PSYCHE.

THE HABITS OF THE ACULEATE HYMENOPTERA.—I.

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[Annual address of the retiring president of the Cambridge Entomological Club, 12 January, 1894.]

The subject of my address is one that has been rarely touched by American entomologists, although offering one of the most attractive and richest fields for research and discovery, as connected with it are many problems of biologic and philosophical importance, which if solved, would throw much light upon many of the moted questions of the day —evolution of species, development of sexes, specialization of organs, transmission of acquired characters, adaptability to environment, etc.

The first American to publish anything on the subject was John Bartram, who published several articles: the first entitled "An account of some curious wasp-nests made of clay," was published as early as 1745 (Phil. trans., vol. 43, pp. 363–368); the second, "A description of the great black wasp of Penn." (l. c., vol. 46, 1750, pp. 278–280); the third, "On the Yellow wasp of Penn." (l. c., vol. 53, 1763, pp. 57–39).

This last paper is of the deepest interest as it evidently refers to the habits of a Bembecid, and the accounts of which, now after over a century and a quarter, have only recently been confirmed, in Europe, by the observations of Fabre and Wesenberg on a similar fossorial wasp, *Bembex rostrata* Fabr.

From John Bartram to our next writer, Benjamin Henry Latrobe, who wrote a paper entitled "Two species of the Sphex or wasp found in Virginia and Penn." (Phil. soc., vol. 6, 1809, p. 73) is an unbroken period of nearly half a century. Then we have a period of longer or shorter intervals, with contributions from Thomas Say, Dr. T. W. Harris, F. W. Putnam, Dr. Lincecum, Dr. A. S. Packard, Wm. Couper, Benjamin D. Walsh, Prof. C. V. Riley, E. Baynes Reed, L. O. Howard, Frederick V. Coville, Charles Robertson, C. L. Marlatt, and Dr. A. Davidson.

It is now, I believe, almost universally conceded by all students, who have given any study at all to the aculeate Hymenoptera, that among them are to be found the most specialized, highly developed and intelligent insects. In fact, the marvellous intelligence exhibited by many of the species in this order, in their social habits, the structure of their nests, care of their young, etc., has from time immemorial attracted the attention of man, and in both ancient and modern literature many allusions to them may be found.

It is surprising, therefore, that so many centuries have past and so little

comparatively is known of the vast majority of the most common forms.

It is hoped that a few new facts respecting the habits of some of our species will be found in this address, but it is intended more as a review of the subject, the principal object in view being to bring together what is known of the habits of these insects to show the uniformity of habits in genera and species of the same genus the world over, and, moreover, to point out just how little real knowledge we possess of our own species, with the hope that it may awaken more interest in these insects and kindle a desire in some of our entomologists to make some effort toward unravelling the life history of at least a few of the common species of his neighborhood.

If every entomologist in the United States and Canada would, during the year 1894, make up his mind to at least make known the habits, development and parasites of one or two species it surely could be done, and then what a vast amount of new and interesting reading we should have next winter. How refreshing it would be to take up one of our entomological journals, or an experiment station bulletin, and see some such article in place of the old, old story, "the canker-worm, the codling moth, the chinch-bug, or the plum Curculio."

The subject merits attention also from an economic standpoint, as, with but few exceptions, all the aculeate Hymenoptera are of the greatest economic importance, either as fertilizers of plants, shrubs and trees, by transporting pollen from blossom to blossom, or as destroyers of injurious insects.

In order to bring out more thoroughly the points to which I have called attention, I propose to take up *seriatim* the different families, give a *resumé* of what is known and at the same time incorporate any new facts that may have come under my observation.

Family I. APIDAE. As the most specialized we may begin, therefore, with this family. Excluding *Apis mellifica* as not indigenous and the Melliponae as not extending into our fauna, we have no less than 35 genera and 520 species belonging to this family. Of these, the genus *Bombus* in structure, social habits, and in the honey-producing qualities of its members, is probably more closely allied to the true honey-bee than any other of our bees and it may, therefore, be considered the forerunner of the honey-bee.

