

## Notes on the Habits of the Bees and Wasps of the Hawaiian Islands.

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(Presented at the meeting of October 7, 1926.)

While the endemic insect fauna of the Hawaiian Islands is of remarkable interest, it may not at first appeal to the visiting entomologist who is unacquainted with its nature, for here he will find neither large nor showy insects in abundance, nor will native species usually be taken in sufficient numbers and variety to represent a respectable day's catch. Some orders of insects are totally unrepresented in the Archipelago, even by introduced species, while smaller groups, such as genera, may together present a very unbalanced condition, in that they contain a comparatively large or a comparatively small number of species. The Hawaiian bees and wasps exemplify this condition very well; in the bees the large endemic genus *Nesoprosopis* contains over 50 species; in the world-wide genus *Megachile* (leaf-cutting bees) there are but five species, of which two are very doubtfully peculiar to the Archipelago; while in the wasps, the genus *Odynerus* has more than 100 native species, a number that considering the small area which these occupy probably far surpasses that of any region of comparable size on the globe; the genus *Crabro* is represented by about twenty, with *Nesomimesa* and *Deinomimesa* containing five each; while in the native Bethyridae, the genus *Sicrola*, composed of tiny, blackish wasps, has 171 described forms, with many more yet to be discovered; on the other hand the immigrant bees and wasps, such as *Xylocopa*, *Lithurgus*, *Sceliphron*, *Trypoxylon*, *Pison*, and *Anophus* have, as is to be expected, very few species, from one to three per genus.

Considerable work has been done on the Hawaiian Aculeates both from a systematic and a biologic standpoint, and for which we are indebted mainly to Dr. R. C. L. Perkins, who for many years collected and studied insects in the Archipelago and whose

very excellent treatises are to be found for the most part in the Fauna Hawaiiensis, and Proceedings of the Hawaiian Entomological Society; among other workers who have contributed to the knowledge of Hawaiian bees and wasps, are Giffard, Swezey, Bridwell, Fullaway and Timberlake, and whose papers are published chiefly in the local entomological journal. From these sources, then, and from the author's own observations have been derived the data which follow.

In a manner that is somewhat comparable to a native race in its decline before the advance of a more aggressive and enterprising people, the Hawaiian bees and wasps—among other endemic insects—in many cases are losing their foothold because of the inroads of man and introduced animals and insects upon those natural conditions to which they are most often so closely adapted; thus we find that the immigrant ant, *Phidole megacephala* (Fab.) now ubiquitous in the lowlands to some altitude in the mountains, has in many places seriously affected the nice biological balance that once existed among the endemic insects there. There are, of course, more natural checks on the increase of the native insect population, such as occasional bad years when food is scarce, excessive cloudiness and moisture—as prevail in many of the mountainous regions—that serve to shorten the working hours of these Hymenoptera and to favor the growth of fungi that often destroy in their early stages great numbers of Aculeates; then, too, there are insect parasites and predators, and among the former are many Encyrtid and other Chalcidoid wasps.

While there are a number of native bees and wasps that seem to flourish equally well in the lowlands and in the uplands, the majority are quite restricted in their habitat and are to some extent distinguished by a peculiar facies—thus among the *Odyneri* on the island of Oahu, the red-marked species are entirely mountain-inhabiting, while those marked with whitish or pale yellow are almost always coastwise forms, with black species in both environments. This distinction does not hold true on the other islands, and on the island of Kauai there are a number of white-banded species that occur in the mountains.

The coast lands, at least on the leeward side of the islands, have a light rainfall which is seasonal in its character; this

freshens up the vegetation and awakens the insect life there for a brief period, following which the region resumes its semi-desert aspect. In the humid mountains there is, with some variation in intensity, a continuous round of seasons, so that bees and wasps and other insects are to be had there throughout the year. In the lowlands, bees and wasps more usually dig holes in the ground or nest in little hollows in lava, but in the uplands, old beetle borings in trees or hollow twigs are preferred. With the exception of one or two wasps, none of the native Aculeates exhibits much architectural ability in the construction of its nest.

