodium Morieri Renault, Bull. Soc. Linn. Normand., 4e Sér., Vol. I, pp. 143–151, pl. iv, v.

Purbeck beds, Isle of Portland, England.

Cycadeoidea forata (Sap.) Solms.

1875. Clathropodium foratum Saporta, Pl. Jurass., Vol. II, p. 297, pl. cxxiv, figs. 1, 2.
1892. Cycadeoidea forata (Sap.) Solms, Mem. Accad. Sci. Ist. Bologna, Ser. V, Tom. II, p. 190.

Gault of Cauville near Havre, France. Saporta's original supposition that this form came from the Oolite of Mans (Sarthe) was subsequently found to be erroneous.

Cycadeoidea Pictaviensis (Longuemar) Saporta, ms.

1870. Cycadeoidea Pictaviensis (Longuemar) Saporta, ms., in Schimper: Paléontologie Végétale, Vol. II, p. 188; Atlas, pl. lxxi, fig. 12.
1870. Araucaria Pictaviensis Longuemar, Et. géol. et agron. sur le depart. de la Vienne, Vol. I, p. 491.
1874. Bolbopodium Pictaviense (Longuemar) Saporta, Pl. Jurass., Vol. II, p. 258, pl. cxviii, fig. 2.

Upper Oxford of Montanaise near Poitier (Vienne), France.

Cycadeoidea Sarlatensis Saporta sp.

1849. Cycadeoidea sp. Brongniart, Tableau, p. 59.
1875. Clathropodium Sarlatense Saporta, Pl. Jurass., Vol., II, p. 293, pl. cxxiii, figs. 1, 2.

Upper Jurassic of Sarlat (Dordogne), France.

Cycadeoidea Trigeri Brongniart.

1849. Cycadeoidea Trigeri Brongniart, Tableau, p. 59.
1849. Cycadites Trigeri Brongn. ms., cf. Saporta, Pl. Jurass., Vol. II, p. 288.
1849. Echinostipes sp. Pomel, Matériaux, p. 17.
1874. Clathropodium Trigeri (Brongn.) Saporta, Pl. Jurass., Vol. II, p. 288, pl. cxxii, figs. 1–3.

Upper Jurassic of Mans (Sarthe), France.

Cycadeoidea micromera Saporta sp.

1874. Bolbopodium micromerum Saporta, Pl. Jurass., Vol. II, p. 262, pl. cxviii, fig. 1.

Corallian of Tonnerre (Yonne), France.

Cycadeoidea Mamertina Crié sp.

1879. Bolbopodium Mamertinum Crié, Les Anciens Climats et les Flores Fossiles de l'Ouest de la France, pp. 15, 18.

Bathonian of Mamers (Sarthe), France.

Cycadeoidea Montiana Capellini & Solms.

1755. Lapideorum balanorum insignis congeries Monti, Bonon. Sci. et Art. Inst. at. Acad. Comment., Tom. III, p. 323, tav. fol.
1892. Cycadeoidea Montiana Capellini & Solms, Mem. Accad. Sci. Ist. Bologna, Ser. V, Tom. II, pp. 169, 181, 214, pl. iii, fig. 1.

Rio della Cavaliera, Bolognese, Italy. Cretaceous?

Cycadeoidea intermedia Ranzani.

1836. Cycadeoidea intermedia Ranzani, Resoconto Accad. Ist. di Bologna, 23a Sess., 26 maggio 1836.
1839. Nov. Com. Acad. Sci. Inst. Bonon., Tom III (Bull. Sci. Med., Vol. I), p. 385, tab., figs. 2, 3, 5.

Fiume Reno, Bolognese, Italy. Cretaceous?

Cycadeoidea Scarabellii (Mgh.) Cap. & Solms.

1854. Mantellia? Scarabellii Meneghini, Ann. dell Università Toscana, Tom. III, p. 74, nota 14.
1892. Cycadeoidea Scarabellii (Mgh.) Cap. & Solms, Mem. Real. Accad. Sci. Ist. Bologna, Ser. V, Tom, II, pp. 170, 171, 176, 181, 207, 214, pl. iii, fig. 3.

Fiume Santerno, Imolese, Italy. Cretaceous? Meneghini maintained that this species belonged to the Miocene in which it was found, but Capellini does not doubt that, like most of the other Cycadean trunks of Italy, it was redeposited from the argillaceous shales of the underlying Cretaceous.

Cycadeoidea Pirazzoliana Massalongo, ms.

1858. Cycadeoidea Pirazzoliana Massalongo, ms.
1892. Mem. Real. Accad. Sci. Ist. Bologna, Ser. V, Tom. II, pp. 171, 176, 181, 208, 212, pl. ii, fig. 1.

Torrente Correcchio, Imolese, Italy. Cretaceous?

Cycadeoidea Veronensis Massalongo.

1858. Cycadeoidea Veronensis Massalongo, Atti d. R. Ist. Veneto, Ser. 3a, Tom. III, Venezia, p. 816.
1859. Syllabus Pl. Foss. Agri Veneti, pp. 20, 132.
1892. Mem. Real. Accad. Sci. Ist. Bologna, Ser. V, Tom. II, pp. 173, 181, 206.

In the garden Feruzzi-Malagnini, wall of the Padri in Verona, artificially so placed. Original source unknown. The specimen was discovered in this position by Massalongo and Scarbelli in 1858 mingled with stalactites and other objects. Capellini states that it was not mentioned in print until 1859 in the *Syllabus* on page 20, and seems not to have been aware that Massalongo embodied it under the same name in his "Elenco dei modelli di piante fossili donati al R. Istituto Veneto," published in 1858 in the Atti, Ser. 3, Tom. III, on page 816. He also includes it, along with *C. Bianconiana*, in the "Elenchus Specierum Vegetalium et Animalium Fossilium," etc., placed at the end of the *Syllabus* (see p. 132).

Cycadeoidea Bianconiana Massalongo.

1859. Cycadeoidea Bianconiana Massalongo, Syllabus Pl. Foss. Agri. Veneti, p. 132.
1892. Mem. Real. Accad. Sci., Ist. Bologna, Ser, V, Tom. II, pp. 172, 181, 205, pl. ii, fig. 2.

Torrente Samoggia, Bolognese, Italy. Cretaceous? Capellini seems not to have observed Massalongo's record of this plant in his *Syllabus*, p. 132. He there says: "Ex form. ignota agri Bononiensis. Caudex."

Cycadeoidea Cocchiana (Caruel) Solms.

1870. Raumeria Cocchiana Caruel, R. Com. Geol. Ital. Bol., Vol. I, pp. 183, 186; figs. on p. 186.

1892. Cycadeoidea Cocchiana (Caruel) Solms, Mem. Real. Accad. Sci. Ist. Bologna, Ser. V, Tom. II, pp. 174, 181, 206, 215, pl. v, figs. 2, 5.

Torrente Marnia in Valdarno, Italy. Cretaceous? The specimens were found erratic in the Pliocene.

Cycadeoidea Maraniana (Scarab.) Solms.

1875. Bennettites Maranianus Scarabelli, ms.

1892. Cycadeoidea Maraniana (Scarab.) Solms, Mem. Real. Accad. Sci. Ist. Bologna, Ser. V, Tom. II, pp. 176, 179, 181, 204, 212, 214, pl. ii, fig. 3; pl. iii, fig. 4.

Castel S. Pietro and Torrente Correcchio, Imolese, Italy. Createaceous?

Cycadeoidea Capelliniana Solms.

1879. Cycadacea specie Ferreti, Atti Soc. Ital. Sci. Nat., Vol. XXI. p. 832.

1892. Cycadeoidea Capelliniana Solms, Mem. Real. Accad. Sci. Ist. Bologna, Ser. V, Tom. II, pp. 174, 181, 207, 212, 214, 215, pl. i, figs. 3, 4; pl. v, figs. 1, 3, 6.

Fiume Idice, Bolognese; Torrente Tresinaro presso Scandiano; Paullo nel Regiano; Vallestra, Regiano, Italy. Cretaceous?

Cycadeoidea Masseiana Cap. & Solms.

1890. Raumeria Masseiana Capellini, Mem. Real. Accad. Sci. Ist. Bologna, Ser. IV, Tom. X, pp. 446, 450, pl. ii.

1892. Cycadeoidea Masseiana Cap. & Solms, Mem. Real. Accad. Sci. Ist. Bologna, Ser. V, Tom. II, pp. 165, 168, 175, 178, 181, 205, 212, pl. i, fig. 1.

Cretaceous (Cenomanian?) clay shales of the Idice Valley, near the Villa di Ozzano in Emilia, Italy.

Cycadeoidea Etrusca Cap. & Solms.

1892. Cycadeoidea Etrusca Cap. & Solms, Mem. Real. Accad. Sci. Ist. Bologna, Ser. V, Tom. II, pp. 177, 181, 204, 212, 214, 215, pl. i, fig. 2; pl. iv, fig. 1; pl. v, figs. 7, 8.

Etruscan Necropolis of Marzabotto, Bolognese, Italy. Cretaceous? Original source unknown. Specimen found placed on a tomb as an ornament or symbolic rite bv the ancient inhabitants. It is the largest of the Italian specimens.

Cycadeoidea Ferretiana Cap. & Solms.

1892. Cycadeoidea Ferretiana Cap. & Solms, Mem. Real. Accad. Sci. Ist. Bologna, Ser. V, Tom. II, pp. 178, 181, 209.

Monte Babbio, Regiano, Italy. Cretaceous?

Cycadeoidea Imolensis Cap. & Solms sp.

1892. Cycadea Imolensis Cap. & Solms, Mem. Real. Accad. Sci. Ist. Bologna, Ser. V, Tom. II, pp. 176, 181, 200.

Fiume Santerno? Imolese, Italy. Cretaceous?

I have not hesitated to place this species in the genus Cycadeoidea because Count Solms gives as his only reason for not doing so that the specimen was too imperfect to be certain that it belonged there. He therefore created a new genus (Cycadea) for its reception. Such a course is certain to lead to great confusion. New genera should only be created where the material is so abundant and complete that it can be adequately characterized. This new genus is not even described, and as he admits, could not be from his specimen. It therefore can have no existence. On the other hand the large number of specimens found in Italy, all referable to Cycadeoidea make it altogether probable that this also belongs there. The only other course would be to hold it entirely in reserve. This he has not done but has given it a specific name.

Cycadeoidea sp. indet. Cap. & Solms.

1892. Cycadeoidea sp. indet. Cap. & Solms, Mem. Real. Accad. Sci. Ist. Bologna, Ser. V, Tom. II, pp. 176, 181.

Fiume Santerno? Imolese, Italy. Cretaceous?

Cycadeoidea Reichenbachiana (Göpp.) Cap. & Solms.

1755. Vegetabilische Versteinerung Walch, Knorr's Petrefacten Sammlung, Text, p. 150; Atlas, pl. iiia, fig. 6.
1844. Raumeria Reichenbachiana Göppert, in Wimmer: Flora von Schlesien, Ed. II, Vol. II, p. 217.
1853. Jubiläums-Denkschr. d. Schles. Ges. f. vat. Cult., 1853, pp. 262, 265, pl. viii, figs. 4-7; pl. ix, fig. 1.
1892. Cycadeoidea Reichenbachiana (Göpp.) Cap. & Solms, Mem. Real. Accad. Sci. Ist. Bologna, Ser. V, Tom. II, pp. 186, 187, 188.

Lednice near Wieliczka, Galicia. This is the large and now celebrated specimen in the Dresden Museum. Its geologic age is still unknown, but is almost certainly not Permian as conjectured by Geinitz.

Cycadeoidea Schulziana (Göpp.) Cap. & Solms.

1844. Raumeria Schulziana Göppert, in Wimmer: Flora von Schlesien, Ed. II, Vol. II, p. 217.
1853. Jubiläums-Denkschr. d. Schles. Ges. f. vat. Cult., 1853, pp. 259, 264, pl. vii, figs. 1-5; pl. viii, figs. 1-3.
1892. Cycadeoidea Schulziana (Göpp.) Cap. & Solms, Mem. Real. Accad. Sci. Ist. Bologna, Ser. V, Tom. II, pp. 186, 187.

Klodnitz Canal near Gleiwitz, Silesia; formation unknown.

Cycadeoidea Schachti (Coem.) Cap. & Solms.

1867. Cycadites Schachti Coemans, Mem. Cour. des Savants Etrangers de l'Acad. Roy. de Belgique, Vol. XXXIII, No. 3, p. 7, pl. iii, figs. 1, 2, 5.
1870. Clathraria Schachti (Coem.) Schimper, Paléontologie Végétale, Vol. II, p. 212.
1870. Bennettites Schachti (Coem.) Carruthers, Trans. Linn. Soc. Lond., Vol. XXVI, p. 699.
1892. Cycadeoidea Schachti (Coem.) Cap. & Solms, Mem. Real. Accad. Sci. Ist. Bologna, Ser. V, Tom. II, p. 187.

Gault of La Louvière, Hainaut, Belgium.

Cycadeoidea Marylandica (Font.) Cap. & Solms.

1860. Cycas sp. Tyson, First Report State Agric. Chem. Maryland, p. 42.
1870. Bennettites sp. Carruthers, Trans. Linn. Soc. Lond., Vol. XXVI, p. 708.
1879. Cycadeoidea sp. Fontaine, Am. Journ. Sci. 3d Ser., Vol. XVII, p. 157.
1889. Tysonia Marylandica Fontaine, Flora of the Potomac Formation, p. 193, pl. clxxiv–clxxx.
1892. Cycadeoidea Marylandica (Font.) Cap. & Solms, Mem. Real. Accad. Sci. Ist. Bologna, Ser. V, Tom. II, pp. 179, 180, 186.

Potomac formation (Lower Cretaceous) at various points in Maryland, chiefly along the Baltimore and Ohio Railroad between Washington and Baltimore and in the vicinity of the latter city.

Cycadeoidea Emmonsi Font. sp.

1857. Trunk of a cycad Emmons, American Geology, Vol. VI, pp. 123, 124; fig. 92a.
1883. Zamiostrobus Emmonsi Fontaine, Older Mesozoic Flora, p. 117, pl. lii, fig. 5.

Upper Trias of North Carolina, exact locality not known.

Judging from the excellent figure of Dr. Emmons, of which that of Professor Fontaine is not a true reproduction, I consider it much more probable that this was a "trunk of a cycad" than that it was a strobile.

Cycadeoidea mirabilis Lx. sp.

