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PHILIPPINE WASP STUDIES

Part 1.---Descriptions of New Species.

BY S. A. ROHWER

Part 2.---Descriptions of New Species and Life History Studies.

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Part II.

Descriptions of New Species and Life History Studies

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PREFACE.

The great wealth of insect life in the tropics has long been a matter of comment among naturalists. And since insects are so abundant there, it follows that, living in such varied environment, many curious habits and structures are developed among them. The ants, bees and wasps form no exception to this statement and we find that these vary more both in themselves and in their handiwork than do those of temperate Europe and America.

As a student of wasp-life, first in the United States and later in the Philippine Islands, the superiority of the tropical over the temperate regions as a field less explored and offering greater opportunity for biological work, strongly impresses my memory. In glancing over the literature which relates to the habits of ants, bees and wasps however, it is seen that with some notable exceptions the works leave much to be desired. This is due chiefly to the fact that the field entomologist is often handicapped for time and so is unable to make a prolonged study of the fauna of one locality. This applies especially to the tropics. I consider myself fortunate, therefore, when in the Philippines, from June, 1916, to September, 1917, I was able to make a resident study of many wasp activities and thus observe them from day to day or week to week. The results obtained indicate, as usual, hardlly more than a skirmish in the vast field that here lies spread before the entomologist who wishes to take up studies along these lines.

The opportunity for this study presented itself when I was engaged by the Experiment Station of the Hawaiian Sugar Planters' Association, in entomological work at the Philippine College of Agriculture, Los Baños, Luzon Island. The college is ideally situated for the study of insect life. It is about 40 miles by railroad south of Manila, and lies immediately at the base of Mt. Makiling. This well forested peak is an ancient volcano which

rises to a height of nearly 4000 feet above sea level. Several thermal springs flow from its sides, and hence we have the name Los Baños (the baths) for one of the towns at the foot of the mountain. Thus the College offers at once a study of the lowland

Fig. 1. College of Agriculture, Los Baños. Mt. Makiling in the background. Photo by L. B. Uichanco.

and generally more widespread fauna of the cultivated and semi-cultivated areas as well as that of the forest itself. The comparative isolation of this mountain probably accounts, in a large measure, for the very rich and rather distinct fauna and flora it supports. Entomologically, thanks chiefly to the efforts of Prof. C. F. Baker, Dean of the College of Agriculture, and his collector, Julian, it is probably the best known region in the Philippines.

The Philippine Islands form a part of the Indo-Malayan region, which includes Java, Sumatra, Borneo, India, portions of China, etc. Los Baños lies approximately in latitude 14° 10′ N. and longitude 121° 10′ E. and has a distinctly tropical climate. Its seasons may be considered three: the warm and moist period, from about June to September; the cool, to January; and the dry period, to May. The rainfall is fairly heavy, and violent storms (baguios) sometimes occur. During the single cool sea-

son which I experienced, the mercury seldom fell a degree or two below 70° F., and in the warm season rose to over 90° F. At no time, therefore, can the weather, at low levels, be termed cold—though the natives themselves will not agree with you on this point—but while flowers and fruits of one sort or another may be found throughout the year, there is a relative scarcity of insect life during the less warm and dryer months, just as occurs in temperate regions in a much more pronounced degree, and if we investigate, it will be found that many insects suspend their activities for a time and hibernate or aestivate as elsewhere.

For the study of insect life the tropics offer decided advantages over the temperate regions; in the former the life-cycles of insects are generally more rapid and in many cases uninterrupted throughout the year. Insects are more numerous, many are of greater size, and the climate, while not always most salubrious, seldom interrupts entomological enterprise. Cloudy weather, or even at times a light rain in the tropics does not spell a cessation of insect activities.

I have derived much information from the works of other entomologists, and it will be found that related wasps of temperate and tropical regions have much the same habits. Those who would gain a better idea of the habits of wasps will do well to consult Fabre's Souvenirs Entomologiques, a large part of which has been translated into English; Peckhams' Social and Solitary Wasps; Latter's Bees and Wasps; Hartman's Observations on Some Solitary Wasps of Texas; Ashmead's Habits of Aculeate Hymenoptera; Dutt, on Life Histories of Indian Insects; Sharp, in the Cambridge Natural History of Insects, V, Pt. 2; Maindron, Notes pour servir a l'histoire des Hymenopterès de l'Archipel Indien et de la Nouvelle Guinée; Howes, in Tropical Wild Life in British Guiana; Isely's Biology of Some Kansas Eumenidae; Bequaert's Revision of the Vespidae of the Belgian Congo; and Rau & Rau, Wasp Studies Afield.

I owe special thanks to Mr. F. Lutz of the American Museum of Natural History, New York, for copying literature inaccessible to me; to Mr. S. A. Rohwer of the United States National Museum, for identifying a number of the wasps considered here; and he has kindly consented to publish his paper as a part of this Bulletin; to Mr. Nathan Banks of Cambridge, Mass., for spider determinations; to Mr. J. A. G. Rehn of Philadelphia, for naming Orthoptera; to Mr. J. C. Bridwell, for information and criticism; to Mr. W. R. R. Potter, illustrator for the Experiment Station here, for valuable hints on drawings, many of the latter being his own work; to Mr. O. H. Swezey for proof-reading, etc.; and to Prof. C. F. Baker, Dean of the College of Agriculture, P. I.

The types of the species described by me are all in the collection of the H. S. P. A. Experiment Station, Honolulu.

INTRODUCTION.

The Hymenoptera may be roughly divided into a stinging or aculeate group and a non-stinging or non-aculeate group. The first comprises ants, bees and wasps, and here the sting (modified egg-laying apparatus or ovipositor) issues from the tip or apex of the abdomen, while the trochanters of the legs are generally simple; the second division includes leaf wasps, chalcis wasps, ichneumon wasps, etc., these having the ovipositor issuing (having its external origin) from before the end of the body, and the trochanters more often two-jointed.

Ants practically always live in communities commonly made up of males, functional females or queens, and more or less sterile females or workers. All these phases have one or two node-like joints on the base of the abdomen. Bees as a rule are more hairy than wasps, though many of the parasitic groups are comparatively naked. At least, some of their hairs are branched. They feed their young with flower products, while most wasps provide theirs with animal food, usually insects and spiders, entire, in chunks, or well masticated.

Social wasps, the "Yellow Jacket" (*Vespa*), for example, live in communities. As in the ants and social bees, the most specialized kinds have three forms of individuals to a nest. These work for the good of the community. With the solitary wasps there are only males and functional females. Each of the latter provides solely for her own young, and even when living in dense colonies, as in certain sand-nesting forms (*Bembex*) and mud-daubers (*Sceliphron*), exhibit no coöperation.

Nests of Wasps.

Since in their immature stages wasps are helpless creatures, it devolves upon the mother to provide them with food and shelter. This brings us to the subject of nests. Properly speaking, wasps of the most primitive type make no nests, but sting and parasitize their prey where they find them, and as these usually live in places well concealed from other enemies, the wasp's brood is fairly secure. Thus here the victim's abode substitutes in a way for the wasp's inability to make a nest. The Bethylidae, usually small black wasps, often classed with the parasitic Hymenoptera, but more properly associated with the Aculeata, illustrate this point. Many prey on lepidopterous larvae, which they attack either in their retreat—as borings in decayed wood, or in rolled-up leaves—or in their cocoons (*Sclerodermus*, *Sierola* and *Holepyris*). The Hawaiian *Sclerodermus immigrans* Brid-

well has been found by Bridwell (1918) parasitizing in its cocoon the larva of *Caryoborus gonagra* Fabricius, one of the so-called bean-weevils. The genus *Epyris*, comprising some of the larger Bethylidae, prey on the larvae of tenebrionid beetles, which they often sting when underground. But where the victim is subdued on the surface of the ground this wasp proves equal to the emergency and buries it. So, too, with the Scoliidae, an extensive and useful family of thick-set wasps that prey on lamellicorn beetle grubs. The latter usually feed in decayed wood, compost heaps or underground at roots, and are there sought and parasitized by the wasps and left without further ado. But there are a few records of Scoliids also burying these grubs. (Forbes, 1908, p. 159.) The prey of some wasps of more advanced type live in well-defined burrows which are utilized as nest holes by these wasps. For example, *Methoca*, a genus placed sometimes in the Mutillidae, but more often with the Thynnidae, parasitizes the larvae of tiger-beetles, and if these, in their struggle for life, crawl out of their retreat, they are afterwards pulled in and buried. The Mutillidae or "velvet ants" mostly enter the nests of bees and other wasps and parasitize their young. Some of the Psammocharidae, also known as Pompilidae or "spider wasps," use the burrows of their victims as a cell for their young. The Ampulicidae or cockroach hunters drag their subdued prey into some hole or other shelter. But a large proportion of the ground wasps, sometimes also called "Fossores" or "digger wasps," are more advanced in development and thus fitted to dig burrows or construct other definite nests, of which there exist a great variety. For instance, *Tachysphex* and *Priononyx*, sphecid wasps, both hunters of Orthoptera (grasshoppers, roaches, etc.), quickly excavate and store their short burrows, which terminate in a single cell or enlargement. *Liris*, *Cerceris* and *Tachytes* are more extensive diggers and may require a week or more in which to dig and provision their tunnels of several cells.† Many wasps are architects, building nests above ground; fewer combine their architecture with burrows. Thus we have the mud nests of many Sphecidae, Pompilidae and Eumenidae, and then there are many *Odynerus* and some Masarids which dig holes, divide off the cells with a partition of clay, and with the same material build a delicate tube over the entrance to the burrow. *Trypoxylon* and some *Pseudagenia*, spider-wasps, frequently divide off cells in pre-existing hollows (bamboos, reeds,

† The order of business in wasp life—mainly nesting activities—is not always the same. We have some species, as **Priononyx**, **Dolichurus** and some **Psammocharidae**, which first secure their provisions and then dig a hole, while others, probably the majority, make their nests and then search for victims.

mud-dauber nests, etc.). Some mud nests are rainproof, others are not, and so the latter are built in sheltered places; hence we find the nests of mud-daubers (Sceliphronini) often placed under eaves of houses, against ceilings and in other safe positions. Some mud architects cover their cells with tree gum and lichens (*Pseudagenia* sp.), or with debris of various sort (*Podium*). *Macromeris* uses a clay-like material of composite character. Some of the more specialized solitary wasps (*Zethus, Zethusculus*) use leaves or moss for nest building, and the very elongate shade-loving *Stenogaster*, material much like, though more frail than used by the paper-making hornets. It seems, then, that the higher wasps very commonly make use of superior building materials—superior in that less of it is required in the construction of a cell than in mud-daubing wasps, for example. Space may be economized, but time does not appear to be.

The Egg.

The cell made or the victim secured, the egg is the next sequence in wasp life. The queen hornet (*Vespa*) may in her lifetime of some months lay several thousand eggs; this is all out of proportion to the egg-laying powers of solitary wasps. *Zethus cyanopterus*, a highly specialized solitary wasp, probably lays fewer than a dozen eggs. *Tachytes*, a locust wasp less highly developed, may produce as many as fifty, and some of the Scoliidae probably somewhat exceed this number. The wasp eggs that I have studied ranged from less than a millimeter in length (*Methoca, Epyris*) to seven millimeters (*Chlorion, Macromeris*). They are whitish or yellowish in color, two or more times longer than thick, usually slightly arched and commonly a little thicker at the head than at the posterior extremity. They may be placed near the food or on its surface.* The Psammocharidae glue their eggs near the base of the spider's abdomen; most Sphecidae that attack grasshoppers, crickets or locusts affix theirs under or partly alongside the thorax, while *Methoca* and *Scolia* sp. place their egg on the underside of the abdomen of the beetle grub. The head end of the egg is often against some tender spot of the victim's anatomy. In those cases where the prey is paralyzed so as to be incapable of motion, the wasp's egg may be only lightly glued to it (*Methoca* sp., *Sceliphron, Scolia* sp., in *Scolia* the egg stands on its head as it were); but where the prey largely recovers from the wasp's sting, it is more securely glued (*Tiphia, Methoca* sp.) or placed in a well-protected position on it (*Larra, Noto-*

* A great many of the non-aculeates insert their eggs in the food, whether it be plant or insect tissue.

gonidea). Most Eumeninae, chiefly potter wasps, suspend their egg by a thread to the roof of the cell, which is provisioned with more or less active caterpillars. Some of the more specialized wasps of this group (*Synagris, Zethus*) lay their egg freely in the bottom of the cell. *Stenogaster* and the social wasps build cells in a more or less inverted position, and there the egg is glued in the bottom of the cell itself. Wasp eggs may hatch in less than two days (*Dolichurus, Methoca* sp., *Notogonidea*) to four, five or more days (*Tiphia* sp.). Cool weather greatly retards the development of the egg, so that two weeks or more may be required to hatch it.

The Larva.

The next stage in wasp development is that of the larva. The larva is a more or less whitish grub, devoid of legs, but possessing adequate jaws. In many cases so gradually does the young grub break through the very thin and closely-adhering egg-shell that it is hardly possible to determine just when the egg hatches; in these cases it seems that the grub punctures the envelope under the mouth and feeds at that point and simply outgrows its envelope. Or else the larva may crawl out of the shell (*Methoca* sp., *Epyris*). The eggs of Eumeninae are reasonably firm, so that after hatching, the shell may collapse but little, and since the eggs of these wasps are not attached to their food, it follows that, in order to feed of themselves, the young grubs must be active from the very first, and this is true of those that I have seen. In the case of the Sphecidae, Psammocharidae, and others, the newly-hatched grub is usually a very helpless creature. When it breaks through the egg-shell it finds food practically in contact with its mouth and so may feed at once. But if at this stage it be removed to another portion of its victim's anatomy it very frequently perishes. Later on, however, after several moults, which are often difficult to follow (except in the Eumeninae), it acquires stouter mandibles, and, becoming more able-bodied, largely abandons its first method of feeding by suction, for a chewing one; thus it reaches out to the different victims or portions thereof, to devour the tougher parts—head, legs, etc.

The soft, footless wasp grubs, one appearing much like another, should, if sufficiently studied, present characters that would place them in natural groups. There is here a field for the taxonomist.

The feeding period of the larva is usually brief, perhaps three to fourteen days, according to species, food and climatic conditions.

The Cocoon.

Directly after it has become full-fed, the grub forms a cocoon.† As a rule the species that nest underground have the tougher cocoons; they may be composed of from one (*Dolichurus, Epyris*) to many separable layers of silk (*Methoca*). Other cocoons may be formed of particles of sand, wood-dust, etc., agglutinized by means of the grub's saliva into a tough shell (*Bembex, Larra*).

The mud-daubers, already protected in a thick cell of mud, make a tough but very thin cocoon; so also with the mud-using Psammocharidae. It is noteworthy, however, that the parasitic Psammocharids, *Ceropales*, spin stout cocoons, even when occupying the mud cells of *Pseudagenia*. Might this indicate that they were formerly burrowing wasps? The cocoons of *Pseudagenia* are thinner than those of their ground-nesting relatives that have to resist the moisture. Some Eumeninae make a thin but rather tough cocoon; others, however (some *Zethus*), merely construct a thin leather-like partition which extends from near the top to a short distance down the sides of their cells. Several species at least of *Stenogaster* make no cocoons, but coat their cell with a shiny substance. Some wasps, of the family Pemphredonidae, are said to spin no cocoons. (Green, 1902.) The inner wall of the cocoon is smooth and varnished. Cocoons usually taper more at the posterior extremity, wherein the larva voids for the first and last time the contents of the intestine. There is some advantage in this, as the cell is kept comparatively clean during the feeding stage, while later the walls of the cocoon readily absorb the moisture of the faeces which gives that end its characteristic color. Before spinning the body of the cocoon the larva usually makes a sort of scaffolding of silken strands to support it. The cocoon is commonly simple, but in some cases one end or even the side may be provided with a collar, knob or chamber (*Methoca, Dolichurus, Epyris*).

The larva now encased within its cocoon has a resting period therein; this may be a question of a few days or of many months, for it is thus that solitary wasps usually pass the winter or the dry season.* The resting larva is usually more yellowish than

† A few make no cocoons.

* A rare exception, at least in temperate regions, is cited by Fabre in the case of a caterpillar wasp, **Ammophila hirsuta** Kirby, which hibernates as a full-grown wasp and in consequence begins nesting operations at a much earlier date than do related species. Davidson (1899), in speaking of **Sphex elegans** of Southern California, says that the majority of these wasps hatch out in July and August and pass the winter concealed in crevices, etc., and that probably not more than fifteen or twenty per cent remain in the larval stage until the following May. Bees very often hibernate as freshly-hatched adults.

when feeding, deeply segmented and possessed of more or less activity.

The Pupa.

The next change comes with the final moult of the larva, the result being the pupa. Before shedding its skin the larva gradually acquires a slightly different form; the thorax becomes differentiated in assuming a smoother, cone-like shape, and pupal appendages may be discerned dimly outlined beneath the skin, which, like a tight-fitting garment, bursts at the back of the thorax and gradually slips down, exposing the forming pupa. This is especially delicate in the Sphecidae, Psammocharidae, etc., but less so in the potter wasps or Eumeninae. The appendages—legs, wings, antennae, etc.—are free, i. e., not fused flatly into the body, as in the moths and butterflies. The pupa is shaped much like the adult wasp, though it may be considerably bent or doubled up upon itself (*Eumenes, Zethus, Stenogaster*) and adorned with spines or tubercles. This stage is of comparatively brief duration—two weeks, more or less. The pupa, at first whitish, darkens with age into the color of the adult wasp. In due time its thin envelope ruptures, and through the insect's motions is gradually worked back to the end of the body, until the wasp is entirely free from it. The wings grow almost visibly as they leave the pupal sheath, so also with the other appendages. It remains within the cocoon and cell until sufficiently hardened and strong, when, with the aid of its jaws and sometimes a little mouth liquid, it soon cuts its way out and emerges an active and independent wasp. As in bees, it seems that the males are first to emerge and they soon busy themselves with finding the females. Thus male Scoliidae, Odyneri and others may be observed awaiting in their breeding grounds the appearance of the females.

The life cycle of wasps for the summer brood or broods may be estimated as about from twenty-five to forty days. The adult wasps, even in the solitary species, may live for several months. They do not always go about nest-building immedaitely, but first enjoy sunshine and flowers before commencing their arduous task.

The Food of Adult Wasps.

Here flower products predominate. In the Philippines, *Premna odorata* Blanco, a wide-spreading verbenaceous tree with flat inflorescences, often beyond reach of the net attracted very diverse insects—among the wasps were *Tachytes banoensis, Chlorion um-*

brosus and *aurulenta*, *Eumenes curvata* and *fulvipennis*, *Zethus cyanopterus*, *Rygchium atrum* and *Scolia*, near *procer*, and *Liacos analis*. The small border-plant, *Alternanthera versicolor* Regel, (*Amarantaceae*) attracted *Scolia manilae* Ashm. and others. Compositae such as *Solidago* and many Umbelliferae yield good wasp catches in temperate regions. The sweet-potato vine *Ipomoea batatas* (*Convolvulaceae*) has the petioles of its leaves provided with nectar glands which furnish food for flies, bees, wasps and other insects. In Kansas, I have seen the stems of the sunflower, *Helianthus*, that had been pierced by a small lepidepterous larva attract many Hymenoptera by the exuding sap. This was also the case with willow trees which exuded a liquid where punctured by the borings of beetles. Bridwell has observed Hymenoptera in California pierce with their mandibles the base of the glandular spines on the stems of sunflowers (*H. annuus*) and draw nourishment therefrom. Vegetation attacked by leaf-hoppers, plant lice, mealy bugs, lantern flies, etc., frequently becomes plentifully sprinkled with honey dew. Such foliage later becomes blackened by a fungus growth and is the favorite rendezvous for numerous insects—flies, beetles, ants, wasps, etc., and an entomologist may reap a harvest there.

When a wasp overcomes a victim destined to serve as food for her young, she may first help herself, feeding at its mouth juices and perhaps also at the sting wounds. The bee-catching wasps (*Philanthus*) appreciate the honey which they force out of their prey's crop, and the little bethylid wasp (*Holepyris hawaiiensis*) gorges itself with the juices which she extracts from her caterpillar prey by piercing with her mandibles, the base of one of its thoracic legs. The Pseudageniae or leg-amputators no doubt derive some nourishment from the leg stumps of their spider victims.

Roubaud (1916) has observed that the larvae of the social wasps *Icaria*, *Belonogaster* and *Polistes* exude upon stimulation by the male or female wasp, a salivary fluid which the wasp laps up.

The Food of Wasp Larvae.

Wasps as a rule provide food of animal nature for their grubs; each group is usually addicted to a certain kind of prey—this may consist of spiders, beetles, grasshoppers, cicadas roaches, bugs, bees, flies, moths, skipper butterflies, caterpillars, etc. Sometimes the food is served in the living (paralyzed) and sometimes in the dead state. The insect or spider captured may often be much larger than its captor and may put up a stiff

battle before it is overcome. A wasp hunting and subduing her prey is an interesting spectacle though frequently tedious to observe.

It is interesting to note that some of the ponerine ants as *Leptogenys* and *Lobopelta*, the lowest subfamily of the Formicidae, and presumably derived from solitary wasps, have a method of hunting their prey—in this case small land crustaceans—much like that employed by some of the more active terrestrial Fossores. In the Philippines I have seen ants of the genus *Lobopelta*, very active and nervous insects, searching beneath leaves, small lumps of soil, etc., in damp, shady places. Every now and then a crustacean would be flushed, to leap away to safety; eventually a less active or a cornered one would be pounced upon by the ant, which quickly paralyzed it by one or more stings on the underside of the body. The victim was then borne away nestward under the ant's body.

A single victim may prove sufficient food for a wasp grub; with other species a number may be required.* Rarely dead and dry food is furnished the grub (*Microbembex*). Sometimes the young wasp is fed from day to day by its parents, being given either entire insects (*Bembex*) or a chewed-up portion of caterpillars (*Synagris*). A few wasps feed their young a honey-like substance (Masaridae; and perhaps *Stenogaster*). Many social wasps give their young a wide range of food.

Sleep of Wasps.

Not much is known about this interesting subject. In the United States, Rau and Rau (1916) have made a number of observations on the sleep of Hymenoptera. They found that some of the Sceliphronini or mud-daubers assemble in sheltered places for the night. Many other Sphecidae, Eumeninae, and some male Scoliidae pass the night on weeds. This applies more to the male sex. They may assume odd positions on these weeds which they grip with their jaws and legs or with the jaws only. Other wasps, mainly Fossores, occupy their nest-burrows or other holes for the night. The more social or specialized wasps sleep in or about their nests—thus we find some of the psammocharid mason wasps keeping watch in the shelter wherein their cells are situated and resting on them. Higher Eumeninae may occupy one of the cells of their nests (*Zethus*, *Synagris*, *Zethusculus*), the *Stenogaster* or slender-bodied forest wasps most certainly sleep or rest on or in their nests. In the tropics however, where

* I know of no case in the Aculeata except in many Bethylidae where more than one egg is laid on a victim.

the hours of darkness are often not particularly cool, wasps that do not hide in the ground may not really sleep a great deal. On moonlight nights I have heard the large Carpenter bees buzzing at Solanaceous flowers; the few wasps that I have inspected during the night, no matter how cautiously approached, were always wide awake and alert.. But where chilly benumbing nights prevail, wasps directly exposed to the atmosphere are quite dead to the world—until the sun arouses them. This is common in temperate regions.

Bequaert (1918), p. 23, speaks of a wasp, *Provespa*, as being "adapted to nocturnal habits and restricted to the Oriental region." He also makes a note of two species of crepuscular bees taken in S. W. United States.

Enemies.

Both young and adult wasps have numerous enemies. Perhaps the most severe check to many species are ants. These obnoxious creatures, belonging to the genera *Pheidole*, *Pheidologiton*, *Solenopsis* and *Monomorium*, for example, often rob the wasp of her prey, occupy her nest, and even penetrate cocoons buried in the ground. It is very noticeable that while a few wasps actually provision their burrows with ants (*Aphilanthops*, *Fertonius*), they have in general a decided aversion and fear of them. Parasitic wasps, beetles and flies are other serious enemies, and a certain large tropical *Vespa* or hornet plunders many a nest of solitary and social wasps. Certain Aculeate wasps (*Ceropales*, *Mutilla*, some *Stizini*, *etc.*), prey upon the young grubs or their food.

Economic Status.

Taken as a whole wasps are beneficial insects and destroy an incalculable number of harmful insects, as well as some beneficial ones; among those addicted to the latter habit are species of *Philanthus* and *Palarus* which prey on the hive bee and others; Mutillidae or "Velvet Ants" destroy the young of other wasps, as do the brilliant cuckoo wasps and a host of other kinds. As a rule, people who are not afraid of spiders regard them as destroyers of obnoxious flies, millers, etc. Perhaps spiders, even up to the giants of their kind, have more wasp enemies than do insects. A whole family, the Psammocharidae or Pompilidae, bring up their young upon spiders. Many genera in other families prey upon them and the mud-daubers (Sceliphronini) literally stuff their cells with such provender. Thus one wasp may destroy up-

wards of a hundred spiders. And yet the latter are usually abundant enough. Their beneficial nature may sometimes be questioned, inasmuch as they are often cannibals, and do not discriminate between beneficial and injurious insects as food.

A very large number of wasps prey upon caterpillars, locusts, flies and beetles; others attack bugs. One genus of wasp (*Larra*) makes the mole-cricket, *Gryllotalpa*, its common prey; and the observing person living in districts where grasshoppers abound cannot fail to note that these are preyed upon by certain wasps.

Hacker (1918) records the big Australian eumenid *Monerebia* (*Abispa*) *ephippium* Fabr. preying on the larva of *Clania ignobilis* Wlk., one of the bagworms (*Psychidae*), a family of moths containing some noxious species.

The big wasps of the genus *Monedula* prey largely upon Tabanidae (Horse-flies). Of *M. surinamensis* Fabr., Belt (1874), p. 239, says: "Horse-flies (*Tabanus*) were too numerous, and drops of blood trickled down our mules' faces where they had feasted. In some parts large, banded black and yellow wasps (*Monedula surinamensis* Fabr.) came flying round us and had a threatening look as they hovered before our faces, but they were old acquaintances of mine in Brazil, and I knew that they were only searching about for the horse-flies with which they store their nests. * * *"

The Scoliidae are eminently beneficial—as is known to economic entomologists. They destroy the larvae of the cocoanut beetles (*Xylotrupes* and *Oryctes*), and smaller species are known to prey upon the larvae of the so-called May or June beetles. The marked success of *Scolia manilae* Ashm., a rather small Philippine wasp introduced by this Experiment Station, into the cane fields of Hawaii, in checking the grub of the *Anomala* beetle, indicates that the Aculeate wasps have a place in the list of beneficial insect importations.

In concluding, I may say that the nests and the burrows of solitary wasps and of some social kinds as well may be robbed with almost invariable impunity. Solitary wasps are never aggressive to the degree exhibited by their social brethren, and while they would sting or endeavor to do so were they incautiously held between the fingers, their weapon is directed mainly against their prey.* They do not appear to sting in the quarrels among themselves. But we know from reliable sources—such as experience—that hornets and many other social wasps behave otherwise; they are bold in their strong communities and protect

* According to Froggatt (1907), the large, metallic-blue thynnid (**Diamma bicolor**) of SE. Australia will, in the female sex, which is equipped with a powerful sting, turn on her back and fight furiously when molested.

their molested paper nests with impressionable vigor. This home-defending instinct is also well developed in social bees and many ants.

DESCRIPTIONS OF NEW SPECIES, INCLUDING ONE SPECIES FROM FORMOSA.

THYNNIDAE.

Methoca.

The six species of this genus taken on the Island of Luzon, P. I., as well as the single specimen from Formosa, while differing from each other, at least in the female sex, by well-marked characters—as body proportions and sculpture—all agree in belonging to quite another section than those of temperate North America, Europe, and even—as far as studied—of South Africa.*

The following are the more marked differences between these two groups:

From the Philippines and Formosa.	From Temperate North America, Europe and South Africa.
♂ Philippines.	♂ Temperate North America and Europe.
Compound eyes proportionately larger and closer together; ocelli in a more elevated, sometimes an equilateral triangle; head shorter or less gibbous behind eyes; proportions of thorax more slender; no enclosed area at apex of propodeum (except in *fimbricornis*).	Compound eyes proportionately smaller and more widely separated; ocelli in a rather low triangle; head longer or more gibbous behind eyes; thorax stouter; enclosed area at top of propodeum = 3 United States species.
♀ Philippines and Formosa.	♀ Temperate North America, Europe and South Africa.
Compound eyes proportionately much larger; scutum of thorax reduced to a flattened or depressed area.	Compound eyes proportionately smaller and more widely separated; scutum convex and better developed.

* The S. African species were loaned me by Mr. Bridwell.

KEY TO SEPARATE THE SPECIES OF PHILIPPINE AND FORMOSAN *METHOCA*.

Females.

1. Disc of pronotum finely but distinctly striate, frontal process obsolete, color black ..... *striatella*
   Disc of pronotum not striate or with only a very few median striae; frontal process strong (except in the impunctate *formosana*) 2
2. Head, thorax and abdomen glossy, almost wholly impunctate; clypeus simple, i. e., no dull thin apical portion; jet black species ..... *formosana*
   Head at least, somewhat punctate or striate, clypeus with a thin dull apical portion (do not mistake the hair-fringed labrum for this) 3
3. Thorax reddish; propodeum widest posteriorly and there subtruncate ..... *punctata*
   Thorax black; propodeum not subtruncate posteriorly.... 4
4. No striae on vertex or upper part of frons; form very slender ..... *fimbricornis*
   Distinct striae on frons and vertex, form moderately slender ..... *monticola*

Males.

1. Antennae beneath with two ranks of curved hair; posterior face of propodeum truncate and bounded by a carina.... ..... *fimbricornis*
   Not having the above characters..... 2
2. The sternite before the apical spine, deeply and narrowly cleft; clypeus without a pale and thin apical portion... 3
   The sternite before the apical spine, at most shallowly emarginate; clypeus with a thin pale apical portion..... 4
3. Propodeum with large well-marked areolate spaces throughout the disc; a row of vertical carinae on propleura..... ..... *striatella*
   Propodeum comparatively, rather finely rugulose; no row of vertical propleural carinae ..... *debilis*
4. Gular suture marked by transverse foveae extending from three-quarters to the entire distance between the occipital ridge and the labium; puncturation near the suture deep and general; well-defined punctures on disc of at least the anterior two-thirds of pronotum; wings clear... *punctata*
   Wings infuscate ..... *fuscipennis*

Gular suture with only about two foveae, and these not distinct and occupying only a small length of distance; puncturation here more sparse and shallower; pronotum, with puncturation distinct only on the anterior half or less; wings infumate ..... *monticola*

The males of Section 2 are difficult to separate, and even the genitalia do not appear to differ here. Additional material and more study will probably improve the status of the species of this genus in the Philippines.

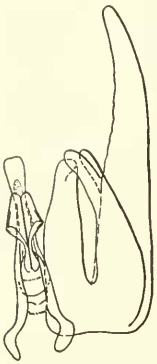


Fig. 2.

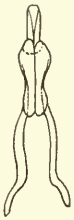


Fig. 3.

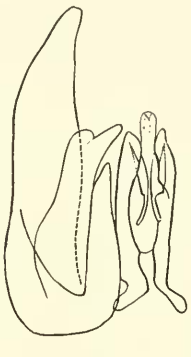


Fig. 4.

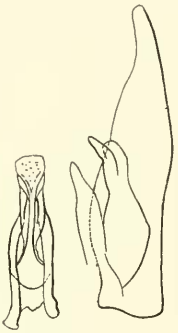


Fig. 5.

Many more species remain to be discovered, and if the giants among the Cicindelidae, as *Manticorna* of Africa and *Amblychila* of North America, and the remarkably-formed arboreal species of Indo-Malaya and other parts of the tropics, some of whose larvae dwell in holes in twigs instead of in the soil, have their respective *Methoca* or allied enemies, then we must look for some wonderful species among these wasps.

Fig. 2. *Methoca monticola*; aedeagus; stipe and sagittae. From above.

Fig. 3. *Methoca punctata*; sagittae; the apical portion is curled laterally and probably unnaturally here. From above.

Fig. 4. *Methoca striatella*; aedeagus; 3-piece stipe and median portion (sagittae). From above.

Fig. 5. *Methoca debilis*; aedeagus; stipe and sagittae. From above.

Methoca striatella, n. sp. (Figs. 4, 6 and 7.)

Female, type: Length 6.15 mm. Shining black; mandibles, antennae except the 4 or 5 terminal articles, the dorsal portion of the neck, legs except fore coxae, reddish, apical segment and a half of abdomen brownish yellow. Quite slender. Head

nearly twice as wide as prothorax, but not large; mandibles bidentate, with a few coarse confluent punctures except at apical third. Clypeus simple, subtruncate and very little emarginate, somewhat raised on median line, margin with scattered punctures. A low frontal tubercle, but no bituberculate process above base of antennae; front, except antennal foveae, as far as posterior ocelli with scattered punctures and very fine, interrupted longi-

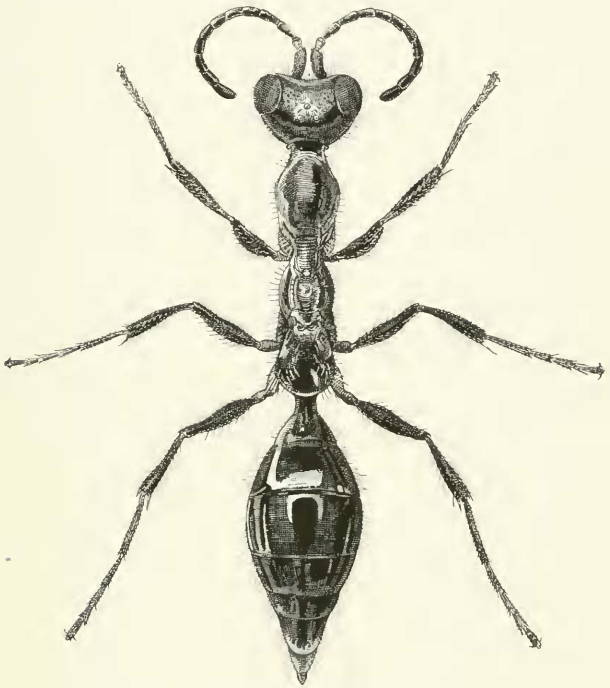


Fig. 6. *Methoca striatella*, ♀, × 13.

tudinal striae; a furrow extending from the anterior ocellus towards clypeus; vertex polished, with sparse punctures, ocelli distinct forming nearly an equilateral triangle; eyes rather large, diverging from inner lower portion towards mandibles; antennae rather stout, articles 3 and 4 subequal and all more or less punctate. Prothorax above with cervical part finely reticulate and separated posteriorly by a transverse short longitudinally carinate furrow. Anterior half of pronotum finely and obliquely striate, posterior half transversely striate and with a few punctures, striae becoming obsolete along pleurae; mesonotum with the an-

terior part (scutum) slender and coarsely rugose, then follows a small median pit, and then the large oblong and convex scutellum, which is well margined and sparsely punctate and a little aciculate transversely; pleura of anterior portion of mesothorax with a few large and curved longitudinal carinae; posterior to this they are striate and punctate. Metathorax inconspicuous, propodeum nodose, polished, with sparse large punctures and

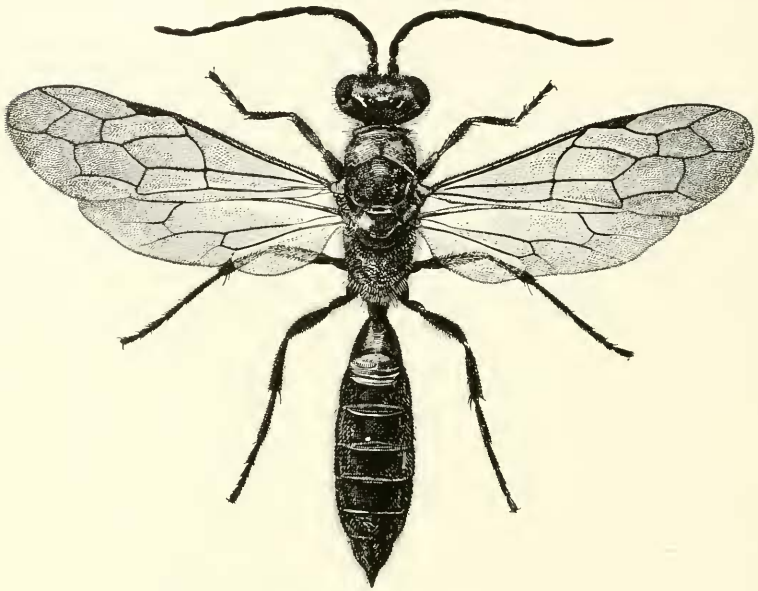


Fig. 7. *Methoca striatella*, ♂, × 7.5.

some aciculations, laterally and posteriorly mostly smooth, stigma oval; legs slender; claws with a basal tooth. Abdomen dorsally impunctate, a few scattered punctures ventrally. Generally clothed with rather sparse, erect white hair.

Male, allotype: Length to extremity of anal spine, 9 mm. Black; apical half of mandibles, ridge under first article of antennae brownish; tarsi largely brownish, with rest of legs almost black, tegulae in part yellowish; wings hyaline; head much wider than thorax; mandibles bidentate, with coarse confluent punctures except at tip; clypeus truncate, rather shallowly emarginate at truncation, with rather sparse punctures and a medain pointed tubercle; front closely punctate except at furrow between antennae, and becoming scattered punctate towards vertex, which is sparsely punctate; ocelli large and forming almost an equilat-

eral triangle; compound eyes large; a horn-like process at the base of each antenna above; antennae except the two basal articles opaque; 3 shorter than 4, 9-13 arched. Pronotum polished, subangulate posteriorly, with a very few punctures, and becoming transversely rugose at anterior upturned collar; pleurae with a V-shaped area with large dorso-ventral striae, more distinct for anterior half. Scutum of mesothorax with anterior median portion convex, posterior part flattened, disc with a few coarse confluent punctures and coarse transverse striae; scutellum sparsely punctate with the anterior transverse sulcus carinate, mesopleurae polished, with rather sparse shallow punctures and with short longitudinal carinae on anterior and antero-dorsal edge; metanotum with a semicircular median excavation. Wings normal; venation yellowish brown. Propodeum everywhere coarsely reticulate, with the cells generally transverse, the largest of which begins at the slope to apex; the basal one is longitudinal and median. Abdomen dorsally smooth and polished, with fine punctures for hair; ventrally 1 and 2 have sparse large punctures; others with their apical portion (beyond transverse row of hairs) rather closely punctate; last sternite mesad with some fine reticulations, its apical margin deeply cleft; ventral portion of anal spine well margined and with a few punctures except in the middle line. Insect set with rather sparse white hairs. Genitalia (Fig. 4): Outer lobe of stipes broad, basal third polished, middle lobe bilobed, inner lobe simple.

Type ♀. 11 ♀ and numerous ♂ paratypes; Los Baños, 1916-1917. Some variation in size in both sexes, and the females may have more reddish brown than in type.

Methoca formosana, n. sp. (Fig. 8.)

Female, type: Length 4.5 mm. Black; apical portion of mandibles and most of first two antennal joints reddish brown; legs with terminal joints in part and coxae apically, yellowish brown. Quite slender, polished and practically impunctate. Head a little less than twice as wide as thorax, well extended behind eyes, and subtriangular as viewed from above. Mandibles comparatively short, bidentate; clypeus rather dull, subtruncate, raised mesially, frons without bituberculation near base of antennae, but with a median pit; eyes unusually large and proximate; vertex rather pointed (rounded subconical), anterior ocellus rather distant from posterior ones; antennae subclavate, basal articles long, 3 and 4 subequal; neck of pronotum with some fine transverse striae, scutum (smaller anterior portion of mesothorax) with two incomplete longitudinal furrows on each side

of median line, a semicircular bordered impression on posterior border of scutellum; propodeum widest behind middle; legs moderately stout, abdomen normal. Adorned with sparse erect white hair.

Type 1 ♀, Taihoku, Formosa, January, 1916; collected by F. Muir.

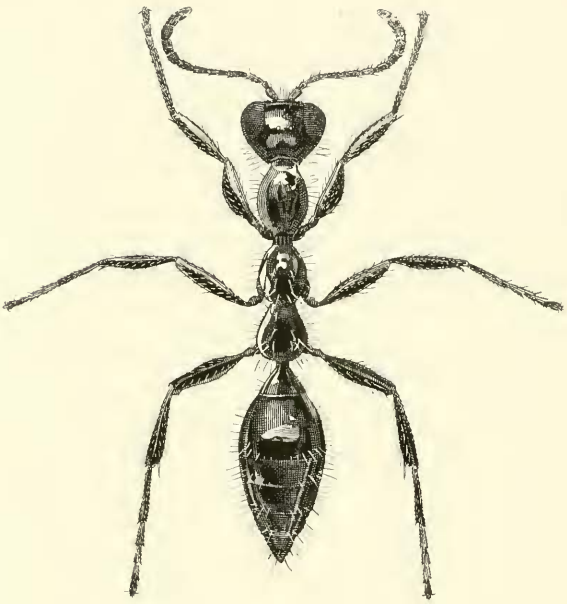


Fig. 8. *Methoca formosana*, ♀, type, × 14.

Methoca fimbricornis, n. sp. (Figs. 9 and 10.)