Mr. F. W. Putnam, in "Notes on the habits of some species of humble-bees" (Proc. Essex inst., vol. 4, 1864, pp. 98–104) was one of the first of our writers to treat of some of our species. In this paper he briefly treats of the nesting habits of *Bombus ternarius* Kirby, *B. fervidus* Fabr., *B. vagans* Smith, *B. virginicus* Oliv, *B. separatus* Cr. and *B. pennsylvanicus* De Geer.

The habits of our species agree fairly well with the observations made upon the European species and are briefly as follows: the female bumble- or humble-bee, which has hibernated in some crevice or other secure place during the winter, appears in early spring with the first blossoms from which it can

obtain pollen and almost immediately selects a place in which to nidificate, forming its nest of dry grass or leaves in some hollow in the open field; or more frequently appropriating the deserted nests of field mice, either in the open field or under old stumps or boards. Here the female constructs her receptacles of a waxy or plastic material, into which she deposits her gatherings of pollen and honey—the food-supply for the future offspring of her colony, laying her eggs directly in or upon the pollen.

The eggs first laid produce larvae, which spin tough cocoons wherein to undergo their transformations and all transform into neuters or workers, which subsequently form the greater part of the community and become of the greatest importance in assisting and performing the necessary economics of the now rapidly increasing family. These are followed later, according to Shuckard, by males and other productive females which are, however, smaller than the normal sized individuals; the normal sized males and females not appearing again until the fall, when they mate and the cycle of their life history is completed, the impregnated females of this last brood wandering off and hibernating and forming the *nuclei* of colonies the following spring.

The number of individuals in a nest is variable; from a dozen or more to over two hundred individuals have been found in a single nest. Mr. Putnam states that a nest of *B. ternarius* contained sixty-five cells, also a number of bunches of pollen in which there were no eggs, thirty-five contained young and thirty were filled with honey, having their tops covered with wax and that this was the only instance of his finding *the honey cells closed over.*

Dr. A. S. Packard in "The humble-bees of New England and their parasites, etc." (Proc. Essex inst., vol. 4, pp. 107–140) has given some interesting and valuable observations on the species found in New England, and considerable new information concerning their parasites.

Mr. Charles Robertson in "Notes on Bombus" (Ent. news, vol. 1 (1890), p. 39) and Mr. Frederick V. Coville in "Notes on bumble-bees (Proc. ent. soc. Wash., vol. 1 (1890), p. 197) from personal observations carried on independently, both reached the conclusion that *Apathus elatus*, a supposed inquiline of *Bombus fervidus*, was in reality the ♂ of *Bombus americanorum* Fabr. or *B. borealis* Kirby, a species that was long confounded with *B. fervidus.*

Mr. Robertson further remarks that Walsh in discussing the effect of mimicry (Proc. ent. soc. Phil., vol. 3, p. 247) mentions having once found *B. fervidus* ♀, surmounted by *Apathus elatus* ♂, and cited this as a case in which a Bombus mistook an Apathus for one of its own species, but remarks "that the mistake here was on the part of the entomologist and not on the Bombus, as he had no doubt taken the true sexes of *B. fervidus.*"

In some particulars, Mr. Coville's observations on *Bombus borealis* as indicating a slight divergence in habits

and thus more closely resembling the hive-bee, warrants me in quoting somewhat largely from his very readable paper. He says:—

The nest, originally that of a mouse, was made of dead grass and lined with wax. It contained when captured the queen and a large number of workers of various sizes, as well as eggs, and larvae in various stages of development. The precise functions of the different sized workers were not evident, but in general the larger ones attended to the mending of the grass covering of the nest and to the bringing in of honey, while the smaller ones for the most part did the inside "house-work," the wax-patching and the nursing, described below. The nursing, indeed, was never done so far as was observed, by a large or even a medium-sized bee.

The eggs are laid several together, in cavities in a mass of wax. This is in direct opposition to the statement of Putnam (l. c.) and of various English writers consulted by me, they stating that the eggs are laid in a mass of pollen, upon which the larvae, when hatched, feed. The substance was tested first by the application of heat, when it melted precisely like bees-wax. It would not dissolve in water, while pollen and an artificial mixture of pollen and honey readily did so. A microscopic examination of the wax showed, however, that it contained a great number of pollen grains; but this would be expected when it is considered how much pollen is used about the nest. The larvae, after hatching, remained incased in a shell of wax, and soon became separated by a wall of the same substance each from its neighbor.