### BEES

The bees of the genus *Nesoprosopis* Perkins (Hylaeidae) are classified in the group *Obtusilingues*, in which the tongue is short, with the tip split or broad. They are of small size, pre-vaillingly black in color, more rarely in part reddish, and frequently marked with yellow or white. The mother bee has relieved her offspring of the work of spinning a cocoon, for she has been found to line the cell as a cocoon with a filmlike substance. "The larval food contains comparatively little pollen, as these bees have no special polliniferous apparatus, and in the cells that I have opened the larva was floating on the liquid food" (Perkins, Fauna Hawaiiensis, I, p. 76, 1899). The bees favor many kinds of flowers but are always abundant on those of Ohia Lehua (*Metrosideros polymorpha* Gaud.), *Myoporum sandwicense* Gray, and *Scaevola* spp., and I have noticed on the latter plant that while the introduced honey bee *Apis mellifera* Linn. with its longer tongue is satisfied to draw nectar from the base of the well-cleft mature flowers, *Nesoprosopis* will search the bush until she finds a blossom that is just beginning to open and that thus probably offers her more available nectar. The nests are often well removed from the feeding grounds. Fig. 1 shows a large nest of a black species from Kilauea, Hawaii, the bee having mined the decayed wood of a *Metrosideros* branch; 18 cells are visible. *Nesoprosopis anomala* Perkins, a handsome, somewhat rare bee with black, red and yellow markings, has several times been reared from its cells in the pith cavity of dead *Pipturus* and *Boehmeria* twigs. It patronizes the flowers or nectar glands of *Acacia koa*.

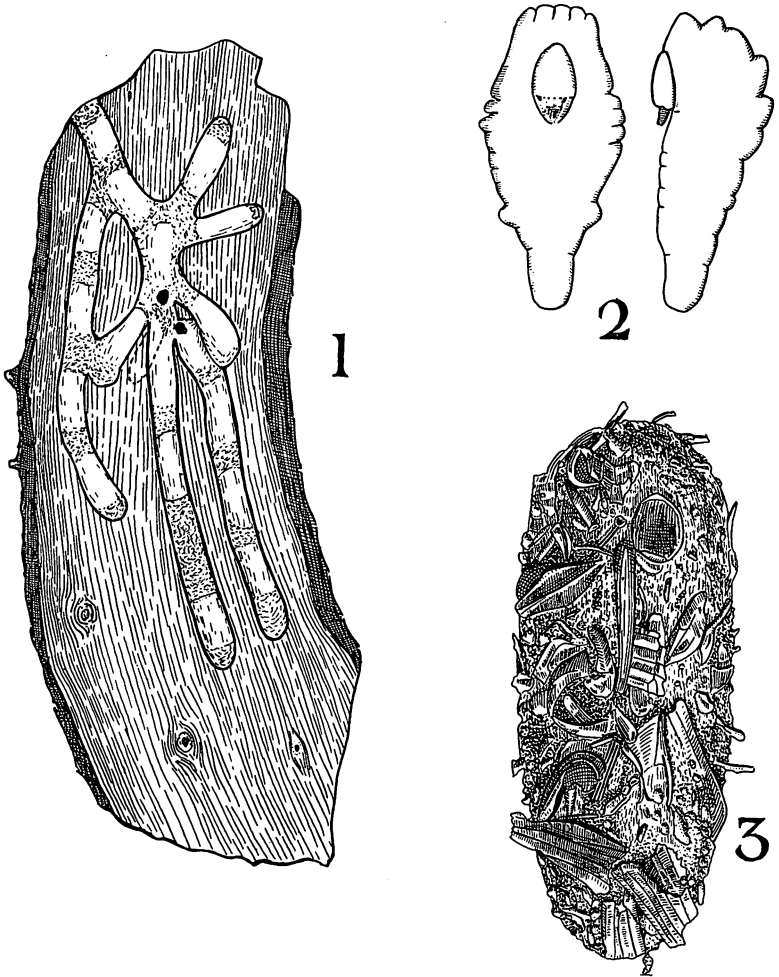


Fig. 1. Nest of *Nesoprosopis pubescens* P. in decayed wood of Ohia lehua (*Metrosideros polymorpha*), Kilauea, Hawaii, 4,000 feet. November, 1919.