Male, type: Length 7.5 mm. Shining black except reddish tip of mandibles, yellowish brown palpi and apical portion of legs. Moderately stout. Head much wider than thorax and subquadrate; mandibles bidentate, with coarse punctures, malar space longer than usual and punctate, palpi long, clypeus rugulose, its anterior portion gently rounded out and there impunctate; a sharp median clypeal compressed process ending before anterior margin; clypeo-frontal fossa deep; frons polished, with large, deep and well-spaced punctures, no tubercles above antennae, a median frontal depression; punctures smaller and closer together on ocellar area; ocelli distinct, arranged in a triangle; vertex with sparse smaller punctures. Eyes nearly parallel inwardly; anten-

nae rather short, first article without carina beneath, third article hardly one-half length of fourth, articles 3-10 or 11 beneath with two rows of long incurved hairs, becoming shorter towards apex of antennae, articles cylindrical; gular region transversely striate. Prothorax subcylindrical, subtruncate in front, collar with large scattered punctures and transversely strigose, posterior portion with large transversely confluent punctures ante-

Fig. 9. *Methoca fimbricornis*, ♂, × 9.3.

riorly and sparsely punctate posteriorly. Mesonotum very coarsely and closely punctate, mesopleurae coarsely punctate and with indications of longitudinal rugae. Scutellum long and rather narrow, very coarsely rugose-punctate and with the transverse, anterior depressed area with 3-4 strong carinae, mesosternum transversely rugose; forewings with two submarginal cells, the basal and the transverse median nervure quite interstitial; legs rather slender. Propodeum coarsely areolate. Abdomen rather depressed, tergites with some fine subapical punctures, sternite 1 irregularly rugose-areolate basally and with large, well-separated apical portion, remaining sternites with fine scattered punctures, apical sternite with posterior margin nearly straight, a little depressed mesially there; curved spine with some scattered punctures on ventral base.

Female allotype: Length, 7 mm. Polished black, mandibles and legs except tarsi, dark red, basal third or more of antennae brownish, the remainder almost black; tarsi, and apex of abdomen in part yellowish brown. Quite slender, especially the thorax. Head about twice as wide as prothorax and narrowing behind the eyes; mandibles bidentate, only sparsely punctate; clypeus long, its membranous apical portion dull and truncate, the remainder

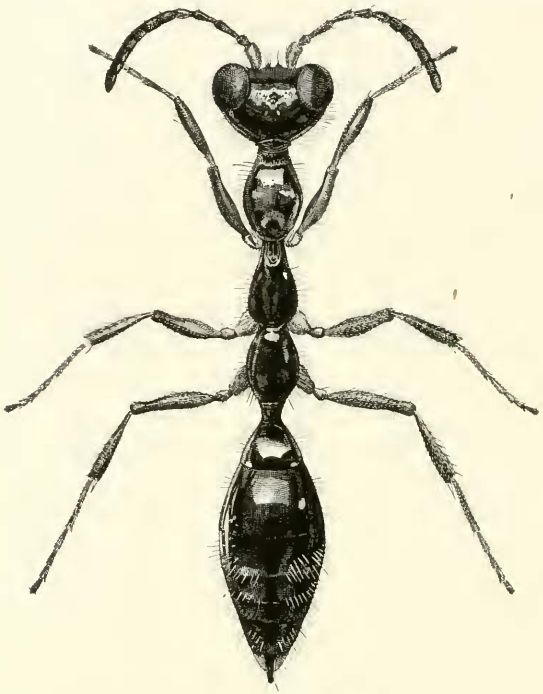


Fig. 10. *Methoca fimbricornis*, ♀, × 11.

smooth and with a strong median pointed tubercle; frons with a bituberculate process above antennae, and a shallow depression, a few vertical striae on raised portion on each side, the remainder of frons, together with the vertex, with rather large and very scattered punctures; ocelli arranged in an equilateral triangle; eyes converging somewhat towards vertex; antennae with the basal articles of flagellum glabrous, these rather long and swollen apically, article 2 more than half as long as 3, which is a little longer than 4; apical joints finely punctate. Thorax and abdomen almost impunctate; the cervical region of pronotum with

transverse striae followed posteriorly by transverse ones curved mesially into longitudinal ones. Scutum of mesothorax nearly flat, with one median carina and a pair of lateral ones; legs rather slender. Very sparsely clothed with pale hairs, with a few dark ones on head and dorsum of thorax and abdomen.

Type 1♂, paratype 1♂, both College of Agriculture, Los Baños; ♀ allotype, low Makiling forest, 1917.

The male is very distinct from others of the genus; the female I place here with some doubt, though she is also well removed from the other species.

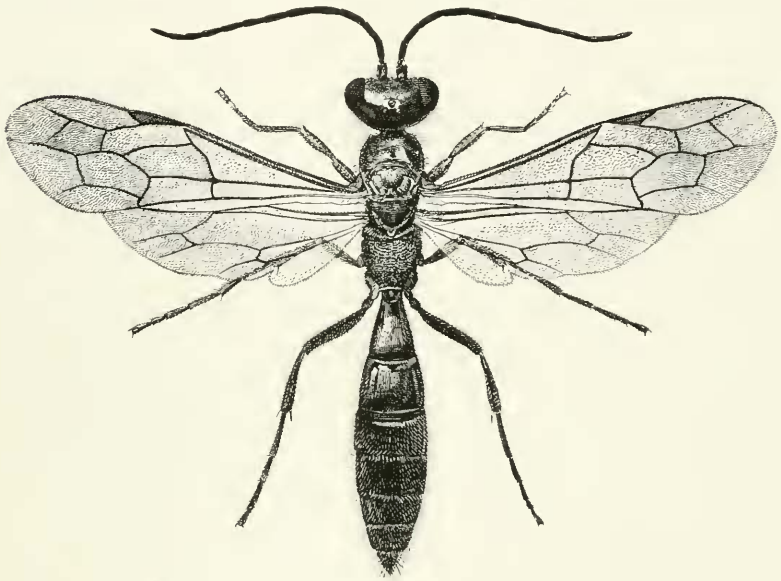


Fig. 11. *Methocas debilis*, ♂, × 9.

Methoca debilis, n. sp. (Figs. 5 and 11.)

Male, type: Length, 7.25 mm. Related to *striatella*. Shining black. Differs from *striatella* in its smaller average size, finer sculpture, slighter build, etc. The propodeum is much less coarsely sculptured, being rugose and showing well-defined areolae only on the middle basal portion; the propleurae have no vertical carinae, the first sternite is separately punctured almost to its base, while in *striatella* it becomes rugose on the basal third. The apical sternites are about as in *striatella*. The genitalia are

much as in *striatella*, but the outer lobe is not so broad as in the latter, and the sagittae or median part somewhat different.

This species varies in size from 6 to 9 mm.

Type 1♂, 1916; numerous paratypes; all from College of Agriculture, Los Baños, 1916-1917.

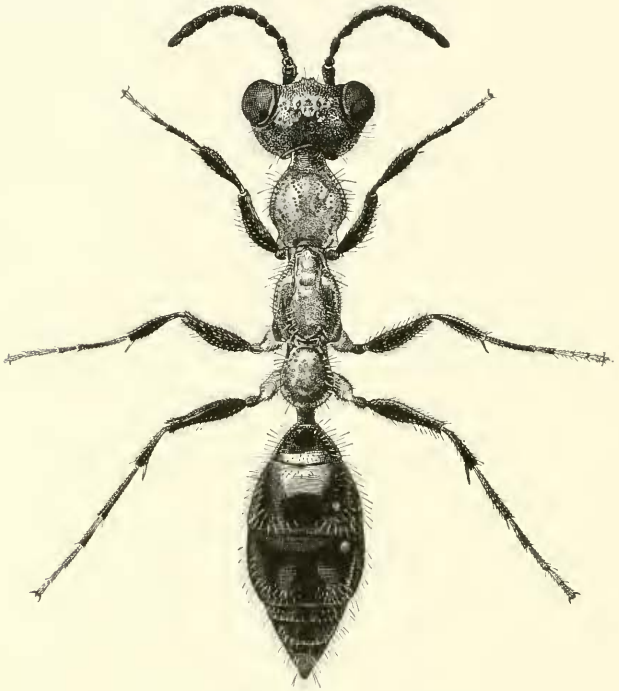


Fig. 12. *Methoca punctata*, ♀, × 11.

Methoca punctata, n. sp. (Figs. 3 and 12.)

Female, type: Length, 7 mm. Head black, thorax red, abdomen black with reddish apex, apex of mandibles dark brown, last 5 or 6 articles of antennae with brown beneath, coxae reddish, tarsi brownish black. Fairly stout for the genus. Mandibles bidentate and with large confluent punctures except apically; clypeus long, subtruncate and consisting of a thinner, more opaque and impunctate apical portion and a thicker, more polished basal piece armed with a small median tubercle, disc impunctate except for the irregular marginal hair punctures; front with a bituberculate process above antennae, the front except antennal fossae,

with large scattered punctures and longitudinal striae as far as posterior ocelli, furrow extending down from anterior ocellus, almost obsolete; vertex with large punctures and finer striae; ocelli in a nearly equilateral triangle; eyes large; antennae punctate, rather stout, articles 3 and 4 subequal. Prothorax above with cervical part, first with transverse and then with longitudinal striae, pronotum with large scattered punctures except on sides; scutum with three carinae; scutellum large, almost impunctate, mesopleurae sparsely punctured; propodeum stout sparsely punctate, wider and subtruncate posteriorly, stigma oval; claws of legs with a basal tooth. Abdomen dorsally impunctate; a few ventral abdominal punctures. Generally clothed with rather sparse, erect white hair.

Male, allotype: Length to extrimity of spine, 10.5 mm. Black, colored as in *M. striatella*, except that the tegulae are all black, wings hyaline. Coarsely punctate. Clypeus truncate with the transverse apical portion thin and yellowish, the thick emarginate basal portion punctate and with a low median tubercle; ocelli forming nearly an equilateral triangle. A tubercle above the base of each antenna; frons coarsely and closely punctate; vertex not so closely punctate, sparsely so posteriorly. Dorsum of thorax punctate, hardly so on posterior part of pronotum, scutum rather sparsely punctate, with a few transverse and lateral rugae, scutellum rather finely punctate; propodeum rather coarsely rugose or rugose punctate, somewhat areolate mesially above; wings normal. Abdomen above with fine hair punctures, beneath with alternate antero-posterior bands of coarser and finer and closer punctures; sternite before spine gently emarginate; ventral side of spine with coarse punctures. Genitalia: Outer lobe of stipes narrower than in *striatella*, middle lobe bilobed, inner lobe blunt; median portion with a thin flat process or flagellum; the more or less membranous portion evidently varies in form according as to whether it is more or less distended or buckled.

Rather sparsely clothed with white hairs.

Type 1 ♀; numerous ♀ and 2 ♂ paratypes, all Los Baños, Luzon, 1916-1917.

Methoca monticola, n. sp. (Figs. 2 and 13.)

Female, type: Length, 6.5 mm. Shining black; mandibles and basal part of antennae dark red, legs very dark reddish, almost black, trochanters and tarsi not so dark, apex of abdomen yellowish brown. Rather slender; head rounded behind the eyes; mandibles with some large confluent punctures; clypeus long, the

anterior portion dull and subtruncate, the stouter basal piece shining and impunctate and with the median tubercle prominent; frons with the bituberculate process present, coarse vertical striae mixed with puncturations, but the antennal fossae rather smooth; vertex with the striae finer and the punctures sparser and large; ocelli in a nearly equilateral triangle, no striae back of a line behind ocelli; antennae with articles of basal half of flagellum rather

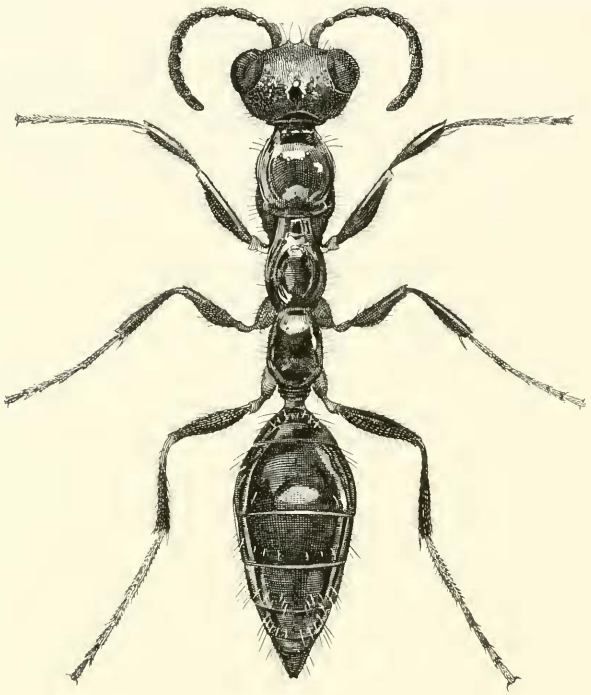


Fig. 13. *Methoca monticola*, ♀, × 13.

fusiform, article 3 a very little longer than 4. Prothorax polished, with a few scattered punctures; dorsum of cervical part anteriorly with some transverse striae and posteriorly with some short longitudinal ones. The small scutum has 3-4 sublongitudinal carinae; scutellum, rest of thorax and propodeum polished, with only a few scattered punctures. Abdomen smooth and polished and almost impunctate. Sparsely clothed with pale erect hairs and fewer darker ones, especially on dorsum of head and thorax.

Male allotype: Length to extremity of spine, 9 mm. Black; apical part of mandibles reddish, carina under first antennal joint yellowish brown, tarsi more or less brown, wings infuscate. Sculptured and punctate very much as in *M. punctata*, it being very close to the latter and the slightly larger *fuscipennis*. Antennae with article 3 shorter than 4, the terminal articles well rounded out beneath. It may be separated from *punctata* chiefly by its darker wings. I am unable to find differences in the genitalia of the three species. The foveae in the gular suture of *monticola* are nearly obsolete, whereas they are well developed in the other two species. The pronotum is practically impunctate for all but its anterior third or so, and the head about the gular region is not strongly punctate.

Type 1 ♀; paratypes 1 ♀ and 1♂; all from Baguio, 5000 feet, Luzon, end of June, 1917.

Methoca fuscipennis, n. sp.

Male, type: Length, 11 mm. Black, wings infuscate. Much like the two preceding species, though more coarsely punctate. From *punctata* it is separated chiefly by its smoke-tinged wings, and it differs from *monticola* by the presence of well-marked transverse foveae, strong puncturation about gular area and by its pronotum, which is punctate for its first two-thirds or so.

Type 1♂, Makiling forest, Los Baños, March, 1917; paratypes 2♂, College of Agriculture, June and July, 1917.

PSAMMOCHARIDAE.

Pseudagenia caerulescens, n. sp. (Fig. 14.)

Female, type: Length, 8.75 mm. Head rather dull greenish blue; thorax metallic blue, with a little purplish lustre; abdomen blue with a greenish lustre; antennae rather light brown; tarsi of forelegs, more or less, apical portion of mandibles, posterior margin of terminal abdominal segments, and pygidium brown. Head wider than thorax, exceedingly finely and closely punctured clypeus with disc evenly convex, its marginal profile a low obtuse wedge with the basal portion steeper and the whole somewhat rounded; clypeo-frontal suture with somewhat more than its middle third subtruncate into the frons; antennae with article 3 longer than 4; only a slight swelling between the ocelli. Pronotum with posterior margin broadly angulate; pro- and mesonotum exceedingly finely and close punctured; metanotum with a few transverse striae on sides; postnotum about one-third as long as metanotum, sulcate in the middle and with one or more transverse carinae; propodeum gently rounded, with a shallow, rather

indistinct median furrow and with well-spaced, broken and rather irregular transverse carinulae, spiracle opening widest uppermost; legs hardly spinose, larger spur of hind tarsi about half as long

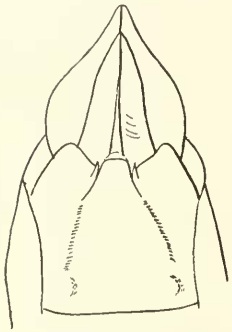


Fig. 14.
Pseudagenia caerulescens, ♂.
View of the two ventral apical segments.

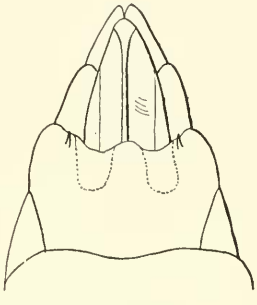


Fig. 15.
Pseudagenia blanda, ♂.
View of the two ventral apical segments.

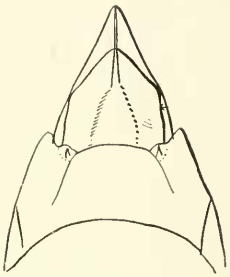


Fig. 16.
Pseudagenia macromeroides, ♂.
View of the two ventral apical segments.

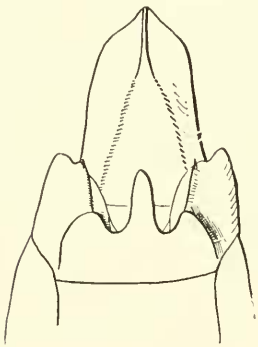


Fig. 17.
Pseudagenia nyemitawa, ♂.
View of the two ventral apical segments.

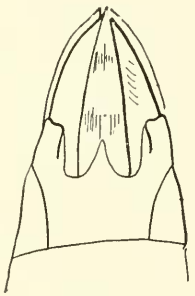


Fig. 18.
Pseudagenia makilingi, ♂.
View of the two ventral apical segments.

as basal joint of tibiae; wings clear, second submarginal cell about twice as long as wide; secondaries with the transverse median vein ending well before the origin of the cubital. Abdomen smooth; pygidium polished, impunctate, somewhat concave in profile. Rather sparsely white pubescent with some erect hairs on head, thorax and propodeum.

Male, allotype: Length, 6 mm. Slender. Colored about as in the female, but the antennae are blackish, except for the two basal articles, which are brownish, the first being quite pale beneath; the clypeus is rather narrowly margined with white, as also the face along the lower half or more of the inner eye margin; the abdomen is a dark blue-black with a portion of the sides of the first two segments brownish in certain lights, and the apical margins of the segments whitish. The clypeus is only slightly convex; it is basally well rounded into the face and the apical margin is broadly truncate; antennae not long, nor very slender, articles 3 and 4 subequal. The sculpture and hair are about as in the female, but the propodeum is flatter, with a wide, well-marked median furrow and the transverse rugulae reduced and substituted by reticulations. Venation as in the female. Sixth visible ventral segment with a low subtruncate median lobe; spine of lateral lobes proximate to median lobe; seventh ventral segment sharply wedge-shaped, sides a little concave below apex; the carina apically linear, becoming broader and flat posteriorly.

Type 1 ♀, building a clay nest at Los Baños, July, 1917. Paratype 1 ♀. Allotype is a son of type, Los Baños, 1917.

The paratypes have on the whole darker antennae.

Resembles *makilingi* in color, but is smaller, and has a shorter postnotum.

Pseudagenia macromeroides, n. sp. (Fig. 16.)

Female, type: Length, 11.5 mm. Rather dull black with silvery grey pubescence; apex of trochanters partly, and posterior edge of abdominal segments narrowly, yellowish brown, antennae and legs with a tinge of brownish, wings hyaline. Head short, wider than thorax, very finely and closely punctured; clypeus convex, its marginal profile well rounded out, slightly wedge-shaped, median third of clypeo-frontal suture truncate into frons and there very shallowly emarginate; a delicate shallow furrow from anterior ocellus to between antennae; article 3 of antennae considerably longer than 4, which is subequal to 5; ocelli in a rather low triangle. Pronotum with well-rounded shoulders, the posterior margin very broadly angulate, almost arcuate, and together with the meso- and metanotum exceedingly finely punctured, the last with transverse striae at sides; postnotum about one-half as long as metanotum, medially sulcate for its posterior portion and with about 4 transverse carinae; propodeum gently rounded, emarginate at base and with hardly a trace of a furrow except on posterior face, and with fine and close transverse rugulae, almost granulate; spiracle opening narrowly oblong, widest at

about middle; legs hardly spinose, larger spur of hind tibiae about half as long as the first joint of hind tarsi; hind wings with the transverse median vein ending just beyond the origin of the cubitus. Abdomen smooth; pygidium polished mesad, with a few punctures towards apex and slightly convex in longitudinal profile. Some erect hair on head, thorax and abdomen.

Male, allotype: Length, 8 mm. Slender, clothed and colored about as in female. Clypeus convex, a little more than twice as wide as long, marginal profile broadly truncate; ocelli in a rather low triangle; antennae moderately slender; article 3 a little longer than 4; postonum about as in the female; propodeum flatter, finely rugulose-granulate with a fairly distinct basal furrow; hind wings with the transverse median nervure and origin of cubital interstitial. Abdomen subpetiolate, brownish at apex. Sixth ventral segment only gently but widely rounded out mesially; seventh visible ventral segment broad, finely reticulate and nearly naked, wedge-shaped apically, a sharp median carina apically, broadening and becoming rounded posteriorly.

Type 1 fresh ♀, Los Baños, July, 1917; paratype 1 ♀; allotype 1 reared ♂, Los Baños, May, 1917.

Builds mud cells similar to the cells of *Macromeris*.

Pseudagenia makilingi, n. sp. (Fig. 18.)

Female, type: Length, 11.5 mm. Metallic blue with a trace of purple on head and thorax; antennae and distal portion of legs brownish black; mandibles blackish, posterior margin of abdominal segments very narrowly pale brownish; wings clear. Head a good deal wider than thorax, which when viewed from above is rather long and of uniform width. Head and thorax with very close and exceedingly fine punctures; clypeus convex, its marginal profile a blunted wedge with a wide but shallow emargination on each side of the point; clypeo-frontal suture truncate into the face for about a third of its width; article 3 of antennae nearly one-third longer than 4; a well-marked frontal impressed line from anterior ocellus to between antennae. Pronotum with posterior margin broadly angulate; metanotum with some lateral striae; postnotum about two-thirds as long as metanotum, broadly and shallowly sulcate and with about five transverse carinae and a delicate median longitudinal carina; propodeum well-rounded, hardly sulcate, with well separated, rather irregular transverse striae on disc, spiracle openings broadest uppermost; legs long, hardly spinose, hind wings with transverse median vein ending well before origin of cubital. Abdomen smooth; pygidium polished, nearly flat in longitudinal profile and with some well-

marked scattered punctures on distal half or more. Fine silvery pubescence and some rather short erect hairs on body.

Male, allotype: Length, 10 mm. Much slenderer and duller than female, the blue hardly metallic; clypeus, frons to above base of antennae, basal joints of antennae beneath carneous white, articles 6 to about 9 yellowish beneath; legs with a portion of coxae beneath pale yellowish or brownish, femora light and dark brownish with tinge of purplish, rest of legs more or less dull brownish, side of first abdominal segment and apical margin of this and following segments pale. Antennae as in the female, quite long and slender, article 3 longer than 4; postnotum two-thirds or more as long as metanotum, shallowly sulcate and with about six transverse carinae; propodeum shallowly sulcate, with fine, rather irregular transverse striae or rugulae. Clothed with silvery pubescence and some erect hair. Sixth ventral segment with a fine, rather thin and flat median tooth, as long as it is wide at base, its sides rather concave, sides of segment drawn out into a somewhat obliquely pointed tooth or process. Seventh sternite shaped like the end of a boat, longer than wide, and with an elevated shallowly depressed, margined slender wedge tapering to a point.

Type 1 ♀, Lower Makiling forest, Los Baños, March, 1917. Paratypes 1 ♀, Los Baños, July, 1917; 1 bred (allotype) and 1 other ♂, same locality, 1917.

SPHECIDAE.

Larrinae.

Hyloliris, new genus. (Figs. 19, 20 and 70.)
(Forest *Liris*.)

Related to *Liris* and *Dicranorhina*.

Head wider than thorax and proportionately large; face much as in *Liris*, with a swelling along inner eye margin, a transverse swelling on forehead; the two posterior ocelli reduced, transverse and proximate; clypeus very wide, with the median portion well produced and bilobed; eyes strongly converging towards vertex; mandibles not excised beneath; maxillary palpi with six and the labial with four articles. Pronotum well beneath the level of mesonotum and fitting into the latter at an obtuse angle; mesonotum quite wide, propodeum truncate at apex. Legs rather long and stout; wings with venation as in *Liris* except that the second submarginal cell is narrower along the marginal, and the second discoidal is wider along the cubitus than in *Liris*. Abdomen short, subsessile.

♀ A tooth just below apex and a large one just before its middle length; pygidium well margined, tapering and constricted near the narrow tip; disc naked with an irregular median carina. ♂ mandibles very long and slender; a small tooth at apical third and a larger one near base; hind femora beneath with an emargination near base and a long basal curved spine, as in *Piagetia;* pygidial area not defined.

Type of genus *Hyloliris mandibularis*, n. sp.

Hyloliris mandibularis, n. sp.

Female, type: Length, 12.5 mm. Dull black; mandibles except apex, and tegulae light brown; basal joint of antennae, posterior edge of fifth tergite and pygidium apically, brownish; fore-

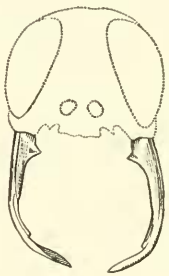


Fig. 19.
Hyloliris mandibularis, ♂.
Mandibles.

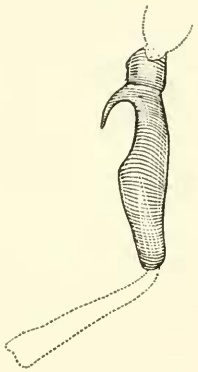


Fig. 20.
Hyloliris mandibularis, ♂.
Hind femur.

wings dusky along basal margin of costa, and all the marginal cell and beyond on either side and below, dusky; mandibles long, crossing; clypeus with the central third or less well produced, cleft mesad and obliquely emarginate at lateral angles; antennae with article 3 longer than 4; interocular space at vertex less than one-half as wide as the width of the clypeus. Head and thorax very finely granulate; postscutellum lightly sulcate mesially; propodeum with disc not margined by a distinct carina, and indistinctly transverse striate, coarser and subrugulose at base, and with a shallow median subapical depression; sides more or less obliquely striate, the posterior face obliquely truncate, with a deep sulcation. Legs rather long and moderately spinose; larger

spur of hind tibia about three-fourths as long as first joint of hind tarsus; tarsal claws long, slender and simple; wings ample, marginal cell truncate and appendiculate. Abdomen stout, a little depressed and subsessile, dull and very finely reticulate; apical sericeous bands on 1, 2 and sides of 3; pygidial area well margined, narrow, tapering rather bluntly, sides constricted, apex with several very small and inconspicuous short finger-like processes; disc rugulose, nearly twice as long as wide at base, with a rather irregular median carina. Golden pubescence on clypeus frons, genae, part of occiput and slightly at porterior angles of scutum. Otherwise nearly devoid of hair.

Male, allotype: length, 11.3 mm. Colored as in the ♀; clypeus about as in ♀ except that the lateral emarginations of the produced portion are more pronounced, forming an acute tooth laterally; mandibles very long and curved; antennae with article 3 longer than 4. Sculpture as in ♀ with following exceptions: propodeum with the posterior face more gently sloping, the disc distinctly margined except posteriorly; narrowed at base and nearly flat; rather finely graulate except along borders, where it is somewhat rugose striate; shallowly sulcate; a smooth median place on posterior border; the pleurae and most of posterior face finely granulate, with indications of striae at the angles. Hind femora well excavate beneath near base and with a curved inner tooth. Last dorsal segment finely reticulate, broad and subtruncate.

Type, the described ♀; paratypes, 8 ♀ ♀ and 6 ♂ ♂. All taken or reared August, 1917, lower portion of Makiling forest, near College of Agriculture.

The specimens tend to become greasy, and vary in size from 9.5 (♂) to 12.5 (♀). In the ♂ the mandibles and armature of hind femora vary somewhat in proportions.

VESPIDAE.

Eumeninae.

Odynerus vespoides, n. sp. (Fig. 81.)

Female, type: Length (h.+th.+t.1+2), 10 mm. Thickset. Rather dull black, with yellow as follows: a lunate area along base and basal sides of clypeus and extending as a detached spot on each side of apex, stripe on outer side of mandibles, along posterior margin of eyes, on the middle of frons and one along lower inner eye margin to and filling the ocular emargination, along underside of first article of antenna, a band across the pronotum, the anterior and posterior third of tegulae, two mesopleural spots,

the upper round, two spots on anterior part of scutellum, one on the middle of mesonotum and a large one on each side of propodeum, a small spot under hind wing base and a larger one on basal pleurae of propodeum, a spot on outer edge of coxae 2 and 3 and on anterior face of 1, on femora beneath except basally, and quite apical on hind femora, most of tibiae above, along basal portion of first joint of hind tarsi; abdomen with two bands, one pre-median, the second subapical on tergites 1 and 2, the two on tergite 1 united laterally, 3-5 with a subapical band, all subapical bands slightly thickened and notched mesially; sternite 2 with a large spot on each side partly split posteriorly, 3-5 with a sinuate subapical band, not meeting mesially; two dull orange stripes on disc of scutum. Wings lightly infuscate, more deeply so along costa. Head hardly as wide as thorax; clypeus convex, about as wide as high, with a moderate emargination apically and which is about one-half as wide as greatest clypeal breadth, closely and coarsely punctate, mandibles about as long as interocular diameter at vertex, with four low rounded teeth, exclusive of apex; labial palpi 4-jointed, fourth joint minute, third about one-half as long as first, second intermediate; maxillary palpi 6-jointed, three apical joints comparatively small; frons closely and coarsely punctate, vertex somewhat less so; a sharp carina between base of antennae; ocelli deep-set, in a low triangle; a large median depression on vertex with a thick stand of erect golden brown hair, protruding well above surface of head; temples gibbous behind eyes and somewhat more than one-half as long as latter; antennae stout, articles cylindrical. Thorax almost uniformly, very coarsely separately and deeply punctured, the largest punctures on propodeum, merging on the pleurae into coarse irregular longitudinal striae; propodeum short, truncate rather shallowly concave posteriorly and there nearly smooth and with a sharp median carina. Venation of ordinary type, second submarginal cell very narrow along marginal; legs normal, tibiae with single apical spur, claws with one tooth before apex. Abdomen stout, rounded, with rather large shallow hair punctures, finely aciculate; tergite 1 hardly half as long as 2, steep anteriorly where there is a low gently rounded pre-median carina; a very shallow median sulcation on 1, punctures along posterior border of segment deeper and closer; tergite 2 slightly narrowed at base; its posterior edge produced into a short thin margin; tergites 3 and 4 with a much wider strip along posterior margin, the strip flaring somewhat so that it extends outwards at a different angle; these extensions appear as a flap at their pleural origin. Anal tergite subconic with a delicate median groove terminating before apex; sulcature on sternite 2 with about 12 complete costae; no posterior depression,

but this segment has large, well-separated punctures, that of the others much finer. While there is some dark pubescence on thorax, the whole upper portion of the insect is covered with rather coarse, suberect to erect bristly black pile arising from the large punctures on the head and thorax, and the smaller shallow ones on abdomen; this pile is rather conspicuous along the base of the abdominal strips and is paler on underside of body.

Described from 1 ♀ from the lower portion of the Makiling forest, Los Baños, taken in the summer of 1917.

This stout, much banded insect might perhaps form a subgenus of *Odynerus*; it bears some resemblance to the subgenus *Rhygchium*.

The rounded transverse ridge on the first tergite and the much developed hind margins of tergites 3 and 4, mark this wasp as a peculiar one.

LIFE HISTORY STUDIES.

SCOLIIDAE.

This family comprises a large number of digging wasps of rather depressed and compact form that prey almost wholly on the larvae of lamellicorn beetles.† They have a very general distribution and in the tropics particularly, are represented by many species of formidable size. They are not highly specialized wasps and form no nests; yet their olfactory—or more probably, their auditory powers—must be highly developed since female Scoliidae are able to locate their prey well buried in the soil, decayed wood, etc. Each species is more or less restricted to a certain species of lamellicorn grub, so that we may regard the diversity and abundance of the latter in a given region as an index to the scoliid fauna of that place.

The adults are often found at flowers; the female wasp however usually spends the afternoon hours seeking her prey, and both sexes of many species pass the night underground. In certain cases the males, as in the American *Elis*, sleep congregated on weeds, Sweet Clover (*Melilotus alba*) being a special favorite.

The beetle grub may be stung to permanent paralysis, as in *Scolia sp.*, or it may be only temporarily immobilized in the case of *Tiphia*. *Scolia* fastens her egg delicately so that the head end is cemented against the venter of the helpless grub, whereas *Tiphia*, as if mindful of the eventual activity of her now quieted victim, affixes her egg much more securely—but not always so

† According to Burkill (1917), **Scolia erratica** Sm. in the Straits Settlements, etc., attacks the grubs of the Red Coconut Weevil (**Rhyncophorus ferrugineus**) as well as those of a Rhinoceros Beetle (**Oryctes**).

firmly that it may not sometimes be rubbed off by the wandering host—gluing it for its length transversely on a certain portion (varying with the species) of the venter, more rarely on the dorsum.* The *Scolia* grub then, secure on its motionless victim, transforms in its birth place, but the young *Tiphia* may be treated to a more or less perilous ride underground, surviving which, it spins up where its victim perishes.

In order to escape from the cocoon, the wasps of the genus *Scolia*, at least in part, neatly cut off the top of the cocoon; *Tiphia* on the other hand, gnaws a somewhat irregular hole near or at the head end of its prison.

The Scoliidae of the Philippines are represented by numerous species, some of them giants in size. Many are forest insects, some appear partial to bamboo groves, while others prefer the open lowlands.

The family is of decided economic importance, as the nature of the literature on these wasps clearly shows.

The data which follow on this family are largely derived from notes and observations by Messrs. Osborn, Timberlake, Swezey and Muir. The identification of the *Tiphia* and the keys to their species is the work of Mr. P. H. Timberlake. The work of rearing and shipping the scoliid and other parasites was carried on under the direction of Mr. F. Muir, who was also responsible for the discovery as a desirable parasite, and the successful establishment of *Scolia manilae* in the Hawaiian Islands.

Scolia manilae Ashmead.

Length, 8-12 mm.; black and yellow.

Scolia manilae (Figs. 21 and 22) was described by Ashmead in 1904, from two specimens collected at Manila by Father W. A. Stanton. It is a rather plain, "untropical" looking wasp. Its black color is variegated with some yellow spots and bands on the abdomen and with a rather thin covering of stiff white hair. The male is more slender than the female and has longer antennae.

It is perhaps the smallest and one of the most abundant and widely distributed of the Philippine *Scolia*. It seems to be confined to the lowlands and therefore often found in cultivated areas where there is food in plenty both for itself and its young. I have taken it on Luzon I., at Manila and Los Baños, and to the south on Cebu and Negros Is. It probably inhabits all islands of any size in the archipelago.

* In many cases, at least, the beetle grubs stung by **Tiphia**, while quite active, yet exhibit, when handled, a comparative muscular weakness in the thoracic region.

While our breeding records at Los Baños show that *Scolia manilae* occurs as an adult throughout the year, it is, as with most other insects, more abundant during the warmer rainy months—from June to October. At this time the males, though hardly more numerous than the females—which they somewhat antedate—are, because of their habits, much more in evidence.

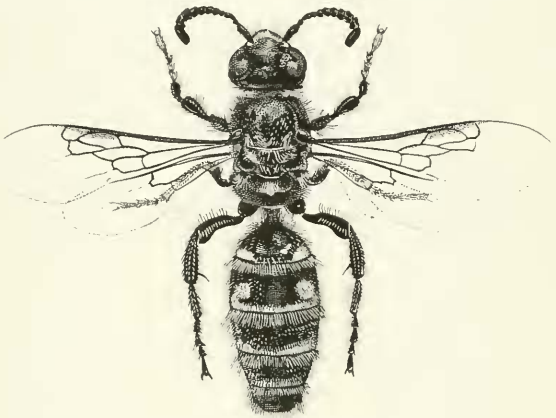


Fig. 21. *Scolia manilae*. ♀, × 3 (after Swezey).

Large numbers may often be seen flying back and forth over a bare space of ground evidently in anticipation of emerging females. They are on the wing both earlier and later in the day than the latter, and both sexes are low fliers.

The females are not often seen except at flowers, and these they patronize only during the warmer hours of the morning. In the city of Cebu, Cebu I., the wasp was abundant on a decumbent weed in the public square, and near Dumaguete, Negros I., on the blue-flowered verbenaceous weed, *Stachytarpheta jamaicensis* (L). At Los Baños it was pretty well restricted to the inconspicuous blossoms of "Cucharitas," *Alternanthera versicolor* Regel, one of the Amarantaceae. This little border plant was common in the garden plots at the College of Agriculture. Under favorable conditions both sexes could be taken in some numbers at these flowers, the males somewhat more abundantly. *Scolia* is rather wary. A female on alighting on a flower will often, as if suspecting danger, remain alert and motionless for some moments before commencing to feed. At other times when busy feeding, she has the habit, when lightly touched on the back, of elevating the posterior pair of legs as if to ward off the offending object. In cool weather the wasps fall to ground when disturbed and "play possum."

After the morning meal the female wasp sets about finding her prey—lamellicorn beetle grubs of the subfamily Rutelides. While very few or no grubs were found in the Philippines parasitized in the field by *Scolia*, it is most probable that the abundant *Adoretus* and *Anomala* are her common victims. The former particularly was used for breeding this wasp. The grubs which *Scolia* prefers are probably in the last stage of their growth, when they are 20 mm. or more in length. But it is evident from the diminutive size of some of these wasps, especially of the male sex, that small grubs must sometimes be utilized.

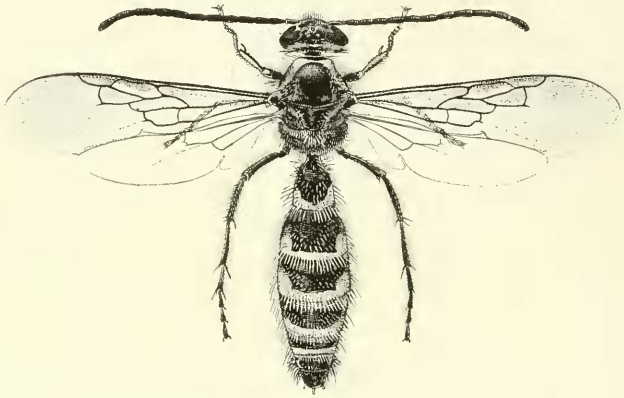


Fig. 22. *Scolia manilae*, ♂, × 5 (after Swezey).

The grubs live from one to several inches in the ground and feed at the roots of plants, particularly of grasses. In spite of the frequent hardness of the soil the *Scolia* wasp by some sense, probably situated in the antennae, succeeds in locating her prey and in digging down to it. The latter resents the intrusion of this unwelcome visitor, but to no avail, for it is soon put into a comatose state, from which it never awakens, by one or more stings in the nerve center of the throat or breast. It now rests quite limply on its back, but may exhibit signs of life in slight movements of the mouth parts. The wasp presses out a sort of cell about it and resting longitudinally on the grub, attaches her pearly white egg so that it stands upright on its head end, on about the seventh ventral segment of the abdomen, (Fig. 23). The incubation period is from two to about three days. The wasp grub feeds with its mouth applied always to the same spot on its host, (Fig. 24). It moults several times, and in the latter part of its life, breaks through the grub's skin and, inserting head and thorax into its victim, soon reduces it to a mere shell. From five to about seven days after hatching it

Fig. 23. Egg of *S. manilae* on *Anomala* grub, × 5 (after Swezey).

spins a light brown, cylindrical oval cocoon (Fig. 25), in the space formerly occupied by the grub. The cocoon is about 12 mm. long and more broadly rounded at the head than at the caudal extremity. It is frequently spun against the remains of the larva and further supported in its cell by some loose peripheral strands of silk. The enclosed grub now has a resting stage of from a few days to some weeks, depending chiefly on the temperature and humidity. It finally sheds its skin for the last (probably about the fourth) time and thus becomes a pupa, delicate, whitish and with appressed or folded appendages. During this stage, which is always brief, it is capable of wriggling its abdomen a little. The cocoon stage lasts three weeks or more—rarely less—according to season. The wasp casts off the thin pupal envelope but waits until it gains sufficient strength and hardness before neatly cutting off a lid from the head end of the cocoon to make its escape.

The life-cycle of *Scolia manilae* in the Philippines varies from about thirty days to over two months—being longest during the

winter season. Hence there are several broods a year, a condition which adds greatly to its efficiency in reducing the *Anomala* grubs in the canefields of Hawaii.

Fig. 24. Young *S. manilae* larva on *Anomala* grub, × 5 (after Swezey).

The wasp was bred in large numbers at Los Baños for shipment to Honolulu, Hawaii. Approximately 100 females, each kept separately in a jelly tumbler, were used for breeding. Each tumbler was half filled with soil, into which was placed daily an *Adoretus* grub, and a sprig of "Cucharitas" moistened with water and honey furnished food for the *Scolia*. All apparatus were kept on ant-proof shelves and tables. The *Adoretus* grubs in the tumblers were examined daily, uusally in the morning, and it was found that on an average about 50% were parasitized, though some which had been stung had no *Scolia* egg upon them. Each parasitized grub was placed on its back in a clay cell, which was then plugged up and placed in soil in a tightly-closing varnish can. The latter packed in a box or basket were then ready for shipment.

The mortality of the wasps in the tumblers was not great. The larger number lived several weeks in these unnatural conditions and we have a record of one female living for 79 days. Sometimes both grub and wasp would succumb to fungous diseases. While some of these wasps would lay quite satisfactorily others laid very few eggs. The one that lived for 79 days in captivity laid 52 eggs, the largest number recorded. Granting an abundance of grubs and no accidents in the natural outdoor life, *Scolia manilae* may well lay over 50 eggs during her existence.