1876. Zamiostrobus mirabilis Lx., Bull. U. S. Geol. and Geogr. Surv. Terr., Vol. 1, 2d Ser., No. 5, p. 383 (issued January 8, 1876); Hayden's Ann. Rep. U. S. Geol. and Geogr. Surv. Terr. for 1874, p. 309.
1878. Tertiary Flora, p. 70, pl. lxiii, figs. 1, 1a.
1884. Nelumbium sp. James. Science, Vol. III, p. 434.
1884. Clathropodium mirabilie (Lx.) Ward, Science, Vol. III, pp. 532 533.
1890. Bennettites mirabilis (Lx.) Solms, in litt. (Sept. 10).
1892. Cycadeoidea Zamiostrobus Solms, Mem. Real. Accad. Sci. Ist. Bologna, Ser. V, Tom. II, pp. 210, 211.

Found lying on the surface of the ground near Golden, Colorado, in the Laramie terrane, but probably belonging to a more ancient formation from which it had been transported.

Cycadeoidea munita Cragin.

1889. Cycadeoidea munita Cragin, Bull. Washburn College Lab. Nat. Hist., Topeka, Kansas, Vol. II, No. 10, pp. 65, 66.

Cheyenne Sandstone, Trinity Division of the Comanche Series (Lower Cretaceous), at Cheyenne Rock, Belvidere, Southern Kansas.

Cycadeoidea Dacotensis McBride sp.

1893. Bennettites Dacotensis McBride, American Geologist, Vol. XII, p. 249, pl. xi, figs. 1, 2; Bull. Lab. Nat. Hist. State Univ. of Iowa, Vol. II, No. 4, p, 391, pl. xii, figs. 1, 2.

Lower Cretaceous strata, valley of Minnekahta Creek near Minnekahta Station of the Burlington and Missouri Railroad, Fall River County, South Dakota (Black Hills).

Cycadeoidea Jenneyana n. sp.

Trunks cylindrical-conical, 15 to 17 inches in diameter and 2 to 3 feet high with concave depression ("crow's nest") at the summit; cross section of leaf stalks very irregular, rhombic or trapezoidal, two of the angles often very acute or prolonged indicating wings, the other angles obtuse.

Divide between Box Elder Creek and Elk Creek, six or eight miles north of Rapid City, South Dakota (Black Hills). Formation not yet determined but probably same as last.

The above description and data as to location are taken from letters received from Prof. W. P. Jenney, Dean of the Faculty of the State School of Mines at Rapid City where the specimens now are. There are two specimens, one of which shows the summit but lacks the basal portion and is 21 inches high and 15 inches in diameter at the lower end. The other shows the base but not the summit, is 17 inches in diameter and quite cylindrical, but truncated at the height of 16 inches. This form clearly indicates that the species at least is distinct from the last and it is possible that when better material is discovered it may require to be referred to some of the less dwarfted genera, such as Bucklandia or Cylindropodium. The distinction is further emphasized by the difference in the shape of the leaf bases or perforations left by their disappearance. I have named the species for Professor Jenney to whose assistance I am so greatly indebted in determining the geological position of the fossil plant beds in the southern portion of the Cretaceous rim of the Black Hills, a region which scientifically he has made his own.

Cycadeoidea Abequidensis Dawson.

1871. Cycadeoidea Abequidensis Dawson, Geol. Struct. Prince Edward Island, p. 45, pl. iii, fig. 29.

Trias of Gallas Point, Prince Edward Island. Sir Wm. Dawson referred this deposit doubtfully to the Lower Trias, but some regard it as the equivalent of the Newark System.

Vol. IX, pp. 89-97, pl. I March 30, 1894

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON

NOTE ON SOME APPENDAGES OF THE TRILOBITES,

BY CHAS. D. WALCOTT.

The results of Mr. W. S. Valiant's long search for the appendages of trilobites have recently been made known by Mr. W. B. Matthew, who described the material sold to the Columbia College of New York by Mr. Valiant.* Mr. Valiant informs me that he discovered traces of what he considered to be antennæ, and that for several years he continued collecting until he found a locality where the specimens were well preserved and show, not only the antennæ, but legs and what he supposed to be the swimming appendages. Not having confidence that he could properly describe the specimens he sold part of his material, and in this way it came to be first described by Mr. Matthew, a student at Columbia College. His step-brother, Mr. Mitchell, continued to collect; and in August, 1893, through the courtesy of Mr. Valiant, I visited the locality with Mr. Mitchell and obtained a few specimens for the National Government.

The most important part of the discovery, announced by Mr. Matthew's paper, is that the trilobita have true antennæ. The discovery of the legs and plumose appendages is also of great interest, as it adds to our information respecting the appendages of the trilobite some of the details of another genus.

A collection was made for the Yale College Museum by Dr.

Read March 24, 1894.

*Am. Jour. Sci., Vol. 46, 1893, p. 121.

C. E. Beecher, and in some notes on the thoracic legs of Triarthrus* he describes and illustrates a dorsal view of the legs of the second and third free thoracic segments. These show that the endopodite of the leg is essentially the same as in Calymene and Asaphus, and that the exopodite is unlike that of Calymene or Ceraurus.

Through the courtesy of Prof. J. F. Kemp of Columbia College, I have examined the material studied by Mr. Matthew; and Prof. A. H. Chester, of Rutgers College, kindly loaned me for study five specimens that he purchased from Mr. Valiant. From these and the specimens in the National Museum a few notes have been taken that permit of some comparisons with the extremities found in Ceraurus, Calymene and Asaphus.† The limbs of Triarthrus differ in the details of the joints of the inner branch of the limb (endopodite) and still more in the character of the exopodite.

Cephalic limbs.—The antennæ are uniramose, and, judging from the position in which they are found, were attached to the body near the postero-lateral angle of the hypostoma (Fig. 1, *e*, Plate 1). In one specimen a cephalic limb somewhat detached from its true position shows a large basal joint and six slender joints (Fig. 1, *f*). The basal joint does not show conclusive evidence of the presence of a masticatory ridge. On another specimen, however, the form of the basal joint strongly suggests that it subserves the purpose of mastication. This is illustrated at *g* in Fig. 1.

A slender jointed appendage like that attached to the basal joint of *g* occurs between it and the antennæ and is probably a portion of another one of the cephalic limbs. No other cephalic appendages have been observed in the material at hand.

Since the publication of my articles on The Trilobite‡ I found in a section of the head of *Calymene senaria* a slender jointed limb that appears to have been an antennule. It is unlike any limb found beneath the head and thorax, and, if not an antennule, it may represent a fifth pair of cephalic limbs. This is

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*Am. Jour. Sci., Vol. 46, 1893, pp. 467-470.

†The Trilobite; New and Old Evidence Relating to its Organization. Bull. Mus. Comp. Zool., Vol. 8, 1881, p. 6.

‡Bull. Mus. Comp. Zool., Vol. 8, 1881, p. 191-224. Science, Vol. 3, 1883, p, 279.

also suggested by a section of the limbs within the head of Calymene, illustrated on Plate 1, Fig. 9, Bull. Mus. Comp. Zool., Vol. 8, 1881. In this, a fifth limb is indicated close to the hypostoma. The trilobite was enrolled so as to include the antennule entirely within the border of the head. A sketch, taken from a photograph of the thin section by transmitted light, is shown by Fig. 8, Pl. 1.

The hypostoma of Ceraurus* shows a rounded indentation of the antero-lateral sides, where an antennule probably passed by it. This character is strongly marked in *Sao hirsuta*, *Proetus bohemicus*, *Amphion fischeri*, etc., as illustrated by Barande.

The character and position of the remaining cephalic limbs of Triarthrus are not shown in any specimens that I have examined, but, from the relations of Calymene, Ceraurus and Triarthrus, especially the two latter, it is probable that their arrangement is essentially the same.

Thoracic limbs.—Many specimens show the thoracic limbs extending out from beneath the carapace of Triarthrus. It was not until by a fortunate dissection that I obtained the material illustrating the limbs in position beneath the thorax. The anterior limbs are formed of a protopodite and a somewhat complex exopodite. The protopodite consists of a short basal and a long joint, (Fig. 2, *d*, *e*,) to which the endopodite and exopodite are attached. This appears to be direct in the posterior limbs of the thorax (Fig. 3, *a*), but as yet the point of attachment of the basal joint of the exopodite has not been seen in the anterior limbs.

The endopodite of the anterior portion of the thoracic limbs varies in the number of joints and in their relative length (Fig. 1, *a*, *a*). Two show four long proximal and three shorter distal joints. Other limbs show two smaller distal, and three or four proximal, while in several there is a more or less uniform gradation from the protopodite to the distal joint. In Fig. 1, some of these variations are indicated. In Fig. 2, eleven limbs are shown, as seen from the under side. The basal (coxal) joint is seen at *b*, *d*, *e*, and nine show the long second joint of the protopodite. At *e* and *f* a new phase is indicated by the enlargement of the proximal joints. This is marked in *a*, *b*, *e*, *d*, and in Fig. 3, the details are more fully shown. These joints occur

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*Loc. cit., Pl. iv., Fig. 5.

on the seven posterior thoracic limbs of Fig. 2; and in the specimen from which Fig. 3 was drawn the limb opposite the tenth segment from the pygidium shows a slightly triangular *second* (meropodite) and *third* (carpodite) joint. In Fig. 2, the limb *a* is opposite the second free segment of the thorax anterior to the pygidum. The limbs *a* and *b*, Fig. 3, clearly show that the four proximal joints are broad and subtriangler in outline. A glance at the abdominal swimming legs of the Phyllocarida (Paranebalia), Schizopoda and Cumacea, suggests that the functions of these legs were both natatory and ambulatory.

The expododite illustrated by Beecher shows the dorsal surface (Fig. 6). A number, presenting the ventral surface, are shown on the right side of Fig. 2. They occur on the same specimen as the endopodities, on the left side, but have been pushed out of place. The most perfect is represented by *m*. The proximal portion is formed of a rather large basal joint and a number of short joints, 7 or 8. The distal end is formed of an inner and outer segmented portion. The inner side is divided into numerous segments by oblique divisions that give the impression of a closely coiled spiral. The outer side is a cylindrical, jointed, stem-like rim that is attached to the inner side, a narrow, distinctly impressed line separating the two, except at the somewhat flattened tip where they merge into each other. On the outer or upper surface of the outer side numerous crenulations occur that extend into long setæ, *n*, Fig. 2; *b*, *b*, Fig. 1. Dr. Beecher considers the expodite as a swimming organ; but from the manifest branchial character of the exopodite and attached epipodite in Calymene (Fig. 7), it seems probable that this exopodite of Triarthrus served largely as a gill, and that the animal used the broad proximal joints of the posterior limbs of the thorax as its principal propulsion in swimming. The exopodite of Triarthrus looks like a consolidated exopodite and epipodite, very much as though these two organs as they occur in Calymene were merged into one.

Several specimens illustrate appendages beneath the pygidium. Some have the broad proximal joints, *d*, Fig. 1, while others show the outer rim of the exopodite *c*, Fig. 1. The material I have seen indicates very little difference between the appendages of the posterior half of the thorax and the pygidium, except that those of the latter are less developed in size and details. Mr. Matthew suspected the presence of a flap, formed by the anchylosing of the appendages beneath the pygidium. From the appearance of a similar structure, where the limbs are matted together along the side of the thorax, this tentative view is received with doubt. More perfect material may show distinctions not recognizable at present.

If future investigations prove, as it now seems probable, that the modified swimming joints of the endopodite are attached to ten or more of the thoracic segments, the anterior eight segments can be grouped together as the typical thorax, and the remaining segments of the body as the abdomen.

Mr. Matthew suggests that the homology between Triarthrus and Limulus may not be as close as between Limulus, Calymene and Ceraurus. This is true from what we now know of Triarthrus, but, if a sixth pair of cephalic limbs should be discovered in Triarthrus the resemblance would be strengthened. Triarthrus does not differ from Ceraurus and Calymene more than would be anticipated in such unlike genera. Triarthrus is essentially a "Primordial" type that has continued until upper Ordovician time. It represents a large group of Cambrian trilobites, while Calymene and Asaphus represent the more highly developed Ordovician and Silurian forms.

Dr. Lang held the view that if a fifth pair of cephalic limbs were found, comparable to the anterior antennæ "Trilobites might then be regarded as original *Entomostraca*, to be derived from the same racial form as the Phyllopoda." He says further, "Xiphosura, Hemiaspidæ, and Gigantostraca are themselves again perhaps racially connected with the *Trilobites*. In any case, however, in the present state of science, it seems probable that all these groups are only connected at their roots with the Crustacea.*"

From the paleontological record I am essentially in accord with this view, but I am not yet prepared to abandon the position taken in 1881, that all these groups should be arranged under one class and not as an appendage to the Crustacea, as proposed by Dr. Lang.

Text Book of Comparative Anatomy, Eng. Ed., 1891, p. 415.

*Loc. cit., p. 421.

I would go still further and form a class of the *Trilobita* and one of the Merostomata.

Two general facts lead me to think that the modern crustacean is descendant from the Phyllopod branch and the Trilobita from a distinct branch.* 1st. The Trilobita branch exhausted its initial vital energy in Paleozoic time and disappeared. 2nd. The Phyllopod branch developed slowly until after the Trilobita passed its maximum and then began its great differentiation that approaches culmination in recent times.

When the trilobite and phyllopod diverged from their common ancestral crustacean the trilobite began at once to differentiate and to use its initial vital energy in developing new species, genera and families. Probably two thousand species and one hundred or more genera are known from the Paleozoic strata. With this great differentiation the initial vital energy was impaired and the Trilobita died out at the close of Paleozoic time.

The Phyllopod branch continued with little variation until after the trilobite passed its maximum, and then began to differentiate until to-day its descendents form the class Crustacea, that corresponds to the class Trilobita in Paleozoic time. Springing from a common crustacean base the two groups have many features in common, and in carrying out of details of structure in the limbs and gills many striking resemblances occur. It does not impress me that trilobites were true Entomostracans or Malacostracans; they have certain characteristics in common, but these are not necessarily the result of lineal descent one from the other but are the result of descent from a common ancestral crustacean type of pre-Cambrian time that lived in the pelagic fauna in which all the earlier types of life were probably developed† and from which, as time passed on, additions must have been made to the paleontologic record of geologic time. The Phyllopods, Ostracods and Trilobita are clearly differentiated in the lower Cambrian fauna. Bernard is

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*This view is only confirmatory of the result of the profound study of the Apodidæ by Bernard (The Apodidæ Nature Series, 1892).

†See Brooks' beautiful memoir on Salpa, with its suggestive theory of the origin of the bottom faunas of the ocean and the early geologic faunas. The Genus Salpa, Memoirs from the Biological Laboratory of the Johns Hopkins University, II, 1893, pp. 140–177.

confidant that the Trilobites may take a firm place at the root of the Crustacean system, with the existing Apus as their nearest ally.*

There is yet much to be learned from the study of Triarthrus. A great amount of material can be readily collected at the locality near Rome, N. Y. It is also of interest to note that the locality at Trenton Falls, N. Y., from which the specimens of Calymene and Ceraurus were obtained, is only seventeen miles from the Rome locality; that both occur within the Ordovician; and that the stratigraphic position of the bed at Rome is between six and seven hundred feet above that at Trenton Falls.†

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*Nature, Vol. 48, 1893, p. 582.