Fig. 2. *Nesomimesa antennata*; resting larva. Manoa, Honolulu.

Fig. 3. *Nesomimesa antennata*; cocoon. Manoa, Honolulu.

"The females of all the parasitic species but one have the abdomen ferruginous at least at the base, but in two species the males are black or nearly so" (Perkins, l. c., p. 77). This condition recalls the genus *Sphcodes* of the nearctic and palaeartic regions also with a red or red and black abdomen, and that in some instances at least has proven parasitic upon genera related to it.

Probably a number of *Nesoprosopis* are parasitized in the cocoon stage by Chalcidoid wasps; Perkins (Fauna Hawaiiensis, Vol. II, Pt. VI, Supplement, P. 631, 1910,) speaks of *Eupelmus* as parasitizing bees of the genus *Prosopis*, and *Eupelmus cupreipes* Perkins, has been reared by Giffard from the cells of a *Nesoprosopis* taken on Tantalus, Oahu, in 1906 and 1906. *Nesencyrtus kaalae* (Ashm.) has been found as a parasite upon the larva of *Nesoprosopis pubescens* Perk. at Kilauea, Hawaii, (Timberlake, Proc. Haw. Ent. Soc. IV, 185 and 224-225, 1919.)

Recently (Bull. 31, Bishop Mus., p. 22-23, 1926) Timberlake described *Nesoprosopis perkinsiana*, a bee that occurs on the islet of Nihoa, about 120 miles W. N. W. of Kauai.

The rest of the bees found in Hawaii belong to the *Acutilingues*, or those that are provided with a pointed tongue. Most if not all of these are exotic. The largest and often the most conspicuous of the lot is the burly, inch-long "Carpenter bee," *Xylocopa varipuncta* Patton (see Timberlake, Proc. Haw. Ent. Soc. V, p. 51, 1922, for the identity of this insect), that is often heard before sunrise buzzing loudly among the blossoms of the "Golden Shower" (*Cassia fistula* Linn.), an ornamental leguminous tree extensively planted in Honolulu and elsewhere in the islands. The bee is an immigrant of many years standing from Southwestern United States and is now widespread on the lowlands of the Archipelago, not usually venturing very far into the mountains. The female is jet black with dark iridescent wings, while the male is tawny brownish-yellow with the wings transparent. It is often referred to among the laity as the "bumble-bee," but apart from the black color of the female, often strongly dusted on the head and thorax with yellow pollen, the size and the buzz, it has little in common with the more hairy social insect that defends its nest in the ground with such vigor,

and of which we have none in the Hawaiian Islands. *Xylocopa* tunnels many kinds of dead wood and seems especially fond of redwood (*Sequoia*) posts and the dead trunks of the "Hau" (*Paritium tiliaceum* St. Hil.) and of "Avocado" (*Persea americana* Mill.). The cylindrical borings are used over and over again and new ones made so that the affected wood is often reduced to a mere shell and the bee has thereby come to be regarded as somewhat of a pest.\* The tunnels are about  $\frac{2}{3}$  of an inch in diameter and except for the entrant part and the connections, are usually made parallel to the grain of the wood; they may be over a foot in length, with the cells about  $\frac{3}{4}$  of an inch long provisioned with pollen and regurgitated honey and partitioned with a paste of wood dust. No cocoon is spun; the pupae are very stout and at first pallid. From field observations one might conclude that females are produced far in excess of males; dissection of bored timber however, reveals the two sexes in fairly equal numbers. Besides, the males, which buzz in a higher key than the females are not usually to be found at large in company with the latter but may be seen poising and darting back and forth near trees and over shrubbery, doubtless in the vicinity of a nest. A post heavily bored by these bees will, when struck a sharp blow, resound with the buzzing of the startled inmates. One may remove an infested piece of wood to another locality and the progeny of bees will continue using the tunnels.