Experiments have shown that an unfertilized female may lay eggs that will develop into adult wasps, but thus far only a few males have been reared.

On the Island of Oahu, Hawaii, where this insect has been

established, it increased very rapidly in numbers. Owing to the less tropical climate of the Hawaiian Is. as compared with its native home the Philippines, the life-cycle seems to average slightly longer in the former place. Thus records show that the egg hatches in from three to five days and that the feeding period for the *Scolia* larva is from six to ten days, and that the whole life-cycle occupies from 40 to 55 days. One captive female lived for nearly four months, but only laid nine eggs during that time. Five bred females on which Mr. Osborn kept records at the insectary at Waipio (near Honolulu), averaged 23 eggs apiece, and the average length of life was 49 days. Thirty-two was the highest number of eggs by one female in this lot.

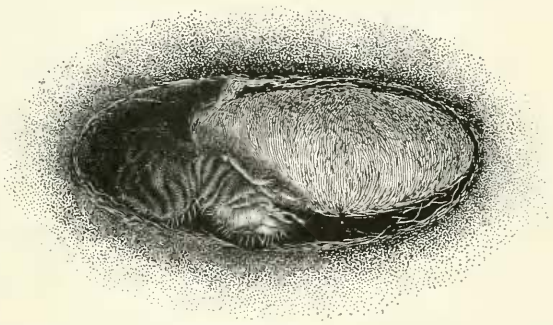


Fig. 25. Cocoon of *S. manilae* on *Anomala* grub, × 5 (after Swezey).

Scolia manilae is now far more abundant in the cane fields near Honolulu than we ever found it at Los Baños, Philippines. Indeed, in view of the rapidly disappearing *Anomala orientalis* beetle from the cane fields here and the scattered distribution of the Rose beetle (*Adoretus tenuimaculatus* Waterhouse), one wonders how the wasp manages to remain so plentiful. Mr. O. H. Swezey has found it in the immature stages on *Anomala* grubs in the field, and we have found it in one or two cases on *Adoretus* grubs in a cane field. On Oahu, we have caught for distribution many thousands of females. They were taken with a net, forceps or fingers,—their sting is not very startling—as they were feeding at the flowers of *Stachytarpheta*, *Bidens* or *Euphorbia* growing along canefield roads. *Scolia* hunting is profitable only on favorable mornings, as during the afternoon both sexes—though the males with probably some exceptions—bury themselves and remain underground until the following morning.

KEY TO THE SPECIES OF LOS BAÑOS TIPHIA.

By P. H. Timberlake.

Males.

1. Head and thorax not reticulated..... 2
   Head and thorax with a fine but distinct surface reticulation.
   Punctures generally sparser in area in front of ocelli; carina on anterior margin of pronotum well elevated; submedian carinae on propodeum straight, generally converging towards apex (in one reared specimen perfectly parallel), median carina reaching two-thirds or quite to apex; 2nd and 3rd joints of antennae nearly or quite equal, the 4th hardly or not over a third longer than the 3rd.
   On *Autoserica* grubs.
   Tiphia ashmeadi Cwfd.

2. Joints 2 and 3 of antennae nearly or quite equal in length, the 4th nearly twice as long as the 3rd; anterior margin of pronotum behind the transverse carina without longitudinal sulci.
   Head and thorax rather sparsely punctured (except on frons just above antenna); truncated part of propodeum finely rugosely sculptured throughout; median carina on propodeum complete.
   On *Anomala* grubs.
   Tiphia segregata Cwfd.

   Joint 2 of antennae distinctly shorter than 3rd, the 4th generally hardly over a third longer than the 3rd; anterior margin of pronotum, with distinct longitudinal sulci behind the transverse carina.
   Head and thorax closely punctured; truncated part of propodeum generally smoother and more polished above; median carina on propodeum often incomplete, sometimes not reaching more than one-third of distance to apex.
   On *Adoretus* grubs.
   Tiphia lucida Cwfd.

Females.

1. Head and thorax not reticulated..... 2
   Head and thorax with a very fine surface reticulation.
   Punctures on head and thorax close set and coarse; inner spur on hind tibia reaching about to two-thirds of the 1st tarsal joint; legs except all coxae, tarsi and front femora reddish, the middle and hind femora more or less suffused with blackish, especially on their outer surface.
   On *Adoretus* grubs.
   T. lucida Cwfd.

2. Punctures on vertex rather sparse, especially just in front of ocelli; carinae on propodeum with a row of punctures alongside each, sublateral carinae very indistinct or practically absent; inner surface of hind femora highly polished and with a few minute scattered fine punctures, which become much larger and rather close-set along the lower margin; inner surface of hind tibiae very finely and closely pubescent-punctate on upper half, and much more thinly so on lower half, the two parts separated by a bare, shining longitudinal, narrow

area; upper half of propleura highly polished and smooth, the lower half rather coarsely obliquely lineolate.

On *Anomala* grubs.

T. segregata Cwfd.

Punctures on vertex more numerous than in *segregata*, but considerably thinner than in *lucida;* carinae on propodeum sharply defined, without punctures alongside, the sublateral carinae distinct and reaching a little beyond the spiracles, and enclosing a distinctly sericeous area; truncated part of propodeum with a rather distinct median carina; hind femora on inner surface very highly polished and with the punctures slightly more prominent than in *segregata*; hind tibiae as in *segregata* except that the lower half of their inner surface is almost entirely bare, and polished without punctures; propleura finely obliquely lineolate on upper half, more coarsely so below.

On *Autoserica* grubs.

T. ashmeadi Cwfd.

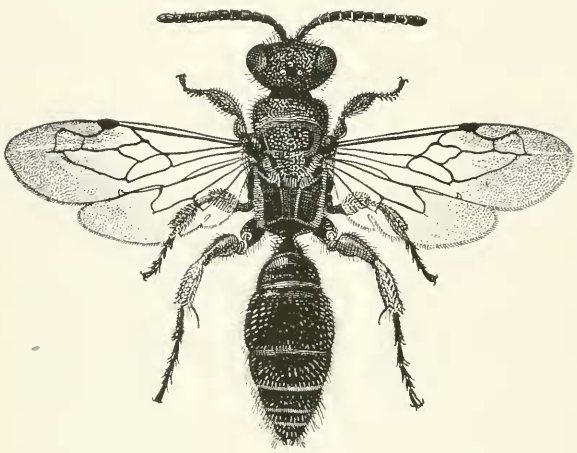


Fig. 26. *Tiphia lucida*, ♀, × 7.

Tiphia lucida Ashmead.

Length 8-10 mm.; black.

This insect (Fig. 26), originally described from Manila, is the commonest *Tiphia* around Los Baños. It was abundant from June to September at the College of Agriculture, and occurred chiefly on the patches of sweet-potato vine (*Ipomoea batatas* (L)). It appears to be a lowland form. It parasitizes the grub of *Adoretus*, which it temporarily immobilizes and lays an egg transversely on the ventral side of the body, to one side of the middle, in the incision separating the last thoracic from the first

abdominal segment. The egg is rather securely glued to the grub, parasitized specimens of which were often brought in from the field, and also grubs which showed, in the brown blotch behind the posterior coxae, that they had rubbed off the parasite's egg. Nothing very definite is known concerning the duration of the early stages of this wasp. At most, it probably has not more than two or three generations a year, for while the summer life-cycle in three instances was found to be 44, 51 and 60 days, respectively, it is very much longer for the rest of the year. We have a record of *T. lucida* remaining in the cocoon stage for over twelve months.

The *Tiphia* larva adheres rather firmly across the base of the thorax of its prey, and when it sheds its skin, this shrivels up into a pad beneath it. The last stage of growth is rapid, so that the *Adoretus* grub soon perishes. The wasp lays fairly well in captivity, as the following breeding record at Los Baños for 1916 shows:

No. Tiphia used	Average No. days each kept	Average No. Adoretus grubs given	Average No. eggs laid
62	11.27	21.4	13.8

The best layers of this lot, which also lived the longest and were given the largest number of grubs, were as follows:

Tiphia	No. days lived	No. grubs given	No. eggs laid
No. 36	32	91	47
No. 37	34	97	58
No. 42	23	59	47
No. 48	28	77	55
No. 53	27	81	53
No. 54	27	72	47

The parasitized grubs were, on account of their activity, placed in soil-filled jars or tins and not in clay cells. This applies for all the *Tiphia*.

This wasp passes the winter months in the cocoon stage, and we have found that at least in the cocoons shipped to the Hawaiian Islands this stage may be very much protracted. Thus, of cocoons sent from Los Baños during March, 1916, the last to

hatch was on December 9, 1916, or in about nine and a half months. Other *Tiphia lucida* showed a cocoon stage of eleven, twelve and thirteen and a half months. The emergences from a shipment were very irregular and often extended over several months.

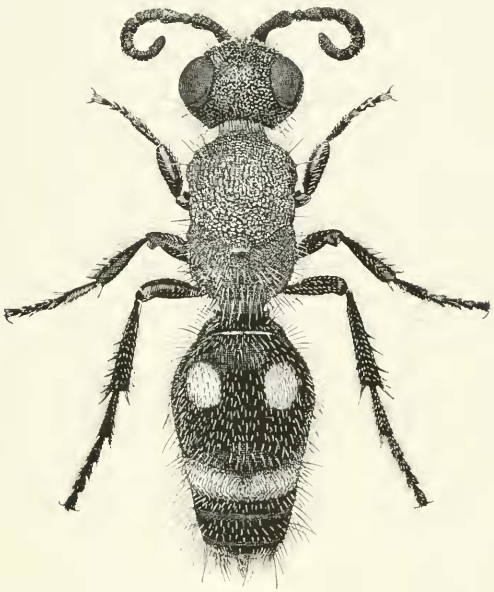


Fig. 27. *Mutilla* sp., which parasitizes the cocoons of *Tiphia*, × 14.

The cocoons of this *Tiphia* were the ones most frequently dug up in the fields by Filipino grub-diggers. Their parasitism did not appear great, one or two yielding a rhipiphorid beetle, but numbers showed small perforations indicating that ants had destroyed the contents.

The country about Los Baños abounded in "velvet ants" or Mutillidae—many of small size. As these insects are known to parasitize the cocoons of various solitary bees and wasps, I was able to rear a small, two-spotted species (Fig. 27) from a bred cocoon of *Tiphia lucida*. On August 30, 1916, I buried seven cocoons, containing the quiescent pale yellowish *Tiphia* larva, in soil in a tumbler and introduced a small *Mutilla* with two white spots on her abdomen. (Fig. 27.) On September 3, I cut open these cocoons and found that two of the quiescent *Tiphia* larvae had been parasitized by *Mutilla*. In the one case the *Tiphia* larva

had a *Mutilla* egg transversely arranged on its dorsum between the first and second thoracic segments. The egg was semi-transparent whitish, about five times as long as thick, somewhat curved, rather broadly rounded at one end and conical at the other. Under a hand lens its surface showed numerous pointed granulations. The second parasitized *Tiphia* had an active *Mutilla* larva a day or two old, on the underside of the body. Like the egg, its skin was also finely roughened. It required about four days to become full-fed, consuming all its prey. It failed to spin a perfect cocoon, but remained as a

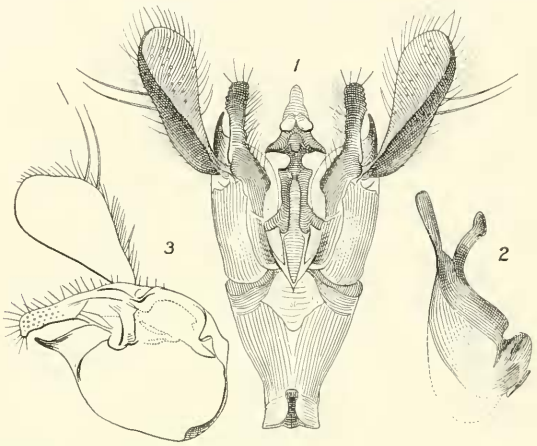


Fig. 28. *Tiphia lucida*, Aedeagus; 2, side view of median portion; 3, side view of lateral portion.

quiescent, dull whitish larva for about eight days before changing into a pupa, which a few days later hatched into a female wasp.

I succeeded in getting several other *Mutilla* ovipositions. One cocoon contained two *Mutilla* eggs. The cocoon's envelope is not visibly perforated by the ovipositor of the parasite.

Tiphia segregata Crawford.

Length 7-10 mm.; black.

This insect (Fig. 29) parasitizes the grubs of several species of *Anomala* and lays a comparatively small egg to one side near the ventral tip of the abdomen between segments 7 and 8. Besides occurring on the lowlands about Los Baños, *segregata* was also found at Baguio, in central Luzon, at an altitude of nearly

5000 feet. There, *Tiphia* and other *Hymenoptera* begin to disappear in July, with the advent of the rains, but in the lowlands it has a more prolonged season, where it appears early in the year.

The life-cycle is rather long, and the broods probably not more than two or three per annum.

Mr. O. H. Swezey describes the stinging and oviposition as follows:

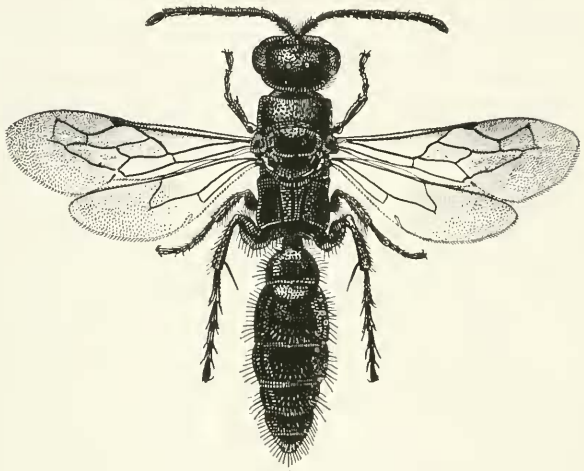


Fig. 29. *Tiphia segregata*, ♀, × 7.

"September 3, 1916, while attending to breeding jars, a female *Tiphia* was noticed to be giving attention to an *Anomala* grub that was on the surface of the soil trying to burrow in. They were both removed to a vial for closer observations.

The *Tiphia* seemed to be most concerned with the posterior part of the grub, continually feeling it all over with her antennae. This apparently annoyed the grub, for it would squirm and bend backward and try to attack the *Tiphia* with legs and mandibles. It would seem as though she was endangered, but she paid little attention to it, just moving out of reach, although it seemed at times as though she would suffer injury. Sometimes she would crawl around on the grub.

After about twenty minutes to half an hour the *Tiphia* gave indications of trying to sting the grub. She finally, while perched transversely on the middle of the back of the grub, which was lying on its left side, extended her abdomen down under and forward between the legs nearly to the head and stung the grub,

paralyzing it. She may have stung it more than once. The actual stinging could not be seen, but the grub quickly became quieted, while the *Tiphia* abdomen could be seen in motion as if trying to find the proper place to sting—or perhaps stinging more than once.

As soon as she was satisfied, she crawled around on the grub a bit, lengthwise of it, apparently to satisfy herself as to which was the posterior end and the correct place to put her egg, for she was continually vibrating her antennae, touching the surface of the grub continually. Finally after a few moments she seemed satisfied with her exploration, and embraced the posterior segment transversely, being curved around the dorsal side so that

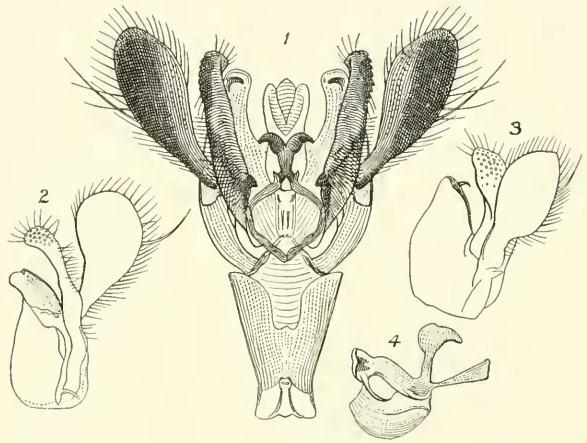


Fig. 30. *Tiphia segregata*, Aedeagus; 2 and 3, side views of lateral portion; 4, of median portion.

the apex of her abdomen came in contact with the right side of the grub just below the lateral fold and in the groove between the last segment and the one preceding it. At this point she rubbed around on the surface of the grub with the apex of her abdomen for about a minute, probably spreading on some substance to stick the egg in position. Finally the egg was extruded somewhat suddenly. It adhered in the spot prepared, and the *Tiphia* immediately left the grub.

This was at 3:00 p. m., and the grub had recovered from the paralysis in fifteen minutes and commenced burrowing into the soil of the tin box in which it was placed."

While this wasp laid well in captivity, only a small portion

of the young reached the cocoon stage, and this was especially true of Baguio examples.

The following is a breeding record for *T. segregata* at Honolulu:

Wasp	No. days kept	No. eggs laid
No. 1	60	40
No. 3	60	28
No. 4	45	77
No. 5	41	64
No. 6	34	90
No. 8	27	27

These and other *Tiphia* often frequent honey-dewed bushes, but I also took a number of *T. segregata* by searching the tops of Cosmos plants growing in a Japanese garden near Baguio. The wasps had evidently retired there that afternoon to pass the night.

Tiphia ashmeadi Crawford.

Length 8-10 mm.; black.

T. ashmeadi is a fairly common insect at Los Baños. Adults were taken from the middle of May to the following February. Like the others of the genus, it passes the dryer season in the cocoon, though beginning to hibernate at a rather late date. Females were often seen on the surface of the soil in well-shaded places, where they were sometimes the center of attraction for several males and the scene of quite a tussle for her possession.

The wasp parasitizes the grub of a lamellicorn beetle of the genus *Autoserica* or an ally, and which is readily identified by its large and very mobile palpi. This grub is more rarely found and more active than either *Anomala* or *Adoretus*. Philippine *Anomala* were not parasitized by this *Tiphia*, although the Japanese *Anomala orientalis* in Hawaii were to some extent.

The egg is laid on the thorax, between the second and third pair of legs. What appears to be the same *Tiphia* also oviposits on segment 4 or 5 of the abdomen. The life-cycle is quite the briefest of the Scoliidae studied, and in the Philippines the wasp was the easiest species to handle. The cycle for the winter months at Honolulu, ranged from about eighteen to twenty-eight days, of which about three days were passed in the egg, and about thirteen

for the larva outside its cocoon. At Honolulu and Waipio Substation on Oahu, T. H., some of the wasps lived for a considerable period; one male in a life of six weeks mated with twenty-one females, and the latter sometimes lived for more than a month.

The following table shows some of the best layers:

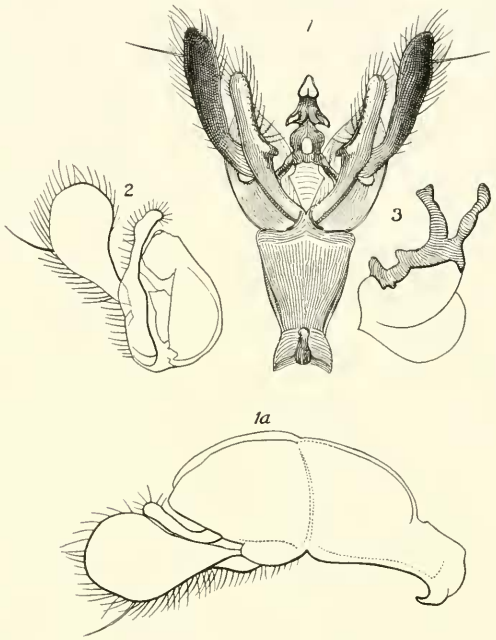


Fig. 31. *Tiphia ashmeadi*. Aedeagus; 1a, side view of same; 2, side view of lateral piece; 3, side view of median portion.

Wasp	No. days kept	Approximate No. **Anomala** grubs given	No. eggs laid
B	32	81	43
D	26	66	19
F	16	45	22
G	24	66	33

Only a few of the *T. ashmeadi* eggs laid on *Anomala* grubs in Honolulu developed as far as the cocoon stage. Out of 291 ovipositions but twenty-six cocoons resulted.

The cocoon stage—at least, for those wasps shipped to Honolulu—was often very great. A certain number shipped during the latter part of 1916 hatched very shortly—or even sometimes en route from the Philippines—and up to the month of January, 1917, but other cocoons of this fall shipment did not produce wasps until from June to September of the following year. Thus in a few cases nearly a year was consumed in the cocoon stage. Cocoons shipped early in 1917 all issued the same year, though covering a period of several months.

While a series of *Tiphia* from Baguio seems identical with *T. Ashmeadi* at Los Baños, the former parasitized mainly *Anomala*, more rarely *Adoretus*. The egg is deposited on the underside of the thorax or immediately posterior to it. It is possible that here is a distinct variety.

THYNNIDAE.

Methoca.

The remarkable little wasps of this genus, which numbers perhaps upwards of thirty species, are found in all parts of the world except Australia. The best known is *Methoca ichneumonides* Latr. of Europe, and it was upon this insect that Adlerz ('03, '05) made his biological studies and first discovered that the genus preys upon the larva of the Tiger-beetle (*Cicindela*).

By a layman, the female *Methoca* would undoubtedly be mistaken for an ant. She is entirely without wings, and her body is slender and polished; nevertheless, she is easily distinguished from any ant, for her abdomen is not notched above at the base nor are the antennae elbowed. Furthermore, her gait is different and her long curved sting may project beyond the tip of the abdomen. The male, on the other hand, is not at all ant-like. Of greater size than his mate, possessed of stout thorax and strong wings, is it any wonder that he was first named *Tengyra*! He, indeed, much resembles some of the scoliid wasps.

The grub which the slender wasp must conquer is a formidable creature. Many times larger than her aggressor, a flesh-eater armed with sickle-like jaws, it would seem proof against the attack of such a puny antagonist. The top of its head and first segment are strongly armored, fit snugly together, and being held in a horizontal position at the surface of its trap-burrow whence it snaps at unwary insects, effectively block the aperture. But the wasp is more than a match for the beetle larva. She herself is exceedingly nimble and hard-shelled, and her very slenderness is an advantage. Moreover, she is cool and cautious and knows when and where to use her long sting—as we shall presently see.

Methoca striatella Williams.

Female, length 5 mm.; black.

I found the female *Methoca* (Fig. 6) at the College of Agriculture from August to November. She was not plentiful enough to be studied in her natural home, and so, like other observers, I had recourse to glass receptacles. Here I met with considerable success. A jelly tumbler two-thirds filled with well-packed soil

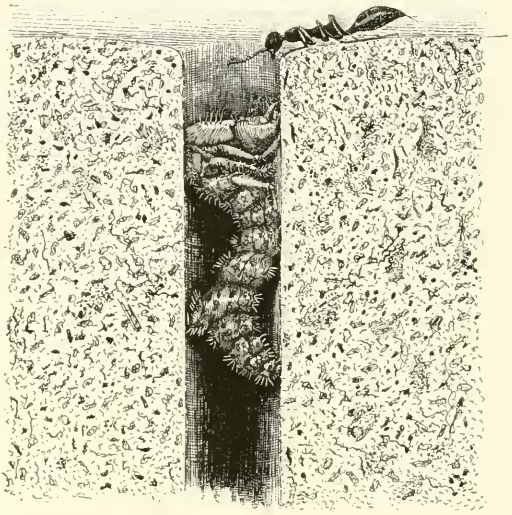


Fig. 32. *Methoca striatella* awaiting her opportunity to sting the tiger-beetle larva, × 10/3.

into which and next the glass several holes, each to accommodate a *Cicindela* larva, had been made, furnished the scene of operations. Provided I had sufficient patience, I encountered no difficulty in obtaining beetle larvae. These dwell in more or less well-defined colonies, each insect occupying a neat, nearly or quite vertical burrow in the soil. The tunnels have no debris nor heap of soil about their mouth, which when stoppered by the animated but ground-colored lid, the head and first portion of the thorax of the larva, form a deadly trap for the unwary insect which walks within reach of the curved mandibles. Being provided with a pair of forward-pointing hooks arising from a hump on the upper side of the abdomen, the larva by anchoring

itself firmly in its burrow with this apparatus is able to withstand the strong pulls of an extra large captive. At your heavy tread the larva vanishes down its tunnel and may not reappear for many minutes. Digging up these insects is laborious; inserting a straw in the burrow for the irate proprietor to grasp and be suddenly hauled out is feasible only in certain cases; lying very quietly in wait beside the hole, with an obliquely-held trowel just denting the soil an inch or two before the aperture, and pushing in this trowel with a sudden speed, thus cutting off the insect's retreat when it is at the top of the burrow, was found to bring the best results.

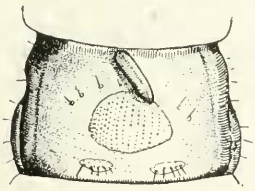


Fig. 33. Egg of *M. striatella* on 5th ventral segment of tiger - beetle larva, × 9.

One beetle larva was placed tail-first into each hole in the soil in the tumbler, a sprig of a weed stuck in the earth and daubed with honey, and finally a larger and a smaller female wasp were liberated in the glass and the lid put on. Soon quieting down after liberation into the tumbler, the actions of the methocas were various; they sipped up honey, rested or walked about their prison, or finally they became interested in their natural prey, the tiger-beetle larvae. These very often stopped up the burrows for a time and worked their way down deeper. During their long captivity (27 days) the wasps, naturally very shy creatures, soon became accustomed to the small quarters, they seldom stampeded unless unduly disturbed, and permitted the removal of the metal lid of the tumbler for their very close inspection.

Since the predatory operations of these two little creatures were not without variation, I will recount several of the affrays between wasp and beetle larva.

October 5, 3 p. m.: The bigger *Methoca* soon became interested in a large larva which rested in its burrow at a distance of three or four millimeters below the surface of the ground, (Fig. 32). The wasp crouching, though with her abdomen well clear of the ground, pushed her rapidly-vibrating antennae over the hole. This caused the larva to slightly raise its head and snap weakly, at which *Methoca* backed away a little but immediately returned to repeat the performance. The larva snapped a few more times. Since the conditions were unnatural, it is probable that the wary tiger-beetle larva was not normally excited. The antennae which waved and wriggled sideways over its bur-

row certainly seemed very alluring; nevertheless, the fishing was poor and the wasp, becoming bolder at her lukewarm reception, poked her head over the burrow—as one would crouch at the brink of a precipice—bent her antennae downwards once or twice and, after the larva had snapped weakly a few times, made two or three feints at darting down towards her prey as if to goad it into action. The last feint aroused the larva a little, and *Methoca*, seeming determined to end matters, faced her adversary and, raising herself up somewhat, brought the abdomen forward so as to be able to sting readily, quickly backed

Fig. 34. Full-grown larva of *M. striatella*. × 2.5.

Fig. 35. Female pupa of *M. striatella*. × 7.

Fig. 36. Cocoon of *M. striatella*. × 4/3.

down into the burrow, descending along the unarmored back or between the back and side of the *Cicindela*. There were some very quick movements from both parties, but almost immediately the little wasp rushed out headfirst, her prey retiring deeper in the tunnel. The procedure to this point occupied about fifteen minutes. I thought that the wasp's attack on her large opponent had been unsuccessful. Not so, however; the long curved sting had done its work and the cicindelid was soon in a nearly comatose condition. *Methoca*, though somewhat ruffled, was unharmed; she brushed herself but did not return to the scene of operations for some minutes. When she finally went to the burrow she approached her helpless victim with great caution and speedily backed out at its movements; eventually becoming bolder, she passed in and out of the burrow, inspected her prize, and gave it one or two strong pulls with her jaws. It seemed that she was not prepared to lay an egg, and so I left her late in the afternoon to find an egg on the larva early the next morning.

October 6, 2 p. m.: The larger wasp was placed in another prepared tumbler, and, finding a medium-sized larva therein, promptly busied herself in subduing it. As before, she teased

or urged it, but becoming impatient at its poor response, she backed down into the burrow at an opportune moment and, always facing her prey, stung it instantly and rushed out. The act of entering the hole appeared deliberate if quick, and the stinging was done with a sort of jumbling speed.

October 7, 8 a. m.: A fresh beetle larva was placed in a shallow hole in the tumbler which contained the larger *Methoca*. The latter vibrated her antennae before it, but the larva was uncomfortable in its short and well-illuminated tunnel and started to crawl out. The wasp, as if standing on her hind legs, bent her abdomen forward so as to have her sting in position, much as do braconid parasites, etc., in stinging caterpillars, and stung the cicindelid during a vigorous scuffle of less than a second while on the surface of the ground. I replaced the helpless larva in the tunnel, but *Methoca*, her possessive instinct at its height, would not be driven away from her prey, which I gently essayed to do with a pair of forceps. By the way of further experiment I grasped the jaws of the larva with the forceps and, pulling up, caused it to move; at this, *Methoca* again curled her abdomen as if to sting, but she evidently felt sure of her previous work and soon walked about her booty.

October 9, p. m.: A tiger-beetle larva had plugged up its burrow for one and one-half inches and rested at the bottom of the tumbler. None the less, the smaller wasp located this plugged tunnel and, after a little preliminary caution, commenced digging out a passage through and in it. But being such a slender insect, with legs hardly fitted for digging, she accomplished little, penetrating a half inch in about twenty minutes. She soon abandoned the work.

October 14: The larger wasp slid down into a burrow and alongside the cicindelid larva, which promptly seized her amidships in her jaws, but was immediately and fatally stung for her pains. The released wasp was apparently unhurt.

October 23, p. m.: The larger wasp became engrossed in a recently inserted larva and leaned inquiringly over its burrow. She grew impatient at the inactivity of the occupant, and at a movement from the latter deliberately lowered herself down, tail-first. At her entry the larva retreated further down, but *Methoca* appeared to be doing her best to place herself in a position to be seized. I was not able to clearly witness the ensuing struggle, but the doomed larva squirmed about violently and took many minutes to succumb.

October 24, a. m.: The larger wasp attacked a larva, which for a brief instant held her in its sickle-like jaws. The released

wasp climbed up the burrow and then descended again tailfirst, stung the larva deliberately, but made haste to retreat.

Although I watched all these operations very closely, it was difficult to see clearly the final, very rapid stinging action of *Methoca;* her prey was presumably stung about the unprotected throat, as Adlerz (1905), Bouwman (1909) and the Champions (1915), have observed in another species. The tiger-beetle larva is severely stung so as to remain in a death-like torpor; indeed, it sometimes perishes prematurely and the wasp grub with it.

After the larva has become quiet and the wasp has cleaned and rested herself, the latter descends into the burrow and devotes further attention to her prey, giving it an occasional pull as if to straighten it out, and crawling over the body and pinching it with her mandibles, particularly about the venter. The egg may not be deposited for some time, and I was never able to see the operation in this species. The egg (Fig. 33) is pearly whitish, slender and slightly curved, rather pointed at the posterior end and more rounded at the other. It is about one millimeter in length. In specimens under observation, eggs were deposited, one to each *Cicindela* larva, from between ventral abdominal segments one and two to as far back as segment six, where one was placed latero-dorsally. As a rule, however, it is to be found on the underside of segment three or four of the abdomen, in the middle or to one side thereof, its long axis more or less parallel with that of the larva, and the broader head end pointing anteriorly. After egg-laying, the wasp fills up the burrow with soil. As will be seen later, a majority of the solitary wasps that nest in the ground drag their prey into some hole well removed from the scene of combat, but the nature of her victim makes this added labor unnecessary for our wasp. Here is a ready-made tunnel of considerable length, the like of which the slender *Methoca* could not begin to excavate—why not bury the tiger-beetle larva in its self-made burrow? The prey is here of exceptional size and the wasp has work enough burying it. The Scoliidae, a family of thick-set powerful wasps, readily penetrate the soil or decayed tree trunk to reach and paralyze the sluggish chafer beetle grubs, but as a rule they find no need for excavating a special grave. This habit, then, does not appear to be the result of inferior talent, but one governed by the nature of the prey.

The egg hatches in from forty to fifty-six hours. Once or twice the larva was seen to have crawled out of the shell, but on other occasions no egg-shell could be seen. The larva in its earlier life is comparatively large-headed, well segmented and rather stout and fusiform. Both ends of the body are rather

glassy translucent, but the median or gut portion is pale orange with scattered white granules. During this first period it is an external feeder, its mouth being pressed against the body of its host. Thus at this stage I was successful in transferring a *Methoca* grub from one larva to another. During about the last two days of its feeding life it develops a greater appetite and, inserting its head and the now curved portion of the thorax into its victim, rapidly sucks up the body juices. The wasp larva is now small-headed and slender, and the mid-gut is dark wine or brown color. It is full grown and ready to spin its cocoon in about five or six days, when it measures from ten to twelve millimeters in length. (Fig. 34.) Even larvae which spin big cocoons do not always find it necessary to completely devour their large prey; in two cases observed the posterior third remained unsucked, the cocoon later abutting on this mass. *Methoca* usually eat out at least the anterior portion of their prey, and when full-fed may sometimes be seen with the head within that of the hollowed *Cicindela*, waving vigorously.

The following are notes on the growth of a single *Methoca* larva:

October 26, early a. m.: Hatched.
October 27, 2 p. m.: Length, 1.80 mm.
October 28, 2 p. m.: Length, 3.50 mm.
October 29, 2 p. m.: Length, 7.10 mm.
October 30, 2 p. m.: Length, 10.00 mm.
October 31, 7 a. m.: Beginning to spin.

The cocoon (Fig. 36) varies in length from eleven to seventeen millimeters, and is from about three to four and a half millimeters in diameter. Abnormally small ones occur. As can be seen from the figure, the cocoon tapers to more or less of a point posteriorly, while anteriorly it ends in a sort of calyx or collar. In spinning the cocoon a rather flimsy outer envelope with a wide flaring mouth is made, and within this the more compact inner cocoon, with a constriction to mark the base of the collar, is spun, this collar being united along its edge with the thin, flaring mouth. Within the calyx or cup may often be found the chitinized portions of the *Cicindela* larva. The cocoon is of a light brown color. Larvae placed in a narrow clay trough spun perfect cocoons, which, as they consist of many well-separated layers of silk, require considerable time for their completion. The wasp bites its way out through the base of the calyx.

I have seen only the female pupa, (Fig. 35). It is whitish, not quite as slender as the adult, but of about the same length. It

bears some tubercles on the head and back of the thorax, and the abdomen is also armed, especially by lateral segmental processes. The sting is very conspicuous, and bent back along apical third of the abdomen, and from its position and extruded condition recalls the pupae of the non-aculeate, parasitic Hymenoptera, such as the Ichneumonidae and Braconidae.

The cocoon stage may occupy from ten to twenty or more days for the summer cycle, or it may extend over a period of months for the drier season. Thus the development of *Methoca* from egg to adult may occupy less than a month. The following data show some *Methoca* life-cycles:

Egg laid, September 29, p. m.; hatched, October 1, p. m.; spinning, October 6, a. m.; adult, October 29; ♀. Cycle 30 days.

Egg laid, October 1 or 2; spinning, October 9, a. m.; adult, October 29; ♀. Cycle 28 days.

Egg laid, October 5, p. m.; hatched, October 8, a. m.; spinning, October 14; adult, November 11; ♂. Cycle 37 days.

Egg laid, October 5, p. m.; hatched, October 8, p. m.; spinning, October 13; adult, November 3; ♂. Cycle 29 days.

Egg laid, October 4, p. m.; adult, November 9; ♂. Cycle 36 days.

As a rule the male and female insects were not taken in the same localities; the former I never saw on the ground, but took these rather handsome wasps flying or running jerkily on the leaves of low weeds or bushes that either harbored honey-dew-producing bugs or were in the shelter of such trees or shrubs. The wings of the male wasp rest flat on the body and reflect a purplish black iridescence. The female, which seems the rarer of the two, was at times similarly attracted to honey-dewed bushes, but was taken more often in rather bare, shaded paths and about leaf trash.

Methoca punctata Williams.

Female; length 6 mm.; red and black.

My notes on this somewhat larger and stouter species (Fig. 12), while fragmentary, are sufficient to show that it differs to some extent in its biology from the wasp just considered. I did not devote sufficient care to the rearing of this insect and so cannot go much beyond the egg stage. As with *M. striatella*, wasps were imprisoned in jelly tumblers with the same species of *Cicindela*. Yet this insect, which is larger and more powerful than the pre-

ceding species, stings her prey much less severely than the latter, so that finally the beetle larva attacked may for a time regain most of its normal activity.

The following are some of my observations on the onslaughts of *Methoca*:

October 24, 10 a. m.: I placed a female *M. punctata* in a tumbler supplied with soil and tiger-beetle larvae. On looking into the tumbler a moment later I saw one of the larvae holding the wasp amidships in her jaws. She was held thus for over a second, during which period she was endeavoring to reach and sting the throat of her captor, and, accomplishing this, was released and came to the surface of the ground, apparently rather dazed or crippled. She crawled about flatly on the soil and brushed herself. But placing her near the scene of the recent struggle, she reconnoitered and, entering the burrow again, apparently with care, stung the *Cicindela*, now nearly quiet, in or near the mouth, crawled over its body, pinching it here and there, and, pulling it upwards, worked upon the ventral part of the thorax. She remained in the burrow for about thirty minutes, but the egg was deposited some time later.

At 3:50 p. m. I noticed that this wasp had stung another cicindelid larva, the latter being one-third out of the burrow and resting upon its back. *Methoca* soon entered the burrow, and seizing her prey by the posterior end, pulled it within, where it was subjected to a vigorous kneading process, the wasp pinching it especially about the thorax. Finally she placed herself venter to venter and head to head on the thorax of her prey and remained thus for a few seconds, presumably ovipositing. Then she climbed out of the hole and brushed herself. Like the first larva, this one was left with the head at the top of the burrow.

October 25, 10:50 a. m.: *Methoca* placed with tiger-beetle larva which was some way down its tunnel. Down the latter the wasp crept carefully, tailfirst and facing her big opponent. The larva soon snapped, and thereupon the wasp grasped in her mandibles a small root that projected into the burrow above her prey. She evidently thought this rootlet a part of the larva's head, for holding it firmly she stung at it repeatedly. But a moment later I saw the wasp a little further in the hole and firmly held in the cicindelid's jaws, the larva moving violently and emitting a brownish mouth fluid. The larva stung, soon quieted down, was duly malaxated, oviposited on and the burrow filled up above it.

October 26, 11 a. m.: Wasp soon located her snapping prey, and proceeding carefully down its burrow, grasped in her mandibles a palpus or mandible of the cicindelid, and holding fast, bent her body beneath the head of her prey, endeavored to sting

it in the neck. She was not immediately successful, as the larva struggled fiercely and, emitting a blackish brown fluid from her mouth, soon messed up her enemy. But in the course of a very few seconds the larva grew quiet and *Methoca*, releasing her hold, got out of the burrow, flattened and scraped her venter on the soil, and rubbed her abdomen with her hind legs in an effort to free herself of the juice so liberally smeared on her body by her prey.

October 26, 3:30 p. m.: The wasp walked down another burrow in a bold but alert manner, and while the cicindelid was snapping viciously she grasped the side of its head or thoracic shield in her mandibles and, bending her body under the larva's head, endeavored, free of and to one side of the big mandibles, to sting it in the neighborhood of the throat. The larva did not immediately succumb, but struggling violently, crawled out of its burrow and wriggled about until its tenaciously clinging and doubled-up foe stung it. The wasp, however, perhaps owing to the unwelcome coating of juice on her body, released her hold before the grub had become quiet. It is to be noted that although this wasp handles her victims more easily than does her slenderer darker relative, she does not reduce them to permanent immobility like the latter. One *Cicindela* which had been stung, but unsuccessfully oviposited on by *M. punctata* lived for five weeks thereafter.

The egg is not pearly white as in the first species, but is lightly suffused with carneous or flesh color. It is, moreover, secured longitudinally on the underside of the third thoracic segment, the head end of the egg being anterior. Its incubation period is longer than that of *striatella;* two eggs under observation each required about 72 hours to hatch, the larvae crawling out of the egg-shells. None was reared through the larval stage, but several cocoons were dug out of the soil by Filipinos. The cocoons resemble those of the other species in being similarly provided with a cephalic collar. The winter season is passed in this stage.

Methoca ichneumonides Latreille of Europe completely or almost completely paralyzes her prey. The egg is laid transversely behind one of the posterior coxae, and from eighteen to twenty-eight days elapse from oviposition to the spinning of the cocoon.

Methoca stygia Say of Eastern United States and Canada usually only partially paralyzes her prey, so that it again becomes rather active. The egg is laid as in *M. ichneumonides.*

Methoca striatella Williams of the Philippines completely paralyzes her prey. The egg is placed more or less longitudinally on the underside of one of the abdominal segments. From seven

to nine days elapse from oviposition to the spinning of the cocoon.

Methoca punctata Williams of the Philippines only partially paralyzes her prey, so that it again becomes rather active. The egg is laid longitudinally on the underside of the third thoracic segment. Incubation is longer than in *M. striatella*.

PSAMMOCHARIDAE (POMPILIDAE).