†The appendages of Triarthrus are replaced by iron pyrites and are usually well preserved. The specimens of Calymene and Ceraurus from the Trenton limestone of Trenton Falls, N. Y., were replaced by calcite and in them there were preserved even more delicate parts than I have yet observed in Triarthrus. Thin sections were made of the latter and photographs obtained by transmitted light, that were used in illustrating the paper in the Bulletin of the Museum of Comparative Zoology, Vol. 8, 1881.

Description of Plate.

Fig. 1.—*Triarthrus becki* (X3). Outline of carapace, with appendages represented as they occur on several specimens, their relative position being retained.

a, a, a, a. Endopodites of limbs showing variation in joints.
b, b. Plumose portion of exopodite.
c, c. The outer or supporting portion of the setæ or fimbriæ of *b, b*.
d. Limbs extending from beneath the pygidium, showing large proximal joints. Those of the left side are imperfectly preserved.
e. Antenna extending back nearly to the postero-lateral margin of the hypostoma.
f. One of the cephalic limbs. The basal joint may be broken away on the inner side.
g. Cephalic limb.

Fig. 2 (X7). Limbs attached to the under surface of an individual preserving 13 thoracic segments and the pygidium. The limbs (*a* to *k*) on the left side are mainly in place. A fracture cuts out one limb between *g* and *h*.

a to *g*. Limbs preserving traces of the enlarged proximal joints.
b, d. Limbs preserving the two joints of the protopodite and two of the large proximal joints.
l, m, o. Exopodites, showing under or side views.
n. Enlargement of fimbriæ of *m*.
r, s. Distal joints of endopodites of right side.
y. Portion of an exopodite showing its inner support.

Fig. 3. Limbs occurring on the under side of an individual of 14 thoracic segments.

a, b, c, d. Limbs with flattened, enlarged proximal joints and slender distal joints.
a. Limb preserving large joint of protopodite, four enlarged proximal joints and three slender distal joints. At *x* the point of attachment of an exopodite is shown, and in the specimen it looks as though *f* had been broken away from *x*.

Fig. 4. Restoration of the thoracic limbs of the fifth segment anterior to the pygidium.

en. endopodite. p. protopodite. a. four proximal swimming joints. b. three distal joints.
ex. exopodite, attached to same joint of the protopodite as the endopodite.

Fig. 5. Restoration of the thoracic limbs of the fourth thoracic segment posterior to the head.
en. endopodite. *ex.* exopodite.

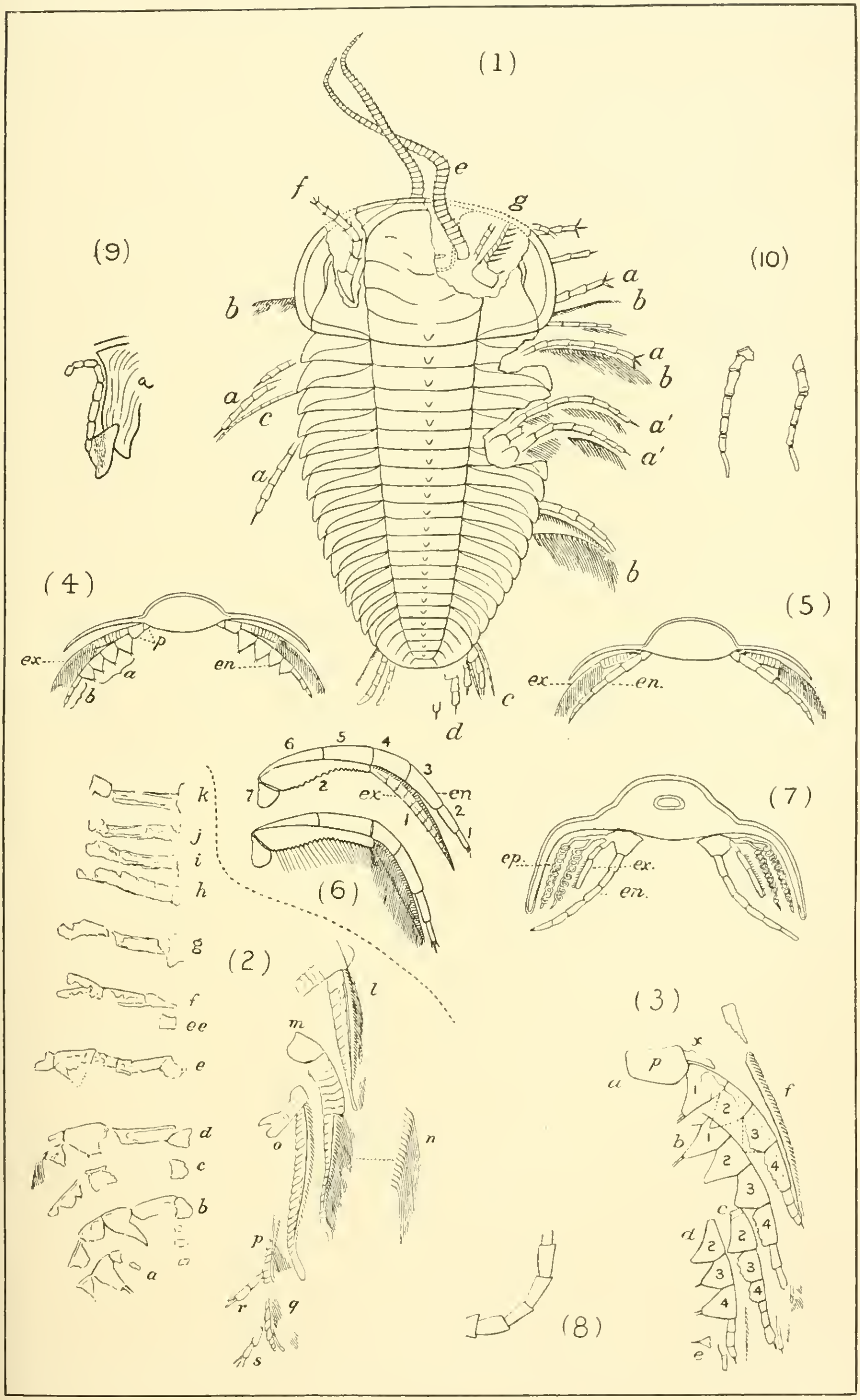
Fig. 6. Diagramatic restoration of the second thoracic limb. (After Beecher.)

Fig. 7. Restoration of thoracic limb of *Calymene senaria.*
en. endopodite. *ex.* exopodite. *ep.* epipodite. (Bull. Mus. Comp. Zool. Vol. 8, 1881.)

Fig. 8. Cephalic limb of Calymene X 3; supposed antennule.

Fig. 9. Cephalic limb figured by Dr. Henry Woodward. (Quart. Jour. Geol. Soc. London. Vol. 26, 1870, p. 487. a. side of hypostoma.

Fig. 10. Slender jointed legs associated in same beds with Calymene at Cincinnati, Ohio.


(1)
e
f
g
a
b
b
a
b
a
c
a'
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(9)
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(8)

VOL. IX, PP. 99-104 APRIL 14, 1894

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON

SYNAPTOMYS COOPERII BAIRD IN EASTERN MASSACHUSSETTS; WITH NOTES ON SYNAPTOMYS STONEI RHOADS, ESPECIALLY AS TO THE VALIDITY OF THIS SPECIES.

BY OUTRAM BANGS, BOSTON, MASS.

Ever since I began to trap small mammals in the modern improved manner, I have been on the lookout for this species and so was not surprised to find, on June 9th, 1893, a fine adult female in one of my traps. The trap was set in an old cranberry bog that had been allowed to run out, and had grown up to clumps of Viburnum and Vaccinium bushes, and under these, grasses and sphagnum and carices had crowded out the cranberry vines to a considerable extent. It was in the middle of the Plymouth woods, about seven miles from the town of Wareham, Plymouth County, Mass. The ground was traversed in every direction by the run-ways of *Arvicola riparius* and in one of these run-ways I caught the *Synaptomys*. She was nursing young at the time, although repeated trapping in the same bog yielded nothing but innumerable *Arvicolas*, a *Zapus hudsonius* or two, and a few *Evotomys gapperi*.

I now had a slight notion of the sort of place to look for *Synaptomys* in, and tried all such localities I could find without success until September 21, 1893, when in an almost precisely similar bog about six miles distant from the first place, in the township of Wareham, I caught an adult female, also nursing, and in an *Arvicola* run-way; and on September 24, an adult male in another trap in the same bog, in an *Arvicola* run-way.

Following is a list of small mammals caught in this last bog, which, as I trapped it pretty clean, may be of interest as showing the species inhabiting such a place, and their relative abundance:

Twenty [20] traps set.

Sept. 19, 1893.	6 Arvicola riparius.
	1 Zapus hudsonius.
Sept. 20.	5 Arvicola riparius.
	1 Evotomys gapperi.
Sept. 21.	3 Arvicola riparius.
	1 Evotomys gapperi.
	1 Sorex personatus.
	1 Synaptomys cooperii.

Sixty-five [65] traps set.

Sept. 22.	17 Arvicola riparius.
	1 Evotomys gapperi.
Sept. 23.	10 Arvicola riparius.
Sept. 24.	6 Arvicola riparius.
	1 Evotomys gapperi.
	1 Synaptomys cooperii.
Sept. 25.	3 Arvicola riparius.
	1 Evotomys gapperi.
Sept. 26.	1 Arvicola riparius.
	1 Evotomys gapperi.
Sept. 27.	1 Evotomys gapperi.
Sept. 28.	Nothing; took up traps.
Totals.	Arvicola riparius, 54.
	Evotomys gapperi, 7.
	Sorex personatus, 1.
	Zapus hudsonius, 1.
	Synaptomys cooperii, 2.

This bog contained about an acre-and-a-half, and was bordered on one side by thick swampy woods and on the other three by open fields of grass, and had a small brook running through it.

Synaptomys cooperii is, I think, rare, or at any rate very local in this section, as I have trapped persistently for two years in every sort of locality the county affords, and have only taken these three examples.

As the country about Wareham, Mass., is not unlike that of

South Central New Jersey, I was anxious to see if my specimens were not referable to *S. stonei* Rhoads rather than to *S. cooperii*. For this purpose Dr. C. Hart Merriam kindly lent me a fine series of fourteen skins and many skulls of *S. cooperii*, partly from his own private collection, and partly from the collection of the Department of Agriculture at Washington. I also, through the kindness of Mr. S. N. Rhoads, of the Academy of Natural Sciences, Philadelphia, had a chance to examine his type of *Synaptomys stonei* and a topotype in the collection of Mr. Whitmer Stone, for whom the species was named.

In the light of this fine material, the specific character claimed for *S. stonei* faded away to mere individual variation, and *S. stonei* will have to stand as a synonym of *S. cooperii*, pure and simple.

The list of specimens I had to work with is as follows:

No.	Sex.	Date.	Locality.	Collector.	Measurement of hind foot.
*215	♀ ad.	June 9, 1893	Mass., Wareham.	O. Bangs	19¶
216	♀ ad.	Sept. 21, 1893	Mass., Wareham.	O. Bangs	18.5¶
217	♂ ad.	Sept. 24, 1893	Mass., Wareham.	O. Bangs	19¶
†3137	♀	Feb. 22, 1887	Indiana, Brookville.	A. W. Butler	18.5¶
3189	♂	Mar. 7, 1887	Indiana, Brookville.	A. W. Butler	18.5¶
827	♂	Nov. 10, 1884	Iowa, Knoxville.	C. K. Cherie	17.5
2601	♂	Aug. 18, 1886	Minn., Elk River.	Vernon Bailey	17
3260	♂	Dec. 10, 1886	Minn., Elk River.	Vernon Bailey	18
3261	♂	Dec. 9, 1886	Minn., Elk River.	Vernon Bailey	17.5
3263	♀	Dec. 26, 1886	Minn., Elk River.	Vernon Bailey	18
3264	♀	Mar. 5, 1887	Minn., Elk River.	Vernon Bailey	17
‡33089		Mar. 4, 1889	Minn., Elk River.	N. Bailey	20¶
53811	♂	May 11, 1893	N. C., Magnetic City.		20
50863	♂	Oct. 23, 1892	N. C., Roan Mt., alt. 6200 ft.	Elmer Edson	18
50862	♂	Oct. 22, 1892	N. C., Roan Mt., alt. 6200 ft.	Elmer Edson	19
35615	♀	Sept. 30, 1892	N. C., Roan Mt., alt. 6200 ft.	Elmer Edson	19.5
55797	♂	Aug. 27, 1893	N. C., Roan Mt., alt. 6000 ft.	Elmer Edson	19
§576	♀	Dec. 2, 1892	N. J., May's Landing.	S. N. Rhoads	18¶
‖168	♂	Feb. 16, 1893	N. J., May's Landing.	W. Stone	20¶
6401	Skull	Mar. 24, 1890	Maryland, Sandy Springs.		

*Collection of E. A. & O. Bangs, Boston, Mass.

†Collection of Dr. C. Hart Merriam, Locust Grove, N. J.

‡Collection of U. S. Department of Agriculture, Washington, D. C.

§Collection of Sam'l N. Rhoads [type of S. Stonei].

‖Collection of Whitmer Stone [topotype of S. Stonei].

¶These measurements taken by collector from fresh animal, all the others were taken by me from dried skin.

Many of the specimens I had were unmeasured, and as the hind foot is the only measurement that can be taken with accuracy from the dried skins, I give this only [in millimetres].

The few that were measured show that there is no difference in size or proportion between *S. cooperii* and *S. stonei* and indeed Mr. Rhoads states himself that there is none.