Their method of obtaining nourishment — instead of by eating away the pollen walls, in which they are supposed to be incased, the workers constantly adding more to the outside — is strikingly different. They are fed by a mixture of pollen and honey supplied to them by a worker. The operation will be described later.

The larvae, when grown, spin a silken cocoon, and at the end of the nymphal stage, the duration of which was unfortunately not noted, emerge by gnawing about the apex of the cocoon so as to form a lid. When the adults first come out their subsequently yellow hairs are pale, almost white. As soon as the bee has left its nymphal quarters the other workers cut away about the upper half of the cell and remove the *débris*. The part which is left furnishes a receptacle for the raw honey and pollen as it is brought into the nest.

When returning from the field the bees settled down upon the alighting-block at the entrance of the box, when full laden, with a low, abruptly ceasing hum, always distinguishable from that of a bee without honey or pollen. The bees went directly, in a most business-like way, to the pots, deposited their loads, and went away again or busied themselves about the nest. If honey-laden, the bee perched herself on the margin of a honey-pot, lowered her head into it, and then drew her abdomen far in, thus forcing the honey from her mouth. If pollen-laden, the bee balanced herself, with her middle and cephalic pairs of legs, on the edge of a pollen-pot, head outward, spread her wings, and then scraped the pollen-masses from her corbiculæ by rubbing the posterior legs together.

The mode of feeding the larvae is as follows: One of the smaller workers, which may be called a nurse-bee, goes to a honey-pot, from which she presumably draws a small amount of honey, and proceeds next to a pollen-pot. She remains here, with her head in the pot, undoubtedly preparing a mixture of pollen and honey, for ordinarily about ten minutes. Then going to one of the larvae, which lie in circular form in their chambers, she injects into the cell, through a small opening previously made, usually by another worker, a brownish fluid of the consistency of honey. This is greedily eaten by the larva. Whether the larvae of both females and workers are fed in the same manner and

with the same mixture could not be decided, but from the analogous case of the honey-bee, it is to be expected that the kind of food does influence the size and function of the bee. The males, it may be added, are commonly supposed to have come from eggs laid by the sterile females (workers).

In early August females (queens) and males began to emerge. Both left the nest within a few days, and did not return, nor were they seen to copulate.

In the first chilly afternoon of autumn the workers become stiffened with cold, and do not return; and after a few freezing days the old queen, too, succumbs. The males also perish, and only the young queens survive the winter.

This genus is parasitized by Diptera belonging to the genera Volucella, Conops, Tachina, Coleoptera belonging to the genera Meloë and Stylops, while *Anobium paniceum* and *Antherophagus ochraceus* Say, prey upon the pollen stored up in their cells. A Lepidopterous larva *Nephopteryx edmandsii* is also supposed to be parasitic, and it itself is preyed upon by *Apanteles nephopterygis* Pack.

The genus *Apathus* structurally closely resembles Bombus and the species are found living in the nests of the latter. The species are stated to be inquilinous or guest-flies, and not true parasites, and this is apparently the sum total of our knowledge. In all the literature at my command, I can find no direct observation respecting the rearing and development of a single species. Shuckard makes this general statement: —

Both sexes appear to have free in and egress to the nests of those Bombi which they infest, without any let or hindrance on the part of the latter, with whom they seem to dwell in perfect amity. In the times of their appearance they closely resemble the Halicti and the neighboring Bombi. Thus the females, after impregnation in the autumn, having hibernated during the winter in selected receptacles, come out with the first gleams of spring conjunctively with the large maternal Bombi, in whose nests they have taken their long repose in perfect torpidity; and as soon as these begin to accumulate the masses of conglomerated honey and pollen whereon to deposit their eggs, the parasite takes advantage of it, lays her eggs too, and thus secures food for her offspring.

The genus *Xylocopa* comprises some of the largest bees known, many of which closely resemble the bumble-bees. The species are not rare and from their method of boring into posts and rafters, in which they construct their nests, they are known as carpenter-bees. About a dozen species are found in the United States.

Our most common species in the eastern, southern and middle States is *Xylocopa virginica* Drury, and its nest is readily found in the rafters or frame work of any old house, barn or out-house built of soft white pine.