This is an extensive family consisting of small to very large wasps noted for their long legs and consequent great agility. The neck is short, and the thorax being usually higher than the head, gives these insects a rather hunchback appearance. The abdomen is without a noticeable pedicel or stem. A number of the species are grey-black or jet black, many have orange wings, while in others they may be iridescent violet black. They are probably the most active runners of all wasps, and inasmuch as the great majority of species prey on spiders, there is much need for swiftness. Bingham (1900-1901) has found *Pompilus bracatus* Bingham and *Salius verticalis* Smith which store their nests with cockroaches. Another species preys on crickets.†

The genera *Macromeris*, *Paragenia*, *Pseudagenia* and others are mason wasps, having advanced beyond the digging stage still adhered to by perhaps the majority of the family. They build cells out of clay or other earth-like material; they may construct these in sheltered or unsheltered places above ground, more rarely in burrows. Cell-groups may be the work of several females, which live in apparently semi-social harmony for months at a time. The method of building cells is here distinctly different from that employed by the other mud-dauber wasps, as *Sceliphron*, *Pison*, *Trypoxylon*, etc., for where these latter spread on the mud with the mandibles, sometimes aided by the forelegs, pompilids use the end of the body for this purpose, bending the abdomen under the thorax in an ungainly manner.* In these wasps the dorsal part of the last segment of the body (pygidium), which forms the mud-manipulating apparatus, is more or less devoid of hair.

The genera *Pompilus*, *Pepsis*, *Salius*, *Aporus*, etc., are eminently diggers. Of these wasps Latter (1913) says, p. 7: "The enlarged and closely approximated coxae are of great value to the

† Froggatt in "Australian Insects," p. 106, credits **Salius (Priocnemis) bicolor** with sometimes storing her burrow with Cicadas. In this he is evidently mistaken, for the insect which he figures (p. 105) for **Salius** is not a pompilid but probably **Exeirus lateritius**, a large wasp related to the Nyssonidae.

* Howes (1917) noted one of these mud-daubing spider wasps in British Guiana thus using the end of her body as a trowel. The insect is wrongly identified there as a sphecid wasp.

insects when excavating their burrows. These nest-tunnels are often driven to a depth of several inches, and all the soil to be removed is brought to the surface by means of the enlarged and rather flattened coxae which act like hoe-heads beneath the body and drag the soil along the floor of the tunnel as the animal backs up to daylight from the dark recesses of her gallery: the close apposition of the middle pairs of coxae ensures that very little soil slips between to be left behind." A few pompilids, however, are satisfied with making no nests of any kind. Hartman (1905) speaks of a brilliant blue Texas pompilid which deposited her spider prey on the margin of her own web, laid an egg upon it and left it to fate. Sharp (1901) speaks of Emery, who states that some pompilids merely sting and parasitize but do not bury their prey.

A curious relation exists between *Pompilus pectinipes* V. de L. and *P. rufipes* L. and *argyrolepis* Costa. Ferton (1905) studied the habits of these insects in Bonifacio. He found that *P. rufipes* and *argyrolepis*, as is usual in the genus *Pompilus*, store their burrows with spiders which they themselves capture, but the related *P. pectinipes* has parasitic habits, for it evidently smells out the closed burrows of the foregoing species, digs them up, removes the wasp egg from the spider's abdomen and, laying her own in its place, refills the burrow. Ferton thinks that the parasitic habit of *pectinipes* is a comparatively recent acquisition, for the insect, unlike the pompilid *Ceropales*, is still armed with a good sting and legs fitted for digging.

The genus *Ceropales* is parasitic on the genera *Pompilus*, *Pseudagenia* and probably others, and is more or less specialized or modified for her work. According to Adlerz (1903), *Ceropales* watches the uneasy *Pompilus* dragging a spider homewards, and at an opportune moment runs up and lays her egg in one of the cleft-shaped stigmata or breathing pores of the spider's abdomen. Subsequently *Pompilus* oviposits on this spider and buries it, but her own young is soon overcome by the *Ceropales* grub, which, hatching earlier from its place of concealment, consumes all. I noticed a similar parasitism in the Philippines with *Xanthampulex* (*Ceropales*) vs. *Pseudagenia* and *Pompilus*, but did not notice the oviposition of *Xanthampulex*.

Spiders of many kinds are overcome by the Pompilidae. *Pepsis formosa*, the big "Tarantula Hawk" of the West and Southwest United States, has often come into literature because of its duels with the great spider, and both spider and wasp, mounted on cards, are included among the souvenirs sold to tourists who visit

* An account of a battle between **Pepsis** and the spider in Texas is given by S. B. Buckley (1861).

the habitat of these creatures.* No less interesting combats take place in the tropical forests, and Bingham (1900-1901) tells of a fight to a finish in the forests of Tennasserim, India, between a very large wasp (*Salius sycophanta*) and a powerful spider of the genus *Galeodes*. *Salius* is about two inches long and is fully as large as our famous "Tarantula Hawk," while the spider *Galeodes* is a rather long-bodied, very active and repulsive creature nearly two inches long, and belonging to the family Solpugidae. The account reads as follows:

"I once saw and timed a fight between the huge fossorial wasp *Salius sycophanta* Grebodo, and a very large species of spider (*Galeodes*) which is common in the forests of Tenasserim, living in holes at the roots of trees and clumps of bamboo. I give a copy of the note I made at the time:—

Camp Ataran, 16th October, 1891.—Found the nest of a large hairy spider, a *Galeodes*, behind my tent among the roots of a clump of bamboos. The animal was outside and I tried to catch it, repulsive looking as it was, with a pair of forceps, but he, or she rather, escaped and ran down a hole. On digging it up I found the hole ran obliquely into the ground for about two feet and ended in a slightly enlarged chamber. I had dug gently and carefully to avoid injuring the spider and thus came on her crouching inside. I tried to pick her up with the forceps, but with a sudden leap she sprang on to my sleeve and began running up my arm. This was too much for me, and I gave a violent jerk to my arm, sending spider and forceps flying. The spider fell close to the side of my tent on a rather bare space and then, to my astonishment, scuttled for its life. I followed and caught sight of the cause of its alarm. A beautiful large *Salius* with black body and tawny red wings, which I recognized as *S. sycophanta*, was flying in an excited way round and round. Looking for the spider, after a hunt, I spied her crouching between a tuft of grass and a bundle of wooden tent pegs that had been thrown down. She had tucked in her legs and made herself as small as she could, and I was struck by the resemblance of her reddish-brown furry body to the color of the ground. Quite a long time the *Salius* kept quartering the ground, and it seemed to me quite evident she was hunting by sight, for as long as the spider remained motionless, although the wasp passed two or three times within an inch or so, she never seemed to find it out. At last, why I don't know, the spider made a rush trying to get to the shelter of a biggish clump of thatching grass about a yard away. Like a flash the *Salius* swooped down on her and then commenced a rough-and-tumble fight on the ground, both combatants rolling over and over so fast that I was quite unable to see whether the wasp managed to sting the spider or the spider managed to bite the wasp. However, the spider in a few seconds shook herself free and again tried to reach shelter, but in vain—the *Salius* with a loud buzz flew right over and, alighting on the ground beyond, faced round and intercepted her. Then commenced a curious scene: the spider stood on the defensive, turning and facing the wasp, as the latter with quivering wings and abdomen paced round and round, evidently watching an opportunity to close again, and the spider quite on its guard, standing up and keeping a vigilant eye on her enemy. This went on, I should think, for fully ten minutes until, perhaps, tired out and taking advantage of the wasp's stopping still for a second, the *Galeodes* made a second rush only to find herself grappled by her enemy.

This time the hand-to-hand or rather sting-to-jaws fight did not last so long; when the spider shook herself clear of her antagonist she was evidently injured. Her rush for shelter was a crippled run, and it was clear she was nearly done for. The wasp, apparently as fresh as ever, leisurely flew after her, caught her up and this time I distinctly saw the sting go in once, twice, three times, the poor spider making but feeble resistance and, unable to bite her enemy, lay still at length writhing a little. Then for a minute or so *Salius* danced her dance of triumph, parading round her prey in a quick jerky sort of walk, flirting her wings and quivering her antennae. Finally, she approached the comatose, if not dead, spider and deliberately bit off the long strong legs. Then, half flying with it and anon dragging it along the ground, she conveyed her shikar to her nest, which was excavated at the foot of a large *padouk* tree (*Pterocarpus indicus*) about fifty yards from my tent. Here she disappeared, and I had little difficulty in finding the entrance to her burrow. Placing my butterfly net over its mouth, I waited. In about five minutes out she came and I bottled her. Then I dug up her nest and found the bodies of no less than five *Galeodes*, all deprived of their legs and all with a single egg attached to the fur on the underside of their stomachs. So far as I could make out, all the spiders were quite dead, except the last caught, which still moved feebly when touched. As I said above, I timed the fight I have described. From the time I saw the wasp looking for the spider to the time the latter lay moribund, having its legs sawed off, was exactly thirty-five minutes.

C. T. Bingham,
Conservator of Forests."

Mandalay, 19th October, 1899.

Ferton (1905) states that *Pompilus crassitarsus* Costa and *Planiceps helveticus* Town. probably prey on trap-door spiders in Europe; a *Pepsis* in Brazil catches such spiders (Poulton, 1917), and Davidson (1905) has found the same relation between *Parapompilus planatus* Fox and the trap-door spider *Cteniza californica* in Southern California.

Pompilids do not always attack spiders in the open, where there is plenty of elbow-room, though probably they more commonly do. Sometimes the wasp will grapple with the spider, at the same time evading its fangs, and during the rough-and-tumble fight that ensues, cripple it with a sting; others are more careful and wound their powerful antagonist without closing in.* Many of the species, particularly the architect Pompilidae, have the curious habit of snipping off the legs of their paralyzed victims close to the body, the work being done with speed and dexterity, and little or no blood will ooze from the wounds. Not all the legs may be cut off, and occasionally none. Perhaps this snipping off is done so as to economize cell-space, but we find that the wasps addicted to this practice carry their victims quite

* Belt (1874, Chapter VIII) speaks of a wasp, evidently a pompilid, as follows: "In Australia, I often witnessed a wasp combating with a large flat spider that is found on the bark of trees. It would fall to the ground and lie on its back, so as to be able to grapple with its opponent; but the wasp was always the victor in the encounters I saw. * * *"

handily beneath them, while those that are not leg cutters almost always adopt the clumsy method of dragging the spider as they run backwards. No Pompilidae, so far as I know, stores more than one spider in a cell, each victim being of sufficient size to feed the wasp grub to maturity.

The sting inflicted by these spider wasps is said to be burning and painful, and in this they differ from many of the other solitary wasps.

Macromeris violacea Lepeletier.

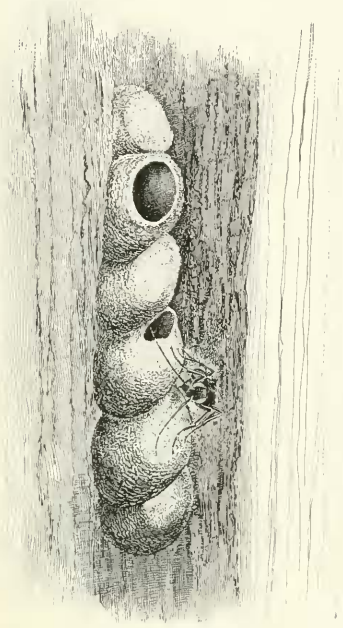


Fig. 37. Portion of a tree hollow showing a *Macromeris violacea* guarding her cells, × 1/2.

Length of body, female, about one inch (25 mm.); body black; wings proportionately large, iridescent violet black; legs long.

Macromeris is alike a denizen of the dark Makiling forest and of the more cultivated areas about the base of the mountain. Conspicuous for her size and dusky coloration, she is occasionally seen making short flights in the woods, banana groves or about palms, and searching the hollows of trees, trunks or other places likely to harbor *Heteropoda venatoria* Linn., a large and decidedly active spider, a well-known creature of the tropics and a frequent resident of the houses there. This spider forms the food of the *Macromeris* grub. At other times the wasp is occupied in building her cells, selecting the material from tree trunks or the covered runways of termites or white ants. She is not a common insect, and if you are able to follow one to her nest, placed well within the hollow of a tree or in a partly open bamboo stem, you will likely find one or more alert and aggressive females perched in the semi-gloom, about a group of large oblique cells, (Fig. 37). Perhaps a male will be present also. He

is a stouter-legged creature that makes a show at being ferocious—a mere bluff on his part, retreating as he does before your advances. Madam *Macromeris,* on the other hand, has much at stake and is far more in earnest, especially if she be the foundress of the little colony, when she is often bold and fearless. She will elevate her wings in an angry buzz and frequently refuses to be routed. This wasp is particularly warlike when she has just brought in a spider; indeed, I was once compelled to imprison an enraged *Macromeris,* an unusual necessity with solitary wasps, in order to examine her nest.

Like her smaller and more amiable cousin, *Paragenia argentifrons,* next treated, these black ogresses may live in small groups or communities in fair harmony for months at a time. But I have found their nesting sites usually less accessible to vision than those of *Paragenia,* and necessitating an awkward pose on the part of the observer, preclude as close a study. The cell material seems to be very largely composed of the earth-like substance employed by white ants in making their long coverways along tree trunks. Bark is also used and doubtless water is added to the material. Maindron (1878), in describing the cells of *M. splendida,* which he found at Ternate and Gilolo (Moluccas), mentions as cell materials, vegetable debris, the bark of trees, and a sort of gummy cement which is insoluble in water. Dutt (1912) in his "Life Histories of Indian Insects," speaks of clay, sand, chewed-up vegetable matter, gummy substances, etc., as used by *M. violacea.*

We are accustomed to see the spider-wasps or Pompilidae running along the ground in search of their victims, but *Macromeris* seems to keep off mother earth as much as possible, and this is quite a natural procedure if we consider the more or less arboreal habits of the big spider which she seeks. Likewise, some of the *Pseudagenia,* smaller but related architects, prefer a tree life.

On November 15, 1916, I first located the nest of *Macromeris.* It consisted ultimately of fifteen neat cells, a compact lot arranged in more or less vertical rows in the darkness of a tree (*Cordia* sp.) hollow, at an elevation of two or three feet from the ground. The cells, their aperture upwards, were obliquely placed. From one to three wasps were present, astraddle the cells. On December 22 I detached the cells. Fourteen of these were completed, while one at the lower end of the inner row was just commenced. A cell recently vacated had the aperture bitten out by the emerged wasp, neatly enlarged and rimmed again for further use; a second cell contained a large spider with a wasp egg on it, a third cell contained a spider and a young wasp larva, a fourth cell had a nearly replete larva, while a fifth was vacant. The nine remaining cells were closed and

contained cocoons. As we shall see later, one is often able to tell whether *Macromeris* is utilizing a cell for the first or for the second time or more. I kept these cells in a receptacle, and all the stored cells save one whose contents I had considerably disturbed came through successfully. In my brief and limited experience with both *Macromeris* and *Paragenia* I have found no parasitism in the nests, whereas the cells of the several *Pseudagenia* which I have studied produced a large percentage of ichneumonid parasites (Cryptinae). Dutt (1912) had similar experiences with Indian *Pseudagenia*. This may be partly explained by the habits of *Macromeris* and *Paragenia,* which, being semi-social, are thus better able to guard their nests, while *Pseudagenia*, quite solitary as a rule, cannot protect their cells and hunt for spiders at the same time, and, furthermore, they desert their completed nests to form others elsewhere. But one might, in consequence, expect to find the semi-social genera the more numerous in individuals, though this does not seem to be the case.

The *Macromeris* whose nest I had destroyed stayed in the tree hollow for some time; they appeared much concerned as they walked about the nesting site, tapping here and there with the antennae.*

On November 28, I discovered that a hollow in a large branch of this same *Cordia* tree, an isolated specimen near the edge of a banana plantation, harbored another *Macromeris* nest. One of these wasps dragging a spider on the roadside was a conspicuous object. She hailed from the banana plantation across the road, which, of course, she was unable to bridge through the medium of trees, heavily burdened as she was. There was no doubt, however, that she was very anxious to climb up anything that offered, in order that she might make a sailing flight towards home, for, utterly unmindful of me, she immediately crawled up my bamboo net handle which I presented to her, then along my hand and arm, and had I not diverted her course, again by interposing the bamboo stick, she certainly would have scaled my person to its highest point. From the end of this stick she parachuted heavily to the tree. Here I noted that she carried the spider close beneth her body, grasping it with her mandibles by the underside and posterior end of the abdomen, near or at the paired papillae-like processes there. All but three of the spider's walking legs had been bitten off close to the body. *Macromeris*, with raised wings, traveling as hastily as possible, climbed up and sailed from one limb to another. I soon saw that she did not belong to the household of which I first spoke, for there she

* Hollow occupied again by August, 1917.

could not be persuaded to enter, but after some angry buzzing she finally disappeared seven or eight feet up, inside a hollow branch. This nest, rather inaccessibly placed, contained three or four wasps at one time. I ascertained that three were females. It had a long existence, as it was not abandoned until the latter part of July. Apparently the faithful wasps await the hatching of their progeny.

Within a week of the time of abandonment of the nest above referred to, I located an old female *Macromeris* which had just begun to build a cell in the partly exposed node of a bamboo stump, said stump also containing a thriving colony of *Paragenia* spider-wasps, which occupied the node below *Macromeris* and is referred to extensively in the next article. This was on the morning of July 28, and I have good reasons to believe that the rather dilapidated *Macromeris* had been the proprietress of some of the recently-abandoned cells in the *Cordia* tree, perhaps a third of a mile away. The bamboo stump was excellently situated for observation and the old and sagacious architect almost immune to fear. By the afternoon of July 29, she had made little progress, the cell being less than one-third complete. But since the interior of the bamboo was smooth, *Macromeris* could only with difficulty secure a sufficiently firm foothold to plaster away; accordingly, I scratched up and dented the wall about her cell, and this assisted her vastly. Like *Paragenia* and *Pseudagenia*, our black giantess chews up and revolves her building material in her mouth, and smears it on the cell with the dorsal tip of her abdomen. By the afternoon of August 1 the cell was complete. It was placed with its long axis vertical, and was furnished with a short nipple at the lower end. It was a well-made affair of a rather springy nature. Its base was the bamboo wall.

At 3 p. m., August 2, *Macromeris* had nearly closed up her cell, within which could be seen a portly spider. Whereas we are accustomed to note a cat's change of nature after she has acquired the responsibility of a family, so also is this change evident in our big black wasp. Heretofore fearless and impatient, she is doubly so now that she has captured her spider, stored it and placed a precious egg thereon. I would not hesitate to call her vicious as she buzzed angrily at my curiosity. By 5:00 p. m. the cell was capped, the wasp putting on the finishing touches. Unlike *Paragenia*, she fetched her material—after the spider was stored—from without the nest. During one of these trips to the field a *Diacamma*, a ponerid, one of the largest Philippine ants, came upon the cell and began biting into its still moist cover, but the ant was angrily nipped and put to flight by the irate *Macromeris* returning with cell material. The wasp,

disburdening, examined the intruder's damage, patching up the spot, biting dry bits from the cell for this purpose. The cell cover was smoother than the rest of the exterior, and its footrest or nipple had evidently been used up in sealing. The old mother had about completed her life's work, her worn body

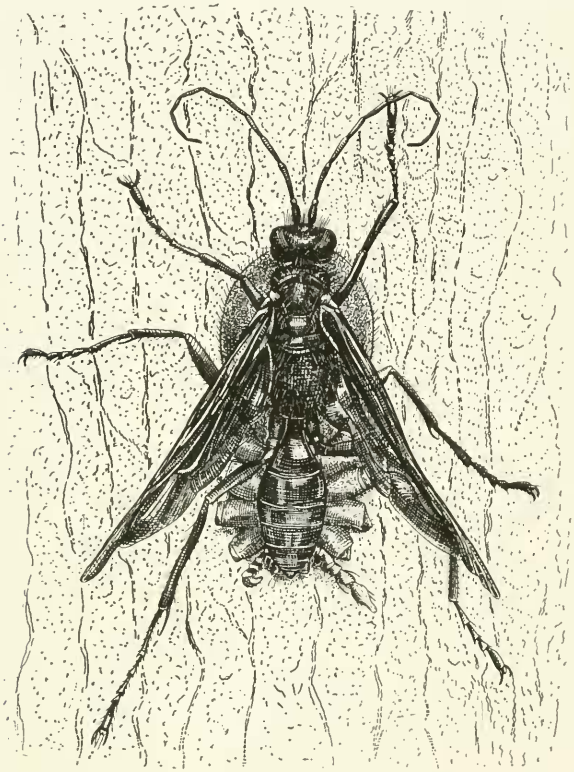


Fig. 38. *M. violacea* with her spider prey, *Heteropoda venatoria*, whose legs she has bitten off, and which she is carrying up a tree. × 2.

probably contained no more eggs, and she devoted her few remaining days to guarding the cell. Perched upon the object of her solicitude, her tarsi would every now and then twitch nervously. It was seldom that she took a brief trip to the field, and I observed her upon the cell during the night. Finally, on the morning of August 15, she was found dead, but hardly stiffened, in the bamboo partition or internode below her cell, which now enclosed a fine large cocoon.

I was able to study another *Macromeris* nest over a period of some weeks. On February 18, 1917, two nests were located higher up on the slopes of Makiling; one was hopelessly hidden far within a hollow tree, but the second was quite accessible, placed as it was in the stump of a deformed old tree, open above. Under the overhang within this hollowed top and concealed from view mainly by a few vines, was an angry wasp and her three-celled nest. Two of these cells were closed. At 11:15 a. m., March 2, there were four cells, while the wasp, with a load of cement in her mouth, appeared to be contemplating a fifth; this was practically completed two days later at 5:30 p. m. Next day there were two wasps about the cells, and though they did not really quarrel, their attitude towards one another was very warlike. At 1:40 p. m., March 7th, I heard a patter and buzz above me, and looking upwards, *Macromeris* came into view on the trunk over her dwelling. She was heavily laden with a big spider, with which she had leaped, evidently, from the higher branch of a neighboring tree to her present position. She carried the spider closely pressed beneath her, underside upwards (Fig. 38), grasping it by the two papillae-like processes near the hind end of the body. The victim was quite large, apparently full of eggs, and had been stung into insensibility. Much heavier than its captor, it was deprived of its four pairs of walking legs. *Macromeris* lost no time in stowing her prize in a cell, first inserting therein the spider's abdomen so that the creature would face out. Then the wasp set to work examining her prey; at this juncture I broke off the cell, but let it lie, its base now open, in the near bottom of the tree hollow. Here a few small ants promptly invaded the cell; this was soon discovered by *Macromeris*, who became greatly enraged thereat. Buzzing in loud anger, her wings widely spread, she grasped the spider by the cephalo-thorax and jerked it violently out of the loosened cell. This freed it of the ants and she dragged the carcass up the hollow, while I cleaned out the cell and plugged up the opened base with cotton and wedged it among the upper cells. *Macromeris* soon stored the spider once more, but she objected much to the protruding cotton and made repeated pulls and digs at it, so that the cell became loosened again and all went tumbling down into the hollow. But the wasp clung angrily to the cell and could not be driven away, and threatened to climb up my forceps. I finally took the cell outside the hollow; at this she was greatly perplexed and hunted for it even on the ground about the base of the tree. In order to replace the cell, which I did more firmly, I was obliged to imprison the warlike insect. Upon being released shortly afterwards the wasp went directly to her cell. The

next afternoon, March 9th, at 2:05, the cell had been sealed up. I watched this nest for two weeks thereafter, but there was little work added. She probably considered her cell-group sufficiently large and would be content to see her brood hatch and perhaps use over again the cells thus made vacant.

I have found *Macromeris* nesting well in the forest at an altitude of perhaps 1000 feet. Here one was seen gathering cell material from a standing tree trunk 100 feet from her nesting site. She, however, was quite shy. Her single capped cell was well ensconced in a natural hollow formed by the root and buttresses of a large tree.

Fig. 39. *M. violacea* cell viewed from beneath, showing spider with wasp's egg on abdomen. About natural size.

Sometimes a male is to be found in the nests. He is tolerated by the females, often perched for long periods on a cell, as he parades about with elevated wings. One of these males I found badly crippled, two of his legs on one side being lacking.

The wasp may search in quite confined quarters for the large spider; this shows that she does not fear it much. Occasionally one finds this spider in close proximity to a wasp's nest and lacking much of its great activity, suggestive that *Macromeris* had stung it but not sufficiently. She may tolerate small gecko lizards in her nest hollow, though I have seen her rout, by a quick dash, a greenish tree lizard.

Evidently other wasps than *Macromeris* prey upon the big *Heteropoda* spider. A *Salius* sp., an insect fully as large as *Macromeris*, but with black and orange wings, and much like *Pepsis formosa*, or the "Tarantula Hawk" of the West and Southwest United States, was once seen hunting for a spider which she had flushed in the neighborhood of a *Macromeris* nest. At intervals *Salius* would fly about the *Cordia* tree to alight and pursue usually a definite set of trails, and as one of these led very close to the interior of the *Macromeris* hollow, one of its denizens would frustrate the strange wasp's venture into the forbidden ground by rushing fiercely out and compelling flight.

The cells of *Macromeris* are fairly uniform, being on the average 33 millimeters long by 20 wide and 20 in height. Their form is shown in Figs. 39 and 41. Externally the walls are rough, with the cap smoother, and the interior still smoother.

The egg is deposited on the underside of the spider's abdomen

(Fig. 39) near its base. Two were examined—one measured 6.5 millimeters long by 1.4 in diameter; the other 7. by 1.5 mm. They were rather dull creamy white, slightly thickened at the head end, as viewed from above almost straight, laterally slightly curved so as to conform with the curvature of the spider's body. Incubation in one case was a little over three days. The wasp grub feeds four or five days fixed almost immovably on the spider's abdomen, and during this time seems to have cast off its skin once. Thereafter becoming more active, it uses its jaws more for chewing than for pricking, and rapidly consumes the harder portions of the victim's anatomy. It finally makes use of the more anterior part of the underside of its body as a table, eating into a dark uninviting mess thereon—the remnants of the spider plus debris, etc.† Finally having consumed all, the grub measures, when straightened out, from 27 to 34 millimeters, or over an inch long, with the greatest width about 9 mm. It is shining white, smooth and well segmented, with the lateral fold strong. The fat bodies are small, intersegmental and dorsal. The anal segments are yellowish. The head is moderately large with the usual brownish oblique facial lines. About seven days after hatching it is full fed (Fig. 40), and soon commences spinning a cocoon. This is a matter of two days or more. When complete the cocoon is about 28 mm. long and 1 mm. wide, broader at the head end and tapering posteriorly, (Fig. 41). It is golden brown and rather shiny, and it lies along the longer axis of the cell, its darkened, more pointed tail end touching the lower or posterior end of the cell; while the body of the structure is well hung by supporting threads. The broader, rounded head end is very nearly in contact with the lower part of the cell cap. When held up to the light the resting larva or pupa is easily visible through the thin walls of the cocoon. The larva may wriggle quite audibly in this enclosure.

Fig. 40. Mature larva of *M. violacea* with remnant of spider on its lap. About natural size.

We must bear in mind that the cell rests directly upon the tree hollow, which usually forms a large part of the floor over which, and prior to spinning its cocoon, the larva of *Macromeris* weaves a sheet of silk, thus making its cell more impervious and secure. In examining the cells of one of these insects it will

† It is interesting to note that this method of feeding is not confined to solitary wasps. Wheeler (1900), p. 295, says regarding the ponerine ant **Odontomachus clarus** in Texas: "These larvae are placed on their broad backs and their heads and necks are folded over onto the concave ventral surface, which serves as a table or trough on which the foode is placed by the workers."

be found that some lack these silken sheets; these are the newer cells, still unoccupied or containing an egg or a larva. Others containing an egg or larva already have this sheet. We find, then, that the wasp economizes in using a cell over again, as do social wasps.

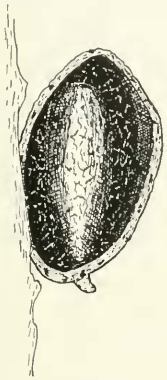


Fig. 41. *M. violacea* cell in vertical section showing cocoon within. About natural size.

Fig. 42. Ventral view of pupa of *M. violacea*, × 3/2.

The pupa (Fig. 42) is, in the female, about 23 mm. long, large-headed and long-limbed. At first it is whitish, but soon darkens with age. The upper portion of the body bears several processes and spines. The abdomen has four forked processes on each side, and a fifth unbranched one. The tarsi are swollen at their tips, and the tibial spines prominent.

On January 29, a. m., I saw female *Macromeris* emerge from her cocoon; she took about thirty minutes to bite and force her way out of it. A copious brown juice which she exuded from her mouth softened the silk at the broader end of the cocoon and thus aided her efforts. Finally an irregular hole was formed and, struggling actively, she parted the last resisting strands. *Macromeris* came out with wings fully developed though somewhat bent down at their tips. She was quite sprightly. A rough hole is bitten out of the cell cap by the emerging wasp.

The life-cycle of the single *Macromeris* that I followed through was:

December-February: Egg stage, 3 days; larval stage, 6 feed-

ing days and 9 days in cocoon; pupal stage, 24 days. Total, 42 days.

M. violacea as observed by Dutt in India was: Egg, 2 days; larva (including resting stage), 10-11 days; pupal stage, 14 days. Total, 26-27 days.

There are many details in the life history of this handsome wasp that remain to be worked out.

Paragenia argentifrons Smith.

Length of body, 17 mm.; grey-black, wings transparent, legs long.

The life of this rather widespread Oriental insect is a most interesting one, for, like its large relative *Macromeris*, it is fond of company and, moreover, is a wasp whose domestic activities are often easy to observe. Its favorite nesting place is the hollow of a bamboo, whether it be a split stump, fence-post or beam, whose aperture does not permit too much daylight to enter and is so inclined as to exclude the rain. It seems to prefer to work in the shaded bamboo groves and indeed is not averse to carrying on its building operations during a light rain or, if needs be, when the sun is on the point of setting. Although more sociable than *Macromeris*, it is not so aggressive, while in the work about the domicile (Fig. 43) it often appears like a case of "too many cooks spoil the broth," since the wasps do not always mind each other's affairs, but, wishing to contribute, interfere. Nevertheless, the little group of *Paragenia* wasps presents a peaceful aspect; in my many observations I have never seen what must be the aggravating conduct of one wasp resented by another. It is but fair to state, however, that some of these insects may bear permanent evidence of rough treatment, in the form of broken antennae or dislocated legs. There seems to be a sort of password system in a nest—often when a female wasp enters the hollow she is challenged by a female within, which makes a short dash at the new arrival and, giving her a brief facial inspection at very close quarters, engages her no further. Everything proceeds quietly. More timid males frequently hang about the entrance, while a confident one feels quite at home within.

Several nests, all in split or cut bamboo, were located, but a large one, first observed on July 10, 1917, proved very easy of access and furnished the bulk of my notes on *Paragenia*. It was situated in a node of a bamboo stump in a grove growing by the side of a stream. This stump, some three feet tall and three and a half inches in diameter and composed of three or four nodes, had been cleft longitudinally so that a slab about one-

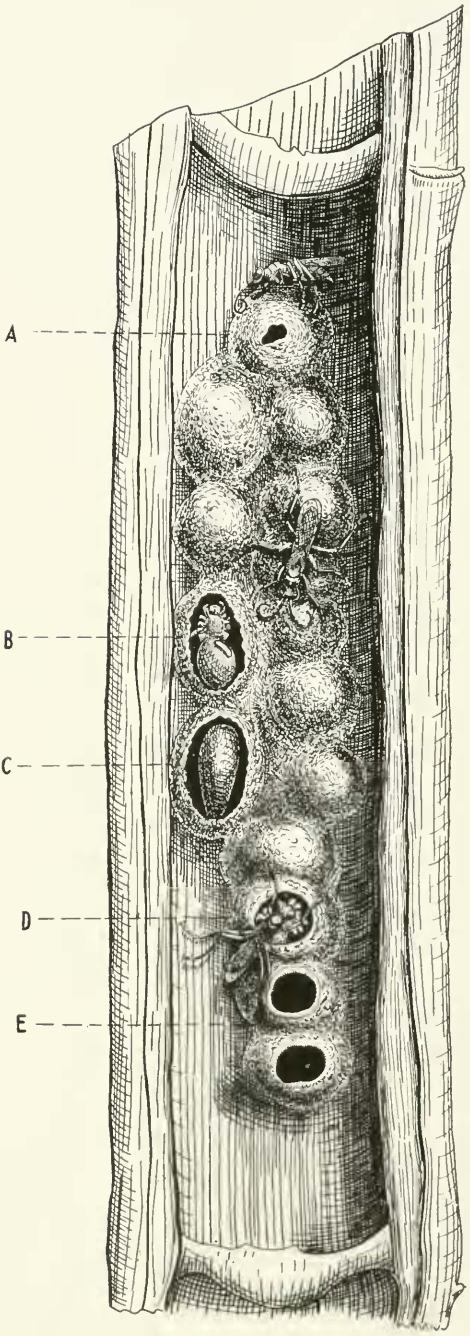


Fig. 43. Node of bamboo stump with one side removed to show cells of *Paragenia argentifrons* within. At A, is shown a cell from which a wasp has recently emerged; at B, is a cell with the top portion removed to show the delegged spider, *Heteropoda gemella*, with a wasp's egg upon its abdomen; at C, is a cell containing a *Paragenia* cocoon; at D, is a wasp which has just stored a spider; while at E, are two cells ready for storing. Length of cell-mass, 6 inches.

third the circumference of the bamboo was separated by a large crack from the main body for about two-thirds the length of the stump. The elastic slab was on the overhanging side and could be further drawn away, thus more fully exposing the contents of two and a half nodes. The topmost of these was soon destined to contain a single cell of an old *Macromeris* wasp, the second sheltered the mud cells of *Paragenia,* while a portion of the node near the base appeared to furnish a nest for *Diacamma,* one of the large ponerine ants.

On July 10, 1917, this *Paragenia* nest was composed of eight mud cells, all sealed and vertically arranged, one touching the other, in one side of the node; on August 16 there were twenty-two sealed cells, one unsealed, and the rudiment of a twenty-fourth. The nest was examined almost daily up to September 12, or for more than two months. It is probable that on July 10 this nest was already two or three weeks old. The greatest number of wasps present at one time in or about it was eight.

It is probable that in most cases but one wasp begins the construction of the nest. The cells (Fig. 43) are longer and broader than high, and their point of attachment forms the basal side. They are composed entirely of mud collected in some moist spot. This mud, gathered by the jaws of the wasp, is turned over and over in her mouth-parts until it assumes the right consistency, when, lowering her head and at the same time bending the abdomen forward beneath her until its dorsal tip pierces the ball of mud, now almost touching the bamboo, she applies part of the mud to the wood, where it is spread on as desired with dorsal end of the abdomen. This mason work is repeated until the mouthful of mud is expended, when the architect flies away again to renew the supply. The walls of the cells rise evenly, and since the builder applies and plasters on the mud from the inside, the structure is always smoother within, and the wasp often assumes a very cramped position as she works in the nearly completed cell. The length of time occupied in building such a cell is variable, as the work is frequently done intermittently, but often extends beyond a day. When the cell is ready for the reception of a spider it has a large well-rounded orifice.

I did not see any of these insects capture their prey (*Heteropoda gemella* Linn.). *Paragenia,* though alert, has by reason of its very long legs a draggling or drooping sort of gait as she searches about the trash at the base of bamboo clumps and other likely places for suitable spiders. These are more or less delegged in the field; perhaps all but the short anterior pair of legs (pedipalps) are severed from the body, or one or more of the true legs may remain attached. The wasp grasps her prey

as does *Macromeris*— that is, by the ventral end of the abdomen —and carries it beneath her body. Thus laden, she backs into the cell partly bringing in the spider with her, and then as she emerges from the cell she tucks in her burden at the same time, using the end of her body very deftly for this. Thus the spider's underside faces the mouth of the cell and lies with the head end upwards. It may be many hours before the egg is laid and the cell closed; in fact, it may remain open overnight. The wasp sticks her head into the cell, attending to the spider in some manner—she often does further tucking in with the extremity of her abdomen, or she may have company, one or more companions, who act towards this spider much like herself. This fussing may be partly due to unpreparedness for oviposition. Finally, after a careful look at her prey, she reverses her position and, sticking her abdomen within the cell, remains thus for some seconds, evidently laying an egg. This is placed near the base of the underside of the abdomen. Then she sets to work promptly to close the cell with a cap of mud. But we must note that now she no longer gathers mud from some moist spot, for, as if conscious of the danger of parasites, she bites off pieces lower down on the cell itself or at its juncture with another and uses this material, moistened in her jaws, for capping. Only occasionally does she fly out for a quick sip of water wherewith to soften the dried mud. Owing to the diminishing size of the cell's aperture she is eventually forced to plaster from the outside, and that is why a portion of the cap is somewhat smoother than the sides.

The length of *Paragenia's* life-cycle was not determined, save that, barring accidents, the mother lives to see at least a good part of her progeny issue from the cocoons and cells. The wasp grub hatching from the egg, proceeds to consume the paralyzed spider; in a few days it is full grown, having devoured practically the whole of her prey, and spins a thin yellowish-brown cocoon, tapering at one end and rounded at the other. As in *Pseudagenia* and *Macromeris*, the cocoon, about 19 mm. long, is secured to the inside of the cell by its tapering end, and also supported elsewhere by strands of silk. The pupa is an interesting object. It much resembles that of *Macromeris*, but in addition to the lateral Y-shaped processes of the abdomen, bears a forked thorn and two successive knobs on the back of the thorax and three pairs of thorns on the top of the head. There are also thorns near the base of the antennae. The cocoon and pupa lie in the long axis of the cell. The wasp in escaping from the cell bites a small hole through the cap. If this cell happens to be needed by one of the mothers of the colony, the debris is removed from it and the emergence hole, made by its

former inhabitant, neatly enlarged and rounded off so that it has the appearance of an unused cell. The bits of mud bitten off in this work are not cast aside, but plastered on the cell's walls, where they will come in handy for recapping the cell after another spider is stored in it. It is probable that the wasps use any cell in the nest they find vacant and do not concern themselves about its builder.

The operations as related above are frequently rendered more complex or irregular through the erratic behavior of one or more of the female wasps. Thus it often happens that when a spider has been tucked away in a cell, not one, but two or three wasps give it their attention, so that we can only guess which is the lawful owner of the prize. The wasps will crowd about the cell; one will poke in her head and become interested in the spider, then she will withdraw and a second *Paragenia* now steps forward and investigates likewise. Perhaps they feed on the spider's mouth or leg juices. On one occasion a wasp hauled the spider out of the cell and let it fall to the bottom of the node, much to the consternation of the others. Again, late in the afternoon a *Paragenia* brought in a spider from the field, but there was no cell ready to store it in. Nothing daunted, however, the wasp, after wandering about a little, dropped her burden on the internode and set to work to make a cell, building it up from a mere rudiment—two short strips of mud laid down many hours previously. She worked rapidly, nevertheless darkness put an end to her industry. I watched her plastering away until 6:10 p. m., and after supper visited the nest again at 7:50 p. m. to find the cell incomplete, the spider unstored, and three female *Paragenia* about the cell-mass. Thus it is evident that the females, at least in part, stand by their nest during the night. At 7 o'clock the next morning the spider still lay in last night's position, but by 8:45 a. m. had been stored in an old cell whose newly-made emergence hole had been enlarged. I pulled the spider out of this cell, and the alert wasp, after cutting off the remaining leg, once more stored it within. Sometimes a couple of wasps will simultaneously build cells side by side—close quarters indeed for such long-legged sprawling creatures—and though they may necessarily interfere with each other's work, there is no quarreling. Again, capped cells may for no obvious reason be opened and sealed up again. One such cell contained a *Paragenia* cocoon, another a spider five days old. In another case one wasp was plastering up a cell which contained a spider while a second wasp was plastering as well as biting open this same cell. But when the egg (here perhaps not the first one) was deposited, the cell was closed without interference.

So that one is inclined to marvel at both the stupidity as well as the common sense of these creatures.

Pseudagenia blanda (Guérin Méneville).

Length 13 mm.; metallic blue; hind femora red.

This very pretty insect is strictly a forest dweller; here she frequents the muddy paths at lower elevations, seeking with much fastidiousness the mud to build her stout cells. She is a shy wasp, as she walks about nervously here and there inspecting the mud. Finally arriving at a suitable spot, she bites out small pieces which she works up in her mouth parts to a more homogeneous and fluid consistency. When a sufficiently large ball has been accumulated she suddenly straightens out, raises herself up and takes wing. Though her cells may be only fifteen or twenty feet away, it is very difficult to follow her flight. During March and April, 1917, I located a few nests; the cells which compose them are cylindrical and rather thick-walled, ranged one alongside another. There may be as many as four cells to a nest (Fig. 44), and in each is stored a delegged spider on whose abdomen is placed the *Pseudagenia* egg; the latter is curved and measures 2.60 x 0.65 mm. I found one nest in a fissure in a stout vine and several at the base of large trees, and as they were roughly plastered over with mud, they blended well with their surroundings.

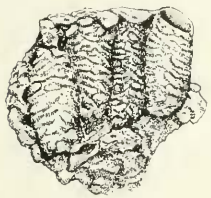


Fig. 44. Ventral view of cell-mass of *Pseudagenia blanda*. Reduced.

I once saw this or an allied species hunting her prey. She ran swiftly, and with the abdomen curved forward beneath her, along tree trunks, inspecting her path with her antennae. This peculiar hunting posture might lead one to suppose that the particular spider which forms her prey is likely to pounce upon her and so *Pseudagenia* has need of her sting well to the front.

Pseudagenia makilingi is likewise a forest insect; she lacks the purple effulgence of *blanda* and has no red on the legs. She fashions a two-celled mud nest, which she hides in a curled-up leaf, etc.

Pseudagenia nyemitawa Rohwer.

Length 12 mm.; metallic blue.

This very agile and handsome wasp, though closely related to the forest-dwelling *P. blanda*, builds a very different sort of

nest. She is occasionally seen within the forest, but I have found her more at home along the wooded banks of a stream at the College of Agriculture. The two or three-celled nest (Figs. 45, 47) is placed in rather exposed situations. It is pasted on tree trunks or twigs, but as the structure seems proof against wind and weather, being varnished over with a tree gum, it remains in position long after the brood or parasite has emerged.