Measurements of eight (8) skulls of *Synaptomys cooperii* Baird.	Minn., Elk River, Mar. 4, 1892. No. 4508,*	Minn., Elk River, Aug. 18, 1886 ♂ No. 3230†	N. C., Roan Mt., Sept. 30, 1892 ♀ No. 47858*	Ind., Brookville, Feb. 17, 1887 ♀ No. 3771†	N. C., Magnetic City, May 11, '93 ♂ No. 53811*	Mass., Wareham, June 9, 1893 ♀ No. 215‡	N. J. May's Landing, Dec. 2, 1892 ♀ No. 567§	N. J. May's Landing, Feb. 16, 1893 ♂ No. 168‖
Basilar length	23.8	23.	23.6	24.	24.4	24.	23.4	24.
Basilar length of Hensel	22.6	21.8	22.	22.6	22.6	22.4	21.8	22.2
Zygomatic breadth	15.2	15.4	16.	16.2	16.6	16.2	16.	16.
Interorbital constriction	3.4	3.4	3.4	3.4	3.6	3.4	3.4	3.4
Greatest length of nasals	7.	6.8	7.	7.	8.	7.4	7.6	7.
Incisor to molar	7.	6.8	6.6	7.	7.	7.	6.6	7.
Incisor to post-palatal notch	12.4	12.	13.	12.8	13.	13.	12.	13.
Foramen magnum to post-palatal notch	9.2	9.	8.8	9.6	9.6	9.2	9.	9.
Upper molar series along crowns	6.4	6.4	6.8	6.6	7.2	6.8	6.8	7.
Basio-occipital to middle of interparietal	7.	7.	6.8	7.2	7.4	7.2	6.8	7.
Fronto-parietal depth at middle of molar series	7.8	7.8	8.	8.	8.8	8.2	8.	8.4
Greatest length of mandible	15.8¶	16.	16.6	16.2	17.	16.4	16.	17.
Lower molar series along crowns	6.	6.	6.4	6.2	6.8	6.4	6.4	6.8

*Skull No. collection of U. S. Department of Agriculture.
†Skull No. collection of Dr. C. Hart Merriam.
‡Collection of E. A. & O. Bangs.
§Collection of S. N. Rhoads [type of S. stonei].
‖Collection of Whitmer Stone [topotype of S. stonei].
¶This measurement is a little too short, as the bone is broken slightly.

From the above measurements, it will be seen that there are no differences of proportion in the skulls of *S. cooperii* and *S. stonei* more than a mere individual variation of the very slightest degree.

I shall now quote from Mr. Rhoads' original description* the specific characters claimed for *S. stonei*.

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*American Naturalist, Vol. 27, pp. 53 and 54, January, 1893.

Mr. Rhoads says:

"*Special characters*, outward appearance and proportions as in *S. Cooperii.* Above blackish-brown, with black hairs more predominant over the shorter brown hairs than in *Cooperii.* The same color reaching around sides of belly instead of being confined to dorsal area as in *Cooperii.* Hoary, gray belly and neck of *Cooperii* replaced by dark plumbeous gray. Feet, including soles, plumbeous, without brown shade. Two middle toes of fore feet, and four inner toes of hind feet, including nails, white. Tail unicolor plumbeous gray. Lips encircled with narrow white edgings."

The color of the type and a topotype of *S. stonei* can be exactly matched by specimens from Massachusetts, Minnesota, Iowa, and North Carolina, of *S. cooperii.*

"Skull narrower," [not so,] "shallower, and viewed from above, less angular than that of *Cooperii,*" [not so,] "but of same length. Lower jaws viewed from below, ditto" [exactly like specimens of *Cooperii*]. "Incisors shorter, broader, and less cylindrical, with sulcation of upper pair much more distinct" [characters entirely inconstant]. "Zygomatic foramen longer and narrower" [not so]. "Sagittal suture and parietals relatively much longer; interparietal tranversely narrower, longitudinally longer" [characters not constant]. "Supraoccipital in *cooperii* twice as wide as deep, in *stonei* thrice as wide as deep."

In the type of *stonei*, the only specimen Mr. Rhoads had at the time he described the species, this bone is so broken that its shape cannot be seen. In a topotype of *stonei* I have examined, I can find no difference from *cooperii.*

"Molars one-third wider and one-eighth longer in *stonei*" [width and length vary with age]. "In *cooperii* the length of the symphysis mandibuli just equals the distance from its posterior end to the angle formed by the antero-inferior border of the masseteric fossa; in *stonei* the symphysis is one-third longer" [inconstant].

"Posterior face of angle of lower jaw in *stonei* very stout, abruptly rounded, and recurved outward; in *cooperii* it is slender, spatulate, elongated posteriorly in a nearly vertical plane, and the margin below the condyle not thickened as in the former species."

It is hard to understand just what Mr Rhoads means. I can find no differences whatever between the lower jaws of *S. stonei* and *cooperii*.

Let us now look at the geographical distribution of *Synaptomys cooperii*, and bearing in mind the powerful effect of well defined faunal areas on a species, see what we should expect the *Synaptomys* of south central New Jersey to be.

We have *Synaptomys cooperii* from Minnesota, Iowa, Indiana, Ohio, North Carolina, Maryland and Massachusetts; would it not seem extremely improbable that we should find anything but *cooperii* in New Jersey?

Prof. Baird, in his original description of *Synaptomys cooperii*, says the specimen was "received from Mr. William Cooper of Hoboken. No locality was assigned, but the animal is undoubtedly North American, probably from the New England States or New York; possibly from Iowa or Minnesota." Why not even more probably from New Jersey, as Mr. Cooper lived there?

Since writing this article I have taken two more *Synaptomys cooperii* in Plymouth County, Mass.; one at Plymouth, January 15, 1894 [ad. ♀], and one at Wareham, March 31, 1894 [ad. ♂]. Both were caught in old cranberry bogs, associated with *Arvicola riparius* and using their run-ways.

VOL. IX, PP. 105-108 JUNE 9, 1894

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON

A NEW RABBIT FROM WESTERN FLORIDA.

BY GERRIT S. MILLER, JR. AND OUTRAM BANGS.

In a small collection of mammals made in Western Florida during the winter of 1893–1894, by F. L. Small are four specimens of a marsh rabbit that seems to be specifically distinct from *Lepus palustris* Bachman.

Dr. Bachman in his description of *L. palustris** gives no definite type locality, but states that the animal is common in eastern South Carolina and from thence south to southern Florida (on the east side). His description was probably based on South Carolina specimens as it evidently refers to the animal found in that region.

The form from western Florida may be defined as follows:

Lepus paludicola, sp. nov.

Diagnosis.

About the size of *L. palustris* with the hind foot shorter, the ear much shorter, and color generally darker and less yellow, especially about the head and on the under parts. Skull throughout slightly broader and flatter than that of *L. palustris*, the rostral part in particular being disproportionately short and broad.

Description.

Type specimen No. 1451 ♀ ad. Coll. E. A. and O. Bangs, Boston. From Fort Island, near Crystal River, Florida, Jan. 28, 1894. F. L. Small collector. Total length 438 mm ; tail vertebræ 35 mm ; hind foot 84 mm ; (taken in flesh by collector) ; ear 45 mm ; (taken from dried skin).

Color of upper parts russet[*] with black hairs thickly intermixed ; the black hairs predominating on the middle of the back and sides of the head and neck and gradually becoming less conspicuous on the sides, rump and legs. The patch running from between the ears back over the nape is a little brighter than the rest of the upper parts, being a clear bright russet,[*] without inter mixture of black-tipped hairs.

Color of the under parts dirty smoke gray[†] becoming pale cinnamon rufous[§] on the under side of the flanks. Band on the under side of the neck wood brown[‡]. Upper side of feet pale russet[*] with the lower side of the hind feet much darker, almost seal brown[‖] ; ears dark russet[*] bordered on the outer edge by an indistinct line of blackish, and outside this an almost white line running half way up the ear. The feet are very thinly haired and the nails very conspicuous.

Lepus palustris and *L. paludicola* show no differences in color that might not readily intergrade; but the skulls and ears of the two are so different as to lead to the opinion that they are two distinct species, rather than local races of the same species. In all the specimens examined, no sign of inter graduation can be found. Therefore it seems best to accord *L. paludicola* full specific rank for the present, or until intergrades do turn up.

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[*] Journal Acad. Nat. Sciences of Phila., Vol. vii, Pt. II, p. 194, 336.

[*] Nomenclature of Colors, Ridgway, Plate III, No. 16.

[†] Nomenclature of Colors, Ridgway, Pl. II, No. 12.

[§] Nomenclature of Colors, Ridgway, Pl. IV, No. 16.

[‡] Nomenclature of Colors, Ridgway, Pl. III, No. 10.

[‖] Nomenclature of Colors, Ridgway, Pl. III, No. 1.

Measurements of four specimens of *Lepus paludicola*, Miller and Bangs.

Number	1451*	1452*	1453*	1454*
Sex	♀	♂	♂	♀
Locality	Fort Island near Crystal River, Florida.	Salt River near Crystal River, Florida.	Fort Island near Crystal River, Florida.	Fort Island near Crystal River, Florida.
Collector	F. L. Small.	F. L. Small.	F. L. Small.	F. L. Small.
Total length	438	470	428	433
Tail	35	45	33	33
Hind foot	84	85	83	82
Ear from notch	45†	44†	44†	43†
Date	January 28, 1894.	January 27, 1894.	January 28, 1894.	January 29, 1894.

Measurements of four specimens of *Lepus palustris*, Bachman.

Number	745*	744*	1292‡	2173‡
Sex	♂	♂	♀	♀
Locality	Falling Creek, North Carolina.	Falling Creek, North Carolina.	Beaufort County, South Carolina.	Beaufort County, South Carolina.
Collector	O. Bangs.	O. Bangs.	W. Hoxie.	W. Hoxie.
Total length	431	439	....	....
Tail	54.5	58	....	....
Hind foot	99	93.5	85.5†	88†
Ear from notch	62	59.5	56†	54†
Date	January 10, 1894.	December 27, 1893.	September 1, 1885.	December 17, 1885.

*Collection of E. A. and O. Bangs, Boston, Mass. ‡Collection of Dr. C. Hart Merriam.

†Measured from dried skin. All other measurements taken by collector from fresh animal. Measurements in millimeters.

Cranial measurements and ratios of *Lepus paludicola* and *L. palustris.*

	Lepus paludicola.				*Lepus palustris.*			
Number	1452*	1451*	1453*	1454*	744*	745*	1629†	2700†
Sex	♂	♀	♂	♀	♂	♂	♀	♀
Basilar length	66	66	64	65	69	....	66	68
Basilar length of Hensel	60	61	60	60	63.8	....	59.4	61.4
Zygomatic breadth	39	38	37.4	38.8	39	38.6	37	39
Interorbital constriction	18	18	18	18	17		18	18
Greatest length nasals	29.6	30	30	31	34	32.4	32.4	33
Greatest width nasals	15	15	15	16	15	12	13	13
Incisor to molar (alveoli)	20	21.2	21.2	21.2	23		21.6	22
Parieto-basioccipital depth	22	21.4	22	23	24	24	23	22.2
Fronto-palatal depth	19.4	18.2	17.6	18	19	19.8	18.4	19
Length of incisive foramen	17	17	16.2	17	19	18.8	18.4	17.8
Width of incisive foramen	8.8	8.4	7.8	8	7	7	8	6.8
Molar series (alveoli)	15	15	14.8	14.8	15	15	16	14.6
Mandible: length	....	57	54.6	....	59	....	60	55
Mandible: depth through articular process	....	37	35.4	36.4	39.8	....	40	38
Mandible: depth at posterior molar	12	13	12	12.4	14	....	14.4	12.6
Mandible: incisor to molar (alveoli)	15	15.6	15	15.6	16.4	....	15.4	16
Mandibular molar series (alveoli)	15.4	15	15	15.4	15.4	....	17	15.2
Ratios to basilar length—								
of zygomatic breadth	59.09	57.57	58.43	59.69	56.25	....	56.06	57.35
of interorbital constriction	27.27	27.27	28.12	27.68	24.61	....	27.27	26.47
of nasals (length)	44 84	45.45	46.87	47.69	49.27	....	49.09	48.53
of nasals (width)	22.06	22.06	23.43	24.61	18.84	....	19.69	9.11
of parieto-basioccipital depth	33.33	32.42	34.37	35.38	34.78	....	34.87	32 64
Nasals: ratio of width to length	50.67	50.00	50.00	51.57	38.32	36.72	40.12	39.39
Incisive foramen: ratio of width to length	51.76	49.41	48.15	47.06	36.84	37.23	43.36	38.20

*Collection of E. A. and O. Bangs. †Collection of Dr. C. Hart Merriam.

Vol. IX, pp. 109-116 June 21, 1894

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON

PRELIMINARY DESCRIPTIONS OF ELEVEN NEW KANGAROO RATS OF THE GENERA DIPODOMYS AND PERODIPUS.

BY DR. C. HART MERRIAM.

The following brief descriptions are here published in advance of a monographic revision of the group which will appear shortly. Of the eleven new forms here defined, *Dipodomys elator* from northern Texas; *D. ornatus* from the state of Zacatecas, Mexico; *D. m. nitratus* from Owens Lake, California; *Perodipus streatori* from the west slope of the Sierra Nevada, and *P. panamintinus* from the Panamints Mts. in California require no comparison with previously described species. The others are less sharply differentiated.

Dipodomys elator sp. nov.

Type from Henrietta, Clay Co., Texas. No. 64,802 ♂ ad. U. S. Nat. Museum, Department of Agriculture Collection. Collected April 13, 1894, by J. Alden Loring (Original number 1,804).

Measurements (taken in flesh).—*Type:* Total length 292; tail vertebræ 173; hind foot 47. Ear from anterior base 14 (in dry skin).

Average measurements of 2 specimens from type locality: Total length 290; tail vertebræ 170; hind foot 45.5.

General characters.—Similar to *Dipodomys spectabilis* but considerably smaller, with much smaller ears; tail more slender and paler, with shorter white pencil; hind feet relatively longer;

facial crescents heavier; nose blacker. Cranial characters unique.

Color.—Upper parts clay-color, lined with dark-tipped hairs on head and back, becoming pale ochraceous buff on flanks; thigh patches large; facial crescents broad and indistinctly continuous to end of nose which is broadly blackish; inner side of legs dusky; dorsal and ventral tail stripes barely meeting in front of white pencil, the white lateral stripes being almost continuous to the white tip; ventral dark stripe pale; dorsal dark stripe pale for proximal $\frac{2}{3}$, becoming blackish on crested part; white pencil rather short, measuring about 23 mm. beyond the tips of the black hairs in the two specimens at hand.

Cranial characters.—Skull small for the size of the animal; rather highly arched on top as in *D. phillipsi;* supraoccipital between mastoid bullæ broader than in any other known species; interparietal nearly as broad as long; ascending branches of premaxillæ broad and slightly expanded posteriorly; nasals somewhat narrowed posteriorly; top of skull broad but not broad enough to hide zygomatic arches, which are far apart; sides of frontals sloping strongly inward from point slightly anterior to plane of fronto-parietal suture; nasals decidely longer than frontal breadth immediately behind lachrymals. Mandible small for size of skull; angle large and pointed. Upper premolar an incompletely double prism, its crown with a well developed antero-internal lobe.

Dipodomys ornatus sp. nov.

Type from Berriozabal, Zacatecas, Mexico. No. 57,990 ♀ ad. U. S. Nat. Mus. Department of Agricultural Collection. Collected December 29, 1893 by E. A. Goldman. (Original number 5,613.)

Measurements (taken in flesh).—*Type:* Total length 274; tail vertebræ 167; hind foot 39. Ear from anterior base 15 (in dry skin).

General characters.—Similar to *Dipodomys phillipsi* in size and pattern of markings but brighter and more golden in color; dark markings more extensive and blacker, ears somewhat larger; hind foot shorter; tail crested penicillate, its tip white.