I have frequently found their nests made in the railings of a porch, in posts, in rafters, in doors, in palings of fences in door frames, in window sills, etc.

Dr. Packard in his Guide, p. 132, has given an excellent account of the nesting habits of this species, as observed by Mr. James Angus, of West Farms, N. Y.

The species bores a cylindrical hole, about half an inch in diameter until the depth of ten, twelve or more inches

is attained. At the bottom of this long tunnel or gallery, the female now deposits a ball of pollen-paste in which she lays a single egg. This is then carefully covered over with a thin partition formed of sawdust and a glutinous substance or secretion and this constitutes the first cell. Upon this another ball of pollen-paste and an egg is laid and again enclosed by a partition and so on until a series of cells, one above another, is formed and the tunnel is filled. The imagos hatch out in July and August and hibernate in the middle States during the winter months.

Mr. L. O. Howard, in "Notes on the hibernation of carpenter bees" (Proc. ent. soc. Wash., vol. 2, 1892, p. 331), records having received in February a pine branch burrowed by this species containing living bees.

Mr. H. G. Hubbard in same publication also records some interesting observations made on carpenter bees in Florida, which agreed with the writer's own observations.

He had found in February the eggs and the young, in various stages of development, in burrows, and in March the adult bees ready to issue from the burrows. By April most of these had escaped and another generation developed during the summer. He described the egg as the largest, finest and most beautiful of any insect egg he had ever seen; a quarter of an inch in length and perfectly transparent, revealing the embryonic larva with great clearness.

He also stated "that on his place at Crescent City they will construct their burrows in a kind of 'hard-pan' or soft sandstone " This species is probably *Xylocopa texana* Cr., a species also common at Jacksonville, Florida.

The nest and parasites of *Xylocopa orpifex* Smith, a California species, has been described recently in Ent. news., vol. 4, p. 151, by Dr. Anstruther Davidson. The nests were discovered on Wilson's Peak, a mountain of 5000 feet altitude, in June and August, 1892. Mr. Davidson says:—

I picked up one piece of wood four inches in diameter and about three feet long, and as there was but one external opening it is presumable all the cells contained therein were those of one bee. From a diagonal entrance the tunnels were driven longitudinally a distance of three or four inches on each side. Parallel to this was another of a similar length, and a third very much shorter, the cells in all numbering twenty. The tunnel is not all of one uniform width but is dilated in the centre of each cell so that the tunnel measures three-eighths of an inch in diameter at the extremities, and half an inch at the centre of each cell.

The partitions are constructed in a manner apparently identical with those of *X. virginica*, but the ribbon-like coil has five complete whorls and is one-eighth of an inch wide. After the partition is completed its angles are filled up with saw-dust and smoothed with a waxy secretion so as to make the bottom of the next cell oval or rounded. These cells have a uniform depth five-eighths of an inch. Here I would like to ask if all the Xylocopae make their tunnels wider in the centre of each cell than elsewhere?

On opening many of the tunnels filled early in the season one or two of the external cells may be found empty, the bees having already made their escape. In the lower cells the bees, though perfect and active, remain until the following spring, when they break through the partitions and escape. In those built late in the summer all seemingly remain until the next spring. How it happens that

the bee resulting from the egg last deposited is the first to escape, when there must of necessity be weeks of difference in their time of deposition, is something I cannot satisfactorily account for. I am led to infer, by the fact of the external cells always containing males and the lower ones only females, that the explanation in part lies therein.

Mr. Davidson found this species was preyed upon by two parasites — a Dipteron, *Agyramoeba simsen* Fabr. and a Chalcid, *Monodontomerus montivagus* Ashm., the latter depositing from 10 to 20 eggs in each cell.

The genus *Anthophora* comprise rather large solitary bees, clothed with a thick covering of hairs, especially in the thorax and hind legs. Almost nothing is known of the nesting habits of our species. All those observed by European authors provision their cells with a supply of pollen and honey, upon which an egg is laid and then the cell is closed up.

Mr. Benj. D. Walsh, in Am. ent., vol. 1 (1868), p. 9, has figured and described the habits of *Anthophora abrupta* Say (= A. sponsa Sm.) "which had excavated its burrow in the mortar between the bricks composing a vast system of underground flues erected for raising early vegetables, building an entrance to its burrow of tempered clay two inches long and three quarters of an inch in diameter." No mention is made of the eggs, duration of larval stage, etc.