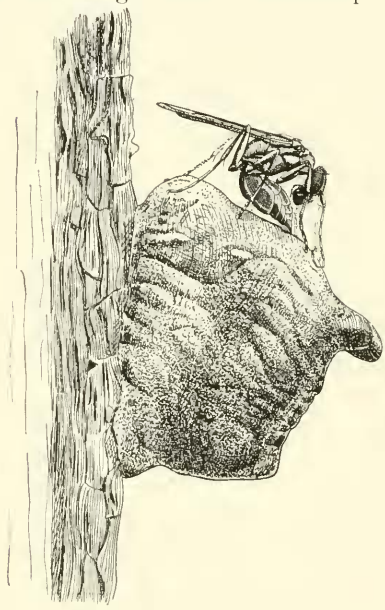


Fig. 45. *Pseudagenia nyemitawa* putting the finishing touches to a two-cell nest which is fastened to a tree trunk. The wasp is revolving a semi-liquid ball of gum in her mouth, and is smearing a bit from this gum on the top of the nest with the dorsal tip of her abdomen, × 1.6.

The energetic architect is rather shy and a swift worker. Several females were observed gathering, at the base of tree trunks, the main building material of the nest, earth-like substance that forms the coverways for the termites or white ants. The wasps first sip up water from some convenient hollow or edge of stream, and the ball of earth subsequently gathered is worked around in her mouth until it assumes the right consistency, when it is plastered on the building site with the dorsal tip of the abdomen, (Fig. 45). The first cell is secured to the bark, etc., along its side, the open end upwards; it is stored as soon as possible with a spider, which, however, may not be captured soon. I happened to see a spider stung by the wasp, its legs snipped off in a minute or less, then it was grabbed by the anterior part of the body, dorsum up, and rapidly dragged beneath the wasp, over boulders and thence to a small tree, the couple disappearing in the crown of the latter. The egg is soon laid on the base of the spider's abdomen beneath, the cell plugged up and another added alongside the first. Before the cell group of two or three cells is completed, a partial coating of varnish may be put on. The cells finished, are more closely united with mud and the ineritable "footrest," a small ledge or projection to the upper and

outer side of the last cell, is added. When *Pseudagenia* is through with the mud she turns her attention to a tree gum, which she works over in her mouthparts and spreads on precisely as she did the mud. Then, without intermission, she brings in another final coating or, rather, patching material—a pale grey lichen—which she works up in her mouth into a sort of viscid paste, also applied like the mud and varnish, but the nest is blotched rather than completely covered with it. We now have as a completed nest, an object which might well pass for an excrescence or other irregularity in the bark to which it is fastened.

Fig. 46. A delegged spider on whose abdomen a half-grown larva of *P. nyemitawa* is feeding. Enlarged.

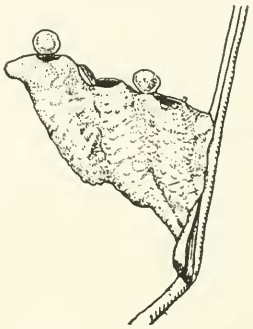


Fig. 47. Three-cell nest of *P. nyemitawa*, showing doors by which wasp has left cell. Natural size.

When on thin twigs, however, it is somewhat disproportionate to be regarded in the light of concealed coloration, particularly when it is plastered on to a thin yellow bamboo twig.

The wasp's egg is over 2 mm. long; the grub (Fig. 46) seems to be of the usual *Pseudagenia* type and spins a rather thin and pallid cocoon, the head end of which points upwards. In breaking its way out of the cell the young wasp attacks the upper end, which it bites in circular fashion, so that when the resulting disc is forced out, it usually stands ajar like a door, the gummy cell covering serving as a hinge. (Fig. 47.)

In examining the cells of this species I came across one containing a darker brown thicker cocoon, which finally disclosed a reddish *Xanthampulex*, a parasitic pompilid, which doubtless laid her eggs on the *Pseudagenia's* spider in the field. The nest is also parasitized by an ichneumonid, several of which I reared.

Pseudagenia nyemitawa, unlike the larger *Macromeris* and *Paragenia*, lives in solitude and deserts her exposed nests when they are completed; thus parasites have a good chance of carrying on their nefarious trade.

Pseudagenia caerulescens Williams.

Length 9 mm.; metallic greenish blue.

This very pretty spider wasp was observed nest-building but once. On August 11, 1917, I saw her erecting her little mud nest within the silken retreat of a jumping spider, the web being in a vertical crack in a bamboo stump. *Pseudagenia* was in the act of bringing in rather large helpings of mud with which she capped the first cell. This completed, she commenced another cell, building it with the base against and below the first. On the morning of August 12 the cell was finished, and at 9:55 a. m. she had already stored a spider and was ovipositing on it; in doing this she rested quietly for a minute or so, her abdomen partly inserted in the cell. Immediately thereafter she took flight, and returning with a supply of mud in her mandibles, commenced sealing up the cell, using the tip of her abdomen as a trowel. But at this point I captured the architect, well knowing that if I waited a little longer she would be gone for good.

The two cells, which were thickest in the middle, were 10-11 mm. long by 6.5 mm. in diameter; exteriorly they were rough and not artistic. Each contained a species of jumping spider with a long conical abdomen and large grasping legs or chelae. Six legs had been cut off.

The egg, which was pearly white, was a little arched in conforming with the curve of the spider's abdomen, and a very little less rounded and more pointed at the tail end. It measured about 2 mm. long by 0.6 mm. in diameter, and was transversely fastened by the head end, on the side and near the base of the spider's abdomen. On August 17th, one of the wasp larvae commenced spinning, and on the thirty-first a male emerged from the first cell. In making his exit therefrom he bit a small hole through the clay near the end of the cell.

Pseudagenia sp.

Length about 8 mm.

Unfortunately I secured no adult females of this species and saw but a single one engaged in nest building, and this one I noted was of a steel gray color with clear wings and red hind

femora. In habits she resembles *P. cacrulescens*, for she also utilizes the more or less cylindrical silk nests of attid spiders as a shelter for her mud cells, (Fig. 48). These webs were quite common on ornamental shrubs, especially Croton (*Cordacium*), a couple of the tough leaves or a rolled-up one concealing the nest. The spiders' nests are from about 1½ to 2½ inches long, and the wasp places from two to four cells, usually arranged in a string, within this tube. *Pseudagenia* uses the spider's doorway in bringing in her prey and balls of mud. She does not appear to molest what spider egg-cocoons there may be present. In one case a web sheltered also a one-individual *Polyrhachis* ant nest, but this small jug-like affair, the work of the queen, was separated by a fine web from the body of the tube.

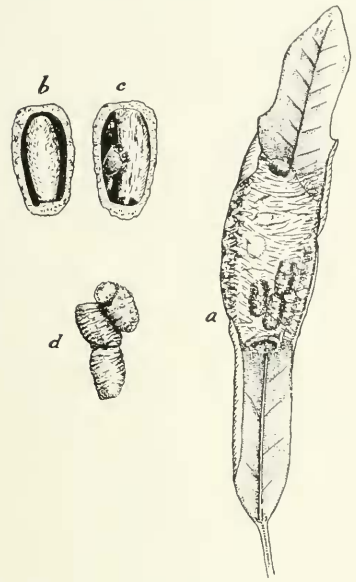


Fig. 48. a, Croton leaf with edges trimmed to expose silken retreat of jumping-spider (*Eugasmia* sp.). Towards the petiole the retreat is occupied by the nest formed by a queen ant of *Polyrhachis* sp. Three *Pseudagenia* cells are shown within. The opening to the nest is towards the top of the figure. b, Cells showing cocoon of *Pseudagenia*; c, Cell with cocoon of an ichneumonid parasite; d, Cells of *Pseudagenia*. b and c × 4/3; other figures reduced.

The mud cells (Fig. 48, d and b) are short and blunt; the cocoon within is thin and tan color and 8 mm. long, and the pupa well armed with abdominal and other processes. Notwithstanding the fact that the *Pseudagenia* cells are well hidden in the spider's web, a black and white ichneumonid wasp gains access to them and parasitizes them heavily, (Fig. 48, c). Hence the reason I reared none of the architects.

Pseudagenia sp.

Lower Makiling Forest, August 17. While observing *Hyloliris mandibularis* nesting in a large decaying tree trunk, I noticed a small spider-wasp enter a hole in the soft wood. Some saw-

dust just outside the aperture indicated that *Pseudagenia* had enlarged the burrow in this old honeycombed log. Upon excavating I found that the short tunnel contained three cells, each supplied with an immobilized spider. One of these had a wasp egg on it and another a third-grown larva. The spiders appeared to be ground forms; one was accidentally destroyed, while of the other two, the first had only the last pair of legs snipped off, while the second had all four pairs severed.

Pseudagenia macromeroides Williams.

Length 11 mm.; grey-black.

This ordinary-looking little wasp was not found to be common. From what few observations I have made on this species, I conclude that the larger cell groups indicate a semi-social habit; 25 or more amassed cells must exceed the labors of one wasp. The cells, which are made entirely of mud, are placed in groups in sheltered places, as within a bamboo node which has been partly hacked open. They are much smaller and more crudely made than those of the big *Macromeris violacea*, but resemble them in general form, (Fig. 49).

Fig. 49. Cells of *Pseudagenia macromeroides*. About natural size.

In a rather far-gone 16-cell nest I found an old crippled female and a male; other nests (cell groups) were deserted or occupied by ants. One cell contained a typical *Pseudagenia* pupa.

A *Pseudagenia*, which I never captured for identification, was common nesting in the bamboo wall-supports of nipa houses.* Several times have I seen this wasp, in my room, carrying her delegged spider beneath her and enter with it through the cut made for slats, into the node itself. Evidently this insect makes use of the mud from the cells of the house *Sceliphron* (*S. deformis*) to fashion her own cells. Water for moistening the clay was handily situated on my washstand, where some had been spilled on the oil-cloth.

A good-sized white and black cryptid wasp hung around the architect's doorway, but I drove her away before any damage was done. The household wasps find but little shelter in houses except from the inclemencies of the weather. Ichneumonid and

* **Nipa fruticans** Wurmb. is a native palm in tidewater lands, and whose leaves furnish "shingles" for bamboo frame houses and huts.

cuckoo wasps, bombyliid flies, ants and others follow her within and decimate her brood as they do outdoors.

Pseudagenia okawa Rohwer.

Length 9 mm.; gray-black.

Fig. 50. Bamboo twig split open to show the three cells of *Pseudagenia okawa*. Natural size.

Unless we make use of a good magnifying glass in our field study of wasps, many species are not to be separated from others. This is particularly applicable to certain wasps that prey on Orthoptera (grasshoppers, crickets, etc.) and to the large psammocharid genus *Pseudagenia*. Here, however, their nesting habits often help us; the shape, number and arrangement of the *Pseudagenia* cells aid in differentiating the species. So, too, with the twig-nesting wasp *P. okawa*. She looks much like some others, but nests differently. I found her partitioning off the hollows of slender twigs into from two to four cells and storing them with delegged spiders, (Fig. 50). I found but three nests—all in twigs on the ground in the shade of a large mango tree. The inner cell plugs are of mud, and the outer one, which shuts off her nest from the outside world—moisture and ants—is in addition, smeared with a gummy substance. I reared four *Pseudagenia okawa* in June, 1917.

Ageniella unifasciata (Ashm.) and *Ageniella williamsi* Rohwer.

Length about 7 mm.; fuscous spot on fore wing.

These two little species, save for the presence in *A. unifasciata* of a distinct median tooth on the margin of the clypeus, are very much alike. Both are abundant lowland insects. *A. unifasciata* may have as many as nine cells to a nest. The cells are commonly arranged in rows on walls, tree trunks, etc., and provisioned with a delegged spider. The cells may be also built on twigs.

* **Nipa fruticans** Wurmb. is a native palm common in tidewater lands, and leaves furnish "shingles" for bamboo-frame houses and huts.

A. williamsi builds a several-cell nest on small plant stems (Fig. 50a), under a clod of earth, etc. As in the first species, these are about 11-13 mm. long and more or less cylindrical.

Fig. 50a. Four-cell nest of *Ageniella williamsi*. About natural size.

Both species pursue their spiders quite fearlessly and bite some or all the legs off before dragging them, beneath their body, to the nest. I once came across a small *Ageniella* excitedly chasing a ground spider; she finally stung it, bit off some of the legs and proceeded to carry it away, when I caught a glimpse of a larger spider dashing toward it, and then our wasp appeared burdenless a foot or so away. Thus the larger spiders do not fear the smaller wasps, and rob them of their prey. So also will a larger *Ageniella* of the same species take over the pursuit and possible capture of a flushed spider, driving the rightful huntress away, who looks on while the chase is resumed. The cells of these wasps are much infested by an ichneumonid.

Ageniella banoensis Rohwer.

Length 13 mm.; grey-black, a fuscous spot on fore wing.

Except for her double size, *A. banoensis* is much the counterpart of the two preceding species. Not so common, she has rather different nesting habits than either, for although a true architect, she builds her mud cells in a hole in the ground, thus perhaps doubly insuring her brood.

On capturing a spider she has the most exasperating way of lugging it about and of making lengthy stops, thus taxing one's time and patience. Once, when under the shelter of a big mango tree, I noticed one of these wasps searching about a limited space of ground; it was evident that she had already flushed a spider and was now trying to find the fugitive. After circling over the ground for some time she aroused a rather long-legged but small-bodied spider, which she overhauled in an open place. The spider was courageous, however, and showing fight, tried to embrace her more agile foe and to leap upon her back. This *ageniella* frustrated, and in a skirmish crippled the spider with a sting; then she pounced upon its back and completely quieted it

by a sting in the neighborhood of the mouth. Then, following a brief delay, the wasp bit off the four pairs of legs at apparently one strong snip for each leg, the member being cut off at the next to last joint, leaving the coxal stub only. This operation, notwithstanding the several interruptions by wandering ants, occupied but a minute and a half. Thereafter she grabbed her prey by the anterior and dorsal portion of the body; she carried it beneath her, halting every now and then to fuss with her burden. This procedure was kept up for half an hour, when I captured the pair.

Another of these wasps was carrying a spider with three uncut legs. This burden was borne for about 100 feet before both disappeared in a shallow hole in a bank. This burrow, later on blocked up, contained three rather short but ample cells, in each of which was a more or less delegged spider with a wasp egg secured on the underside of its abdomen. The eggs were pearly white, somewhat curved, and 2.35 x 0.58 mm. in dimensions.

The second nest I located was a little way inside a rat hole in a bank. A short tunnel leading to a single cell contained a delegged spider. I interrupted the proprietress at work, and I here noted that she operates like the rest of her cell-making tribe. On this occasion she was gathering mouthfuls of moist soil about a foot away from her nest to seal up the entrance to her burrow, using the end of the body as a plasterer.

My observations on this insect were from March to August, 1917.

Pseudagenia aegina Smith.

Length 9 mm.; thorax red, two bands on forewing.

The nest of this pretty species is shown in Fig. 51. It was found well in the forest and was suspended from a bank by a small rootlet. It is made of rather dark soil or mud arranged so as to give the nest a granulated texture. It is one-celled and yielded a male wasp. The insect is not uncommon about the edge of the forest.

Batozonus bioculatus (Bingham).

Length 15 mm.; black; antennae, legs and wings largely orange.

During the rainy season this conspicuous orange-winged insect might often be seen searching for the corpulent web-spinning spider *Poltys* sp., with which she provisions her nest-hole. She is a handsome pompilid, and, apart from her gaily-colored wings,

has the antennae and one or two basal abdominal spots of the same orange color.

On two occasions I saw this wasp capture her prey, and on the first of these the performance on the part of the huntress was somewhat remarkable. During the latter part of August, 1916, I noticed one of these wasps hunting excitedly in a small garden plot at the College of Agriculture. The area had a few small bushes about its center and was bordered by a small ornamental plant, "Cucharitas" (*Alternanthera versicolor* Regel). To this Cucharitas border the wasp presently flew and, searching about, soon located a double spider thread, the two strands being quite close together and perhaps uniting further on, leading from this low border to a bush about four feet away and secured thereto, at a height of a little less than three feet from the ground, by several guy-threads. *Batozonus* was at first able to walk along this double rope, but farther along ran and flew rapidly over the single part, selected the correct guy-rope and thus located her prey in the bush. The spider did not question the wasp's motives, but dropped to the ground, crawled up the bush, and repeated this performance in an effort to escape. The poor arachnid, however, fat and stiff-bodied, was not of those swift species which frequently evade their would-be wasp captors, and so in a short time she was overhauled and effectively stung. Then the victorious wasp apparently fed for a while on the mouth-juices of her prey, but suddenly noticing a stream of small dark ants passing nearby, lowered her antennae in consternation and seemingly upon the nearest ants, and then grabbing her very large prize, she dragged it away to place it three-quarters of an inch or so upon a tuft of grass. The spider was eventually borne away and interred.

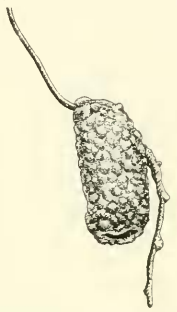


Fig. 51. Cell of *Pseudagenia aegina* suspended from a rootlet. Natural size.

On August 9, 1917, while on a hillside, I brushed a large-bodied spider off my person and then noticed that one of these yellow-winged wasps was searching the ground about my feet. She soon located this spider, which being rather clumsy hardly served to intimidate her, and so after a struggle she grasped and climbed upon the dorsum, and with her head towards the caudal end of the spider, stung it in the region of the chelae or jaws and immediately stopped its activity. Then seizing the spider with her mandibles by the base of one of the forelegs, she backed

away with it and placed it upon a little seedling plant two and a half inches in height. She circled about it so as to impress the locality in her memory and flew away in search of a suitable place to make a burrow. Soon coming back, she perched the spider upon another weed, commenced one hole, but abandoning this work, examined the spider once more, and going to another spot twenty to thirty feet away from her prey, she began digging for good, at 9 a. m. She bit out much of the soil and used her forefeet also in excavating. At 9:22 a. m. the burrow was about complete. It was nearly vertical and only about 1¼ inches deep. *Batozonus* now returned to the spider, grasped it by one of the hind legs and swiftly backed away with it towards the burrow. On her way thereto she encountered a cast-off skin of a spider; this she charged furiously for some seconds, and after this ridiculous performance resumed her journey. Halting about eleven feet from her burrow, she pulled her prey six inches up on a fallen twig, placing it in a fork; this act was carefully done, for the wasp saw to it, by quick pulls at the spider, that the latter was in a secure position. She resumed her digging, but visited the crotch several times to see that the spider was unmolested, and at 9:35 a. m. dragged the spider down and to within two inches of the burrow. Soon she seized it by the base of one of its legs and backed down into the hole and out of sight with it, the passage being a tight fit. *Batozonus* remained below for a few seconds only for the act of laying her egg, and could presently be seen, her head almost on a level with the surface of the ground; she was engaged in filling up the burrow, tamping down the soil vigorously with the end of her abdomen. This tamping was done with such a rapid motion that the wasp was seen to fairly vibrate in a longitudinal plane. She bit off the top edges of the burrow and sometimes brushed in a little soil with her forefeet, then tamped again. Tamping was long-sustained and constituted by far the principal filling operation, being very effective in making a firm blending core of soil. When the burrow was but little filled, the tamping insect was in an approximately vertical position. The tamping process was finished at 10:09, when *Batozonus* commenced backing over to the nest site, carrying in her jaws lumps of soil and other material wherewith to conceal the position of the burrow.

I caught this wasp and dug up the spider, which lay on its side, practically immovable at the bottom of the burrow. The wasp's egg was placed longitudinally on the abdomen, far to one side of the mid-ventral line, near the base. It was pearly white and polished, a very little thickest below its middle length and more rounded posteriorly. Moderately stout, it was gently curved

to conform with the profile of the spider's abdomen. Length about 3 mm.; thickness .8 mm. A cocoon dug up in the field was rather stout and of a tan color. In emerging the wasp had cut around the top of the cocoon, thus forming a neat circular lid.

Pompilus analis Fabricius and its Parasitic Relative, *Xanthampulex* (*Ceropales*) *luzonensis* Rohwer.

P. analis: Length 11-19 mm.; black; tip of abdomen red, wings clear.

X. luzonensis: Length 8 mm.; reddish.

Pompilus analis is well distributed in the Indo-Malayan region. This wasp is particularly interesting on account of the loose funnel-like depressions she makes in the soil to store her spiders in, and because of the fact that *Xanthampulex*, a smaller orange-colored wasp of the same family, robs the *analis* larva of its food supply and life by laying her own egg on the spider caught.

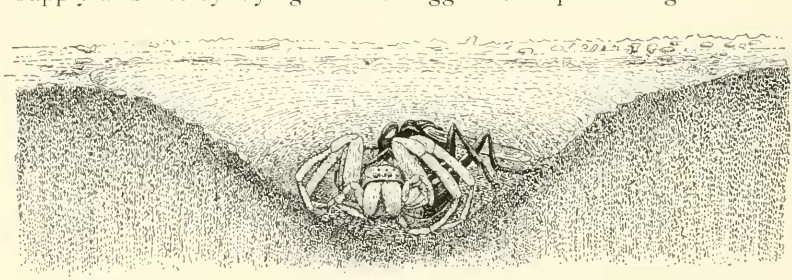


Fig. 52. Vertical section through the funnel nest of *Pompilus analis*, showing wasp in the act of laying an egg on the spider, *Heteropoda gemella*. × 3/2.

I found but two nesting spots of *Pompilus*, and these were at the foot of trees. The first and largest was discovered February 18, at the base of a large tree at the forest's edge, where, having been attracted to this tree by an inaccessible *Macromeris* nest, I came across *P. analis* disguising one of her burial grounds by placing debris upon it. In comparison with her size, she dragged pieces of wood, soil and leaves of prodigious dimensions and weight to this spot, and other heavy material she would test by pulling at it, and if beyond her strength, it was abandoned for portable objects. The soil about here was loose and dry, and I wondered that a wasp would barely cover up her spider in this region of ants and other enemies. I brushed the soil lightly

away from this spot and thereby exposed six long-legged spiders, stung to immobility or nearly so. Most of these had the full number of legs; one was already almost consumed by a stout, nearly full-grown wasp grub; three others had each a small grub upon them, the fifth bore a wasp egg, while the sixth showed neither egg nor grub. On March 3, I again visited this locality and scraped up three more paralyzed spiders, two bearing an egg, the third a larva. March 5, two more parasitized arachnids were exhumed. Thus it is probable this single *Pompilus analis* provisioned these eleven spiders within two weeks. Individual depressions—they cannot be called burrows—were made for the reception of her victims, and the whole nesting place covered an area of perhaps more than a square foot of ground, more or less protected by the buttressed portions of the tree trunk.

I saw *P. analis* carry home her victim, lay an egg upon its abdomen, and bury it. February 27, I saw her excavating. She would drag about large pieces of debris, then using her forelegs would dig with vigor in the loose soil and thereafter tamp down the slight excavation formed, by thumping it strongly and with vibrating speed, with the tip of her abdomen. The final result was merely a shallow funnel-like depression, and in such a cavity as this she buries her spider. Early in the afternoon of March 1, I noticed *P. analis* walking backwards, dragging a rather large and long-legged spider by one of its anterior appendages to the nesting place at the base of the tree; here she placed it in a small depression and commenced digging nearby. I took up the spider and placed it upon my knee, but she perceived the act and pulled the spider off, and resuming her digging, soon had a shallow funnel-like depression formed in the dry soil. To this spot she now dragged the nearby spider, and presently got upon its back, and grasping it with her legs, bent the abdomen beneath that of the spider and laid an egg near the base of the abdomen on the ventral side, the procedure occupying less than a minute, (Fig. 52). I immediately took up the spider to examine the pearly white egg and then replaced it in the depression. The wasp, however, did not know what to make of the interruption. Finally, when during her examination the egg dropped off the spider, she noticed this mishap and soon commenced digging and re-examining her prey. Half an hour was spent thus, except for two short trips that she made afield; after the second of these she got down again to business. She finished another funnel, dragged the upright spider to the middle of it, then she dug under her prey a little, and in the space thus cleared out repeated the process of oviposition, which again

occupied less than a minute, more than half an hour intervening between the two ovipositions. Now she straddled her exposed victim from different sides and brushed earth over it, and finally spread soil over the spot and smoothed it down. To make it firmer, soil was hammered down here, using her down-curved abdomen as a hammer, the point rapidly striking the soil, not by the muscularity of the abdomen, but through the leverage of the legs. This tamping occupied much time.

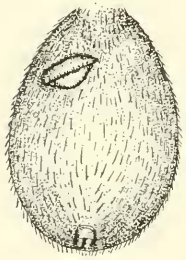


Fig. 53. Ventral view of spider's abdomen, showing the smaller, freshly hatched grub of *Xanthampulex luzonensis* attacking the larger, nearly hatched egg of *Pompilus analis*. Enlarged.

I brought home the parasitized spiders and soon noticed a small hymenopterous larva on the *Pompilus* egg, (Fig. 53). Where had the invader come from? If of the same habits as the parasitic *Ceropales* wasp noted by Adlerz (1903), the mother of the grub in question lays her egg when the chance comes in the field—when *Pompilus* has caught her spider and is proceeding homewards with it. Adlerz noted that *Ceropales* laid her egg in one of the breathing pores on the underside of the spider's abdomen. Here it cannot be brushed off as the spider is dragged to the nest, and as it precedes the egg-laying of *Pompilus* on this same spider, it hatches first, crawls out of its retreat, and consumes the rightful egg and eventually the spider. Thus, later on, when I had obtained several cocoons, some produced the smaller red *Xanthampulex* wasp and others *Pompilus analis*.

Another enemy of *Pompilus* is a very small tachinid fly. One morning, having seen a *P. analis* filling up her nest depression, I dug up the spider that afternoon and found on and about the wasp egg six little fly maggots, each perhaps one-third the bulk of this egg, which was soon eaten up and likewise most of the spider. The maggots then disappeared, to emerge fifteen days later as flies.

The egg in *P. analis* has an incubation period of about two and a half days, and its wasp enemy *Xanthampulex* has the life cycle (egg to adult) of about thirty-five days, and of this the feeding period of the larva was found to be eight days.

Psammochares luctuosus (Cresson), a common black spider wasp of the United States mainland, and now plentiful in the Hawaiian Islands, though digging a separate burrow for each of her spiders, has a tendency to bury all these close together.

AMPULICIDAE.

This is a small group of rather long-necked, often metallic wasps that prey on cockroaches (Blattidae). It seems that few of these wasps dig burrows; they are content with storing their victims in some pre-existing cavity and have even been known to use keyholes for nests. Many are forest insects, others appear more partial to cultivated areas, and at least one tropical species may carry on its hunting and nesting operations in houses.

They do not sting the roaches very severely, so that these often regain much of their former activity. The prey is usually stored in a cavity of some sort, which may or may not be stuffed with earth or other available material. While it is probable that one roach usually suffices as food for a single wasp grub, Bridwell (1917) records a case in which a South African *Dolichurus* supplied her cell, a mere unsealed hole in a stick, with two roaches, which the single grub consumed. Réaumur (1748), in speaking of the observations of M. Cossigni on a species of *Ampulex* on the Isle of Bourbon, states that this wasp, which preys on a large roach (Kakerlaque), will, when necessity arises, trim its prey by removing portions of its anatomy so that it will fit a selected crevice.

The egg is fastened to the underside of the roach, and the grub resulting frequently consumes the entire insect. Picard (1911) states that the larva of *Ampulex fasciata* Jurine enters the body of its host, wherein, after becoming full-fed, it spins a cocoon, which, as figured by Picard, bears a nipple-like process at each extremity. The cocoon of *Dolichurus stantoni* (Ashmead) has a curious ribbed structure at its anterior end, (Fig. 56).

Dolichurus stantoni (Ashmead).

Length about 7 mm.; shining black.

This glossy black little cockroach hunter is an abundant wasp. Noted for her extreme though very necessary activity, we find her patronizing the nectar glands of the sweet-potato vine, sipping honey-dew, or more rarely, searching among fallen leaves and clods of earth for the swift little cockroach *Blatella bisignata* (Brunner) that forms her prey. The wasp is a lover of sunshine and appears to be an inhabitant of the cultivated or semi-cultivated areas.

Dolichurus does not usually make her own tunnels; she seeks out a convenient hole wherein to store her prey or to pass the night. When the morning sun has stirred these wasps to activity,

their first thought after washing seems to be food and exercise, and we find that the males, which are smaller and with blunter abdomens and comparatively longer antennae than the females, are then more in evidence. Towards nightfall, however, the latter sex appears in greater numbers at honey-dewed shrubs, apparent evidence that the males "turn in" earlier.

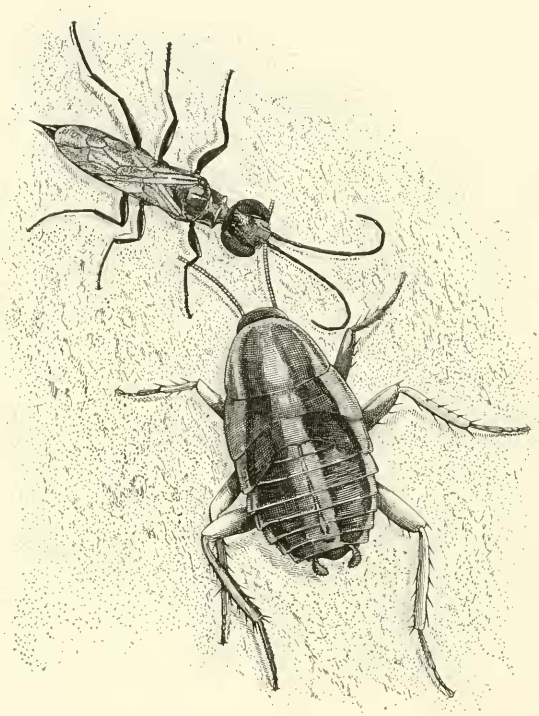


Fig. 54. *Dolichurus stantoni* dragging a young cockroach, *Blatella bisignata*, to her nest-hole, × 6.

Blatella bisignata (Brunner) is the most common cockroach of the fields. Occurring at all seasons of the year, it does not shun daylight, but may often be seen in the sunshine, running over the leaves of the sweet-potato, while if one disturb a pile of dead weeds, a number of the roaches exposed by this act will rush for shelter. It seems to be more plentiful in the immature or flightless state, when its two yellowish brown dorsal stripes certainly make it more conspicuous.

A female wasp sallies forth in search of her prey. She runs rapidly over the ground, peeking in cracks and looking under fallen leaves, etc. Once in a while she takes a short flight to some other hunting ground. Sooner or later the desired roach is flushed, usually an immature one, which departs with much speed, the wasp hotly pursuing. The fugitive is not satisfied with remaining in one hiding place, unless the shelter is exceptionally good, but decamps constantly. In a straight run the thoroughly aroused wasp is not the equal of her prey, nor does her vision appear to be especially good, but excitedly fluttering her half-raised wings she searches about, partly running and partly flying and circling. She may lose this roach, but eventually captures another, grabbing a cercus or leg with her mandibles and bracing herself as well as she can, holding on grimly, she brings her abdomen forward and soon stings her victim somewhere in the breast. The blattid is then done for; though not stung to immobility, it is now deprived of its swift action and behaves in a docile if stubborn manner as the wasp manipulates it. She grasps it near the base of an antenna, and backing away or running sideways drags her more or less resisting victim along, an awkward performance, (Fig. 54). Now she will release the roach and run about swiftly, seeking for it a temporary place of safety—a small tuft of grass, growing leaf, etc. Eventually returning, the prey will be hoisted upon the selected spot, and *Dolichurus* is off again to see about a burial place. Though she may enter what to the onlooker seems many a promising cavity, it is some time before she is satisfied. The roach may be visited again and again before she has decided upon its future home. Finally it is dragged in the same awkward manner to the crack or hole she has selected for it; the wasp lets go her burden here, enters, turns around and, partly emerging, pulls the roach inside. Some minutes elapse before *Dolichurus* reappears; she has worked over the roach and laid her egg on one of its mid-coxae. She may now cleanse herself somewhat and then sets to work filling up the roach's tomb. She picks up small lumps of soil in her mandibles and carries them into the cavity, gradually filling the same. The location is then disguised somewhat and the wasp takes wing.

September 12, 1916. A wasp utilized a short hole in a decayed twig which lay on the ground. The hole not being deep enough for the wasp, she took out some of the filling, went and got her prey—a young roach of another species—stored it and, coming out very shortly, filled the burrow.

July 11. Late in the morning I caught a female *Dolichurus* and put her in a vial. Then I placed a lively young roach with

her. The vial was a very small one, and so the proceedings could be studied minutely. After a few seconds the wasp became interested in the roach, which she spurred on with short runs, from one end of the tube to the other, and soon administered one or more ventral quieting stings. Then, placing herself venter to venter and head to head to her prey, she operated her jaws on the anterior (inner) disc of the labium—perhaps the tongue—of her victim, for the purpose, I should judge, of sucking out its mouth juices. This act was viewed under a strong lens. It was not an act of kneading with the mandibles, or malaxation. Soon I placed the two insects in a properly prepared jelly tumbler, and though the wasp died the day following, she had oviposited on her victim and buried it.

Fig. 55. Ventral view of *Blatella bisignata*, showing *Dolichurus* egg on right middle coxa, × 5.

Although *Dolichurus* is perhaps the swiftest and most restless digger-wasp that I have seen, she works fairly well in captivity. During the summer and late summer of 1917 I had occasion to breed some of these wasps for colonization purposes. A strongly-made wooden cage with wire-netting windows, and of about 20 cubic feet of space was used. The floor was covered with fine earth into which was inserted a few little plants, and a large number of clay cells an inch or so deep were obliquely sunk to their mouths in this soil. Then after some difficulty a good number of roaches, nearly all young, was liberated in the cage, and finally thirty or more female *Dolichurus* were admitted. They had sunlight a good part of the day, and water was sprinkled daily in the cage and much-appreciated honey was applied to the screen and plants. During their week's stay in the cage the wasps became quieter and even exhibited some attachment for their prison, for if one managed to escape she would linger about the cage so that she could be readily retaken. Towards evening they went to bed in the mud cells or under them, to arise the next morning when it became sufficiently warm. But though assembled in rather large numbers, not a natural condition, they were by no means fond of each other's society, as we shall very soon see. A rightly-disposed wasp would in the course of her

meanderings give eager chase to the cockroach she had aroused; she might finally succeed in catching and stinging it, and if undisturbed (an improbable thing), would haul it about the cage, especially about the screen sides and ceiling, backing up with her burden. Finally she would deposit it somewhere and search for a nesting site, choosing in the end one of the mud cells. This she would enter and re-enter and then depart for her prize, which she would drag for a way, drop it, and visit the selected cell again. She might do this several times, bringing the burden nearer at each inspection. When the roach finally reached its tomb it was deposited directly in front of and facing the latter. The wasp entered for a last inspection, turned around, reached out and pulled in her prey by its antennae. She remained some minutes within, when she came out and commenced filling the cell with lumps of soil. This was quite a job, the wasp sometimes bringing in pieces as big or bigger than herself, and far weightier. It is to be noted that she always used her mandibles and not her legs in filling a burrow or in clearing one.

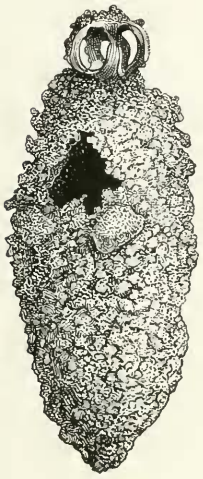


Fig. 56. Cocoon of *Dolichurus stantoni*, showing emergence hole, × 9.

Thus acts an unmolested *Dolichurus*. But alas! what turbulent scenes filled that cage! Brigandage and grievous quarrels were the rule! Death sometimes resulted! *Paragenia*, if we remember her, is a wasp so peaceably disposed that she often nests in small colonies, where the wasps "butt in" constantly, and with apparent safety, on their neighbors' business. The very antithesis of this conduct is here manifest. A dolichurid captures a roach; the scene occurs within eyesight of a larger wasp, who gives battle to the rightful owner. While this rough-and-tumble fight is in full swing, a third wasp, seeing the prostrate cockroach, appropriates it and drags it afar. After the combatants separate, each rushes about anxiously, with upraised wings, seeking the roach.

An inquisitive wasp enters a cell in which there is one of her busy sisters engaged perhaps in the delicate operation of laying her egg on the roach. The intruder hurries out, pursued by the very indignant occupant. Let even a wasp pass too near another's cell, to one filling her tunnel, and there is a fight or a flight. Oftentimes a wasp will choose a certain cell or small part

of the cage as her private property and dart down upon a passer-by.

Such affairs may happen frequently of an afternoon, and in consequence greatly reduce the number of roaches parasitized. The fights among the wasps are very fierce and often last many seconds. Of course, their movements are rapid, but the little wasps are stiff in their heavy armor; they do not fight face to face, but endeavor to curl about each other's middle, their heads often or usually free of each other, their stings likewise. They fight in a sort of jerky manner—with their legs it would appear—perhaps using their stout and no doubt powerful coxae and femora. At any rate, permanently disjointed wings or legs sometimes result, and a weakened insect may be attacked again so that it eventually dies.

Seldom does a dolichurid attack a mature *Blatella*; these are too swift and powerful. I saw one of these wasps being dragged rapidly over the ground and under a clod by one of these roaches, which finally freed itself of the unwelcome companion.

The egg of *Dolichurus* is pearly white, slightly curved and rather slender. It is deposited for its length along the outer face of one of the middle coxae, its blunter and broader end nearer the base of the latter, (Fig. 55). The roach which bears it has usually lost the greater length of its antennae, and becomes moderately active, without regaining the power of making a long-sustained or rapid run. One such insect which I kept in a small vial had a decided appetite and ate pineapple, etc., until weakened by the larva. The egg hatches in a little over thirty hours, the head being at the blunter end, which lies near the base of the leg and where there is a convenient soft area whereon the larva may commence feeding.

The following is a life-history table:

Egg laid	Egg hatched	Cocoon formed	Adult emerged
July 10, 11:40 a. m.	July 11, 9:15 p. m.	July 15, 6:00 a. m.	Aug. 1
July 11, 3:00 p. m.	July 12, 7:15 p. m.	July 16, 7:00 p. m.	Aug. 2
Sept. 12, 4:15 p. m.	Sept. 14, 10:00 a. m.	Sept. 19, 6:00 a. m.	

It is seen from the above that the life history for a fossorial wasp is remarkably brief, though doubtless during the cooler months the cocoon stage is considerably extended. Segmentation is visible in the egg some hours before it hatches. The larva works itself out of the thin shell, which then forms a sort of adhesive bed for it on the roach's coxa. It is large-headed and its undulating mid gut shows a sort of orange color from

ingestion. At first it feeds externally—that is, with its head pressed against the roach's body, so the latter suffers little injury —but the grub grows rapidly, both in size and appetite, and inserts its head and a portion of the thorax into its victim's body and quickly sucks out the life juices. The roach is soon reduced to a mere shell, which the grub also devours. The dirty white larva now spins its cocoon (Fig. 56), a tough and non-flexible affair, lined inwardly with silk, outwardly covered with grains of earth, etc., and terminating in a curious ribbed structure which the grub spins through the anterior end of the cocoon proper. The wasp in emerging from the cocoon bites out an irregular hole near the anterior extremity.

As an adult *Dolichurus* has a long season and in consequence several generations yearly; it was found from March to September, and was very plentiful in May, June and July. It is now established on the Island of Oahu, Hawaiian Is., from specimens shipped in from Los Baños in 1917. It spread rapidly, and very soon made its appearance in the moist mountain forests of the island. On January 7, 1919, I saw several specimens along a roadside at an altitude of about 450 feet, and approximately 12 miles (airline) northwest of its point of liberation back of Honolulu.

The genus *Dolichurus* seems best represented in the Old World tropics; they are rare in Europe and also in America; there seems to be only one representative in temperate North America.

Ferton (1894) has studied the habits of *D. haemorrhous* Costa near Marseilles, France. It captures a roach (*Loboptera decipiens*), which it buries in a hole 7-8 cm. deep. The egg, which is 1¼ mm. long, is glued to one of the middle coxae; it hatches in 3-4 days, the larval feeding stage is about eight days, and the insect passes the winter in the cocoon, which, by the way, lacks the terminal hoop-like process of *Dolichurus stantoni*. Turner (1917) speaks of Lefroy capturing the Indian *D. gilberti* Turner "preying on small Blattidae."

SPHECIDAE.

Sphecinae.

A large subfamily, for the most part consisting of good-sized wasps. Their habits are very diverse, for where one digs tunnels far away from human habitations, another is the tame creature that plasters her mud cells against our walls and stuffs them with spiders. Like the swifts and swallows among birds, the Sceliphronini among wasps frequently take advantage of the works of man as a convenient nesting place.

The Sceliphronini or mud-daubers make up a very cosmopolitan group and are the familiar thread-waisted wasps often seen at wayside puddles, where they gather mud for nest-building. All, as far as known, prey on spiders. The nests of the Sceliphronini are more or less characteristic in the size, shape of cells, etc., for each species. While the common metallic blue *Chalybion caeruleum* of America makes entire cells of mud, her equally abundant sister *C. violaceum* of the Old World seems merely to plug up ready-made cavities. Maindron (1878), in speaking of *Sceliphron lactus* in the Moluccas, says that in building a cell the insect leaves both ends open until the last, so that she may the more readily enter and leave it; he adds that the wasp passes the night in one of the cells. This is an unusual procedure for insects of this group, which are commonly recorded as sleeping some distance from their nests.