Color.—Upper parts bright golden clay-color, darkest on head and median back, brightest on sides; thigh patches large; facial crescents large, broad, and very black, meeting broadly over bridge of nose which is solid black for $\frac{1}{3}$ the distance from nostrils to eye except a small white spot over extreme end of nose; narrow ring round eye, inner sides of hind legs, and dorsal and ventral tail stripes black; tip of tail pure white. The white side stripes of the tail disappear near the junction of the distal and middle thirds, the black stripes uniting in a broad belt anterior to the white pencil. The face is mainly white between the eye and facial crescent, though the white is somewhat obscured, particularly near the eye, by dark-tipped hairs.

Cranial characters.—Skull similar to that of *D. phillipsi* in general size and form, but proportions different. Mandible larger and heavier with much longer and broader angular processes. The basal length and mastoip breadth are essentially the same in the two species, but the naso-occipital length in *ornatus* is much less and the zygomatic breadth very much greater. While the zygomatic breadth is actually greater in *ornatus*, the breadth across the top of the skull is decidedly less: hence when viewed from above, the zygomatic arches stand out beyond the sides of the cranium, while in *phillipsi* they are hidden beneath the edges of the frontals and parietals. In *ornatus* the top of the cranium is much flatter than in *phillipsi*; the supraoccipital is narrower between the mastoid bullæ; the nasals are not narrowed behind, and the ascending branches of the premaxillæ are shorter and more slender and have no trace of the posterior expansion commonly present in *phillipsi*. The upper premolar is a single prism and its crown has no trace of the antero-internal lobe of *phillipsi*.

Dipodomys perotensis sp. nov.

Type from Perote, Vera Cruz, Mexico. No. 54,285 ♀ ad. U. S. Nat. Mus. Department of Agriculture Collection. Collected May 21, 1893 by E. W. Nelson (Original number 4840).

Measurements (taken in flesh).—*Type:* Total length 265; tail vertebræ 162; hind foot 40. Ear from anterior base 14 (in dry skin).

Average measurements of 8 specimens from type locality: Total length 271; tail vertebræ 168; hind foot 40.4.

General characters.—Similar in size and general appearance to *Dipodomys phillipsi* and *ornatus* and intermediate between them in coloration; white terminal pencil short, and in one specimen absent. Cranial characters substantial.

Color.—Upper parts brownish clay color, intimately mixed with and darkened by blackish-tipped hairs on head and back; strongly suffused with ochraceous buff on sides and flanks; facial crescents large and black, meeting across the nose; inner side of leg and sole blackish; lateral white stripes of tail disappearing near junction of distal and middle thirds; white terminal pencil small and in one specimen absent (possibly the result of injury in early life).

Cranial characters.—Skull similar to that of *D. ornatus*, but even narrower on top [consequently very different from *phillipsi*]; zygoma visible from above; top of skull more strongly arched anteroposteriorly than any other known species; breadth of supraoccipital between inflated mastoids greater than in *phillipsi* or *ornatus*. Angle of mandible larger than in *phillipsi* but smaller than in *ornatus*.

Dipodomys merriami nevadensis subsp. nov.

Type from Pyramid Lake, Nevada. No. 54,552 ♀ ad. U. S. Nat. Mus., Department of Agriculture Collection. Collected June 26, 1893, by Vernon Bailey (Original number 3,990).

Measurements (taken in flesh).—*Type:* Total length 240; tail vertebræ 140; hind foot 39. Ear from anterior base 13 (in dry skin).

Average measurements of five adults from type locality: Total length 243; tail vertebræ 143.5; hind foot 39.9.

General characters.—Similar to *D. merriami* but with shorter tail and longer hind foot; coloration paler and more buffy.

Color.—Upper parts pinkish buff, darkened on head and back by intermixture of dark-tipped hairs; facial crescents distinct but hardly meeting across nose, though bridge of nose is somewhat darkened; face in front of eyes pure white except where interrupted at base of whiskers by facial crescents; underparts and thigh stripes pure white; dorsal and ventral tail stripes dusky, meeting at end of tail; inner side of legs to heel dusky.

Dipodomys merriami nitratus subsp. nov.

Type from KEELER, EAST SIDE OF OWENS LAKE, CALIFORNIA (No. $\frac{25359}{32772}$ ♂ ad. U. S. Nat. Mus. Department of Agriculture Collection). Collected December 29, 1890 by E. W. Nelson (Original number 160).

Measurements (taken in flesh).—*Type:* Total length 237; tail vertebræ 140; hairs 26; hind foot 39. Ear from anterior base 13 (dry skin). Basilar length of skull 22 mm.

Average measurements of 23 specimens from type locality: Total length 239; tail vertebræ 141; hind foot 37.8.

General characters.—Smaller than *D. merriami*, with relatively larger hind feet and wholly different coloration; dusky markings obsolete.

Color.—Upper parts uniform intense ochraceous or tawny-buff not mixed with black-tipped hairs; facial crescents obsolete; no dusky or blackish markings anywhere; no superciliary stripe, but a distinct white spot over eye; upper and lower tail stripes concolor with back; white side stripes continuous.

Dipodomys merriami nitratoides subsp. nov.

Type from TIPTON, SAN JOAQUIN VALLEY, CALIFORNIA. No. 54,674 ♂ ad. U. S. Nat. Mus. Department of Agriculture Collection. Collected June 25, 1893, by Clark P. Streator (Original number 2,978).

Measurements (taken in flesh).—*Type:* Total length 246, tail vertebræ 148; hind foot 36. Ear from anterior base 12 (in dry skin).

Average measurements of 13 specimens from type locality: Total length 237; tail vertebræ 144; hind foot 35.

General characters.—Similar to *D. m. nitratus* in size and color, but with strongly marked facial crescents meeting over bridge of nose; ears smaller.

Color.—Upper parts everywhere uniform fulvous; facial crescents dusky and meeting over bridge of nose; dorsal tail stripe darker than back; crested part of tail same color as back; ventral tail stripe dull fulvous, continuous to end of tail; inner aspect of hind legs to heel dull fulvous; under parts and thigh stripe white; spot ever eye obscured by dark tipped hairs.

Dipodomys merriami exilis subsp. nov.

Type from FRESNO, SAN JOAQUIN VALLEY, CALIFORNIA. No. $\frac{34843}{45823}$ ♂ yg. ad. U. S Nat. Mus. Department of Agricultural Collection. Collected September 23, 1891, by Vernon Bailey (Original number 3,277).

Measurements (taken in flesh).—*Type:* Total length 241; tail vertebræ 143; hairs 21; hind foot 33. Ear from anterior base 12 (in dry skin). Bisilar length of skull 21 mm.

Average measurements of 20 specimens from type locality: Total length 227; tail vertebræ 135.5; hind foot 34.

General characters.—Similar to *Dipodomys merriami* but smaller and darker, with upper surface of nose and posterior aspect of ankles black.

Color.—Upper parts nearly uniform clay color, darkened with sepia from abundant admixture of black-tipped hairs, and darkest on the head; sides and flanks tinged with ochraceous-buff; black crescents at base of whiskers sharply defined and meeting in median line so that the bridge of the nose is black: superciliary stripe whitish, not interrupted as in *D. merriami;* ears dark; posterior aspect of ankles and lower leg black; upper and lower tail stripes sooty blackish, meeting along terminal third, thus interrupting the white side stripes; under parts silky white.

Cranial characters.—Skull similar to that of *D. merriami* but much smaller; nasal bones shorter.

Dipodomys merriami atronasus subsp. nov.

Type from HACIENDA LA PARADA, SAN LUIS POTOSI, MEXICO. No. 50,276 ♂ ad. U. S. Nat. Mus. Department of Agriculture Collection. Collected August 20, 1892, by E. W. Nelson. (Original number 3,229).

Measurements (taken in flesh).—*Type:* Total length 267; tail vertebræ 162; hind foot 40.

Average measurements of 4 specimens from type locality: Total length 250; tail vertebræ 152; hind foot 38.5.

General characters.—Similar to *D. merriami* but darker; pelage coarser, particularly on head.

Color.—Upper parts dark clay-color, everywhere mixed with dark-tipped hairs and suffused with ochraceous buff, which is strongest on the sides; nose from black tip to between eyes grizzled with coarse yellowish, dark-tipped hairs; facial crescents large, black, meeting over end of nose; inner side of thighs and dark tail stripes blackish; white lateral tail stripes mixed with dark hairs and disappearing in middle third of tail.

Perodipus streatori sp. nov.

Type from CARBONDALE, MARIPOSA CO., CALIFORNIA (at west foot of Sierra Nevada). No. 64,310 ♀ ad. U. S. Nat. Mus. Department of

Agriculture Collection. Collected April 3, 1894, by Clark P. Streator. (Original number 3,673).

Measurements (taken in flesh). *Type:* Total length 292; tail vertebræ 179; hind foot 43. *Average* of 26 specimens from type locality: Total length 295; tail vertebræ 180; hind foot 43.

General characters—Similar to *P. agilis* but larger; ears smaller; tip of tail normally white.

Color.—Upper parts Isabella brown, darker along the middle of the back and on sides of neck; sides and flanks suffused with ochraceous buff; a distinct white spot over eye and at base of ear; top of nose, crescent through base of whiskers, and narrow ring around eye blackish; a band of white overlaid by dark-tipped hairs runs from base of whiskers to ear, including the eye: innerside of thigh and sole of foot blackish; dorsal and ventral tail stripes dusky, meeting in a broad subapical dark ring beyond which the end of the tail is normally *pure white* as in many species of *Dipodomys*; under parts, thigh stripes, and ring at base of tail pure white. Two very young specimens have the white tip of the tail sharply defined but short; some of the old specimens lack the white tip, in others the white side-stripes are nearly continuous to the tip.

Cranial characters.—Skull similar to that of *P. agilis* but larger and heavier; parietals longer antero-posteriorly (inner border decidedly longer than anterior); fronto-parietal suture strongly sinuous, convex forward at median line; supraoccipital broader between mastoid bullæ on top of skull.

Dental characters.—Molariform teeth larger and heavier; crown of last upper molar longer antero-posteriorly and usually more subquadrate; osteodentine islands dark.

Perodipus panamintinus sp. nov.

Type from PANAMINT MTS., CALIFORNIA (on head of Willow Creek). No. $\frac{28566}{40670}$ ♂ ad. U. S. Nat. Mus. Department of Agricultural Collection. Collected May 12, 1891, by E. W. Nelson (Original number 853).

Measurements (taken in flesh).—*Type:* Total length 305; tail vertebræ 183; hind foot 44. Ear from anterior base 15 (in dry skin).

Average measurements of 16 specimens from type locality: Total length 301; tail vertebræ 180.6; hind foot 44.6.

General characters.—Largest species of the genus; coloration ochraceous buffy; does not require comparison with any known species.

Color.—Upper parts pale buffy clay-color, tinged with pale ochraceous; thigh patches large, colored like back; facial crescents and end of nose broadly blackish but barely or not continuous over sides of nose; inner sides of legs dusky; dorsal and ventral tail stripes pale dusky. the ventral stripe failing or indistinctly continuous on distal third, permitting the lateral white stripes to meet below on distal third, nearly as in *P. richardsoni.* Eyelids and anterior part (more than ½) of reflexed upper border of ear blackish; posterior part of ear whitish.

Perodipus ordi columbianus subsp. nov.

Type from Umatilla, Plains of Columbia, Oregon. No. $\frac{24181}{31594}$ ♀ ad. U. S. Nat. Museum. Department of Agriculture Collection. Collected Oct. 18, 1890, by Clark P. Streator (Original number 386).

Measurements (taken in flesh).—*Type:* Total length 254; tail vertebræ 148; hind foot 40. Ear from anterior base 13 (in dry skin).

Average measurements of 15 specimens from type locality: Total length 244.5; tail vertebræ 140.5; hind foot 39.

General characters.—Similar to *P. ordi* but less ochraceous in color and with markings more pronounced; ears blackish instead of flesh color; supraorbital white spots more conspicuous.

Color.—Upper parts clay-color, finely mixed with dark-tipped hairs; thigh patches large, more tinged with ochraceous than rest of upper parts, this color reaching down on inner side of leg in a narrow stripe to heel [no dusky on inner side of leg]; facial crescents blackish and nearly continuous with a blackish spot on end of nose; supraorbital white spots unusually conspicuous; interior of ear conch and reflexed upper border blackish; back side of ear whitish; dorsal and ventral tail stripes dusky, the ventral failing or nearly failing on terminal fourth, where the white sides stripes commonly meet or nearly meet for a short distance; tip of tail dusky all round from upper stripe.

Cranial characters.—The skull of *columbianus* differs from that of typical *ordi* in having the basioccipital much broader, the postero-external angle of the maxillary wing of the zygoma more strongly produced backward and downward and the angle of the mandible larger.

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ABSTRACT OF A STUDY OF THE AMERICAN WOOD RATS, WITH DESCRIPTIONS OF FOURTEEN NEW SPECIES AND SUBSPECIES OF THE GENUS NEOTOMA.

BY DR. C. HART MERRIAM.

The following brief abstract of a study of the North American Wood Rats and Desert Rats, with descriptions of a dozen new forms from Mexico and the western United States, based on the rich collections of the United States Department of Agriculture, is here published in advance of a more formal paper on the group. The genus *Neotoma* is here restricted to the species in which the crown of the last lower molar is made up of two transverse loops; the species having the crown of this tooth shaped like the letter S are transferred to the genus *Ptyssophorus* of Ameghino, previously known from a single fossil species from South America. As thus restricted, the genus *Neotoma* is divided into two subgenera, *Neotoma* proper and *Teonoma*, which are complementary in their geographic distribution, *Neotoma* proper being Sonoran or Austral, while *Teonoma* is Boreal. It is convenient to subdivide the former into four minor groups, none of which is worthy of the distinction of subgeneric rank. These groups may be designated, from a typical species in each, as follows: (1) the *leucodon* group; (2) the *mexicana* group; (3) the *desertorum* group, and (4) the *arizonæ* group.

Subgenus NEOTOMA Ord, 1825.

Type, *Neotoma floridana* Ord, from Florida.

Tail commonly round, scant-haired and tapering, but in one species moderately bushy; hind feet small or moderate.

Rostrum of moderate length, never more than one-third the length of cranium; sagittal area usually rounded, the broadest part always considerably anterior to plane of interparietal, whence the sides curve gradually backward to interparietal shield; spheno-palatine vacuties always open.