The habits of *Entechnia* (*Anthophora*) *taurea* was briefly and incompletely described by Say at the time of its specific description, Bost. journ. nat. hist., vol. 1 (1837), p. 411. He says:—

The manners and habits of this species may be likened to those of *A. parietina* Latr. It digs a cylindrical hole in compact clay or adhesive earth on the side of a bank, or in earth retained amongst the roots of an upturned tree. The hole is two or three inches in depth; the sides and bottom of a dark brown color, quite smooth and somewhat polished, containing a quantity of white pollen, considerably larger than the artificer itself. The entrance consists of a cylinder extending downwards from the mouth of the hole more than an inch in length and consisting of small pellets of earth compacted together, very rough on the exterior and smooth within.

The genus *Melissodes* has apparently the same habits as Anthophora, as I once detected *Melissodes bimaculata* entering its burrow, formed in an open field, the entrance to which was directly under a small, flat stone. Unlike Anthophora, however, it had neglected to build the tubular entrance so characteristic of this as well as other solitary bees. On turning the stone over I found the burrow after extending about an inch and a half directly under it curved downward and became perpendicular, the cell formed of clay being at the bottom at the depth of about eight inches.

The genus *Ceratina* is represented in our fauna by four species, the habits of only one of which is known, *i. e.*, *Ceratina dupla* Say. This species hollows out the stems of almost any pithy plant in which to nidificate, the elder, blackberry, raspberry, and syringa being the most favorite plants. I have most frequently found its nests in the

second years' growth of raspberry stems. The nest usually consists of several cells, separated from each other by partitions at regular intervals and filled with a kind of honey-paste upon which the larvae feed. The larvae transform into imagos the last of July or during August.

From this bee, the Rev. J. L. Zabriskie has bred two interesting parasites, *Diamorus zabriskii* Cr. and *Axima zabriskii* How.; while Dr. Packard also records a species of Melittobia (=Anthophorabia) from this bee.

The genus *Megachile* represents the leaf-cutting bees, so called from the peculiar habit of the female in cutting small, more or less circular, pieces out of the tender leaves of various plants wherewith to line its cells. These cells are placed in burrows made in the ground or in wood.

Mr. F. W. Putnam in "Notes on the leaf-cutting bee" (Proc. Essex inst., vol. 4, 1864, pp. 105–107) has published some interesting observations made on *Megachile centuncularis* Linn., a species common to Europe and the northern parts of North America. He says:—

My attention was first called, on the 26th of June, to a female busily engaged in bringing pieces of leaf to her cells which she was building under a board on the roof of the piazza, directly under my window. Nearly the whole morning was occupied by the bee in bringing pieces of a leaf from a rose-bush growing about ten yards from her cells, returning at intervals of a half minute to a minute, with the pieces which she carried in such a manner as not to impede her walking when she alighted near her hole. About noon she had probably completed the cell upon which she had been engaged, as during the afternoon, she was occupied in bringing pollen, preparatory to laying her single egg in the cell. For about twenty days the bee continued at work, building new cells and supplying them with pollen. At the end of this time she had probably completed her allotted task, as she was not seen again.

On the 28th of July, upon removing the board, it was found that the bee had made thirty cells, arranged in nine rows of unequal length, some being slightly curved to adapt them to the space under the board. The longest row contained six cells, and was two and three quarters inches in length. The cells averaged about one half an inch in length; the whole leaf structure being equal to a length of fifteen inches. Upon making an estimate of the pieces of leaf in this structure, it was ascertained that there must have been at least a thousand pieces used. In addition to the labor of making the cells, this bee, unassisted in her duties, had to collect the requisite amount of pollen (and honey?) for each cell and lay her egg therein, when completed.

Mr. Putnam found the cells internally to be hard and smooth owing to the movements of the larvae; they measured .35 inch in length by .15 inch in diameter. The full grown larvae spin slight silken cocoons within which to pupate. Imagos began emerging July 31 and continued during the first week in August.

This species is parasitized by *Melittobia megachilis* Packard, and the eggs of this parasite are supposed to harbor the smallest Hymenopteron known, *Pteratomus Putnamii* Pack.