The spiders which these mud-daubers capture are relatively small and easily handled; sometimes they are stung to death, and in other cases paralyzed. I once saw a *Sceliphron caementarium* in Hawaii suspended from a leaf by her two hind legs while with the other four she held an attid or jumping spider, and, bending her abdomen forward, stung her captive on the underside (the side facing her body) of the body.

The genus *Podium* of the American tropics is related to *Sceliphron* and is likewise a mud-dauber of the household as well as of the forest, but stores her cells with small cockroaches (Howes, 1917).

The genus *Ammophila*† comprises slender digger wasps, of interest because of the care and precision with which they sting and paralyze their caterpillar victims, and are remarkable for other nesting instincts.

The genus *Chlorion* with its subgenera includes some handsome wasps of stout build, many exceeding an inch in length. They are familiar the world over, and although frequently loud and threatening in their actions and sometimes nesting in large colonies, never attack one. The Philippine species, of which I collected eight, have much the same habits as their relatives in other parts of the globe; they store their nests, commonly one-celled burrows, with paralyzed locusts, grasshoppers or crickets. Different *Chlorion* species usually have somewhat different nest burrows. Thus *C. aurulentus* var. *ferrugineus* is the most domestic and fearless of the lot, and digs her short tunnels next her neighbor's under the shelter of eaves, buildings, etc., and even deigns to hunt her prey in Nipa houses; *C. umbrosus* var. *plumi-*

† Now referred to as **Sphex.**

ferus nests also in colonial style, in cultivated areas, and digs deep burrows, but away from the homes of men; a wary coal-black species was seen digging her ten-inch-long burrow in bare cultivated ground and storing brown tree-crickets (*Mnesibulus bicolor* Haan); in the shade of the forest a smaller red and black *Chlorion* was found nesting in a hole in a decayed log; a slenderer wasp of the *Isodontia* group, provided with slim mandibles, and legs unfitted for digging, was observed gathering tomentum or wool-like material from the underside of a green leaf, and she evidently makes use of some pre-existing hollow as a nesting place, dividing off cells therein with the material gathered. This is in keeping with the habits of the American *Isodontia philadelphica* and *elegans*, the former using the modified leaves or "pitchers" of *Sarracenia flava* (Pitcher Plant), which she partitions with moss, the latter wasp (Davidson, 1899) using the stems of White Sage (*Audibertia polystacha*) and dividing the hollow with fibrous bark. Both store tree-crickets (*Oecanthus* sp.). *I. elegans* has also been found by S. A. Johnson (Fernald, 1907) nesting in burrows made by the bee, *Anthophora occidentalis*, and Rau & Rau (1918) have found *Chlorion* (*Isodontia*) *elegans* using an old Carpenter-bee tunnel.

C. lobatus Fabricius, a large brilliant metallic blue species of India, is, according to Dutt (1912), put to ornamental use. He says, p. 226: "In Bengal ladies make a charming use of the delightfully brilliant skin of this wasp. Circular discs neatly cut out of its body are fixed in the center of the forehead by the way of ornamental decoration. The wasp is known there by the popular name of Kauch poka, or the Golden Insect."

A feature especially applicable to the Sphecinae is the squeaky little buzz they emit while at work. Most observers interpret this sound as one of pleasure, but Latter (1913), speaking of *Ammophila sabulosa*, says that "She kept up an angry, rasping buzz which effectively scared away a fly of parasitic (cuckoo) habit. * * * I have little doubt that the noise serves to warn off intruders on mischief bent." Who knows!

Chalybion violaceum (Fabricius).

Length 17 mm.; slender; iridescent blue.

This brilliant and common household insect can hardly be said to construct mud cells, as in the blue American species; she is a poor architect that stores her small spiders in some convenient hollow, as a rung socket, penholder base, old mud-wasp nest, etc., and simply plugs up the aperture, first with mud or

moist earth, and finishes this off with a mixture formed of the excreta of geckos (lizards), giving the plug a whitish or plaster-like appearance. D'Herculais (1882) has also noticed this curious habit in the case of *C. chalybeus* at Port Natal (Africa), the material there used being bird excrement.

One cell of *C. violaceum* formed in the base of a penholder contained 13 spiders, representing 7 or more species; upon the abdomen of one was a wasp egg. The cocoon is dark, thin and torpedo-shaped. The insect has a long quiescent period in its cocoon, for while the adults were abundant about houses in early spring, a little later they were mostly in the cocoon stage, remaining thus for some months.

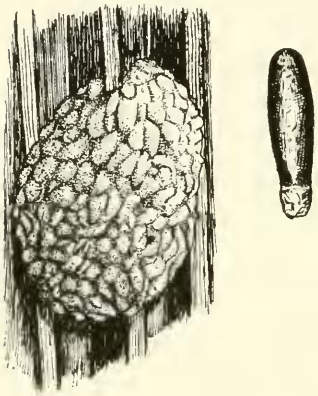


Fig. 57. Completed nest of *Sceliphron intrudens* secured on underside of palm leaf. Reduced. Cocoon of same; slightly enlarged.

Fig. 58. Two-cell nest of *S. intrudens*; unfinished. Reduced.

Sceliphron intrudens (Smith), var.

Length 27 mm.; black; wings and legs (in part) orange yellow.

This is one of the largest and handsomest of the Sceliphronini, and while not so common as its smaller Philippine cousins, is, nevertheless, a familiar insect, as it bites out mouthfuls of mud in moist places along the lower forest trails. Although she will fasten her heavy, ball-like nest far up on the rafters of Nipa houses, she appears more at home out of doors, nesting under the shelter of the fan leaves of the "Buri" palm (*Corypha elata* Roxb.) (Fig. 57), or else high up on a forest vine, fully exposed

to the inclemencies of the weather. The nest is a heavy mass of clay streaked with little ridges and enclosing several cells. At first the cells, which are built parallel to one another, have only medium-thick walls (Fig. 58); when their number is complete, however (usually three to five), their exposed surfaces are covered by additional mud, with the final effect as shown in Fig. 57. A cross-section of such a nest will show vault-like cells—their inner walls only 1 or 2 mm. thick, their outer 5 mm. or more. I opened several nests; some of the cells had been appropriated by a colony of *Crematogaster* ants, while others contained or had contained parasites—in one case a brilliant green cuckoo wasp, in another 20 muscoid fly puparia. Another nest had part of its cells occupied by a pompilid wasp, *Pseudagenia*, that had subdivided the large cell to suit her needs. Several of these wasps were reared. Another cell of this nest was used by a leaf-cutter bee (*Megachile*) as a home for her brood, while still another contained some decayed lepidopterous larvae, indication that the eumenid wasp *Rhygchium* had come in for her share of cell space. Thus three species of Hymenoptera had made use of this nest, and such a circumstance recalls my reading somewhere of annoying mistakes made by observers in giving a wasp the credit for building a nest which is really the work of another species.

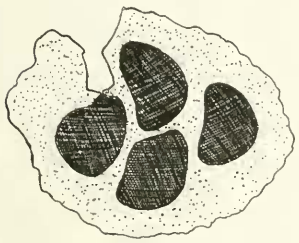


Fig. 58a. Cross-section of a completed nest of *S. intrudens*, to show the thick outer walls. Reduced.

This big mud-dauber stores her cells with a variety of spiders, some of goodly size, and on one of which, in each cell, she lays an egg; this is somewhat curved, 4 mm. long by about 0.9 wide. It is placed on the underside of the abdomen of a quiescent spider. The grub which hatches feeds at first immovably, sucking its victim's juices; later on it transforms into the biting stage, when it consumes the spiders by chewing them up. When full-fed it measures about 26 mm. long, is rather slender and of a pale dirty brownish yellow color. In spinning it first makes a weak scaffolding of silken threads and then forms the typical thin, blunt cigar-shaped cocoon, in this case quite dark in color (Fig. 57).

Some of the completed nests are two-thirds as large as a tennis ball; the wasp often spends many days in adding to the

bulk and ornamentation. One such large nest kept the architect employed for over a month.

Sceliphron works rapidly, fetching rather large pellets of mud in her mandibles; she places one on the nest and quickly stretches it downwards a little, and works briefly over it, up and down, emitting the while a squeaky buzz.

Building operations were observed from March till August, 1917.

Sceliphron deformis (Smith).

Length 19 mm.; black, with yellow bands on thorax and abdomen.

This is the most domestic of the Philippine Sceliphronini, but at the same time a common forest wasp. This species more than the other kinds observed is fond of concealing her several-celled clay nest (Fig. 59), and thus when building in bamboo houses she will select a dark and hidden place therein, as behind a book case, or more commonly will enter the bamboo wall poles at their intersection with the bamboo laths, and there emit her speaky buzz as she manipulates a mud pellet. In the forest her cells are not infrequently plastered flat against some sheltered bank. The cells (Fig. 59) taper in characteristic fashion at the posterior extremity and are finally daubed over with a protecting layer of mud.

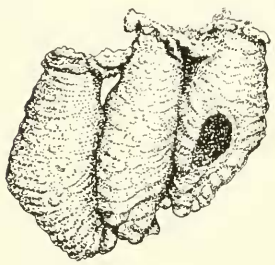


Fig. 59. Three-cell nest of *S. deformis*; one cell hatched. Natural size.

In hunting for her spider prey the wasp runs very rapidly along the branches of trees, flying from one to another in her quest.

The very open houses of the tropics do not exclude wasp parasites, and so we find several of these which attack the cells of our *Sceliphron deformis*. One is a small muscoid fly, another a golden bombyliid or bee-fly, while a third is a black and white cryptid wasp whose grub spins a delicate white cocoon in the usurped cell. A steel-grey spider wasp (*Pseudagenia*) often appropriates cells in a *Sceliphron* nest, subdividing these with mud to suit her needs; thus one cell is converted into two or three *Pseudagenia* chambers, into each of which is stored a delegged spider.

My notes on this wasp are from June to August, 1917.

Sceliphron madcrospatanum (Fabricus).

Length 18 mm.; black; yellow on thorax, legs and pedicel.

One of these common little lowland wasps built her mud cells in the College insectary, plastering them on the under surface of the metal lid of a jelly tumbler, said lid being jammed into another so that the undersides faced each other and presented a wide gape to one side. She was an exceedingly tame insect, and I could pick up the lids, gently separate them and minutely examine her at work. Sixteen days were required to complete her 9-cell nest, whose rather thin-walled cylindrical cells she arranged in two rows, and as they were stored, she plugged them and plastered over the space between them with mud. Although a swift worker, she did not keep regular hours, nor fill one cell as quickly as another—weather and material regulated her activities to a certain degree. Being in plain view from the insectary table, at which I spent a good deal of time, I was able to keep pretty good tab on her operations. She did not sleep in the vicinity of her cells, but would arrive at her nest not earlier than 7:30 a. m., sometimes as late as 9, and once at 10:20 a. m.; and on the next to last day I did not see her at all. Her day's work was completed at a comparatively early hour, often at 3:30 p. m., though she would sometimes be seen much later, but not at work. She could build a cell in from half to three-quarters of an hour; the mud is brought in her mandibles and probably other mouthparts supporting, and applied to the desired spot and drawn with a series of biting or munching motions, first downwards and then upwards, the forefeet on either side appearing to support somewhat the fresh mud. The cell complete, the next step was to fill it with numerous, rather long-legged spiders of divers kinds; these were captured outside the insectary, the wasp flying with one to near her nest and performing the rest of the journey on four feet, the front pair of legs and her jaws holding the victim closely to her chest. The egg is laid on the first spider introduced. The wasp, after examining this spider, backs out of the cell, turns about and then backs in and lays the egg; this is shining yellowish white, of nearly uniform thickness, slightly curved, and about 3.10 mm. long by 0.85 mm. wide.

It usually happens that she is unable to completely store a cell in one day. Leaving her victims in an open receptacle exposed to the attack of ants is not to be thought of, so the cell is temporarily closed for the night with a thin concave disc of mud very different from the stout and permanent plug used when storing is complete. One load of mud with a few bites of dried clay from the cell itself is sufficient material for this disc. It is

noteworthy, however, that even though a cell be completely built, so long as it contains no spiders at the close of day it is left open. Sometimes when spiders are slow in coming, a temporary plug is put on for two nights in succession, the plug being removed in the morning in about five minutes' time.

The mother wasp, hard worker that she is, undoubtedly secures sufficient food at flowers, and such meals may partly account for her irregular working hours. But this specimen was fortunate in eventually discovering a jar of honey on a nearby table; to this she helped herself frequently and with evident relish; I took advantage of her docility and managed to have her crawl on my finger and there feed at a drop of honey.

My observations on this species were chiefly in July and August, 1917.

Chlorion aurulentus (Fabricus), var. *ferrugineus* (Lepeletier).

Length 27 mm.; black; head and part of thorax with golden brown pubescence; legs reddish, wings iridescent purple.

During July and August this large reddish brown wasp is noticeable because of her fondness for human habitations; she may often be seen hunting for her prey about the walls and ceiling of Nipa houses, and small colonies frequently nest in the dry soil sheltered by eaves, or the wasp may even burrow in a shed or stall.

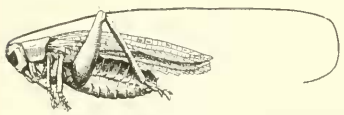


Fig. 60. *Gryllacris brevispina*, prey of *Chlorion aurulentus* var. Natural size.

C. aurulentus excavates several rather shallow tunnels, apparently one-celled, which she stores with *Gryllacris brevispina* Stal., a brown tree locustid, (Fig. 60). The capture of the latter is a rather interesting spectacle. The prey, though of smaller size than the wasp, is a stoutly-made carnivorous insect, which feeds by night, hiding during the day in leaf-roller nests whose caterpillar occupant she has probably eaten, in the hanging bunches of the leguminous pods of *Leucaena glauca* (L) (*Ipel-ipel*) or among dried leaves on trees or shrubs. The loud-buzzing *Chlorion* visits such objects as the above, and locating a *Gryllacris*, proceeds to eject it from its place of concealment; but the hunted insect is loath to get out and the hymenopteron, not anxious to enter, tries various devices whereby she may safely reach her prospective prey. One wasp searched the curled and dead leaves on a coffee bush. She finally selected a leaf,

bit into it at various points, and tried to unroll it with her stout legs and mandibles. But the enclosed locustid was "sitting tight." At last the wasp worked a good-sized hole in the lower end of the leaf, and now at this opening and now at aperture above, inserted her abdomen and worked it about, evidently in an attempt to locate and sting the occupant. Finally she urged it out from below and it fell to the ground; at this point the *Chlorion* was disturbed and hardly followed up her success, but tried another leaf, a rolled-up green one from which she quickly expelled the sluggish occupant, and following it to the ground, paralyzed it with a sting. She flew with it to a tree, and at this juncture I captured her.

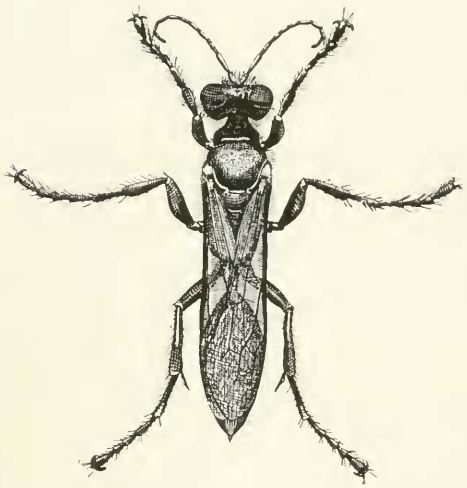


Fig. 61. *Chlorion umbrosus*, var. *plumiferus*, ♀, × 2.

One of the *aurulentus* burrows which I dug up was oblique and extended about two inches below the surface. The single terminal enlargement contained three *Gryllacris*, one a mature female, the others young. They were paralyzed to a degree, and the smallest had a freshly-hatched wasp larva feeding between the first and second coxae. A cocoon which I dug up was rather stout, pale brown and about 28 mm. long. The wasp frequently excavates in decidedly hard ground.

Male *aurulentus* are sometimes taken at the flowers of *Premna odorata*, a verbenaceous tree.

Chlorion umbrosus (Christ) var. *plumiferus* Costa.

Length 29 mm.; black; silvery hair on head and thorax, wings nearly clear.

Probably the best known oriental *Chlorion* (Fig. 61) and one of very wide distribution.

At Los Baños it was the commonest of the big wasps and

quite sociable among themselves; several females would nest close together at the bases of small plants or bushes in a garden plot on the college grounds. The considerable heap of soil brought up in excavating the burrow would readily locate it; else the loud though harmless buzzing of the proprietress would serve this purpose.

The tunnel at first slopes but little, then it goes down steeply from 10 inches to over a foot, piercing a tough stratum of clay. It is one-celled and provisioned with various locustids, grasshoppers, young or mature; cone-headed grasshoppers and *Ducetia adspersa* Brunner being among the commonest. The latter insect, by the way, is quite a nuisance, for it devours the ornamental flowers of the various *Canna* which are commonly grown as border plants, and *Chlorion* does a good work in reducing this pest. The paralyzed prey may be larger than its captor, but never so heavy that it cannot be carried on the wing. Several are stored in a single cell and the *Chlorion* egg placed between the first and second pair of legs. The egg is 5 x 1 mm., and slightly bowed. I fed a couple of the larvae to full growth, when they measured about 37 mm. long. About four and a half days were required for this feeding stage, when one of the young wasps consumed four rather large grasshoppers and two small ones which I captured and incapacitated.

Fig. 62. Cocoon of *C. umbrosus* var. Natural size.

The silken cocoon (Fig. 62) is about 35-36 x 8.5-9 mm., and therefore more slender than that of either *C. aurulentus* or *A. mutica*; it is also considerably thinner and of a brownish yellow texture. The insect passes the dry and cool months in this stage, remaining in the cocoon as a resting larva.

Bingham (1900-1) speaks of a variety of *Sphex umbrosus* nesting in a large colony at Mandalay. He says in part:

"Today I went down in the morning to see the swarm by daylight, and a marvellous sight it is.

"The site of the barrack, round which the *Sphex* was swarming, was on a slope. To get a level space for the building the ground had been cut away to the west, leaving a perpendicular bank, extending along three sides of the end of the barrack at a distance from the edge of the lower verandah of from twelve to fifteen feet. This space for a length, as I have said, of forty or fifty yards, as also the perpendicular face of the bank itself, was one mass of the wasps' burrows. There must be some thousands of the insects about, and the loud buzzing, with the incessant motion of the brilliant little creature flying, digging, walking around, is most astonishing. When disturbed they rose in clouds and flew about

one's legs, but did not attempt to attack, as the true wasps (*Vespidae*) or the honey bees (*Apis*) would have done.

"A noticeable thing was that the openings of the burrows all faced the verandah, the direction of the burrows radiating outwards from the barrack. One or two that I dug up showed that they had been tunnelled obliquely into the ground for about a foot or so and then, turning at an angle upwards, ended in a slightly enlarged oval chamber. If one stood still the wasps took no notice, but continued their work unconcernedly, some walking about with the alert jerky air and quivering of the wings peculiar to fossorial wasps, others dug on industriously, paw over paw like any terrier, while others continued bringing in their captures of green grasshoppers stung into a state of unconsciousness. These they stuffed, and pulled and pushed into their burrows always head downwards. The grasshoppers I found belonged to the family *Locustidae* and all that I saw were in the immature stage, unable to fly.

"Of other species of *Sphex* I have found and dug up at various times the nests of *Sphex aurulentus* Fabr. var. *ferrugineus* Lepel., and *Sphex nigripes* Smith. The latter I found provisioning its nest like *S. umbrosus*, with immature *Locustidae*; while in the nests of *Sphex aurulentus* I found only the immature forms of some large species of *Acrididae*. It is probable that the species of *Sphex* keep to *Orthoptera* as their prey; each species confining itself to some one species of locust or grasshopper, for the captures I found in the nests of *S. nigripes* belonged to a different and larger species of the *Locustidae* from the species I found *Sphex umbrosus* bringing in as noted above."

Chlorion luteipennis (Mocsáry).

Length 30 mm.; black; wings orange.

During May, 1917, a small colony of this rather scarce insect was found nesting in a sandy excavation, digging gently sloping tunnels 10 to about 18 inches long and storing them with Locustidae. The prey is deposited before the burrow and the wasp entering turns about, grasps the locustid's antennae in her mandibles and drags it within. The wasp's egg is shining creamy yellow, 6 mm. long and 1 mm. wide, gently curved, and is secured ventrally on the locustid, being transversely fastened on the anterior edge of the mesosternum just inside the left fore coxa, (Fig. 63). I reared one larva until it was 22 mm. long. A single tunnel was found to have two horizontal cells instead of the usual single one. Some of the cell contents had been destroyed by small ants.

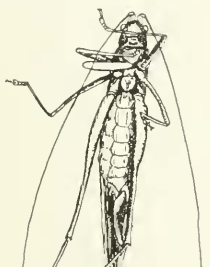


Fig. 63. Ventral view of grasshopper, showing egg of *Chlorion luteipennis* secured on its thorax. About natural size.

By July 10 the colony had disappeared. Like other lowland forms, these wasps are greatly annoyed by ants, especially the ubiquitous *Pheidolegiton*, and this must partly account for the scarcity of the *Chlorion*.

Ammobia mutica (Kohl).

Length 29 mm.; black; wings iridescent purple.

During August and a part of September, 1917, several of these fine dusky wasps were observed digging their burrows in a flat area well shaded by sparse though wide-spreading vegetation. The burrow is at first vertical, or nearly so, to a depth of about three inches, when it extends horizontally for about two or three inches more, the terminal portion being somewhat enlarged to form a cell. In making this burrow the rather shy and fickle insect bites out the rich soil with her stout mandibles and also scrapes away the dirt with her well-fringed forefeet, the tarsi of which when so used are curved inward and upward, thus forming a sort of rake.

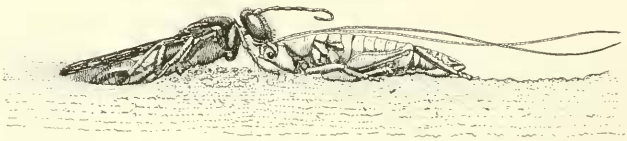


Fig. 64. *Ammobia mutica* entering burrow with prey. About natural size.

The wasp stores the cell with the young of various Locustidae or long-horned grasshoppers, upon the first one of which brought in she deposits an egg; this is pearly white, slender and curved, and about 7 mm. long, and transversely arranged on the locust's breast between the first and second pair of legs. She is careful to close up her burrow after she stores each victim. From an examination of several burrows it is evident that the provender is often slow in coming and the wasp larva may be as much as half grown before the cell is completely stored. The wasp provides her cell as time and weather permit, and, working as she does in the middle of the rainy season, heavy precipitation must often retard or even undo her labors. Several times I saw this *Ammobia* fetch a locust to her burrow. She would fly very easily with her prey, alight to deposit it on its venter or side a couple of inches before the closed burrow, and commence to open up the latter, and as the tunnel was stuffed with soil only for an

inch or two down, this was quickly done. Our wasp now backs out to the surface of the ground, where she turns about and, grasping the locustid by the head or thorax, backs in, dragging her prey after her (Fig. 64). I dug up the burrows of two or three of these wasps shortly after they had brought in one or more grasshoppers, and found in one case ten grasshoppers, evidently of three different genera, and a small wasp larva; in the other, nine or more victims, one constituting a fourth species to the bill of fare, and a half-grown wasp larva. Some of the locusts appeared to be of a carnivorous type. Other newer burrows contained a single grasshopper bearing a wasp egg.

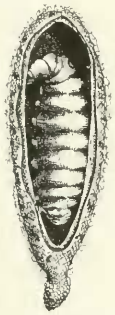


Fig. 65. Cocoon of *A. mutica* cut open to show resting wasp larva within. Natural size.

Fig. 66. Female pupa of *A. mutica*. Natural size.

In plugging up her burrow temporarily, the wasp scrapes in the dirt with her forefeet and tamps it down with her head. The burrow might not be filled quite to the level of the ground, so that one could find it readily enough. However, when a sufficient number of grasshoppers is stored, *Ammobia* fills up the burrow for good; a painstaking job when compared with the previous temporary closures of the abode of her young. One wasp took twenty minutes at this task. She fills in carefully and does much tamping with her head; the burrow is plugged to the level of the surrounding ground and its situation disguised by scraping and distributing debris over it.

The wasp provides several burrows during her lifetime. Storing them at irregular intervals, and even when the young wasp occupant is eating, cannot be called feeding her grub from day to day and is by no means a step towards social evolution. It is interesting to note, however, that this wasp (and others as well) knows how much food her grub requires, though her provisioning may and often does extend over a period of several days.

I kept several of the wasp grubs in jars, and when their supply of food gave out, fed them with locustids which I had captured, having cut off their legs and portions of their heads so as to render them harmless. These were readily devoured. Three of the grubs reached their full growth and spun cocoons, (Fig. 65). The full-fed larva is of a dirty whitish color and has a straight length of about 36 mm. and a width, below its middle portion, of 9 mm. The head is small, the lateral body fold distinct, more scalloped anteriorly, and the posterior end of the body is broadly rounded-truncate. Compared with the larva of the big black *Macromeris* wasp, that of *mutica* is more slender and has a smaller head. The cocoon has a length of about 39 and a width of 14.5 mm. There is plenty of scaffold silk work. It is rich golden brown, darker, stouter and stronger than that of the related *umbrosus*, and consists of two well-separated envelopes. It is widest above the middle and tapers more gradually posteriorly, where it terminates in a sort of nipple.

I brought three of these cocoons with me to Hawaii. Next year, May 28, 1918, becoming impatient, I cut open the cocoons to find two mouldy and the third containing a resting larva (Fig. 65). As in many resting wasp larvae, the color is now yellowish and the segmentation more deeply indicated and the anterior part well arched. I was fortunate in seeing this big grub transform into a pupa. On May 30, 1:00 p. m., the anterior or thoracic portion of the larva had become somewhat more swollen and stiffer; on May 31, 7:30 a. m., it was becoming loose and shrivelling, especially at the posterior extremity; now the body appeared more rounded and the thorax especially, from its quick development, arched and tight-skinned. As the larva lies on its back, some of the pupal appendages may be seen under the thin skin. At approximately 10:15 a. m. the larva was squirming gently, the skin split back of the head, now partly collapsed on the well-humped thorax, which is separated from the abdomen by a clearly-defined waist. The pupal head being exposed showed the base of the antennae, as cramped organs doubled up and folded on the larval breast; they gradually straightened out and appeared to be issuing from the relatively small larval head case, reminding me of the vast quantity of material that the magician pulls out of his little wooden box. Everything was growing while emerging free of the larval skin and virtually pushing the latter back. The ovipositor or sting-sheath could be seen in the middle of the eighth ventral segment of the larva, and therefore well forward of the tip of the abdomen towards and near which it will eventually migrate. The freed mouthparts lengthen considerably and in an hour the pupa

is practically rid of the moult skin, though it has not yet reached its final form. The full-formed pupa (Fig. 66) is delicate, especially so at the waist, and hardly mobile; it is dirty yellow, with the appendages somewhat glassy and well provided with knobs and spines. It measures 27 mm. long. The lateral processes of the abdomen probably assist in keeping the tender creature in position. I was in hopes of hatching this pupa, and although it got pretty far along in development, it could not survive the attacks of the numerous mites of which I freed it daily. Unlike some of the stouter-skinned pupae, its movements were infrequent and very slight.

The wasp is much troubled by ants. One of the commoner *Polyrhachis*, a silk-spinning tree-ant represented in the Philippines by many species, happened to tumble into a half-filled *Ammobia* burrows; the ant, not of an aggressive kind outside the domain of her nest, was much frightened and the wasp quite concerned, since, like most Fossores, she had a decided aversion to ants. Finally the *Polyrhachis* was gingerly seized in the wasp's jaws and thrown out unhurt. Another *Polyrhachis* falling into this burrow was, after several half-hearted attempts on the part of the proprietress to eject her, allowed to crawl out.

The heavy rains force the *Pheidolegiton* ants out of their burrows, and their obnoxious armies frequently traverse an *Ammobia* burrow. The wasp cannot cope with these myriad small but vicious creatures and so must abandon her work. If the burrow be but temporarily filled or partly exposed to rain, the ants are likely to raid it and destroy the contents.

Larrinae.

The members of this subfamily are smaller and usually more thick-set wasps than the Sphecinae and exceedingly active. The typical Larrinae prey on Orthoptera (crickets, grasshoppers, locusts, mantis, etc.), and many of the smaller species capture bugs. In Africa, Bridwell took *Nitela*, one of the smaller Larrinae, that was carrying Psocidae to its nest. Some, as *Tachytes* and *Liris*, have deep, many-celled nest burrows, while *Tachysphex* is noted for her shallow, one-celled tunnels. A few (*Hylo-liris*) nest in the forests, in decayed wood, but most like the hot sunshine. The eggs of the Larrinae are fixed transversely to the underside of the thorax of the paralyzed victim. The grubs, as far as known, have moderately large heads and the lateral tubercles of the thorax better developed than usual. The cocoon is a firm oval affair formed of agglutinized soil, wood dust, etc. The interesting manner in which the larva fashions this cocoon

is explained by Fabre for *Tachytes* and by the author in the case of *Larra* and *Notogonidea*.

In the Philippines I found the genus *Notogonidea* (Sens lat) commonest and the best represented in species (9). *Larra*, *Liris*, *Dicranorhina*, *Hyloliris* (a peculiar sylvan genus described here as new), *Lyroda*, *Tachytes*, *Tachysphex* and *Nitela* were also represented.

It appears strange that while *Lyroda subita* Say of temperate America provisions her cells with little *Nemobius* crickets (Gryllidae), *L. formosa* Smith of the Philippines preys upon mature or immature grouse-locusts (Tettigidae), insects not closely related to crickets.

Larra luzonensis Rohwer.

Length 13 mm.; shining black; hind femora red, wings clear.

I did not find this glossy little wasp common at Los Baños. It was sometimes seen on the leaves of honey-dewed bushes or else on the ground hunting her prey. A much rarer, somewhat larger, jet-black species is found in the neighboring forest. Our smaller species occurs as an adult throughout the year.

There seems to be very little on record about the habits of the genus *Larra*. Fabre in his Nouveaux Souvenirs Entomologiques XII, speaks of watching *L. anathema*, a large European species, follow the superficial burrows of the mole cricket, and states that it probably attacks young specimens of this insect, as the mature ones are too large and powerful to handle. According to Hartman (05), in his paper on some Texas wasps, *L. americana*, also a large species, inhabiting North America, provisions the cells of her burrow with crickets, and I take it that he means ordinary field crickets or *Gryllus*.

It was some time before I discovered the nature of the prey of the little Philippine species. Late in 1916 I watched two females hunting. They proceeded along the ground at a rather slow gait, pausing now and then to examine some crack or hole where, I suppose, prey was suspected. In July of the following year I noticed a *Larra* digging into the surface burrows of a young mole cricket, probably *Gryllotalpa africana*. She excavated almost wholly by biting out the soil, and at times appeared quite excited. More satisfactory data were secured on July 30, when at 8:30 a. m. I saw a wasp searching meadow ground. Soon she halted at a spot and there dug with vigor, backing out once or twice and again resuming her digging. In her immediate vicinity a young mole cricket, evidently made aware of the unhealthiness of the neighborhood, hastily issued from the ground and pro-

ceeded to blunder off, but just then, and in some excitement, the huntress emerged and, quickly finding the hurrying cricket, pounced upon it and administered one or more quieting stings, apparently on the underside of the thorax. Then, after chewing at her prey for a brief period, she mounted crosswise upon the thorax and, bending her abdomen under the latter for a few seconds, laid an egg. By this time *Solenopsis* ants, ubiquitous and unpleasant insects of the lowlands, had discovered the paralyzed cricket; *Larra* resented the presence of these foragers by making short dashes and gingerly bites at them. But they became numerous and bold and would not be driven off. Much to my surprise, the cricket, after receiving several good nips and stings from these ants, awakened and hastily made off, her wasp captor now showing no further concern. Evidently the cricket is paralyzed just about long enough for the wasp to lay her egg upon it, and this she does so that it will not be bitten nor rubbed off as the mole cricket plows its way through the soil. The egg is strongly secured crosswise to fit into the deep inter-segmental incision of the underside of the first and second divisions of the thorax, its curvature corresponding with that of its bed. It is whitish, somewhat polished, slightly thicker and more broadly rounded at one end, and seemed to be about 1.5 mm. long. The cricket itself was 14 mm. long, somewhat larger than the *Larra*, and provided with short wing-pads.

Thus we have a rather curious condition here—a wasp, belonging to a group which digs nest burrows and provisions them with more or less paralyzed prey which are imprisoned in cells, adopting the habit of leaving her prey, momentarily immobilized, at large, but minimizing the perils of her progeny by securing the egg more efficiently than do her sisters. Probably some others of the genus *Larra* act similarly.

The mole-cricket, which I now captured, seemed as active and strong as ever and burrowed rapidly into the earth of the tumbler provided it.

The egg hatched in about four days, when it seemed to have split longitudinally, but, the shell, being so thin, as in most of the sphecid wasps, it was hard to distinguish and decide just when the larva began to be freed therefrom. On August 6, two days after hatching, the eggshell could be made out on the underside and posterior end of the wasp grub, the latter having considerably increased in size and gradually encircling the cricket. On the morning of August 7 the strongly-curved wasp larva, quite firm and well segmented, encircled three-fourths of the thorax of the cricket, which, though still digging, was evidently losing some of its vigor. The larva's head appeared inserted into the back

of the victim's thorax. Early next morning it almost completely encircled, like a tall collar, its unfortunate victim, but on the following morning, August 9, there remained the full-fed glassy white wasp grub and only a couple of horny pieces of its former prey—all else had been consumed in the final great spurt of the grub's voracity. The *Larra* grub is about 14 mm. long, medium stout, with a moderate-sized head; lateral fold rather well marked and, as is usual in Larrids, tuberculate on the thorax. On the middle line of the underside of the twelfth segment is a small, rather low tubercle. The larva now began forming a cocoon, and as the former was placed in a vial partly filled with moist and loose soil, the process was easy to follow, and resembled that in the genus *Notogonidea*. The larva first supported itself by a few silken threads and then commenced the cocoon proper, forming a wet and agglutinized soil girdle or band about its middle, and from which numerous silken stays now radiated. She augmented this band on both borders until completely encased in an oval cocoon.

On September 10, or just a month after spinning, a rather small female *Larra* hatched from the cocoon. So the life-cycle in the one case observed was as follows: Egg stage, 4 days; feeding larval stage, 9½ days; cocoon stage, 31½ days. Total, 45 days.

At least the female of this species passes the night underground. One which I confined in a jelly tumbler half filled with soil buried herself regularly at the close of each day.

Notogonidea williamsi Rohwer.

Length 7 mm.; black; propodeum rather coarsely reticulate.

This common little lowland species was frequently observed seeking her prey; she would walk about rapidly, peeking under lumps of soil, in crannies, etc., and eventually succeeded in grabbing and stinging *Nemobius histrio* Saussure, the minute cricket with which she stores her burrow. Finding the latter is usually a matter of accident, for the prey is so much smaller than the wasp that it is swiftly borne away on the wing and the pair lost to view.

On November 18, 1916, I found one of these burrows, with the proprietress filling it up with bits of soil which she carried and manipulated with her mandibles. The burrow was only about two inches long and opened at the edge of a leaf flattened down on the gravely soil; it was more or less horizontal and terminated in three roomy cells, one of which was empty; the other

two contained partially paralyzed crickets, three in one cell and nine in the other. The victims were in several stages of growth and had a body length of from 2.5 to 6 mm., there being two adults among them. A majority of the middle and larger-sized ones were minus a hind leg, and one cricket in each cell bore the wasp's egg arranged transversely and glued at the head end behind one of the fore-coxae. The egg is pearly white, about 1.66 mm. long and 0.47 mm. in thickness; it is slightly curved and somwhat swollen at its free end. One of these eggs hatched early in the morning of November 19; the other at about 6 o'clock that evening.

Fig. 67. Larva of *Notogonidea williamsi* spinning cocoon, × 3/2.

The cricket victims, hemmed in on all sides by a wall of earth, are in a fairly active state; they may give one the impression (owing to the wasp's sting) of being tame, for they make no violent movements. Pent up in this dark recess they await their end. At first the wasp grub is a tiny and feeble creature that feeds wholly by sucking the juices from its victim's body, to which it is glued. Thus we note the pulsating or undulating movements of the gut, visible in the tender grub, as through the ingestion of food it darkens in color. Later on the young wasp becoming larger and stronger, will push its head within the cricket's body and thus eat to better advantage. In about thirty-six hours we find that at least one of the crickets has been devoured and that the wasp grub, evidently having discarded its first skin, is now more active and very voracious. As with a great many other species of wasp grubs, the prey is consumed to the last remnant, which, becoming more or less mixed with soil, forms an uninviting black mess; this is worked up upon the underside of the grub's body as upon a table, in a rather anterior position. Into this it bites greedily (as illustrated for the spider wasp *Macromeris*, Fig. 40), but, soon becoming dissatisfied with such innutritious fare, reaches about with snapping jaws for the living game. But all having been placed in a rather roomy vial for more adequate study, the inmates moved away at its approach; crowded in their natural cell no such opportunity for escape offers. However, I tumbled a small victim near the ravenous larva, which shortly seized a middle leg and commenced chewing it, the owner of said limb offering but feeble resistance. Later it bit off a foreleg which it placed on its lap and almost entirely consumed. After some more vigorous chewing the larger part of a middle leg disappeared, the victim twitching at the bites. Then the grub attacked the body itself, the poor cricket

hardly struggling, but touching its enemy with the palpi. Thus it was soon overcome, killed and devoured. In like manner are all the crickets disposed of.

In about three and a half days the larva is full-fed and ready to spin its cocoon. It is now about 10 mm. long, with a medium-sized head bearing bidentate mandibles. Anteriorly the lateral tubercles are rather prominent. It commences its new vocation by spinning some strands of silk, which it fastens to opposing walls, and soon suspends itself in the hammock thus formed. From this point of vantage it reaches down, grasps particles of soil in its mandibles, draws back, at the same time leaving a thread fastened to the wall, and agglutinizes the particles about its body in the form of a narrow and moist ring, (Fig. 67). During this process its lower lip moves with almost vibrating rapidity. In one case observed the width of the ring at the end of thirteen hours was about one-quarter the length of the grub. The latter, notwithstanding its corpulence, is very flexible. It will squeeze its head between ring and body and thus work its way to a reverse position, whence it will begin building on this edge of the band, which is more or less suspended by radiating silken strands. After working in this position for about a half hour it will again reverse and build up the opposite edge. This band, which is of hardly greater diameter than the grub's body, is of considerable length (or width) before it is closed up at both ends. Exteriorly at least the cocoon is completed within eighteen hours. It is of rather brittle consistency, with the head end lighter brown than the rest.

One cocoon measured 8.8 x 3 mm.; another, 7.4 x 2.7 mm.

A female wasp emerged from one of the above on or about December 17. Many adults were seen in November and December. The life-cycle is approximately: Egg stage, 36 hours; feeding larval stage, 3½ days; cocoon stage, 24 days. Total, 29 days.

Cratolarra pitamawa Rohwer.

Length 8-9 mm.; black; pygidium almost bare, polished.

Cratolarra was several times observed nesting, and as far as could be observed she makes short, one-celled burrows, which are stored with a young gryllid cricket, more or less incapacitated with a sting. The egg is laid transversely under the thorax and the burrow is then closed, the wasp bringing in bits of earth with her mandibles. Incubation is a little less than two days; the young grub, first immovably placed, sucks out its victim's juices, but later, gaining in strength, devours also the harder parts of its

prey's anatomy. Fig. 68 shows one of these grubs making a meal of a cricket's thigh. The grub does not appear satisfied with the amount of provender—a single cricket—which the mother has furnished, and ate half of another cricket which I

Fig. 68. Larva of *Cratolarra pitamaua* devouring leg of cricket, × 2.5.

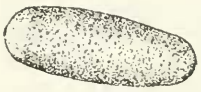


Fig. 69. Cocoon of *C. pitamaua*, × 2.5

offered her. Attaining its full size in about three and a half days, it spins the usual agglutinized shell of soil (Fig. 69), 7 x 2.5 mm. for the male and 11.5 x 4.5 for the female.

The life-cycle in two cases observed was as follows:

Eggs laid	Eggs hatched	Feeding larva stage	Cocoon stage	Total	
Aug. 25, 1 p. m.	Aug. 27, 6 a. m.	Aug. 30, 11:30 a. m.	Sept. 22	28 days	= ♂
Sept. 21, 10 a. m.	Sept. 23, 5 a. m.	Sept. 26, 5 p. m.	Oct. 28	37 days	= ♀

Notogonidea luzonensis Rohwer.

Length 12-13 mm.; black with silvery abdominal bands, hind femora often red; margin of clypeus smooth.

A plowed field is a favorite hunting ground for this common wasp. Partly-grown crickets (*Gryllus*), sometimes a good deal bulkier than herself, are the object of her search. After more or less of a scramble the wasp manages to get on its victim's back and administer the paralyzing sting. Sometimes she is able to fly with her victim, and then again the cricket is far too heavy for such a procedure. I once saw a laden *Notogonidea* climb far up a bamboo telephone pole in order to make a steeply gliding flight nestwards. When, however, the wasp flies away with her cricket she is very hard to follow. But on one or two occasions I

was able to circumvent this difficulty by first capturing a rather heavy young cricket and carefully throwing it down before a wasp on the hunt; the dazed cricket was immediately seized and stung and borne laboriously homewards.