(1) *Neotoma leucodon group.—Neotoma leucodon, latifrons, micropus, baileyi, floridana* and *pennsylvanica* form a fairly well circumscribed group, differing from the other subdivisions of the genus in having the frontals abruptly spreading and flattened immediately behind the interorbital constriction, the orbital margins upturned and pinched in, almost forming a bead; the nasal bones short and cuneate, tapering evenly to a dull point behind; the postpalatal notch moderately or broadly excavated (moderately in *leucodon*, very broadly in *floridana*); the upper molar series very much broader anteriorly than posteriorly (m ^{1} nearly $\frac{1}{3}$ broader than m ^{3}); m ^{1} comprising three transverse loops, the anterior of which is but slightly indented by the antero-internal sulcus—never divided by the deepening of this sulcus as in the *mexicana* series; color of teeth white or nearly white (except in *floridana*, which is an aberrant member of the group*). *N. pennsylvanica* has certain primitive characters not shared by the others, and is more nearly intermediate between the subgenera *Neotoma* and *Teonoma* than any known living species. The group inhabits the Lower and Upper Sonoran Zones from Perote in Vera Cruz and Berriozabal in Zacatecas, northward to southern South Dakota.

(2) *Neotoma mexicana group.—Neotoma mexicana*†, *pinetorum, orizabæ tenuicauda, fulviventer, fallax and fuscipes* form a group of closely allied species agreeing in certain important cranial characters whereby they differ from all the other subdivisions of the genus. *N. fuscipes*‡ and *fallax* are somewhat aberrant members of the series. *Neotoma torquata* Ward probably belongs here also. The group seems to occupy a midway position in the genus, lacking the more specialized characters that distinguish the others.

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*In most species of *Neotoma* the osteodentine is dark and the reentrant angles are filled with a blackish substance.

†One subspecies of *mexicana* is here recognized: *N. mexicana bullata* from the Santa Catalina Mts. in Arizona.

‡The subspecies of *fuscipes* here recognized are *macrotis* Thomas from the southern coast region of California; *streatori* from the western slope of the Sierra Nevada and adjacent parts of the upper Sacramento Valley, and *dispar* from the east foot of the Sierra along the western edge of the Mohave Desert region. *N. monochroura* Rhoads and *N. splendens* True seem to be typical *fuscipes*, and *N. macrotis simplex* an intergrade.

The upper molar series is of more nearly equal breadth throughout, the anterior molar not being so broad relatively as in the other groups. The postpalatal notch is usually narrow, though it is broadened anteriorly in *N. fuscipes macrotis* of southern California. The frontals increase in width but slightly from before backward, never expanding abruptly behind the interorbital constriction as in the *leucodon* series. The anterior lobe of m ^{1} is completely divided by a deep sulcus on the inner side into two loops, except in *fuscipes*, in which the sulcus is relatively shallower and more anterior in position, the division being less complete than in other species. So far a known the group is restricted to the Upper Sonoran and Transition Zones, where it ranges from southern Mexico (States of Jalisco, Michoacan, Mexico, Puebla, and Vera Cruz) northward in the interior to Colorado and northern Arizona, and along the Pacific Coast to Oregon.

(3) *Neotoma desertorum group.—Neotoma desertorum and intermedia** constitute the third group into which it is convenient to divide the restricted genus. The group is not very sharply defined, some forms of *intermedia* coming very close to aberrant forms of the *leucodon* series. The frontals increase in breadth gradually from before backwards, much as in the *pinetorum* group—not suddenly behind the constriction as in the *leucodon* series. There is no supraorbital bead in typical *desertorum*, but *intermedia* shows a decided tendency to the formation of such a bead. The postpalatal notch is narrower than in any other division of the genus. In dental characters the group resembles the *leucodon* series, the molars being decidedly broader anteriorly than posteriorly, and m ^{1} being made up of three transverse loops, the anterior of which is but faintly indented by the antero-internal sulcus. The members of the group inhabit the Sonoran deserts of northern Mexico and the southern United States, ranging from Chihuahua and Sonora northward to northern Utah, northern Nevada, and middle California.

**Neotoma intermedia* Rhoads inhabits the valleys of the coast reigon of California, south of Monterey Bay. A somewhat paler form, usually more or less suffused with pale ochraceus buffy, inhabits San Gorgonio Pass and the western edge of the Colorado Desert. It was provisionally named *gilva* by Rhoads, and has just been renamed *venusta* by True (in a publication received since the present paper went to press), but seems hardly entitled to the distinction of a separate name. *N. californica* Price seems to be a typical *intermedia*. Two subspecies, *albigula* Hartley from south and west Arizona, and *melanura* nob. from Sonora, are here recognized.

(4) *Neotoma arizonæ group.*—*Neotoma arizonæ and N. lepida** Thomas stand somewhat apart from the other subdivisions of *Neotoma* proper, having bushy tails like those of *Teonoma*, only smaller. In cranial characters they are hardly separable from the *desertorum* group. They inhabit a small area on the southern part of the Colorado Plateau in northern Arizona, northwestern New Mexico, and southeastern Utah, and seem to be restricted to the lower part of the Upper Sonoran Zone.

Respecting the descriptions of new species which comprise the bulk of the present paper, it should be remembered that each relates to a particular pelage. As a rule the summer and winter pelages are different, the winter coat being grayer, the summer coat more ochraceous or fulvous. In some species the summer coat becomes more fulvous or even rusty with age, and the tips of the black hairs wear off, changing the appearance of the animal materially.

Neotoma leucodon sp. nov.

Type from San Luis Potosi, Mexico. No. 50,137 ♂ ad. U. S. Nat. Museum, Department of Agriculture Collection. Collected August 14, 1892, by E. W. Nelson (Original number 3076).

Measurements (taken in flesh).—*Type:* Total length 358; tail vertebræ 164; hind foot 38.5. Ear from anterior base 30 (in dry skin).

Average measurements of 7 males from type locality: Total length 352; tail vertebræ 160; hind foot 39. Average of 3 females from type locality: Total length 342; tail vertebræ 156; hind foot 37.

General characters.—A large species related to *Neotoma micropus* but differing materially in color and in cranial and dental characters.

Color.—Upper parts ochraceous-buff tinged with fulvous and plentifully lined with black hairs; sides relatively free from black hairs; nose and face between eyes grayish; underparts white, with plumbeous underfur on sides of belly; fore and hind feet pure white; tail sharply bicolor, blackish above, white beneath.

Cranial characters.—Skull with the broad frontal platform of *micropus* and *floridana*, but with sides of frontals decidedly upturned and *postpalatal notch narrow*; ascending branches of premaxillæ very long, nearly reaching plane of narrowest part of interorbital constriction; nasals narrow behind and relatively short, barely cutting plane of orbits; jugals short as in *fuscipes*; length of palate from incisive foramina to postpalatal notch nearly or quite equal to length of incisive foramina: audital bullæ large; infraorbital va-

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*The status of *N. lepida* is not very clear. If the type is not a small female of *N. arizonæ*, it must be very closely related.

cuities large; basisphenoid spine about the same breadth as presphenoid.

Dental characters.—Molars large, very broad anteriorly (m^1 nearly $\frac{1}{3}$ broader than m^3), and *white*—the whiteness due in part to the absence of color in the osteodentine, which is dark in other species, and in part to the absence of the usual dark fillings in and about the reentrant angles. M^1 with only 2 salient angles and 1 vertical slit on inner side, the anterior loop being undivided; crown of m^3 a trefoil, the anterior lobe pyriform; m_1 with antero-internal sulcus obsolete, and middle loop more transverse than in *micropus*.

General remarks.—Specimens of this new species have been examined from La Parada, San Luis Potosi, Berrizoabal, Zacatecas and Perote, Vera Cruz. The Perote specimens are somewhat smaller and have the postpalatal notch narrower and the nasals more acutely pointed behind.

Neotoma latifrons sp. nov.

Type from QUERENDARO, MICHOACAN, MEXICO. No. 50,135 ♂ ad. U. S. Nat. Museum, Department of Agriculture Collection. Collected August 8, 1892, by E. W. Nelson (Original number 3058).

Measurements (taken in flesh).—*Type:* Total length 350; tail vertebræ 149; hind foot 42. Ear from anterior base 26 (in dry skin).

General characters.—Similar to *N. leucodon* but smaller, with smaller ears, shorter tail, longer hind feet, and cranial differences.

Color.—Upper parts ochraceous buff tinged with fulvous and moderately lined with dark hairs; the fulvous tinge strongest on sides where it runs forward to cheeks; under parts and feet white, the white of belly and chin clouded with plumbeous from under fur; tail indistinctly bicolor, dusky above, becoming soiled whitish beneath.

Cranial characters.—Skull similar to that of *N. leucodon* but differing in having the frontal platform even broader, its sides strongly spreading immediately behind interorbital constriction, and forming a projecting angle before leaving orbital fossa; skull as a whole shorter and relatively broader; molars narrower and less crowded; m^1 with antero-internal sulcus more pronounced.

Neotoma fulviventer sp. nov.

Type from TOLUCA VALLEY, MEXICO. No. 50,165 ♀ ad. U. S. Nat. Museum, Department of Agriculture Collection. Collected Nov. 5, 1892, by E. W. Nelson (Original number 3744).

Measurements (taken in flesh).—*Type:* Total length 350; tail vertebræ 160; hind foot 34. Ear from anterior base 26 (in dry skin).

General characters.—Similar to *Neotoma tenuicauda* but larger, darker, and under parts dull fulvous instead of white. Ears and feet small; tail slender; texture of pelage fine and soft.

Color.—Upper parts dull fulvous becoming almost dusky along the middle of the back; under parts pale fulvous; fore and hind feet white; tail bicolor, blackish above, soiled whitish below.

Cranial characters.—Skull similar in general to that of *tenuicauda*, but larger; nasals slightly longer (cutting plane of orbits) and rounded instead of truncate behind; jugal very short; anterior spine of basisphenoid longer; distance across molar series posteriorly greater than length of series on crowns [in *tenuicauda* less]; incisive foramina falling considerably short of plane of m ^{1} [in *tenuicauda* reaching or nearly reaching this plane]. Contrasted with *N. orizabæ* the skull of *fulviventer* is lighter, the nasals truncate anteriorly [instead of projecting acutely], and the molars narrower.

Dental characters.—M ^{1} with 3 well developed salient angles and two vertical slits on inner side as in *tenuicauda* and *pinetorum*; m ^{3} also as those species.

Neotoma orizabæ sp. nov.

Type from Mt. Orizaba, Puebla, Mexico. No. 53,653 ♂ ad. U. S. Nat. Museum, Department of Agriculture Collection. Collected April 20, 1893, by E. W. Nelson (Original number 4674).

Measurements (taken in flesh).—*Type:* Total length 356; tail vertebræ 163; hind foot 33. Ear from anterior base 28 (in dry skin).

General characters.—Similar to *Neotoma fulviventer* but upper parts more buffy ochraceous instead of fulvous; belly white instead of dull fulvous; hind feet shorter; pelage coarser; skull and teeth different.

Color.—Upper parts bright ochraceous buff, brightest and purest on the the sides, obscured on the back by black hairs, and becoming grayish on the head; under parts and feet white, the chin and sides of the belly clouded by the plumbeous under fur which shows through; a salmon spot on each side of the breast; tail sharply bicolor, dusky above, whitish below.

Cranial characters.—Skull similar to *N. fulviventer* in general form and tooth characters but heavier; frontal narrower interorbitally with edges more upturned; postpalatal notch broader; nasals projecting much further anteriorly and narrowly rounded off in front [instead of truncate anteriorly]. The ascending branches of the premaxillæ extend only a short distance beyond the nasals.

Dental characters.—The molars are broader and heavier than in *fulviventer* and have larger dentine islands. M ^{1} has 3 salient angles and 2 vertical slits on the inner side.

General remarks.—Specimens of this general type, differing more or less in minor particulars, have been examined from Chalchicomula, Puebla, Mt. Malinche, Tlaxcala, and Cofre de Perote, Vera Cruz.

Neotoma mexicana bullata subsp. nov.

Type from Santa Catalina Mts., Arizona. No. 16,863 ♂ ad. U. S. Nat.

Museum, Department of Agriculture Collection. Collected June 1, 1889, by Vernon Bailey (Original number 114).

Measurements (taken in flesh).—*Type:* Total length 335; tail vertebræ 151; hind foot 34. Ear from anterior base 22 (in dry skin).

General characters.—Similar to *N. mexicana*; audital bullæ peculiar.

Color.—Upper parts dull ochraceous buff, becoming grayish on the head and legs, and copiously lined with black-tipped hairs on the back; fore and hind feet pure white; under parts white; under fur plumbeous; a faint ochraceous pectoral collar in type specimen; tail bicolor, grayish brown above, whitish beneath.

Cranial characters.—Skull similar to that of *mexicana* in size and general characters; nasal bones broadly truncate posteriorly; audital bullæ rather small and curved toward median line anterioriy in a manner not observed elsewhere in the genus, the inner side decidedly concave, and sloping inward.

Neotoma baileyi sp. nov.

Type from Valentine, Nebraska. No. $\frac{4311}{5034}$ ♀ ad. Merriam Collection. Collected June 16, 1888, by Vernon Bailey (Original number 41).

Measurements (taken in flesh).—*Type:* Total length 371; tail vertebræ 165; hind foot 39. Ear from anterior base 23 (in dry skin).

General characters.—Similar in a general way to *Neotoma floridana*, but ears smaller, tail shorter, color grayer; differs also in cranial characters.

Color.—Upper parts grizzled gray; face nearly clear gray; fore and hind feet white; tail sharply bicolor, dusky above, white below; under parts white to roots of hairs except on sides of belly where the basal fur is plumbeous and shows through.

Cranial characters.—Skull clearly of the *Neotoma floridana-micropus* type, having the frontal platform broad and flat, and the postpalatal notch broadly excavated, but differing from *floridana* in the following characters: Nasal and nasal branches of premaxillæ decidedly shorter; basisphenoid spine narrower and sloping from base to apex where it is continuous with slope of presphenoid; presphenoid without the enlarged base of *floridana*; palate much shorter; incisive foramina decidedly shorter [length of palate from incisive foramina equals length of incisive foramina; in *floridana* the palate is much shorter than incisive foramina]. Molar teeth above and below decidedly larger and heavier than in *floridana*; m [1] with antero-internal sulcus nearly obsolete, as in *micropus*.

Neotoma fallax sp. nov.

Type from Gold Hill, Boulder Co., Colorado. No. $\frac{5678}{6345}$ ♂ ad. Merriam Collection. Collected November 1, 1889, by Denis Gale.

Measurements of type (taken from dry skin): Total length 330; tail vertebræ 140; hind foot 31; ear from anterior base 22.

General characters.—Similar to *N. intermedia* in external appearance, but differing in important cranial and dental characters, which place it in the *mexicana-pinetorum* series, of which it is an aberrant member. M $_3$ with 3 instead of 2 salient angles on outer side—a unique character.

Color.—Upper parts buffy clay color, everywhere finely lined with black hairs; under parts white, the under color plumbeous and showing through except in a narrow strip along the median line where the hairs are white to roots; fore and hind feet pure white; tail bicolor, dusky above, white below.