The nest-holes are usually deep—often a foot or so; sometimes they are dug by the wasp, or they may be ready-made affairs, as, for example, Cicada emergence holes, and holes occupied by her larger relative, *Liris aurata*. The wasp is much pestered by ants, and a little Tachina fly is also an enemy to her young. This fly locating a *Notogonidea* burrow will sit patiently by it, like a heron stalking her prey, watch the proprietress enter with her prize and fly away in search of another, thus leaving the dipteron free to enter the burrow, which she does immediately, to emerge therefrom in half a minute or so; during this short interval she has undoubtedly deposited her own young on or near the paralyzed cricket. Thus the fly maggots will shortly consume the wasp's egg and the food supplied.

The wasp is rather a tame insect and she will frequently nest in the well-prepared flower pots placed under the shelter of sheds; one utilized one of these soil-filled pots placed in the insectary. In digging she bit off soil and pushed it past her with the legs, and when deeper in the burrow backed up with the load carried between head and forelegs. I first observed her (a specimen with the hind femora reddish) on September 9; in a few days she had excavated several holes in the pot, which I took back with me to Hawaii, where in October and November it yielded me a dozen wasps and one spoilt cocoon. Some of the wasps had the legs all dark and some had the hind femora red.

Dutt (1912) speaks of *N. tesselata* in India, digging after crickets. I never saw this happen in the Philippine species, though it it probable that some dig for their prey, as several species have elongate bodies and stouter legs well fitted for digging, thus approaching the genus *Larra*, which seeks its victims underground.

Liris aurata Fabricius.

Length 20 mm.; black, with golden pile on head and thorax; legs largely brown, wings with purple iridescence.

This is a rather stout, handsome wasp somewhat less than an inch long, and endowed with a low, swift flight. She is not uncommon in cultivated areas, where one may see her along paths or feeding in the sweet-potato plots. Or she may be engaged in hunting crickets in a plowed field, and being a powerful insect, readily subdues her prey.

Although undoubtedly a good digger, *Liris* appears to rely somewhat upon pre-existing excavations for her nest; this is accordingly situated in the burrow of some small animal, deserted termite cavity, or other suitable place. Of the few nests that I have tried to dig out—until my enthusiasm was exhausted—all were profound affairs, perhaps three feet or more in depth, nor did I reach any of the wasp's cells.

The prey consists of crickets (*Gryllidae*), which are carried, usually in flight, beneath the wasp's body. The victims were found to be of two species, commonly immature; in one instance observed the cricket proved so heavy a burden that *Liris* had to drag it along, venter down, to her burrow 150 feet away. The wasp plunges headfirst into the tunnel, carrying the cricket beneath her, and this agility secures her prey in some measure against parasitic flies that often hang about the entrance to the nest. In one case *Liris* deposited her burden before the tunnel and made a short running dash at a watchful little grey tachinid parasite perched nearby on a blade of grass and tried to seize the fly in her mandibles. It evaded her, however, and so, after looking around for this enemy, the wasp resumed her storing. *Solenopsis geminata* is another enemy to be reckoned with; such ants often occur about the burrow's entrance, but the wasp's cells are so far underground and in so moist a clay that they probably do not investigate to a dangerous depth.

We sometimes see two or three female *Liris* using the same tunnel; this gives the insect the appearance of being social, which, however, is not the case—far underground each wasp has her own cells.

Liris, in common with some other sphecoid wasps, is possessed of a very good eyesight, for, seeing you at a distance of 25 feet, she will turn about to face you, and rearing the anterior part of her body well free of the ground will sway it rapidly from side to side; this action may improve the facetted or mosaic vision by making the object of gaze a moving thing. In the dark recesses of the earth, however, *Liris* uses some other sense than vision.

Tachytes banoensis Rohwer.

Length 15 mm.; black; stout and bee-like; tawny pubescence and silvery pile.

I found two species of this genus at Los Baños, both stout insects, the larger a forest form possessing an exceedingly swift flight; the smaller, common in the fields, much recalling *T. mandibularis* Patton of the United States.

Tachytes hunts for her prey (*Conocephalus vestitus* Redt.), a very alert and bright-colored short-winged, *Xiphidium*-like grasshopper, on the wing, and her high-pitched buzz is often audible when the low-flying wasp is out of sight. Her victim, easily subdued, makes a light burden for the wasp, which flies away with it faster than the eye can follow; as a consequence I found no nest-holes of *Tachytes*. The wasp was once observed to capture a small cricket, a very different insect from her ordinary prey. She sometimes abandons her victims after stinging them—as if in acknowledgment that some mistake had been made.

The males are very active insects and were most commonly found at flowers, particularly those of the verbenaceous tree *Premna odorata*.

Dicranorhina (*Piagetia*) *luzonensis* Rohwer.

Length 9 mm.; black; forelegs red, wings with a dark blotch.

Hardly anything appears to be known about the habits of this genus, and aside from the remark by Bingham (1897) concerning a specimen of a Natal *Piagetia* pinned with a cricket in the British Museum, I can find no reference about its biology.

The Philippine species shows a marked partiality to dwellings, and while nothing was discovered about its early stages, the adults, which were found throughout the year, frequently entered the very open rooms of the Nipa house at which I stayed. Sometimes when it was growing dusky one would be seen running over the curtains, bedding, etc., and one was captured at light. One specimen which I observed for some days made a practice of following the same route in its frequent trips about the house, first running along the railings of the front porch, then flying to the back of the house and continuing her journey along the outer walls to the porch again. Others performed rather similarly on one of the buildings at the College of Agriculture nearby. It is not improbable that they hunt along these places for crickets of some sort. I took very few of these insects on foliage, and then always close to buildings.

The gait of *Dicranorhina* is peculiar; it runs rather slowly as it monotonously visits the same places, the body sloping obliquely downwards from head to tail so that the end of the body trails or nearly.

Hyloliris mandibularis Williams.

Length 9.5-13 mm; black, wings with costa largely dark; male with very long mandibles; head large.

I was fortunate in locating in a fallen tree trunk, in the lower part of the Makiling forest, a small colony of these remarkable wasps (Fig. 70). On August 17, 1917, two specimens were seen to enter a hole in the decayed wood and a third to alight nearby. This gave the settlement a strongly communal aspect, which was further accentuated by the fact that the wasps

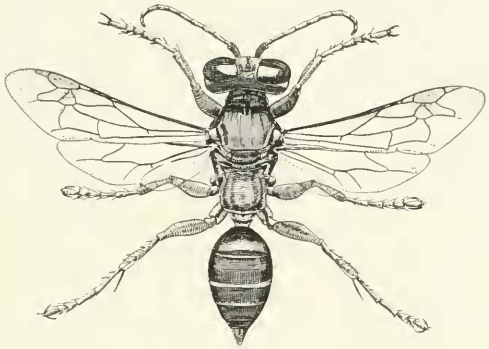


Fig. 70. *Hyloliris mandibularis*, ♀, × 3.

had the strange habit in both sexes of keeping the wings in a semi-erect position* and then of moving them up and down a little and walking about at the same time, much as do the vespid wasps, *Polistes*, *Icaria*, etc. This habit is unique among the Larrinae, as perhaps also that of nesting in decayed wood. Later I saw a *Hyloliris* fly into one of the holes, with her comparatively large immature orthopterous prey, *Calypototrypus* Sauss. (Fig. 71), beneath her. Several days later I dug up the colony, in which there appeared to be three actively-working females and some freshly-emerged wasps, three cells containing crickets and cells with cocoons, both hatched and unhatched. The burrows, which were betrayed by sawdust, were very irregular. Two of them seemed to have a common entrance. Their courses in the soft decayed wood, though more or less parallel with the grain, were quite without order; old cells appeared scattered

* A spider-wasp **Pseudagenia gilberti** Turn. which I observed in North Queensland, Australia, is colored much like a **Polistes**, which it resembles the more because of the habit of holding the wings semi-erect. I did not notice other **Pseudageniae** do this.

along in a haphazard manner, and I found in the stored cells neither eggs nor larvae.

The paralyzed inmates were a curious lot of short-winged wood crickets (Fig. 71), possessed of extremely long antennae. The cells occupied by cocoons contained sawdust; the cocoons shaped just like those of *Notogonidea* and *Larra*, i. e., bluntly oblong and thickest above the middle. They were formed of fine sawdust, and were fairly tough, moderately smooth outside and apparently varnished within. They measured 10-15 mm. long by 4.5-6 mm. thick. The greater number contained pupae, a large one of which measured 14 mm. long and was shaped much like the adult insect, but the abdominal segments 2 to 5 bore transverse subdorsal tooth-like ridges and there were on each side about four simple lateral tubercles. A wasp under observation required about a day and a half, after becoming freed of the pupal envelope, to acquire its full strength. Evidently a brood of these wasps was emerging from this colony, the only locality in which I secured the insect.

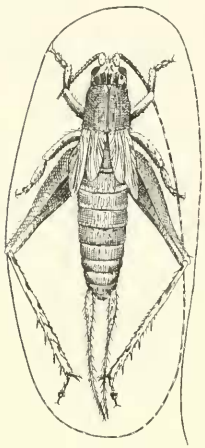


Fig. 71. *Calyptotrypus* sp., prey of *H. Mandibularis*. Enlarged.

Trypoxyloninae.

These comprise slender wasps with a short neck and thorax and a long club-shaped abdomen (except in *Pison*).

They usually prey on spiders, and all to some extent use mud for nest-building. There are those that are true mud-daubers and construct neat cells; most species, however, are content to find a hollow of some sort, an empty *Sceliphron* cell, a broken reed, a bamboo or bramble hollow, where they partition off cells with mud discs. According to Bodkin (1917), *T. brevicarinatus* Cam. of British Guiana usually forms her nest beneath a palm leaf and may cement together as many as 25 cells. *T. albitarse* in the United States is a large black species which also makes entire mud cells. Many species are noted for the lavish space they apportion out for each cell. Howes (1917), who induced *T. cinereohirtum* to build in glass tubes, noted that the female half partitioned her several cells, thus when stored enabling her to lay her eggs all on the same day. The cells subsequently are completey closed. He found that the male takes some interest in the nesting activities, and while not performing any of the manual

labor, he often guards the entrance to one or two nests. Howes further observed that *T. leucotrichium*, which nests in reeds which are open from below, stuffs the cells with long-legged spiders so that these jam and do not slip down and out. The genus *Pison* includes rather stout little wasps sometimes building in ready-made cavities, tubes, between the leaves of books, etc., and, again, forming delicate, filagreed oval cells in the angles of walls, or freely suspended from roots, etc., as represented in the many-celled nest in Fig. 72. This nest produced a bombliid-fly, a parasite of wasps. *Pison argentatum* is the commonest species at Los Baños. It preys on spiders.

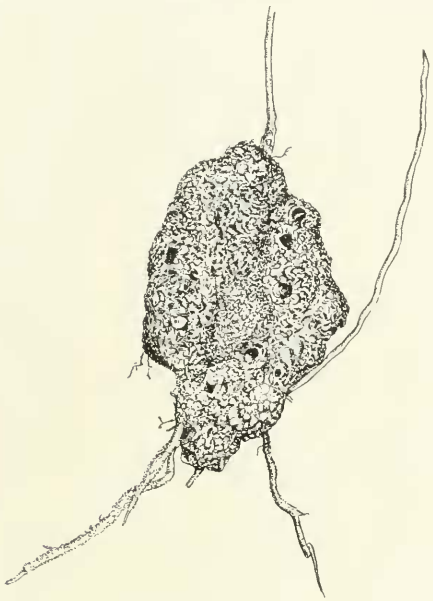


Fig. 72. Nest of *Pison* sp. suspended from rootlets, × 2 3.

In my experience the tropical members of the genus *Trypoxylon* are more particular than the Sceliphronini (with whom they often associate in gathering mud in the Philippine forests) as to the kind of spider used to store their cells. The attids or jumping spiders are one of their favorites, and these may be of proportionally large size, so that sometimes but two or even one suffices for a single wasp grub. Like the adult, the larva and pupa and cocoon are slender, the last resembling somewhat that of the Sceliphronini.

Ashmead (1894) records three species as supplying their nests with Aphids.

Trypoxylon elongatum Ashmead.

Length 15-21 mm.; black and red; very slender.

This attenuated forest insect (Fig. 73), in company with other

species of the genus and with sylvan forms of *Sceliphron*, *Eumenes* and *Pseudagenia*, frequents muddy portions of forest trails, where she gathers mud to partition off her spacious cells. The two nests which I found were in bamboo twigs lying on the floor of a little ravine. Their dimensions were as follows:

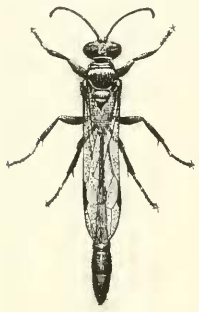


Fig. 73. *Trypoxylon elongatum*, ♀, × 2.

No. 1—Bore of bamboo, 13-15 mm.; inside length of cells, 24, 12, 22, 22, 31, 20, 34, 34 and 47 mm.; 12 spiders; total length of cells, 275 mm.

No. 2—Bore of bamboo, 8-10 mm.; inside length of cells, 25, 17, 25, 14, 31 and 32 mm.; 6 spiders; total length of cells, 155 mm.

The discs of mud partitioning off the cells were thin and dish-shaped; two are illustrated in Fig. 75. Most of the cells were provisioned with one or two attid (jumping) spiders, some of which were of fair size, 10 mm. or so long, and several of the more recently captured, capable of moving their mouth parts.

For so slender an insect the *Trypoxylon* egg is comparatively short and stout; it measures about 2 by 0.65 mm., is slightly curved along the spider's abdomen, where it is secured lengthwise, and a little more broadly rounded at the head end, which in this case points towards the tip of the spider's body. It is white with a yellowish tinge, and rather polished.

Fig. 74. Full-grown larva of *T. elongatum*, × 3/2.

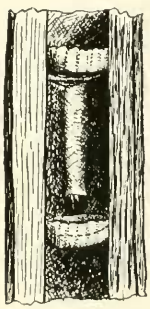


Fig. 75. Cell and cocoon of *T. elongatum* in bamboo stem, × 2/3.

In its younger stages the wasp grub may feed in an arched position, i. e., with the middle portion of the body held clear of its victim; this seems due to the fact that as it increases in size

the two ends of its body remain largely in their first position and so the grub must buckle up, so to speak. Even later, when it chews up the spider's legs, it retains a well-curved position. A large full-fed larva (Fig. 74) is about 18.5 mm. long, distinctly slender, thickset below the middle, and very well segmented by scallops in dorsal and lateral profile. The head is fairly large and bears stout, dark-tipped mandibles. The tip of the body is obliquely subtruncate and the thorax is armed with a few bristles. The general color is yellowish white, the gut is darker, while the end of the body is clear. The feeding larval stage is a little less than five days. A large cocoon (Fig. 75) measures 24 mm. long by 4.3 wide; it is thin and shaped somewhat like that of the Sceliphronini, but has the fore end sharply squared off, whence, as elsewhere along its length, silken stays radiate to the cell walls. One or two thin discs may be spun first, just above the cocoon. The posterior end is bulb-like and its dark and shiny color contrasts strongly with the pale brown or tan of the main portion.

A female pupa measures about 19.5 mm. long; it is quite slender; the head and thorax are devoid of armature, but the abdomen bears spine-like processes and the legs are only weakly armed. The color is creamy yellow.

My notes on this insect are for August-September, 1917. Other *Trypoxylon* may utilize beetle borings as a nesting place, and I found one wasp that had partitioned off a mud-dauber's cell (*Sceliphron*) for her brood.

CERCERIDAE.

A family of thickset wasps with large heads and rather broad, well-marked constrictions between the abdominal segments. The widespread genus *Cerceris* is represented by numerous species, which generally prey on various species of beetles, weevils constituting the fare of one, leaf beetles of another, and so on. Fabre in speaking of the large European *C. tuberculata* has found its weevil prey weighs 250 mg., while the wasp itself tips the beam at only 150 mg. *C. simplex* of Brazil stores a tenebrionid beetle (*Epitragus*, Poulton, 1917). These wasps are excellent huntresses, and entomologists sometimes reap a harvest of rare beetles when they unearth the perfectly-preserved cell contents of a *Cerceris* colony. J. Knükel D'Herculais (1882) once exhumed thirty nests of *C. buprestícida* and thus secured 450 specimens of buprestid beetles.

As an entomologist, *Cerceris* is fairly good—that is, if she really strives to capture only related beetles, even if these be of very diverse size and form—but this group adhesion, however, is

not as pronounced the world over as has been thought. The two Philippine *Cerceris* studied show that some of these insects may wander well outside family limits in selecting beetles.

Cerceris angularis Cockerell.

Length 16-21 mm.; black and red; wings dark.

This fine, stoutly-made wasp (Fig. 76) haunts the shaded ravines of the Makiling forest, where I found it nesting as a well-defined and old-established colony, in a vertical bank composed of a sort of fine loose conglomerate, whose lower portion had an area perforated here and there by the wasps' tunnels.

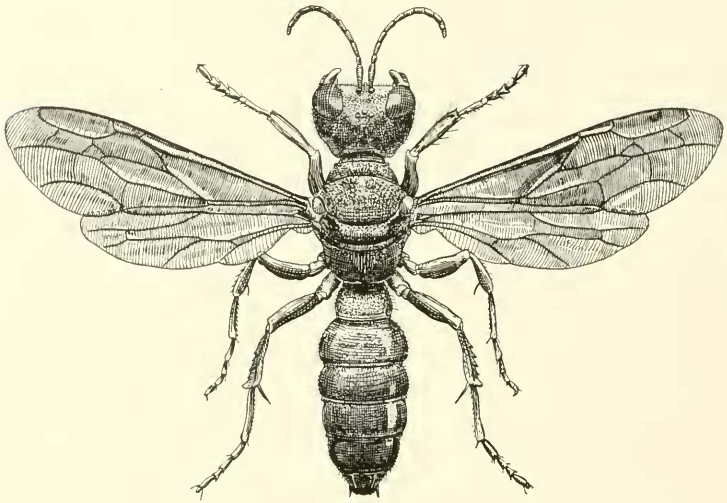


Fig. 76. *Cerceris angularis*, ♀, × 3.

My attention was first drawn to this nesting site on seeing a large wasp flying heavily laden with a brilliant blue-black and red long-horn beetle which she clasped beneath her. Subsequently I saw other beetles, different species of Lamiinae, in transport to this bank.

Setting to work with the trowel revealed at a horizontal depth of 6-12 inches several fresh *Cerceris* burrows and a quantity of old and deserted cells, containing cocoon and beetle debris. The galleries appeared to be largely stuffed with soil, but I located numerous cells quite close together; this would indicate that each female had a many-celled tunnel. These cells were of

ample proportions, a good inch long, oval and horizontally formed and with smooth solid walls. Many held beetles and wasp larvae or eggs, while others contained cocoons. The provender was more or less flexible and well preserved, but in all cases stung to complete immobility. All told, I dug out 14 species of beetles from these cells, two large species of Anthribidae and the remainder long-horn beetles of the subfamily Lamiinae; the largest of these measured 21 mm. long or about the length of the wasp herself. Another beetle measured 19 mm. The two Anthribidae, with their long antennae, much recall a long-horn beetle, and one might suggest that the similarity deceived *Cerceris* into catching beetles outside her accustomed group. Perhaps my observations on the next species will dispel this idea.

The egg of *Cerceris angularis* is proportionately large, for it measures 6 x 1.08 mm. and is thus the equal of those of some of

Fig. 77. Beetle showing egg of *C. angularis*, × 4/3.

Fig. 78. Full-grown larva of *C. angularis*. Natural size.

Fig. 79. Cocoon of *C. angularis*. Natural size.

the large *Chlorion*. It is shining white, slightly curved and a little broadest at the head end. It is fixed along the underside of the beetle (Fig. 77) in such wise that the head end rests upon one of the fore coxae.

Cerceris grubs seem difficult to rear; their natural life in the damp cells is a condition hard to imitate. Thus I did not get much data on their growth. Younger individuals are whitish, and those about to spin cocoons lemon yellow. A full-fed individual is 28 mm. or over an inch long, well segmented and proportionately slender. There is no need here even of a moderate-sized head; the small and comparatively long head with sharp and slender mandibles and elongate underlip fit it well for forcing apart the segments of the corselet, etc., of its heavily-armored food supply, and the grub's slender thorax, capable of much extension, follows the head into the beetle's body to get at the meat. The abdomen terminates in an unevenly-lobed and narrow cylinder (see Fig. 78), apparently a character of *Cerceris* larvae

and perhaps useful in forming a sort of lever or brace when the larva needs the force to push and bite into the joints of its prey. The mother wasp does not feed her young from day to day, but stuffs a cell with beetles, lays her egg on one of the latter and closes the chamber. Consequently, when spinning time arrives some days later, the big grub finds itself surrounded by a debris of beetle fragments (for it devours only the tender interior), wing cases, antennae, legs, etc.; these, with an addition of grains of earth, compose a loose outer covering for her cocoon. It gathers up the fragments one by one and loosely fastens them together with silk. In this framework the real, thin but opaque rich brown cocoon is spun. The head end of the cocoon (Fig. 79) is quite the widest and the posterior extremity somewhat knobby. The smaller cocoons measure 24 x 6 mm. and the larger 28 x 9 mm. In emerging, the wasp makes a couple of clean scissor-like cuts which free it at the broader end of its cocoon.

My observations are from July to September, 1917.

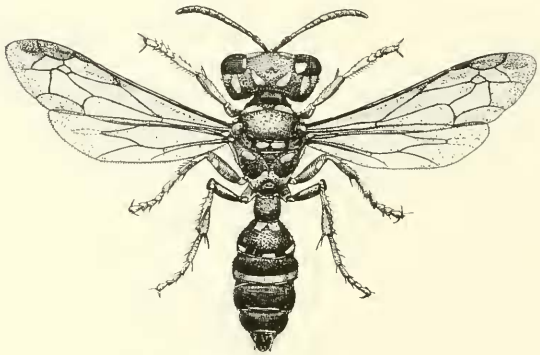


Fig. 80. *Cerceris spiniger*, ♀, × 3.4.

Cerceris spiniger Rohwer.

Length 12 mm.; black, marked with yellow; wings fuscous on costa near apex; head remarkably broad.

This species (Fig. 80), which I observed from June to August, 1917, lives in the woods in small colonies, digging neat and steeply-inclined tunnels to a depth of about 16 inches in the rich soil. The soil which is brought up from below by the burrowing insect contrasts in color with that of the surface and is in part formed into a sort of short horizontal vestibule or half-tube leading along the surface to the tunnel. One nest had two cells with long passageways, one cell being provisioned with nine small

beetles and contained also a quarter-grown wasp larva, while the other held the mother wasp and 17 beetles. The beetles were of eight species—Anthribidae, 1 species; Curculionidae, 1, and Chrysomelidae, 6, the last comprising the bulk of the store.

The larva is of the same general type as that of the preceding species.

Later on I dug up another nest and secured five dull brown baggy cocoons of weak texture. A pupa secured from one of these measured 11.5 mm.; it had a broad head bearing in the middle of the vertex a porrect, forked finger-like process; the thorax and appendages were stout, the legs being rather spinous, while the comparatively slender abdomen was provided with subdorsal and lateral processes.

VESPIDAE.

Eumeninae.

Here belongs a very large assemblage of wasps related to the social species, and while the Eumeninae have but two phases (male and female), it is also true that sometimes, as in the lower Vespinae, the third caste or differentiated egg-laying female or queen cannot be distinguished.

The Eumeninae vary considerably in form—there are the thick-set *Odynerus* and the slender species of *Eumenes*. Some are over an inch in length. Most of the species whose nesting habits are known use clay for making cells, and while a large number employ this material merely to partition off cells in some suitable cavity, as the hollow in a twig, a deserted mud-dauber nest, etc., many build their own nests of mud. Among the latter are the jug-making *Eumenes* or "Potter Wasps." Fabre, Dutt, Hartman, Cretin and Howes give good accounts of the nesting habits of wasps of this genus. Some of the *Odynerus* build mud cells, others use pre-existing hollows, while many dig their own neat burrows, over the entrance to which they may or may not construct a clay tube. Isely (1913) gives excellent accounts of the life-history of some of the Kansan Odyneri. A few tropical wasps of the *Zethus* group make nests of pieces of leaves.

Caterpillars practically always are stored in the cells. In a few cases sawfly and chrysomelid beetle larvae are used. The egg is usually suspended from the ceiling of the cell by a filament. On one occasion I saw a very small species of Philippine Eumeninae hunting caterpillars on the leaves of a shrub. A wily caterpillar hanging from her thread dropped part-way to the ground. The wasp appeared conscious of this trick and began an extended search for the caterpillar, circling again and again

around the latter's jumping-off place, but she could not locate her prey.

Some of the more highly specialized Eumeninae have habits in common with their social brethren, i. e., feeding their young from day to day and abiding by their nests during the night. This applies to *Zethus* (*Calligaster*), some *Zethusculus* and *Synagris*. *Odynerus tropicalis* H. de Saussure of Africa feeds her young from day to day (Bequaert, 1918). This latter habit occurs also in other solitary wasps of entirely different groups (Bembecidae and Sphecidae), but I do not regard it here as a development towards social life.

Rhygchium atrum Saussure.

Length 20 mm.; thick-set; black; antennae and most of wings, orange.

This is a tame household insect and in a sense therefore rather a nuisance. But inasmuch as it seems to prey wholly on the larvae of certain moths of the leaf-roller type (Pyralidina), this fact should counterbalance any annoyance it may occasion.

While some species of this genus fashion neat cells of clay, the handiwork of *atrum* is rather crude and consists solely in partitioning off a pre-existing cavity with plugs of mud. The mother *Rhygchium* was a frequent visitor to the chemistry laboratory and insectary at the College of Agriculture, where she sometimes attracted unfriendly notice by plugging up Bunsen burners and other apparatus with mud. In dwellings she makes a specialty of nesting in the bamboo furniture, and as this is often shifted about, the poor insect is then at a loss where to stuff the heavy caterpillar she is carrying and which she may perforce exhibit to the unappreciative household while assembled at the noon meal.

One of these insects made her nest in a reclining bamboo chair; she scarcely objected to my presence in this chair, but that afternoon brought in seven caterpillars. Other nests were found in shallow rung holes, the wasp coiling up her slender prey within them.

The empty cells of the leaf-bit nests of *Zethus* (*Calligaster*) are not infrequently appropriated by *Rhygchium*, who stores them and seals them up with mud. In another case, a large empty mud nest of *Eumenes fulvipennis*, lying on a shelf in the insectary, was utilized by a couple of *Rhygchium*; the empty cells were close together, and so there was quite a skirmish whenever the two mothers met. Then they faced one another in hostile attitude and made snaps at their mandibles.

The wasp may often be seen hunting for caterpillars, and her actions are then much like *Odynerus*, to which genus she is closely allied and sometimes even included therein. The provender, an active green larva, nests in seeming security in a leaf, a portion of which it rolls up and fastens thus with silk. I observed the wasp examining the leaves of a weed (*Amarantus* sp.). With alert antennae she would alight on a curled leaf, bite first into one end and then the other, and wheel about swiftly in fear that the uneasy occupant would escape. She did not sever the silken guys, but bit holes through the leaf and at an opportune moment hauled out, stung and carried away the unfortunate larva.

Several caterpillars are placed in one cell and a plug of mud plastered over the aperture. The egg is suspended by a filament.

The wasp is an indefatigable worker, starting the day early and sometimes laboring until so late an hour that in the approaching dusk she has difficulty in locating her cell.

Stilbum, no doubt, and other Chrysididae are often household insects and probably one of the worst parasitic enemies of *Rhygchium*.

Odynerus luzonensis Rohwer.

Length 8 mm; black, with yellow marks.

I found a single burrow of this insect; it extended obliquely into the side of a small termite mound. A short earthen tube was the entrance, and the single terminal cell contained a stout well-grown *Odynerus* grub and five rather dark-green larvae of a lycaenid butterfly. The grub spun up and successfully passed its transformations.

Odynerus vespoides Williams.

Length 10-11 mm.; black, with seven abdominal bands of yellow.

This yellow and black wasp (Fig. 81) appears to be rather an uncommon insect and a denizen of the forest. On August 27, 1917, I saw a *vespoides* in the lower Makiling forest sealing up her nest. She had used as a cell a short gallery, apparently an old beetle boring in the upper surface of a fallen tree trunk. This contained three or four small moth larvae, and was sealed up flush with the surface of the trunk, with a very sticky tree gum of some sort, which was apparently impervious to the heavy forest rains.

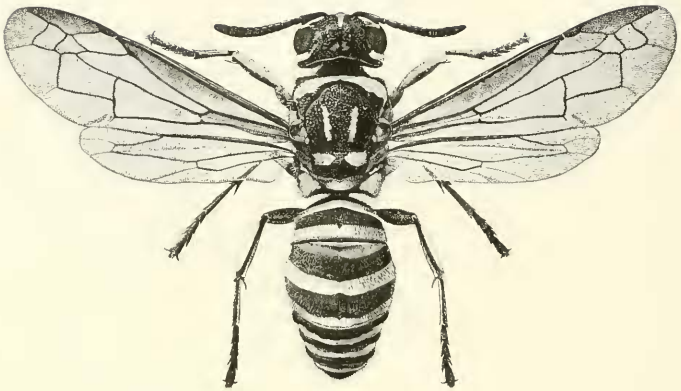


Fig. 81. *Odynerus vespoides*, ♀, type, × 5.

Eumenes curvata Saussure.

Length 29 mm.; polished black; wings iridescent purple, petiole long.

This is a fine glossy black wasp (Fig. 82), her slender length being over an inch, her black wings showing a purple glitter. She and her stouter orange-winged cousin may dwell in the forest or nest in your house.

The first nest of *E. curvata* which I observed was very conveniently situated, i. e., horizontally affixed at a height of about 4 feet to the upper surface of a couple of insulated and intertwined electric light wires in my room. The builder was tame enough, and when disturbed would poise in air and regard you from a distance. She began her nest on the afternoon of November 1, 1916, and deserted it as a 7-celled affair, molested by ants, on November 17. Although she had plenty of time on her first day of work to complete a cell, she plastered but three lumps of mud on the wire and called it quits, said cell being finished at 1:45 of the following afternoon. This cell had the following dimensions: Width, 22 mm.; height, 15.5 mm.; length, 15 mm. The jug-shaped aperture pointing skywards was only 3 mm. across the mouth. Owing to the large size of the wasp and to her condescending disposition, nest-building could be watched at close range. The vase-shaped cells are each built in peripheral layers; the object of attachment when sufficiently broad constitutes the direct base of the cell itself; also, the side part of another cell may form a portion of a neighboring cell. The archi-

tect is a good deal longer than the biggest cell dimension. We may first see her perched in the muddy road gathering moist clay in her month, and when she has accumulated a ball as large or larger than her head, she takes wing, holding her load in her mouth and probably also partly supported by the base of her forelegs. In building the cell walls she uses her long mandibles and her antennae for inside, and her two forelegs for outside work, the antennae seeming to be measurers of some kind. The forelegs are opposers to the trowel work of the mandibles, and spreaders and distributers of the large lump of mud.* She tops off the cell with a narrow circular lip, which she makes flare out by flattening down on all sides with her mouth parts. Two hours and three-quarters were required to build the second cell to her nest. As soon as it was completed the wasp walked on top of the cell and proceeded to lay an egg in it. The aperture of the jug was but 3 mm. in diameter, while the bulbous portion of the wasp's abdomen measured very much more, but, thanks to the flaring mouth of the cell, *Eumenes*, by sitting on top of the mouth and bending her body somewhat, was able to insert it perhaps 3 mm. into this opening and to suspend her egg to the ceiling of the cell.

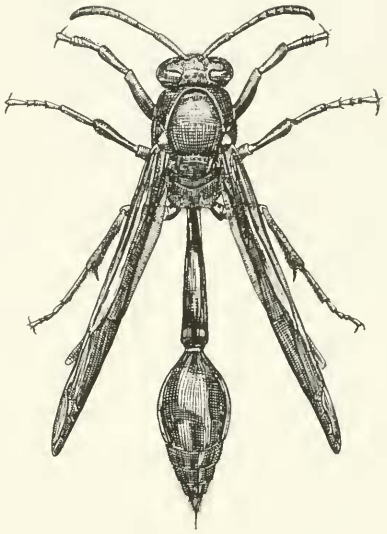


Fig. 82. *Eumenes curvata*, ♀, × 2.

The next job on hand is the immediate gathering of caterpillars and storing them in the cell. She flies to the field or forest and finally secures a suitable larva, occasionally one of the Noctuidae or Notodontidae, but more commonly a measuring worm (Geometridae). One nest of this species contained several larvae

* This mode of work is very different from that used by the architect spider wasps (**Pseudagenia**, etc.). **Eumenes** deposits her ball of mud all at once and uses her mandibles and forelegs to manipnate it; **Pseudagenia** usually uses only a portion of her load of mud at one time, spreading this on with the dorsal tip of the abdomen (Fig. 15), and is constantly working up the mud in her jaws, doing the mixing and spreading simultaneously.

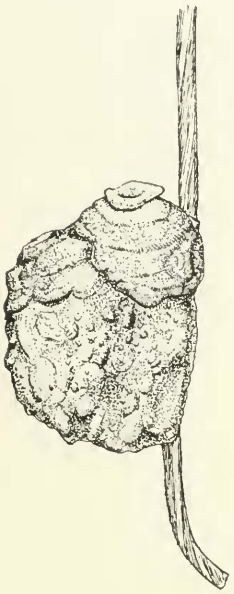
of slender build, lacking the terminal pair of prolegs, and with a pair of long slender processes arising from the end of the body; these I determined as the larvae of Drepanulidae or sickle-winged moths. The prey is partially paralyzed, and the wasp presents rather a grotesque appearance as she passes the caterpillar through the small aperture of her cell and through which it may squeeze only under considerable pressure. The caterpillar is inserted head first, *Eumenes* seizing it by the neck with her mandibles, and moving her jaws, as a whole, back and forth by the up and down movement of her head, with the aid of her forelegs, levers the victim inside. Several caterpillars are stuffed into each cell and the latter then sealed up. By this latter operation the cell loses some of its symmetry, for she daubs mud on the aperture and also bites off the rim of the mouth and moistens and plasters the pieces on again so that the affair much resembles a lump of mud. Sometimes she is overtaken by darkness when she has her cell but half stored; here she is not as provident as *Sceliphron maderospatanum*, who always temporarily seals up a partly-provisioned cell at the close of day. Next morning *Eumenes* carefully studies the cell with her antennae, finishes the storing and seals it up. She never sleeps in the vicinity of the nest.

Eumenes builds in a variety of situations. One wasp considered the upper surface of a shelf beneath a small table a good nesting site, but this lowly position brought her close to the bamboo floor, where she was greatly annoyed by the household kitten, which really limited the edifice to but three cells.

December 22, 1916. A wasp inspected my room for a nesting place. At last she selected a bamboo upright, and alighting thereon, scrutinized a space on it. Finally she flew off and then approached to an inch or so of the selected place, viewing it on the wing, from different angles, retreating and then re-approaching; this was clearly a locality study, for she disappeared out of the window and returned presently with mud which she pasted on the chosen spot.

In the forest her nests are often plastered against tree trunks, in a position likely to escape moisture; or they may be attached to boulders and banks of conglomerate soil—away from rain. In such places the nests are frequently made with one or two covers of mud, separated from each other and from the cell-mass by a considerable air space; these covers are quite fragile and by no means waterproof, and perfect ones are not readily found. They may keep parasites from getting into the cells when the nest is complete, but parasites probably do not usually wait for the completion of their hosts' cells. I found several cryptid ichneu-

monids in cocoons in covered nests. Fig. 84 illustrates, natural size, one of these doubly-covered nests with the covers partly removed. It was plastered on the upper surface of a boulder and partly sheltered by the overhanging bank of a creek.



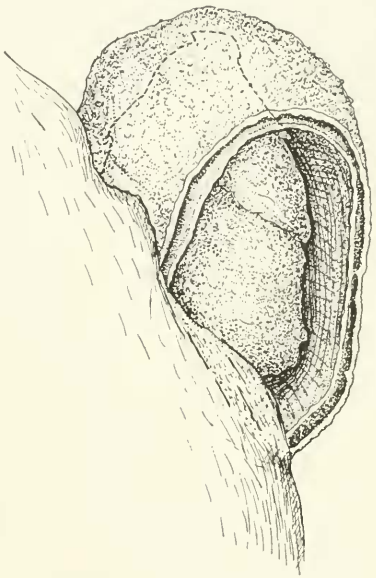


Fig. 83. Uncovered nest of *E. carrata*, × 3/4.
Fig. 84. Covered nest of *E. carrata*, with cover partly removed to expose cell-mass, × 3/4.

This same *Eumenes* may also fasten her bunch of cells on twigs or vines. During nest-building, and particularly after the full number of cells are made, their jug-like mouths are bitten down and the whole more or less plastered over with mud.

The egg, which is suspended by a filament shorter than the egg's length, hatches in three and a half or four days. As with other *Eumenes*, the larva does not entirely quit the eggshell, but, suspended from it, reaches down and feeds by pressing its mouth against one of the caterpillars. When strong enough, however, it drops down among these and devours them without further ado. It has, as far as I could ascertain, three moults for its feeding period and becomes full-fed five or six days after hatching. It is then a decidedly stout fusiform grub (Fig. 85) about 23 mm. long that spins a tough silvery-white cocoon, whose

own walls adhere closely to those of its cell except at a compartment containing caterpillar debris, frass, etc. It soon moults again to form a pupa (Fig. 86), whose cramped length is from 16 to 19 mm., according to sex. It is whitish, spinose on the abdomen, rather firm and inactive.

The life-cycle was determined as about 32-35 days.

The wasp has plenty of enemies—among them the fine metallic

Fig. 85.
Full-grown larva of *E. curvata*. Natural size.

Fig. 86. Cell of *E. curvata* with pupa within. Note the chamber on ventral side for refuse. Natural size.

Stilbum, also an ichneumonid, while I found one *Eumenes* pupa filled with a little chalcid wasp (*Mellitobia* sp.).

Eumenes is active at all times of the year.

Eumenes fulvipennis Smith.

Length 29 mm.; rather dull black; antennae and wings orange; petiole with lateral tooth.

This is a less slender insect than the preceding and, as far as my observations go, not so addicted to forest life; otherwise her nest habits are quite similar. She will build in very odd places—in the middle of the floor, for example; on a beam, post or stem of a plant. One specimen which was building a nest in the insectary would first take quite a sip of water from a tin basin, and fly afield to return with a load of mud, often far larger than her head.

A large nest built on a slender twig was 4 inches long and 2 inches thick and very much resembled a lump of mud, no sign of the mouths of the cells remaining. It hatched out six males and three females.

The prey of this wasp consists of semi-looper caterpillars (*Plusia* sp.), or measuring worms (Geometridae). One *Eumenes*

which had a nest on a vine-laden post near a bed of carrots did much to rid these vegetables of semi-loopers.

The egg is 4 mm. long and 1.20 mm. thick, and has, in addition, a suspensory thread 1.25 mm. long. It is but slightly curved and with both ends practically alike. In one case the incubation period was nearly six days. It hatches into a well-segmented little larva, which feeds in a suspended position from the tough egg-shell, and a day later it hangs down from the shrivelled moult skin (Fig. 87), which remains attached to the shell. Later on, however, it becomes large and strong enough to descend among its provender and consumes it.

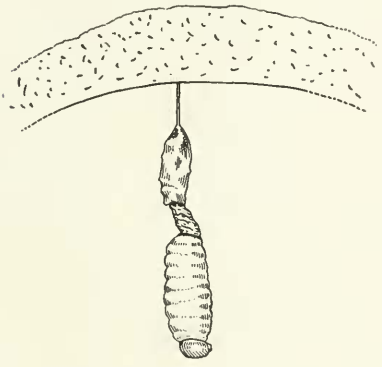


Fig. 87. Portion of roof of cell of *Eumenes fulvipennis*, from which egg-shell is hanging by filament; thence hangs the first moult skin of the larva, and finally the larva itself, × 2.

Stilbum cyanurum Forster, the big Cuckoo-wasp, is an enemy of *Eumenes*, and in one cell I found a partly consumed *Eumenes* pupa and what I took to be the *Stilbum* grub.

The *Eumenes* larva, as in its black relative, spins a tough cocoon, leaving, however, all debris between it and the cell wall.

I sometimes came across single little jug cells, suspended from some very fine rootlet or from horsehair fungi—evidently a precaution against ants. These cells were neat and retained their jug-like opening, but I did not note the eumenid architect in this case.

Zethus (*Calligaster*) *cyanopterus* Saussure.

Length 26-30 mm.; shining black; wings iridescent purple; petiole striate, depressed.

In architectural ability and motherly care, *Zethus* (Fig. 88) has few rivals among wasps. We cannot class her with those that make nests in haste, stock them and leave the results to fate; she is a prudent mother who cares for her offspring by day and by night.

She is one of the slowest and most steady of flyers, and may thus be distinguished on the wing from the large black *Eumenes curvata*, of similar size, which has a rather jerky flight and which she very superficially resembles.