Cranial characters.—Skull similar to that of *mexicana* but differing from *mexicana* in the following particulars: Nasals narrower posteriorly and reaching posterior plane of lachrymals; ascending branches of premaxillæ exceeding nasals but little; audital bullæ less globular; frontals much broader posteriorly.

Dental characters.—Molars as in *mexicana*; m ^{1} with a strongly developed antero-internal lobe (having 3 instead of 2 salient angles on inner side); m $_3$ with antero-external loop (having 3 salient angles instead of 2 on outer side, and 2 reentrant angles instead of 1.)

Neotoma fuscipes streatori subsp. nov.

Type from Carbondale, Amador Co., California. No. 64,439 ♂ ad. U. S. Nat. Museum, Department of Agriculture Collection. Collected April 4, 1894, by Clark P. Streator (Original number 3685).

Measurements (taken in flesh).—*Type:* Total length 382; tail vertebræ 175; hind foot 38. Ear from anterior base 25 (in dry skin).

Average measurements of 3 adult specimens from type locality: Total length 380; tail vertebræ 183; hind foot 37.

General characters.—Similar to *N. fuscipes* in size and color, but ears broader; ankles somewhat darker; hind feet from ankles pure white. Cranial characters pronounced.

Color.—Upper parts dark grizzly brown, strongly suffused with fulvous, which is brightest and palest on the sides. Under parts creamy white. Tail bicolor, blackish above, whitish below, with distinct line of demarkation; black upper surface covering slightly more than half of circumference of tail. Ankles dusky, in sharp contrast with pure white of feet, and darker than legs; dusky ankle patch covering both sides of but not reaching metatarsus, leaving outer side of heel white.

Cranial characters.—Skull similar to that of *N. fuscipes dispar*; palate short, barely equalling length of interpterygoid fossa and of basisphenoid [much longer in *fuscipes*]; incisive foramina reaching back past plane of first molars [not reaching this plane in *fuscipes*]; pterygoid fossa narrow and rounded anteriorly as in *dispar*.

Neotoma fuscipes dispar subsp. nov.

Type from Lone Pine, Owens Valley, California. No. $\frac{25391}{32801}$ ♂ ad. U.

S. Nat. Museum, Department of Agriculture Collection. Collected December 25, 1890 (Original number 2310).

Measurements (taken in flesh).—*Type:* Total length 410; tail vertebræ 208; hind foot 39. Ear from anterior base 31 (in dry skin).

General characters.—Similar to *Neotoma fuscipes* in size and proportions except that the tail is not so long; coloration pale, much as in the Mohave Desert *N. mexicana desertorum*; tail strongly bicolor.

Color.—Entire upper parts ochraceous buff, palest on the head; back moderately lined with black-tipped hairs; feet and under parts white; the white of the belly enroached upon by the buffy-ochraceous of the sides; tail bicolor; above brownish-gray; below soiled white, with distinct line of demarkation. The grayish-brown of the ankles is pale and does not extend out over the metatarsals.

Cranial characters.—The skull is clearly of the *fuscipes* type, having the long rostrum, long nasal bones, and last upper molar of that species. It differs from typical *fuscipes* (from north of Monterey Bay) in the following particulars: Zygomatic arches narrow and much less spreading anteriorly; nasal branches of premaxillaries shorter; palate shorter; interpterygoid fossa longer; postpalatal notch somewhat broader and evenly rounded anteriorly; angular processes of mandible much sharper (not rounded off as in *fuscipes*). The best characters are the shortness of the palate, the depth of the pterygoid fossa, and the broadly rounded form of the postpalatal notch. In typical *fuscipes* this notch is narrow, abruptly truncated anteriorly, and usually enroached upon by a blunt projection from the posterior edge of the palate. In subspecies *macrotis* the pterygoid fossa is much broader and shorter.

Neotoma desertorum sp nov.

Type from FURNACE CREEK, DEATH VALLEY, CALIFORNIA. No $\frac{25739}{33139}$ ♂ ad. U. S. Nat. Museum, Department of Agriculture Collection. Collected January 31, 1891, by T. S. Palmer (Original number 43).

Measurements (taken in flesh).—*Type:* Total length 305; tail vertebræ 128; hind foot 30. Ear from anterior base 27 (in dry skin).

Average measurements of eight males from type locality: Total length 299; tail vertebræ 132.5; hind foot 30. Average of thirteen females from type locality: Total length 284; tail vertebræ 128; hind foot 29.

General characters.—Similar to *N. intermedia* in general appearance but decidedly smaller, with larger ears, softer and more silky pelage, coloration more ochraceous buffy instead of gray. Skull characters distinctive.

Color.—Upper parts pinkish buff, most intense on the sides, becoming grayish on the head, finely lined on the back with blackish hairs; fore and hind feet pure white; tail bicolor, pale dusky above, white beneath; under parts superficially white, more or less washed with salmon on the neck, breast and belly (often forming a roseate pectoral collar); hairs plumbeous at base except a pectoral patch and an irregular strip down the middle of the belly, which are white throughout. Some specimens from old Fort Yuma have the upper parts very pale buffy.

Cranial characters.—Skull much smaller, thinner, and less angular than that of *intermedia* or *albigula*; interparietal much smaller and less elongated transversely; interorbital constriction much narrower, with edges more upturned; audital bullæ much larger; opening of posterior nares narrower; nasals truncate but less broadly than in *intermedia*.

Neotoma desertorum sola subsp. nov.

Type from San Emigdio, Kern Co., California. No. $\frac{31516}{43381}$ ♂ ad. U. S. Nat. Museum, Department of Agriculture Collection. Collected October 24, 1891, by E. W. Nelson (Original number 1369).

Measurements (taken in flesh).—*Type* (male): Total length 330; tail vertebræ 148; hind foot 36. Ear from anterior base 29 (in dry skin). Female from type locality: Total length 324; tail vertebræ 151; hind foot 33.5.

General characters.—Similar to *N. desertorum*, but larger.

Color.—Upper parts ochraceous buff, lined with black-tipped hairs; fore and hind feet and underparts white; basal fur plumbeous on sides of belly and chin; tail bicolor, grayish brown above, white below.

Cranial characters.—Skull similar to that of *desertorum* but larger; interorbital breadth greater; interparietal much larger; audital bullæ less inflated; nasals longer, and broader posteriorly; ascending branches of premaxillæ shorter and slighter.

Neotoma intermedia melanura subsp. nov.

Type from Ortiz, Sonora, Mexico. No, $\frac{17819}{24756}$ ♂ yg. ad. U. S. Nat. Museum, Department of Agriculture Collection. Collected November 13, 1889, by Vernon Bailey (Original number 671).

Measurements (taken in flesh).—*Type:* Total length 333; tail vertebræ 170; hind foot 34. Ear from anterior base 25 (in dry skin).

General characters.—Size rather small; ears large; coloration peculiar; back olivaceus; *tail black above* (probably a peculiarity of winter pelage); cranial characters of the *albigula* type.

Color.—(Winter pelage) Upper parts olivaceus from a fine intermixture of black-tipped hairs on an ochraceus-buffy ground; sides nearly clear ochraceus-buff; fore and hind feet pure white; ankles blackish in sharp contrast to color of hind feet; tail sharply bicolor, dorsal side *black*, ventral side white; under parts white; chin, throat, breast and line down middle of belly white to roots of hairs; sides of belly with plumbeus under fur.

Cranial characters.—Skull similar to that of *N. intermedia* but smaller; nasals narrower posteriorly: anterior loop of m^1 partly divided by antero-internal sulcus.

Geneal remarks.—This animal in winter pelage looks like immature specimens of *N pinetorum*, but the marked cranial characters serve to distinguish it at once. No specimens in summer pelage are at hand from the type locality, but specimens from Hermosillo and Magdalena, apparenty the same sub-species, are grayer, the black hairs of the back are inconspicuous, and the upper side of the tail is less black.

Neotoma intermedia angusticeps subsp. nov.

Type from S. W. CORNER OF GRANT CO., NEW MEXICO (only 5 miles from Mexican boundary). No. $\frac{2325}{2833}$ ♂ ad. Merriam Collection. Collected April 12, 1886, by A W. Anthony (Original number 62).

Measurements of type specimen: Total length 335 (measured in flesh). Tail vertebræ 150; hind foot 33; ear from anterior base 25 (in dry skin).

General characters.—Similar to *N. albigula*, but ears smaller; color more strongly fulvous; skull more elongated and narrower.

Color.—(Summer pelage) Upper parts fulvous, becoming ochraceous buff on the head, and abundantly lined with black hairs; feet and under parts creamy white to roots of hair, except on sides of belly where the basal hair is plumbeous; tail bicolor, grayish brown above, white beneath.

Cranial characters.—Skull similar to that of *albigula* but longer and more slender: Basal length 42; basilar length of Hensel 39 5; greatest zygomatic breadth 24; interorbital constriction 6. Cranium rather smoothly rounded —not so angular as in *intermedia* and *albigula;* zygomatic arches narrow and less angular posteriorly than usual in the group; frontals broad interorbitally but not widening rapidly behind constriction, the orbital margins neither beaded nor upturned; nasals cuneate; ascending branches of premaxillæ normally thickened behind nasals but not divaricating; interparietal shield subquadrate; anterior loop of m ^{1} only slightly indented by sulcus.

Subgenus TEONOMA Gray, 1843.

Type, *Neotoma cinerea drummondi* (Richardson) from the Rocky Mts. 57° N. Tail very large, bushy, and somewhat distichous, like a squirrel's; hind feet very large.

Rostrum much elongated, measuring more than one-third the total length of cranium; posterior roots of zygomata widely spreading; sagittal area long, narrow, and sharply angular, its broadest part far back, on or nearly on plane of anterior border of interparietal, whence the sides bend abruptly back to interparietal shields; spheno-palatine vacuties closed or open.*

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*In a previous communication (Proc. Biol. Soc. Wash. viii, July, 1893, 112), I called attention to the circumstance that the long vacuities always present on each side of the presphenoid and anterior part of the basisphenoid in *Neotoma* proper, are closed by ascending wings from the palatine bones in *N. cinerea* and *occidentalis*. I then regarded this character as of sub-generic weight. It now appears to be of specific weight only, for the vacuities are open in the new species from Colorado here described as *N. orolestes*.

The members of this series are a very compact group, comprising *N. cinerea* with its subspecies *drummondi* and *occidentalis*, and *N. orolestes* nob.

Neotoma orolestes sp. nov.

Type from SAGAUCHE VALLEY (20 miles west of Sagauche) COLORADO. No. $\frac{35906}{48215}$ ♂ ad. U. S. Nat. Museum, Department of Agriculture Collection. Collected August 13, 1892, by J. Alden Loring. (Original number 482).

Measurements (taken in flesh).—*Type:* Total length 413; tail vertebræ 175; hind foot 41. Ear from anterior base 31 (dry skin).

General characters.—Similar to *N. cinerea;* size large; tail large and bushy; sphenopalatine vacuities open.

Color.—Upper parts in summer pelage buffy-ochraceous, more or less suffused with fulvous and everywhere lined with black hairs; top of head grayish, becoming clear gray on nose; cheeks buffy-ochraceous; under parts and feet white; color of hind legs reaching out a short distance over tarsus; sides of belly with plumbeous underfur; tail bicolor; dorsal side concolor with back on proximal $\frac{1}{3}$, becoming dusky on distal $\frac{2}{3}$; ventral side whitish, obscured by pale fulvous proximally.

Cranial characters.—Skull similar to that of *N. cinerea* but differing in having the sphenopalatine vacuities open, the ascending wings of the palatines leaving a long open slit on each side of the presphenoid and anterior third of the basisphenoid. The mandible differs in having the angle larger, longer, and more everted, the extreme tip falling outside of the vertical plane of the condyle.

VOL IX, PP. 129-132, PL. 2 JULY 27, 1894

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON

DESCRIPTION OF A NEW FIELD MOUSE (*ARVICOLA TERRÆNOVÆ sp. nov.*) FROM CODROY, NEWFOUNDLAND.

BY OUTRAM BANGS.

Since November, 1893, Mr. Ernest Doane has been collecting mammals for me in Newfoundland. He has so far sent, among other things, a series of over sixty beautifully prepared skins and skulls of an *Arvicola* that seems to be entirely different from any known species.

This *Arvicola* may be defined as follows:

Arvicola terrænovæ sp. nov.

Diagnosis.

About the size of *Arvicola riparius* Ord, but with larger feet, and of a slightly different coloring, especially about the under parts, which are so much lighter and never show the rufous tinge so common in *riparius*, with nose-patches similar to those of *A. xanthognathus* Leach and *A. chrotorrhinus* Miller, though not so pronounced as in either of those two. Skull rather broader than that of *A. riparius* and the zygoma more flaring, suggesting the general appearance of the skull of *A. xanthognathus*. The enamel pattern more like that of *riparius*, but the posterior loop of the last upper molar trifoliate.

Description.

Type.—No. 1104 ♂ ad. Coll. of E. A. and O. Bangs. Boston, Mass. From Codroy, Newfoundland, Nov. 27, 1893, Ernest Doane, collector. Total length, 187 mm.; tail, 54 mm.; hind foot, 24 mm.; ear, 12 mm. (These measurements taken in flesh by the collector.)

Above: Brown, of a color between raw umber and Prout's brown, becoming gradually lighter on the sides, with a slight sprinkling of shining black-tipped hairs on the back.

Under parts: Grey No. 9,* with an indistinct line of darker (about the color of the sides) running up the middle of the belly nearly to the front legs.

There is a well defined nose-patch extending from the nose to and around the roots of the whiskers, of a dull tawny color. The base of the hair is everywhere blackish slate. The tail is distinctly bicolored—above, black; below, grey No. 10,* and quite hairy.

Cranial and dental characters: The skull of *Arvicola terrænovæ* is broad and short, and has the flaring zygoma and great interorbital constriction of *A. xanthognathus.* The rostral part is also narrow as in that species. The pattern of enamel folding is, on the other hand, more like that of *A. riparius*, with the difference that the last loop of the posterior upper molar is trifoliate, as against the cresent shape of *riparius* There are one or two other trifling differences in the enamel folding that can be better seen by a critical examination of the accompanying drawing.†

This Arvicola seems to occupy an intermediate position between the *xanthognathus* and *riparius* groups. The indication of nose-patches can occasionally be found in individuals of *A. riparius*, but I never have seen a series from any one place that shows any tendency to this marking, while every one of my series of sixty-three *A. terrænovæ* has a distinct, though dark colored and not conspicuous nose-patch.

The rather peculiar marking of the under parts is constant through the entire series; indeed, I have seldom seen a series of mammals more uniform in every respect.

Mr. Doane found this field mouse common everwhere about Codroy, where he spent the winter, and where all my specimens came from.

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*Ridgway's Nomenclature of colors, Plate II.