Z. cyanopterus in Java has certainly been wrongly considered a social insect by Forbes ('85), and doubtless the ample proportions of its beautifully-fashioned nest of leaf-bits lend to this view. The nest is normally a structure of several months' occupation, but is often appropriated by tree-inhabiting ants, as certain species of *Crematogaster* and Dolichoderinae, before its completion, and almost invariably after its abandon-

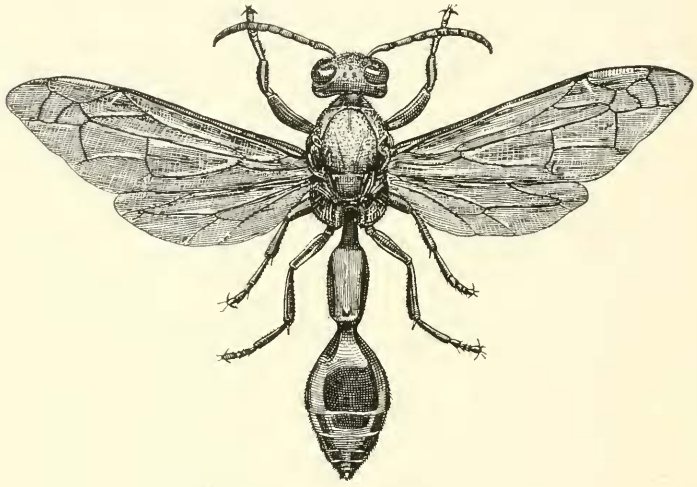


Fig. 88. *Zethus cyanopterus*, ♂, × 2.

ment by the mother wasp and her brood. It consists of from one to four cells, each bent at the neck and enlarged at the bottom. The oldest or uppermost cell is strongly secured to a twig, palm leaflet, rattan flagellum, vine, etc., as the case may be, and from its underside the second cell and then those following depend. A well-defined roof, likewise of leaf-bits and always characterized by a tail-like extension of variable length, shelters this group, which is finally covered over by layers of leaf-bits until the whole affair assumes a shapely and rounded aspect, (Fig. 89).

For some time I was unable to locate the tree from whose foliage *Zethus* secured her leaf-bits, for she appears to patronize but a single species of tree. The wasp, in this case building in a hibiscus bush very conveniently situated on a lawn, would

always fly away in the same direction, into the nearby jungle, to return presently carrying a green leaf-bit in her mandibles. I lost sight of her when she plunged into a vine-laden ravine. Some weeks later, however, I found in open country, a "Bancal" tree (*Sarcocephalus orientalis*, Rubiaceae) which supplied building material for some half dozen *Zethus* for a distance of perhaps 600 feet or more. The "Bancal" has large leathery leaves which remain green for a considerable time and undoubtedly have superior properties as nest-building material. On one occasion I observed four wasps gathering their leaf-bits from this tree; the work is usually performed on the higher parts of this "Bancal," and many of the leaves show that they have been drawn on time and again (Fig. 90). It is evident from the figure that the leaf-bits, probably largely on account of the toughness and thickness of the leaf itself, do not resemble the neat handiwork of the leaf-cutting bees. They are chewed along one or more of their edges, which makes them adhere the more firmly to the nest.

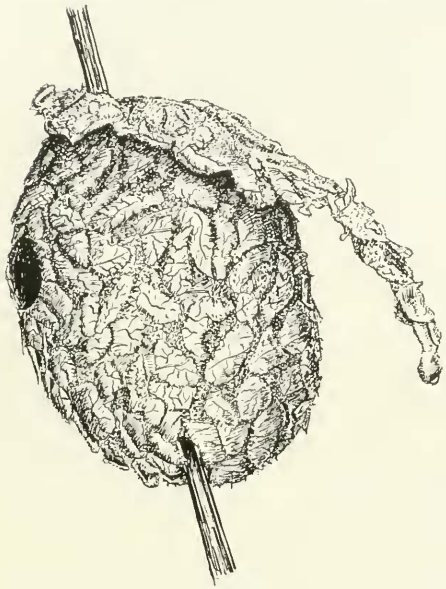


Fig. 89. A four-cell nest of *Z. cyanopterus*, showing one emergence hole, × 3/4.

Nest-building here, as compared with that process in most mud-using wasps, is, owing to the nature of the material, quite tedious. I did not observe the very first steps. The first work seems to be the thickening of the point of attachment by the application thereto of more or less masticated leaf-bits. Then the neck of the first

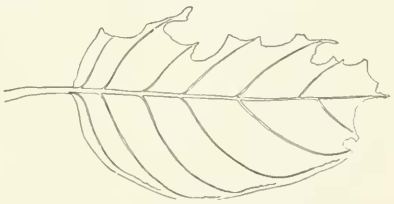


Fig. 90. *Sarcocephalus* leaf from which portions have been bitten out by *Z. cyanopterus* for nest building, × 1/3.

cell is begun; the wasp, working from two near points (Fig. 92) on this thickened base, applies leaf-bits, more or less on edge, thereto, securing each near the base of and on the inner side of its neighbor in a shingling manner. In this way an arc is soon formed, which, with the addition of more leaf-bits, becomes a collar. Sooner or later the upper edge of this collar is strengthened and made more smooth by the chewing up of its components into a greenish pulp. Shingling from the lower part of this collar now proceeds, the wasp applying the leaf-bits from the inside and working downwards. Thus the shingling is done in a different

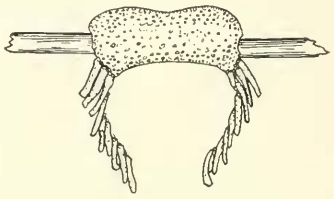


Fig. 92. The beginning of a cell of *Z. cyanopterus;* semi-diagrammatic. On the upper side is shown the foundation thickening of well-masticated leaf-bits; at either end of this twig-girdling ring the leaf-bits are shingled so as to form a ring, the cell-opening and from which leaf-bits are shingled vertically and downwards to complete the cell. Somewhat enlarged.

Fig. 91. Egg of *Z. cyanopterus.* Slightly enlarged.

direction from that on the collar, and the bottom of the cell is compelted last. Several layers are put on, and smaller portions of leaf are applied as an interior finish, and these being vigorously chewed up form a comparatively smooth surface. The cell (Fig. 93) has now an interior depth of about 30-32 millimeters, with a mouth of 8 mm. in width and 12.5 mm. below the middle. This, the first cell, probably requires the longest time of all to construct. About five days of variable and rather cool January weather were required by a *Zethus* in making the fourth cell of her nest.

Fig. 93. The first cell of a *Z. cyanopterus* nest, × 3/4.

Hardly is the cell completed when an egg is deposited therein. Unlike *Eumenes, Odynerus, Rhygchium* and most other *Eumenidae* whose eggs are suspended from the ceiling of their cells by a filament, but as in *Synagris*, that of *Zethus* is laid unattached to the bottom of the cell, so that if the latter be unduly inclined the egg will tumble out. The egg (Fig. 91) is creamy

white and fairly polished. It is very little curved, the rounded ends are practically similar, and it measures about 4.70 mm. in length by 1.20 mm. in thickness. The incubation period was not determined beyond the fact that, for a wasp, it was not rapid. From oviposition up to the time when the larva is full-grown, the mother exercises great care in protecting her young. During the day, if the weather be promising, she occupies herself in part with improving the nest, strengthening the cell, extending its mouth, forming the protective roof, or putting on an extra layer or two of leaf-bits, and in part with keeping guard within the ample cell, her stout head blocking the entrance, her antennae coming to attention at your movement, and, if hard pressed, retreating well within the cell and biting any offending object. She is, however, a really timid insect and when frightened away keeps at a distance until the danger seems past. She always stays in the cell at night and never appears to be asleep, as I have found her ever awake and watchful far into the night.

The egg-shell is quite tough, as is usual with the Eumeninae, so that it retains much the same shape as the egg. The young larva is more or less curved into an arc, whitish, cylindrical, and has a large head. It sheds its skin very shortly after hatching, and is active and tough from the first, wriggling its body and working its needle-like mandibles hungrily. The mother feeds it from time to time with freshly-killed moth caterpillars, apparently Pyralidina. One such caterpillar I saw captured. The wasp flew about the crown of a small tree (*Litsea* sp.) and examined the leaves for her prey. Finally she found a leaf rolled up lengthwise, perched herself upon its distal end and, cutting through it with her stout jaws, inserted her head into the opening thus enlarged and hauled out a small caterpillar. This she did not appear to sting, but chewed off the head and most if not all of the thorax of the unfortunate captive. It is this remnant of caterpillar—all good and tender meat—that *Zethus* carries away beneath her and delivers to her offspring.

At the close of the day the wasp enters the cell occupied by her young and stands watch. This she does also quite frequently during the day, especially in dull weather. She goes into the cell headfirst and, turning about in the enlarged bottom, advances to guard the entrance. But soon the growing larva attains such proportions that it occupies most of the enlarged portion of the cell, and assuming a curled position, refuses to be dumped out

through human agency, and while there is still ample room in the cell for both mother and young, the former can no longer turn about therein, though she may attempt it, and so holding her wings close to the body, she backs in.

Fig. 94. Vertical section through *Z. cyanopterus* cell containing a pupa and showing the two discs closing the cell, × 3/4.

The mature larva is quite stout, with the head rather small. When it is full-fed the mother closes up the mouth of the cell with leaf-bits, and while the inner side of this plug is rather crude, the outer face, which is slightly concave, is quite neat. The occupant can hardly be said to spin silk, though it elaborates a thin leathery partition (Fig. 94) some 6 mm., more or less, below the leaf partition and extends it slightly down the cell walls. The remainder of the walls is thinly coated with a larval juice of some sort.

The pupa (Fig. 94) as it lies in its bent attitude is about 22 mm. long. In a rather advanced stage it is creamy yellow.

When first freed from the pupal envelope, the adult is quite feeble in its humped attitude, and the wings not yet longitudinally folded, are bent apically. Some time must elapse before it acquires sufficient strength to bite its way to freedom through the two doors of the cell.

Unless there is an emergence from another cell before the last is sealed up, the wasp may set about making another cell. She is therefore at first compelled to forego the comforts of a bedchamber and spends the night out of doors, or partly so, using the commenced cell as a shelter. Otherwise a cell from which an adult has issued is cleared out for another brood. But probably this process is not often repeated.

The *Zethus* nest in the hibiscus bush I observed almost daily for a period of 127 days (December 24, 1916-April 22, 1917), and when I first found this nest, its proprietress had commenced to build the third of what proved to be a 4-celled nest, and so on December 24 it must have been at least two weeks old.

The male wasp (Fig. 88) may linger about the nest for several days, and he was noted resting on or near it at night. But the progeny does not appear to stay around the old homestead.

What enemies does the mother *Zethus* strive to guard

against? No doubt the large solitary hornet (*Vespa dcusta*), a very destructive creature, may sometimes try to gain entrance into the open cell. Ants frequently swarm on bushes and must be considered a menace. The ubiquitous eumenid wasp *Rhygchium* appropriates the cells of old nests and would not be so harmless if given free access to an occupied nest. But perhaps the most successful foe of our wasp is a large chalcid wasp, *Leucospis*, a cosmopolitan genus of mostly black and yellow species which have the peculiarity of longitudinally folded wings. This insidious creature has been found by Fabre to parasitize the cells of *Chalicodoma* and *Anthidium*, both solitary bees. No doubt it preys upon many other species of solitary bees and wasps. Apparently *Leucospis* does not enter the cells of *Zethus*, but hangs around for days and at an opportune time thrusts her long ovipositor to the base, through the leafy layers, and may thus reach the young wasp within. Sometimes the watchful proprietress perceives the pest and routs it by a short dash; on other occasions, however, the parasite works in safety, hidden behind the bulk of the nest, the poor mother wasp standing guard at the entrance to the cell.

One finds many incomplete nests, usually full of ants. The rutelid beetle *Adoretus* sometimes uses deserted nests during the day as a retreat, crawling in among the leaf layers, and a small moth caterpillar spins up and feeds on the leaf-bits.

This gifted wasp is to be found throughout the year, and while not abundant was more frequently taken during the rainy season. It seems to have a special fondness for the umbellate flower heads of *Premna odorata*, a small wide-spreading tree of the Verbena family.

The wasps of the genus *Synagris*, though not very closely related to *Zethus*, have some habits in common with it. According to Roubaud (1910), who studied this genus in Africa, the less specialized kinds of *Synagris* carry on their nesting activities much as in *Odynerus* and *Eumenes*, storing the cells with caterpillars and then closing them. But more highly-developed forms, although they also make mud cells, feed their young from time to time and guard the nest just as in *Zethus*. *S. cornuta* goes further still, in that she feeds her young, not with a somewhat chewed-up caterpillar, but with one worked into a mass. The cells, although of mud, have the narrowed and bent neck and enlarged bottom of the leaf-bit cells of *Zethus*.

Zethus seems to differ in structure from some of the American forms and appears restricted to the Old World tropics.

Some of the American species of *Zethus* build mud nests,

Zethusculus hamatus Zav. has been studied by Howes (1917) in British Guiana; it makes delicate cells of ribbon moss peeled into little hoops. These cells resemble the shell of certain snails. The egg of this *Zethusculus*, though attached to the roof of the cell, is apparently sessile. The food of the larva are caterpillars. *Zethusculus lobulatus* De Saussure has been studied by Ducke (1914) in Para, who illustrates a compound nest of chewed-up pieces of leaves and built by several females. Each female here attends to her own cells. Other species nest in holes in wood.

Vespinae.

The Vespinae or social wasps, known in temperate regions by only a few genera, are represented in the tropics by many. While some species can scarcely be induced to sting, there are numerous others which defend their nests very promptly, and it is a divided question whether all the species are docile when unmolested.

Perhaps the best represented Philippine genus and the one commonest in species, is *Icaria*. These are usually rather small wasps, resembling somewhat an undersized *Polistes*. They build in many situations; some make an uncovered pedicelled nest as in *Polistes* and *Polybia*, while others make a paper cover for their cells; such nests, often flat or oval in shape, are placed between palm leaflets, or other leaves, against boulders, tree trunks, etc. The wasps are stingers of good or moderate ability, and at your first venture usually stand at attention with alert wings and visage, awaiting definite hostilities. Though there is scant temperate weather in this part of the tropics, the *Icaria* communities do not appear to be perennial; numerous deserted nests are to be found, though many of these are doubtless ruined by the big *Vespa deusta*. It seems, however, that at least some species of *Icaria* have a sort of swarming habit, as one may meet with a good wasp colony engaged in building a nest, where a day or two previous none was to be seen.

Icaria is a very interesting genus which, owing to the abundance of its species and their often comparative mildness or disposition, should be thoroughly studied.

Of the Philippine *Vespa* I met with two species, both very large wasps. *Vespa luctuosa* Saussure, the smaller of the two, is a grey-black insect with nearly transparent wings and measures in the worker about 20 mm. long. It builds large paper nests on trees or bushes. I found the insect common in a banana grove where it fed at the elongate flowers of this plant. A couple of these wasps made repeated clumsy and unsuccessful attempts to pounce on

blue-bottle flies which were feeding at a bunch of the decayed fruit.

A very familiar sight to the casual observer is the big yellow-winged *Vespa deusta*, Lepeletier (Fig. 95) as it flies about the more rural dwellings, trees, banks, etc., searching for something it may destroy. The queen is nearly 32 mm. long, black, with orange wings; the worker is about 25 mm. long. This wasp is a slow flyer, and though common, only one or two at a time are to be seen. Both castes are often met with. She is a most destructive creature and a perfect bane to some of the *Stenogaster* and *Icaria*, whose nests she destroys with impunity. Being of great size and powerful build, she probably meets with little opposition among the majority of other wasps. A note of January 14, 1917, reads: "A. M. I saw one of these wasps alight on a leaf of a Buri palm (*Corypha elata Roxb.*), said leaf being curled up into a cone within which a good-sized paper nest of a small pale yellowish *Icaria* was secured for its ventral length along and to each side of a rib of the leaf. The nest was only a few inches long, and the more or less horizontal comb was covered with a low paper roof. The entrance to the interior of the nest faced outwardly. Without hesitation the burly wasp squeezed through the door, the owners standing aside and looking on. *Vespa* stayed inside for some minutes; in the meantime ten or fifteen *Icaria* arrived from the field, but these as well patiently awaited at the door for the big predator to finish her pillage. I became impatient, and when I jarred the leaf the wasp finally backed out, carrying in her mandibles a white object, probably one or more *Icaria* larvae, and flew away in a good straight line. Further shaking showed that the nest contained a number of *Icaria*. The next day, as I passed by the nest, I noticed that there was a hole in the roof, probably the

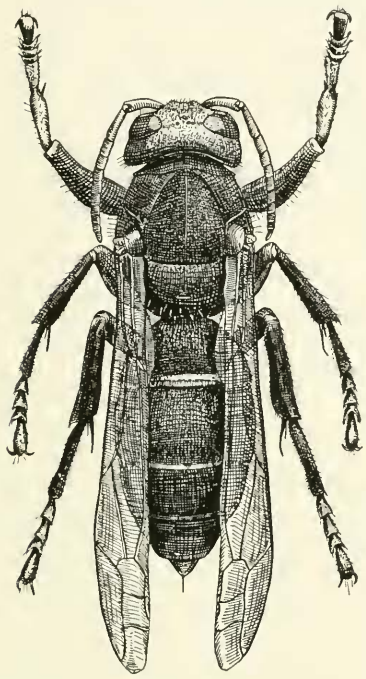


Fig. 95. Queen of *Vespa deusta*, × 2.

work of the robber, made in entering or leaving the frail structure. Some time later the break was repaired. I soon discovered that if an *Icaria* or a *Stenogaster* nest were desired it was better to collect it immediately rather than to wait a few days at the risk of having it mutilated by *Vespa*."

Another note of July 7 reads: "3 p. m. A *Vespa* hunting among some Buri palms chanced upon a nearly completed nest of the big mud-dauber (*Sceliphron intrudens*). The nest was already thick-walled with mud and needed only the more or less artistic ribbing for its completion. Our wasp alighted upon it, but finding no open cells, set to work biting at the softer recent daubings of the proprietress. But the mud beneath was stone-like and her efforts were futile. In the meantime *Sceliphron* returned with a ball of mud, but *Vespa*, with a dash from the nest, promptly drove her away. The safe-breaker, stout-jawed as she was, chewed vainly for five minutes at the cement-like material before she flew off in disgust."

I soon came to regard these wasps as a nuisance and destroyed them when possible.

Stenogaster (*Ischnogaster*).

This is a genus of exceedingly slender forest wasps typical of Oriental and Australian regions. Although usually placed with the Vespinae or social wasps, they have some characters of the Eumeninae and some of neither subfamily. Those that I have observed do not fold their wings longitudinally in repose. Some are solitary wasps and others are social, and although the latter condition may here be somewhat rudimentary, the wasps themselves are highly specialized and architects of surpassing ability. I have never found the social *Stenogaster* in any but quite small and harmless communities, and have not studied these sufficiently to determine if they live as a true society. Among the solitary species are *S. eximius* (Bingham) of Ceylon, *S. micans* (Saussure) var. *luzonensis* Rohwer of the Philippines, and a small unidentified one from the same Islands; of the social ones are *S. nigrifrons* (Smith) of Burma, *S. mellevi* (Saussure) of Java, and *S. depressigaster* Rohwer and *S. varipictus* Rohwer of the Philippines. It seems doubtful if they have three phases.

The nests are very diverse and delicate and fashioned from decaying wood, grains of earth, etc. In some cases the cells are plastered along one of their sides to a stone or tree trunk; more commonly, however, they are suspended as a nest, from a fine

rootlet, fern, or from a species of fine hair-like fungus which grows on dead leaves, stems, etc. Some of the nests are extremely slender, with more or less vermiform passages and cylindrical cells; others, as in *S. melleyi* and *S. micans* var. *luzonensis*, have six-sided cells. The egg is glued to the bottom of the cell and the larva fed from time to time with a soft paste whose composition I did not ascertain, but suspect it to be a plant product. At least some of the larvae do not form cocoons, and in one case the cells are not closed, though far within a tube; the pupa is so fashioned here as to exceed the cell opening in dimensions.

The wasps are eminently lovers of the shady forest, in whose uncertain light they frequently escape notice; some have the habit of patronizing certain leaves or fine hanging rootlets, upon which they alight again and again. The flight is easy, in graceful jerks, and quite noiseless.

The *Stenogaster* are among the most remarkable and least known of wasps, and their peculiar form, more or less intermediate position, their love for the forest's shade and, lastly, their beautiful and varied nests, will always make me regret that I did not become acquainted with them sooner.

Stenogaster depressigaster Rohwer.

Length 15 mm.; very dark brown, with paler markings; pedicel very slender.

Although the shady swimming pool, deeply ensconced between high forested banks, was an object of my frequent patronage, yet a full year passed before I became aware that its immediate region abounded in nests of solitary wasps, several species of which did not appear to venture outside these dense woods. A radius of 100 feet would include the four species of *Stenogaster* I took in the Philippines. The fine *Cerceris angularis* here mined the vertical bank in an old established colony; the red and black *Pseudagenia aegina* hung her granular cylinder from some root, and *Eumenes*, *Sceliphron*, *Trypoxylon*, etc., favored the spot. A very peculiar, fragile and exceedingly slender nest suspended under a bank by one or two stiff black horsehair-like threads—a species of fungus—and partly exposed to the spray of a roaring cascade, finally came to my notice. Clinging to this frail piece of workmanship were two or three very elongate and graceful little wasps, which at my too near approach took wing and, poising in air a few feet away, eyed me, no doubt with nervous apprehension. When the danger seemed past, they cautiously and in characteristic jerky flight approached their domicile and

Fig. 96. Nest of *Stenogaster depressigester*. About × 3/4

once again settled on it. A brief examination of the external features of a nest (Fig. 96) convinced me that it was made up of cells placed in irregular tiers, each consisting of four or five cells arranged in more or less spiral fashion, the lowest and terminal open passageways or cells now being the only objects of the wasp's solicitude. But when I saw two of these slender insects each enter a terminal narrow passage and disappear far within, I wondered at the nest's structure. Dissection revealed an entirely different household arrangement. The serpentine passage* extended the length of the nest and gave forth vertical pockets or cells used as brood chambers by the wasps. Fig. 97 shows the arrangement of a nest of medium size, and although there is more or less irregularity in cell disposition, the vertical entrances to the cells are almost invariably, if not always, at approximately right angles to the one above and below, and thus alternate openings (passages at the terminal portion of the inner cell wall) are in the same vertical plane. This probably comes about from the spiral arrangement of the passageway. In commencing a nest, one or several wasps may do the work; naturally, cells are first made, and these harbor an egg before their completion, and when sufficiently lengthened turn into a passageway.

A brief search revealed several nests; one was suspended from a slender fern, while another proved the largest of the lot, an affair of over 20 cells and harboring at least six wasps, several of which were females. This is the nest illustrated by Fig. 96, and it measures 170 mm. in length by 7.5 mm. in diameter, or about the dimensions of an ordinary lead pencil. The nest suspended from the fern was a beautiful structure, showing in bands, the differently-shaded nest material, probably earth and decayed wood. I thought to secure this also, but desirous of having the unsuspecting inhabitants add to its length, delayed the robbery. I was anticipated, however, by another *Stenogaster* enemy, no doubt the large pillaging *Vespa deusta*, who wrecked this home four times in eight

* I suspect that there may be sometimes two passages in the stouter nests.

days, tearing apart the cells, punching holes into others, and making great havoc with the contents. Nevertheless, the little builders were very persevering and at least three times repaired their ruined domicile. Some of my other study nests suffered a similar fate.

As in other social wasps, the egg (Fig. 98) is glued to the bottom of the cell. It is about 1.5 mm. long and very firmly secured along its curved middle to the cell, and upon its incurved outer surface the wasp deposits a sticky, rather transparent ball of jelly-like food. The young larva, hatching from the stout egg, the shell of which retains much of its shape, curls and partly imbeds itself in this food, which it proceeds to devour, (Fig. 98, lower). Gaining in size, it curls itself at the bottom of the cell; its body contour, together with a few of its fine hairs, now keep it from tumbling out (Fig. 99), while the underside of the body (the side towards the cell base), more tightly curled than the outer, forms a sort of funnel into which the wasp now places the viscid lump of jelly. When pupation time arrives, the grub merely smears a thin film on the walls of its abode and pupates head downwards in this inverted cup, whose open end, being a little eccentric and slightly narrower than the main bore of the cell, prevents the curious, humped, triangularly-bent pupa from falling out. The pupa (Fig. 100) is so bent upon itself that the mandibles touch the end of the body; and it is the head and upper thorax side of the triangle which forms a base a little wider than the cell's mouth. Thus it lies in an upside-down position. The exuvium, in some cases at least, remains in the cell. Measured from its longest side, i. e., from the surface of the mesonotum to the angle formed by the pedicel and the rest of the abdomen, the pupa is 9 mm. long. There is a pair of prong-like affairs on the mesonotum and a low median spine on the metanotum; the head

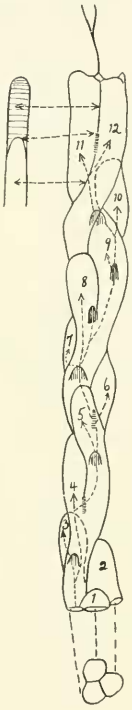


Fig. 97. Nest of *S. depressigaster* showing arrangement of cells and passage-ways. The numbers indicate the cells, and the tops of the passage-ways are shown in two planes by series of parallel lines. The passage-way between cells 11 and 12 is in a plane parallel to the line of vision; the wall above, as well as the rounded top portion of the passage, which is extended below, is shown to the left in broadside view, × 1.

bears a median, rounded tubercle just before the ocelli, and the abdomen and legs are not armed.

When the adult hatches it remains head down in the pupal position for some hours. Evidently it fears no effusion of blood to the head and eventually crawls down the tube to freedom.

I found more of these nests higher up in the forest, hanging under the shelter of palms, leaves, overhanging boulders, under partly-fallen trees, and in the archways formed by the prop-like roots of huge forest trees; they were practically always in positions sheltered from rains. But in one or two instances, so close were these frail non-waterproof nests to a waterfall, that

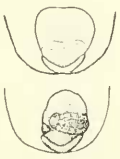


Fig. 98.

Fig. 99.

Fig. 100.

Fig. 98. Above, vertical section through base of cell of *S. depressigaster*, showing egg with food-mass placed upon it. Below, cell base showing young larva encircling food-mass. Enlarged.

Fig. 99. Half-grown larva of *S. depressigaster*. Enlarged.

Fig. 100. Pupa of *S. depressigaster*, as it lies in the cell, × 5/3.

the spray frequently struck them and forced the proprietors to edge around to the lee side of their dwellings, to which they habitually cling and where no doubt they rest at night; and after a heavy downpour the swollen stream so augmented the cataract, that the nests, soaked with water, broke up and were abandoned. But once did I find one of these nests near habitations; it was suspended under the apex of the roof of a rustic sort of open seedling house, itself in a well-wooded country. Like the smaller solitary species whose nest is illustrated in Fig. 103, these insects will often suddenly buzz their wings when on the nest and thus cause the featherweight structure to sway as in a light breeze. The nests are sombre earth color, variegated with lighter or darker bands, and are not at all conspicuous. The wasps are often seen in small companies hanging to some slender rootlet.

Extended observations on this species will doubtless reveal very interesting habits; the wasps are very homelike and will repair their nests time and again—even after *Vespa deusta* has destroyed or deformed every cell it contains—and bravely start life's gamble anew.

Stenogaster varipictus Rohwer.

Length 14mm.; brown, with pale yellow markings.

This is not a rare forest insect—that is, if it be rightly looked for—since it is by no means conspicuous and usually nests in rather inaccessible places. In a small way, it seems to be a social wasp; one to several insects attend to a cell group. It may be, however, that each female has her own lot of cells in this cell group. We usually find several nests in one place, such as on

Fig. 101. Nest of *S. varipictus* on the bark of a tree, × 1.

Fig. 102. Nest of *S. varipictus*, with cells sealed by mother wasp, × 1.

the smooth and somewhat overhanging side of the trunk of a large forest tree, on the overhang of boulders, especially when these are more or less surrounded by water, or they may even be fixed along the underside of green leaves, and one small nest so located had its sheltering leaf constantly struck by water dripping slowly from the bank above, much to the annoyance of the proprietress.

The nest (Figs. 101 and 102) consists of one or more rows of fragile cells, their mouths pointing downwards, and the object to which they are attached serving as part of their sides. The cell material appears to consist of fine grains of sandy mud mixed perhaps with particles of decayed wood. I did not witness nest-building, but the structures show that the cells may be built from either side of the row, of which there may be as many as four; the lowest being first made and the succeeding ones built partly on the bottom ends of the preceding. There may be thirty or more cells to a nest and one consisting of 16 cells had two wasp attendants.

The egg is glued to the bottom of the cell; it may be placed in a partially completed one or in one which has already hatched a wasp. The larva is broad, arcuate and yellowish white. When it is full-fed the mother seals up the cell. It does not appear to

Fig. 103. Nest of a species of solitary *Stenogaster*, × 3/2.

spin a cocoon, but impregnates the cell walls with a silvery sort of material.

These nests, if they escape the searching eye of the big yellow-winged hornet, are occupied at least for some months; the colonies, at any rate, are maintained in the same localities for years.

On May 3, 1917, I found one female wasp resting on a 3-cell nest; on visiting this nest again on August 17 it had been increased to seven cells, more or less complete, and at least two of which were being used again. The nest contained four *Stenogaster* larvae and one egg.

Stenogaster; smallest species, undetermined.

Length about 12 mm.

As may be seen from Fig. 103, this little wasp constructs a beautiful nest; in the single case observed it was ultimately a 7-celled affair secured to a slender rootless which hung out of a low bank in the forest. Although the shy proprietress was frequently seen, and she resembled a good deal a small *S. depressigaster*, she remained unidentified through my failure to capture her, for she deserted the nest before its completion.

The cells, as can be seen, each open directly with the exterior and are arranged in a somewhat zigzag fashion. When on July 16, 1917, I first saw the nest it consisted of the two discs and one open cell, containing a wasp egg or young larva; on August 23, when I saw the wasp for the last time, there were six separate cells, the two basal ones being sealed up and a seventh cell commenced. The two discs on the stem above the nest remind one a good deal of the metal plates fastened to the mooring lines of vessels and serving as rat guards. Their function in the case of the nest may well be an imperfect protection from ants, or perhaps they may serve as umbrellas, though neither they nor the cells are strictly rainproof. The wasp builds rather steadily and has several young or eggs to attend to simultaneously. The cells each require a day or more to be completed. The nest, which is rather dark grey-brown, appears to be made of decayed

wood and is stouter and stronger than that of its social relative *S. depressigaster*.

At first each cell is unembellished cylindrical, but eventually several longitudinal ridges or ribs are added, being made confluent with those of the cell above it. The egg is laid in the bottom of the cell, and it is probable that the grub is fed much as in the preceding species.

The life-cycle is not very brief, if we base it on the two following observations: July 17 the first cell contained an egg or young larva; August 2 or 3 this cell was sealed by the mother; July 19 the second cell contained a larva, but was not closed until August 16 or 17. However, as these were the only cells closed, and as both produced an ichneumonid parasite September 4 and 8, the growth of the *Stenogaster* may have been retarded, or perhaps the wasp had been feeding the parasite itself for some time!

The *Stenogaster* was a decidedly timid insect and difficult to perceive in the semi-gloom of her environs. She was away from her nest much of the time, and when at home was sometimes seen examining her cells, but more frequently resting along the middle of the nest, buzzing her wings once in a while and thus causing the lightly-hung structure to sway as in a gentle breeze.

Stenogaster micans (Saussure) var. *luzonensis* Rohwer.

Length 21 mm.; black, with yellow markings, wings pale smoky.

The males of this rather large and graceful wasp, having much time at their disposal, are not infrequently seen in the lower Makiling forest, where they disport themselves at certain spots along the paths and glades. It is otherwise with the female, (Fig. 104). Household duties seem always to keep her occupied and make her habitat a less conspicuous one.

Although my observations on this insect are very incomplete, I can safely say that it is solitary in habits. The frail and exquisite nest (Fig. 105) is a pear-shaped structure suspended at its globular end to a fern, horsehair fungus, etc., sheltered by an overhanging and often inaccessible part of a bank, or even under an imperfect cover of dead leaves or other forest trash, supported by twigs, vines, etc. The nest is made of moist and well-decayed wood chewed into a pulp and formed into a delicate paper which is not rainproof. The architect, then, is occasionally found about the decayed trunks of trees, patronizing her specially selected log for many days at a time. She is a cautious insect and, flying from her partially-built domicile to near the trunk, ap-

proaches the latter with care and in light progressive jerks, and alert to any danger, alights on a chosen spot. Here material is bitten out, and when a sufficient load of it accumulates in her jaws she flies off and away in her peculiar graceful flight, which, though not rapid, and following each time the same path, is, owing to the wasp's slenderness and the conditions of light in the forest, quite difficult to follow. Furthermore, she works slowly—the trips are at intervals of approximately fifteen minutes, and so both time and patience are taxed.

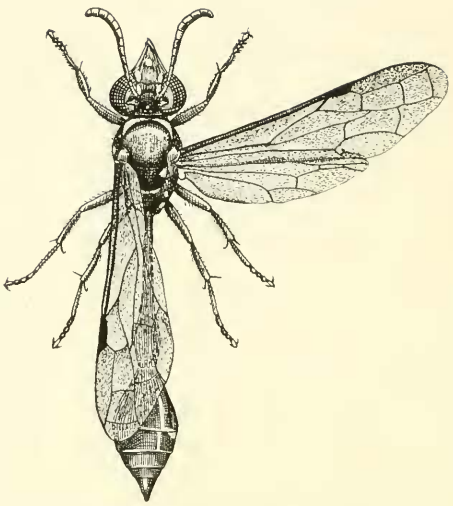


Fig. 104. *Stenogaster micans*, var. *luzonensis*, ♀, × 3.

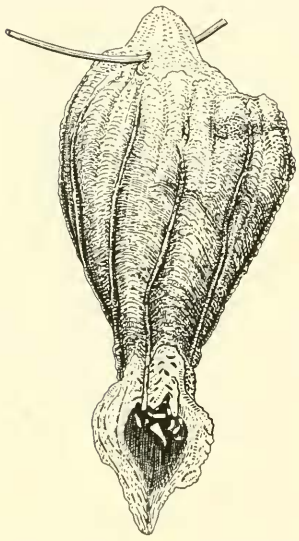


Fig. 105. Completed nest of *S. micans*, var. *luzonensis*, × 1.

On July 20, 1917, I found one of these wasps building her nest, which was fastened to the delicate stem of a little fern growing well out of reach, under an overhanging ledge of the creek bank. This locality was within the forest and in the constant thunder of a small cascade. The nest was secured by a small central pedicel and consisted of one tier or horizontal comb of about 12 rather shallow cells. Desirous of identifying the architect, I caught and then released her; but from now on, however, the nest was deserted. On August 9, I visited this unfinished nest and was surprised to find the cells considerably darkened again as well as lengthened. Evidently another fe-

male seeking a nesting site had chanced upon and welcomed this unfinished structure and was building it up. The two figures will serve to illustrate the growth of such a nest. The material used makes a more delicate nest than those of *Vespa* or *Polistes*. The basal portion of the nest forms the bottom of all the cells as well as the two outer sides of all peripheral cells, all being pretty hexagonal. Where two outer sides of the same cell meet, a sharp ridge or carina is formed, which is continued to near the tip of the nest, the walls of the main nest being simply extended down from these cells and drawn into a neck of filagree work and ending finally into an aperture with one of its sides formed into a spear-shaped extension.

I found two incomplete and deserted nests, both in the shelter of banks; another in the course of construction was well up the side of a ravine, where it was suspended from a thread of horsehair fungus and imperfectly protected from the weather in being under a mixture of fallen leaves, twigs, etc. —a doubtful shelter at best. I located this nest first by following the wasp's flight and then by stumbling upon her domicile in the underbrush. This was on September 3, but I had previously noted this (?) wasp (identified by the direction and path of her flight) in company with one or two other females (which flew in other directions) on July 26, gathering nest material from the trunk of a fallen tree which lay in the bed of a ravine. Here in a small forest opening were quite a number of males of this species. The nest up the slope was only a few inches above ground and about two-thirds built. But it was well hidden, as must needs be to escape the piracy of the large *Vespa deusta*. On September 6, after some heavy rains, I visited this nest again, to find it in a more unfinished state than on September 3, it having probably suffered as a result of the precipitation. On September 10, the nest was about three-fourths done, and on the 16th, it was completed, at least exteriorly.

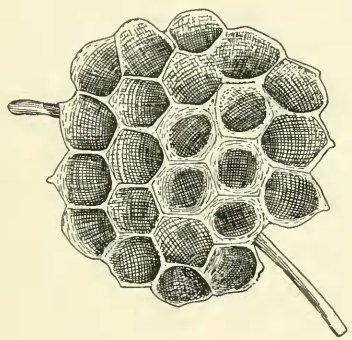


Fig. 106. Nest of *S. micans* var. *luzonensis*, with only the basal portion made. Viewed from beneath, × 1.

The male wasp has the habit of alighting again and again on the same leaf, carefully approaching this rest by a succession of jerky, pausing advances. He appears to be extremely nervous

and is seldom quiet for any length of time. Often two males will meet in mid-air to indulge in peculiar vertical gyrations—a sort of loop-the-loop. Occasionally one meets with a specimen with large anthers glued to the back of the head. The males usually occur in small groups. Though doubtless more partial to bright forest weather, the wasp works and plays during dull days and even in light rain.

A British Museum guide catalogue figures two *Stenogaster* (*Ischnogaster*) nests from Java, and the larger one exactly resembles that of *S. micans*. After describing *I. eximius* of Ceylon, Bingham (1890) quotes Mr. E. E. Green, who sent him a few of the nests, which resemble those of *S. micans* var., as follows: "Each nest seems to be the property of one pair only. It is a low-country insect. * * * My friend (Mr. John Pole, a very accurate observer) assures me he has repeatedly seen this same species, and no other, associated with these nests. * * * Mr. Pole writes of the wasps: 'Their habit seems to be to remain in the opening, using the lacework at the bottom as spyholes.'"

J. nigrifrons of Burma constructs "a social many-celled nest, tier above tier," as the allied *I. melleyi* is stated to do by de Saussure.

CONCLUDING REMARKS.

Approximately 182 species of aculeate wasps (including a few Bethylidae) were collected in the Philippines, and of these 52 are treated biologically in this paper. The list is as follows:

	Species.	
Bethylidae	5	
Thynnidae	6	All belong to *Methoca*.
Mutillidae	8	
Scoliidae	15	
Psammocharidae (Pompilidae)	54	Of these, 20 are *Pseudagenia* or related mud-workers.
Ampulicidae	3	
Sphecidae	15	
Larrinae	19	
Crabronidae	7	
Trypoxyloninae	8	*Trypoxylon* 6, *Pison* 2.
Pemphredonidae	1	
Mimesidae	5	
Bembecidae	4	
Nyssonidae	1	
Oxybelidae	1	
Cerceridae	5	
Eumeninae	14	
Vespinae	11	
Total	182	

The Psammocharidae furnished 15 species for biological data, the Sphegidae 8, and the Eumeninae 6.

Some of the wasps, notably the highly-specialized genus *Stenogaster*, are partial to the shady forests; others, as some Psammocharidae and Larrinae, seem to prefer the hotter and more open lowlands, while others still, as various Eumeninae, are at home in either environment.

A number of wasps hunt or build in and about the bamboo and palm houses, especially when these are in the vicinity of a woodland. These dwellings are very open, and their timbers often pierced by the borings of small beetles, the numerous bamboo uprights regularly perforated for the support of other framework, and the thatching of *Nipa* palm leaves offer inviting places for nest-building. Thus in the house in which I lived for over a year, and which was situated on the edge of the Makiling forest, at least 20 species of wasps nested or sought their prey

within its walls. Three species of mud-daubers (Sceliphonini) were the most conspicuous builders, and two species of these wasps, and the two, inch-long *Eumenes* dwelt in the forest as well.

The various wasp enemies, Ichneumonidae, Bombyliidae and Chrysididae, were also present indoors.

While there appears to be a tendency towards social life in several widely-separated groups of wasps, the vespoid forms are the only ones through which it has been brought to a conclusion and become an accomplished fact—in the Vespinae.

We find true social life in the Hymenoptera characterized by several elements, chief of which are: the division of labor, marked in the higher forms by three phases, viz: egg-laying females or queens, sterile females or workers, and males—then we have the more or less elaborate communal nest, which may afford shelter for both adult and young wasps—and finally, the habit of feeding the wasp-grub from time to time until it is full grown. A strongly-developed instinct to defend the nest is also present in the majority of social wasps.

Now, there are a number of solitary wasps which possess one or more of these traits. Many of the Bembecidae, sand wasps which often live in colonies, feed their young from day to day; others of this family lay the egg before storing any food, and some *Microbembex* provide their young with food in several instalments and close up the cell before the grub is full-fed. The Peckhams (1898) have noted that the American larrid, *Lyroda subita*, feeds her young from day to day, while *Ammobia mutica* of the Philippines may continue to store a cell with grasshoppers until her larva has reached a considerable size.

It does not appear to the writer, however, that the cases just mentioned indicate progress towards social life. With some of these wasps, as *Ammobia mutica*, and possibly *Microbembex*, it suggests a prey or food difficult to secure at all times—hence the more or less protracted period required to fully store the cell. The erratic *Bembex* do not show an industry commensurate with their activity, and they probably feed their young with as many flies as they are able or feel inclined to catch in a day.

Some Psammocharidae, as *Macromeris, Paragenia*, and probably a few *Pseudagenia*, of the eastern tropics, manifest habits which more nearly approach those of the Vespinae. The Psammocharidae are lower down in the scale of development than the Vespinae, and have arrived at this relative specialization as an independent branch, which, if further developed, would terminate perhaps in a group of social wasps parallel, but not closely related to our present communal forms. While these interesting

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