†Excellent figures of the skulls of *A. riparius*, *A. xanthognathus*, and *A. chrotorrhinus* can be found in "On a Collection of Small Mammals from the New Hampshire Mountains, by Gerrit S. Miller, Jr ", in the Proceedings of the Boston Society of Natural History, Vol. XXXVI, Plate 3.

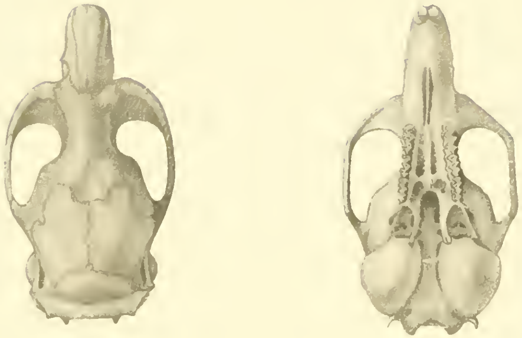

Fig. 1. Fig. 2.

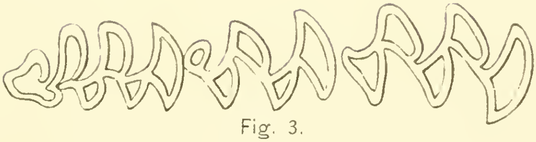

Fig. 3.

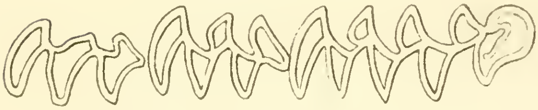

Fig. 4.

A. M. Westergren, del.

Forbes Lith. Mfg. Co.

Figs. 1 and 2. Skull of the Type *Arvicola terræ novæ*—Bangs. About × $\frac{2}{3}$

Fig. 3. Maxillary Molar Series. About × $10\frac{1}{2}$

Fig. 4. Mandibular Molar Series. About × $10\frac{1}{2}$

Measurements of ten adult specimens of *Arvicola terrænovæ* Bangs.

No.	Locality.	Date.	Sex.	Total length.	Tail vertebræ	Hind foot.	Height of ear.
Type *1104	Codroy, Newfoundland	Nov. 27, 1893	♂	187	54	24	12
Topo-type 1133	“ “	Nov. 23, 1893	♂	175	47	25	12.5
“ 1120	“ “	Dec. 11, 1893	♂	160	47	23	13
“ 1134	“ “	Apr. 15, 1894	♂	176	45	24	13
“ 1135	“ “	Apr. 17, 1894	♂	178	50	24	13
“ 1136	“ “	Apr. 16, 1894	♀	156	45	23	13
“ 1137	“ “	Apr. 10, 1894	♀	158	46	25	13
“ 1138	“ “	Apr. 16, 1894	♀	170	55	22	12
“ 1139	“ “	Apr. 10, 1894	♀	172	48	23	13
“ 1140	“ “	Apr. 10, 1894	♀	170	48	24	12

*Collection of E. A. and O. Bangs, Boston, Mass.

Cranial measurements of ten adult specimens of *Arvicola terrænovæ* Bangs.

	Type	Topo-type	Topo-type	Topo-type	Topo-type	Topo-type	Topo-type	Topo-type	Topo-type	Topo-type
No. . . . . *	1104	1109	1106	1105	1135	1137	1139	1140	1143	1145
Sex	♂	♂	♂	♂	♂	♂	♀	♀	♀	♀
Basilar length	27.	26.	26.2	25.8	28.	25.4	26.8	27.	25.2	26.4
Basilar length of Hensel	25.4	24.2	25.	24.2	26.4	24.	25.	25.8	24.	24.8
Zygomatic breadth	16.2	15.8	15.4	15.6	16.8	15.2	16.	16.	15.2	16.
Interorbital constriction	3.8	4.	4.	3.8	4.2	4.	4.	4.	3.8	4.
Greatest length of nasals	8.4	7.8	7.2	7.8	8.	7.2	7.6	8.	7.	7.4
Greatest breadth of nasals	3.2	3.2	3.2	3.	3.4	3.	3.4	3.4	2.8	3.4
Incisor to molar	8.4	8.2	8.4	8.2	9.2	8.	9.	9.	8.	8.2
Incisor to post-palatal notch	14.4	13.8	14.6	14.	15.4	14.	14.4	15.	13.4	14.2
Foramen magnum to post-palatal notch	10.8	10.2	10.	10.	10.8	10.	10.4	10.4	10.	10.2
Upper molar series along crowns	6.8	6.6	6.6	6.4	7.	6.6	6.6	6.8	6.4	6.6
Basioccipital to middle of parietal	8.6	8.4	8.2	8.4	9.2	8.6	8.4	8.6	8.2	8.4
Fronto-parietal depth at middle of molar series	9.	8.8	8.6	8.6	9.2	8.4	8.8	8.8	8.2	9.
Greatest length of mandible	17.	16.8	17.	16.6	17.8	16.4	17.4	17.6	16.2	17.4
Length of lower molar series along crowns	7.	6.6	6.8	6.4	7.	6.4	6.8	7.	6.4	7.

*Collection of E. A. and O. Bangs, Boston, Mass.

Vol IX, pp. 133-138 September 15, 1894

PROCEEDINGS

OF THE

BIOLOGICAL SOCIETY OF WASHINGTON

DESCRIPTION OF A NEW MUSK RAT FROM CODROY, NEWFOUNDLAND.

BY OUTRAM BANGS.

A fine series of musk rats lately received from Codroy, Newfoundland, shows such differences from *Fiber zibethicus* (Linn.) of Eastern North America that I think it must be regarded as representing a distinct species.

This *Fiber* may be defined as follows:

Fiber obscurus sp. nov.

Diagnosis.

Smaller than *F. zibethicus* (Linn.), with the under parts and sides less ferruginous and the upper parts much darker. The lips and the hairs about the under side of the nose are much lighter (pure white). The fringe of long hair around the toes of the hind feet is decidedly lighter than the feet, while in *F. zibethicus* this fringe is generally of about the same shade as the feet. The under fur is darker than in *zibethicus*. Skull smaller and smoother, not rising into such pronounced bong ridges with age, with the rostrum relatively larger and the audital bullæ relatively smaller, while the interorbital constriction is actually broader.

Description.

Type.—No. 1155 Collection of E. A. and O. Bangs, Boston, Mass. From Codroy, Newfoundland, May 14, 1894, Ernest Doane, collector. Total length, 476 mm.; tail, 200 mm., hind foot, 70 mm.; ear from notch, 22 mm. (Measurements taken in flesh by the collector).

Upper parts: General color Prout's brown,* shaded a little with Vandyke brown,* darkening on the top of the head to almost black. The long shining hairs are black all over the back, but on the sides they shade off a little to a very dark reddish brown.

Under parts and sides of the head of a shade between Prout's brown,* and broccoli brown,* paling off on the under side of the neck and legs to almost fawn color.* Lips and hair under the nose white. Under fur slate grey everywhere. Feet blackish slate,* with the fringe of long hair around the toes of the hind feet Isabella color.*

Cranial characters: Skull small and smooth, and broad between the orbits, with large rostrum and small audital bullæ.

Specimens taken later in the season than the type are rather more reddish (ferruginuons) in general color, but compared with specimens of *F. zibethicus* of corresponding dates from Massachusetts, Nova Scotia, etc., the difference is quite as great as between the type and examples of *F. zibethicus* of the same date as the type from those localities.

I have carefully compared musk rats from our Eastern Coast from Connecticut to Cape Breton and can find no difference in specimens of the same age and season and no tendency towards a small dark northern race,† and therefore incline to the belief that *F. obscurus* is an insular form peculiar to Newfoundland. I have however never seen any musk rats from Labrador, and it is possible that there the animal may be more like the one found in Newfoundland.

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*Ridgway's Nomenclature of colors.

†The largest musk rat I have examined is from Shenacadie (Cape Breton) Nova Scotia. It is a very old adult male. No. 2007, Collection of E. A. and O. Bangs, and measures, total length, 632 mm.; tail, 291 mm.; hind foot, 87 mm.; ear from notch, 26.5 mm.

Cranial measurements of ten adult specimens of *Fiber zibethicus* (Linn.).

Locality	Mass., Wareham.	Mass., Wareham.	Mass., Wareham.	Mass., Wareham.	Nova Scotia, Shenacadie.	Nova Scotia, Halifax.	Nova Scotia, Shenacadie.	Nova Scotia, Shenacadie.	Nova Scotia, Shenacadie.	Nova Scotia, Shenacadie.	Average measurements of the ten specimens
No.*	922	924	923	925	2009	2004	2007	2008	2010	2011	
Sex	♀	♀	♂	♂	♂	♀	♂	♂	♀	♀	
Basilar length	62.4	62.4	62.	61.2	61.2	59.8	63.4	67.	65.8	61.8	62.7
Basilar length of Hensel	58.8	59.4	58.6	58.	58.2	57.4	60.6	64.4	62.6	59.	59.7
Zygomatic breadth	41.2	42.2	40.	39.8	39.8	38.4	39.8	44.2	42.2	39.6	40.72
Interorbital constriction	5.4	6.	6.	5.6	6.2	6.	6.6	5.	6.6	6.2	5.96
Greatest length of nasals	22.6	22.6	23.4	22.4	22.6	21.2	23.6	25.4	24.8	22.6	23.12
Greatest breadth of nasals	9.4	9.2	9.2	8.8	9.6	8.6	9.4	9.8	10.2	9.	9.32
Incisor to molar	23.2	23.6	22.6	22.4	23.	22.2	23.6	26.6	25.4	22.8	23.54
Incisor to post-palatal notch	36.6	37.6	36.6	36.4	35.8	36.4	36.6	40.	40.6	37.	37.36
Foramen magnum to post-palatal notch	21.8	21.4	21.6	21.2	22.	20.6	23.6	24.	21.6	21.6	21.94
Upper molar series along crowns	14.6	15.2	15.2	14.6	14.8	14.4	15.	14.8	14.8	15.	14.84
Basioccipital to middle of parietal	19.	18.8	18.4	18.4	17.4	17.4	17.4	19.	19.	17.8	18.26
Fronto-parietal depth at middle of molar series	21.2	20.4	20.6	20.	19.8	19.8	20.	22.6	21.6	20.2	20.62
Greatest length of mandible	44.6	44.4	43.2	43.	43.2	42.2	42.4	47.	46.	43.4	43.94
Length of lower molar series along crowns	15.6	16.4	16.	15.4	16.	15.4	15.2	16.4	15.4	16.	15.78

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*Collection of E. A. and O. Bangs, Boston, Mass.

Cranial measurements of ten adult specimens of *Fiber obscurus* Bangs.

No. . . . . *	Type 1155	1101	1156	1158	1162	1161	1151	1152	1153	1157	Average meas-urem'ts of the 10 specimens.
Sex	♀	♀	♀	♀	♀	♀	♂	♂	♂	♂	
Basilar length	54.6	56.8	51.4	54.8	57.2	52.4	58.	54.4	53.4	54.2	54.72
Basilar length of Hensel	52.	54.	48.8	52.	54.8	50.	55.4	52.4	50.4	51.2	52.10
Zygomatic breadth	36.6	38	34.	35.2	38.2	35.8	39.	36.2	36.	35.4	36.44
Interorbital constriction	6.6	7.2	6.4	6.8	7.	7.	7.	6.4	6.4	6.4	6.72
Greatest length of nasals	22.2	22.	19.4	20.8	20.8	20.2	22.4	20.	19.6	20.	20.74
Greatest breadth of nasals	8.	8.	7.6	7.6	8.8	8.	8.8	7.4	8.	8.	8.02
Incisor to molar	21.	21.8	19.4	20.6	22.	21.	22.	20.6	20.2	20.2	20.88
Incisor to post-palatal notch	33.2	34.	30.4	32.8	34.4	31.	34.4	32.8	31.6	32.6	32.72
Foramen magnum to post-palatal notch	18.4	19.6	18.	18.4	20.	18.8	20.6	19.	19.	18.	18.98
Upper molar series along crowns	13.	13.2	12.6	13.	13.2	12.	13.8	12.4	13.	13.	12.92
Basioccipital to middle of parietal	17.	17.4	16.6	16 8	17.4	16.4	18.	17.	17	17.	17.06
Fronto-parietal depth at middle of molar series .	18.	18.8	16.4	17.4	18.8	17.	19.2	18.	17.2	17.4	17.82
Greatest length of mandible	38.4	40.2	36.	38.	40.	37.	40 4	37.8	37.6	37.4	38.28
Length of lower molar series along crowns . . .	13.4	14.	13.4	13.4	13.4	12.	14.2	13.	13.4	13.	13 32

*Collection of E. A. and O. Bangs, Boston, Mass.

Measurements of ten adult specimens of *Fiber zibethicus* (Linn.)

No.	Sex.	Locality.	Date.	Total length.	Tail vertebræ.	Hind foot.	Height of ear from notch.
*922	♀	Massachusetts, Wareham	July 26, 1893	622	259	84	23.5
924	♀	" "	Aug. 4, 1893	619	284	84.5	28
923	♂	" "	Aug. 7, 1893	622	281	80	26
925	♂	" "	May 6, 1893	582	257	84	23
927	♂	Massachusetts, West Tisbury	June 28, 1893	620	267	79	20.5
2004	♀	Nova Scotia, Halifax	July 17, 1894	540	225	77	25
2007	♂	Nova Scotia, (Cape Breton) Shenacadie	July 26, 1894	632	291	87	26.5
2008	♂	" " " " "	July 30, 1894	598.5	278	81	23.5
2010	♀	" " " " "	July 29, 1894	622	287	85	25
2011	♀	" " " " "	July 25, 1894	558.5	247	80	23
Average measurements of the ten specimens, ...				601.6	267.6	82.15	24.40

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Measurements of ten adult specimens of *Fiber obscurus* Bangs.

No.	Sex.	Locality.	Date.	Total length.	Tail vertebræ	Hind foot.	Height of ear from notch.
Type *1155	♀	Codroy, Newfoundland	May 14, 1894	476	200	70	22
“ 1101	♀	“ “	Dec. 6, 1893	517	228	74	18
“ 1156	♀	“ “	May 20, 1894	440	173	70	19
“ 1158	♀	“ “	May 8, 1894	474	220	71	19
“ 1160	♀	“ “	May 7, 1894	517	220	70	20
“ 1162	♀	“ “	July 9, 1894	504	217	72	21
“ 1151	♂	“ “	May 15, 1894	520	223	69	20
“ 1152	♂	“ “	May 14, 1894	480	217	69	20
“ 1153	♂	“ “	May 7, 1894	447	190	70	19
“ 1154	♂	“ “	May 15, 1894	495	220	74	22
Average measurements of the ten specimens, ...				487	210.8	70.9	20.

*Collection of E. A. and O. Bangs, Boston, Mass.

ALPHABETICAL INDEX

Names of new species and subspecies are printed in **heavy type**