The female collects food materials for her cells from a number of flowers, as various morning-glories (*Convolvulaceae*), *Hibiscus*, *Cassia*, *Passiflora*, etc., and it is interesting to watch one of these bees at work in the early morning on *Convolvulus*

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\*An injurious carpenter bee in India is the large blue and green *Xylocopa latipes* (Drury) that tunnels several kinds of woods and "occasionally causing serious damage to the rafters of the tea factories and other buildings," (Stebbing, E. P., Journ. Bombay Nat. Hist. Soc. XVI, 668, 1905). Despite the injurious nature of the work of *Xylocopa* they are meritorious as assiduous pollinators of flowers. To quote Maxwell-Lefroy in "Indian Insect Life," 1909, under "Insects and Flowers in India," by I. H. Burkill: "The *Xylocopas* are the most important of flower-visiting insects in the plains of India, and are of very general distribution. They have large eyes and long tongues, and they visit persistently all day, and some of them also on moon-lit nights. The Sunn hemp crop is largely fertilized by them, and possibly the Indian pulses. *Cassias* in *Calcutta* are commonly visited by one of them and many large, showy flowers."

blossoms, often flying at first directly before the flaring tube, then as if realizing that her own bulk is far too large to penetrate these narrow depths, she flies over the top and to the base of the flower, where the latter is readily punctured and the desired nectar secured.

While this bee is frequently well laden with acari (mites), it lacks the acarid chamber, a pouch opening on the anterior face of the first abdominal segment, common to *Mesotrichia*, a subgenus of *Xylocopa* of the old world, and to some Eumenid wasps (Bequaert; Vespidae of the Belgian Congo, Bull. Amer. Mus. Nat. His. XXXIX, p. 104, 1918.). Perkins (Proc. Haw. Ent. Soc. I, p. 28-29, 1906) has observed this acarid chamber on some carpenter bees from India, also in a Mexican *Odynerus*, and on an Australian wasp, where the cavity was located in the posterior face of the propodeum,

*Xylocopa varipuncta* holds its own very well against *Phidole megacephala*, the dominant ant of the low and middle elevations of Hawaii and probably its chief enemy, for while these ants do invade the nests and carry off the immature stages, the bee's squeaky buzzing within the tunnels seem to deter their attacks somewhat; at any rate, the colonies usually persist for a long time.

Among the hymenopterous parasites of *Xylocopa* spp. may be mentioned tiny wasps of the family Encyrtidae, that entirely fill the body of the bee larva (see letter of Kunhi Kannan of India to Prof. Poulton in Trans. Ent. Soc. London, 1925, p. xii-xiii.); while *Polychrum repandum* Spinola, one of the Sapygidae, a family related to the Scoliid wasps, is a parasite in the cells of *Xylocopa violacea* L. in the south of Europe (see Parker, H., Boll. Lab. Zool. Generale e Agraria, Portici, XVIII, 268-270, 6 figures).

In some parts of the world, Cantharid beetles parasitize the larvae of the Carpenter bee (*Xylocopa*), and of bees belonging to the genus *Anthophora*, gaining entrance to the nest in the first or triungulin stage by clinging to their huge winged hosts which carry them homewards. This parasitization was noted long ago by Fabre (Ann. Sci. Nat. Zool. Ser. IV, Vol. VII, 1857, pl. 17) in the case of *Anthophora* by *Sitaris humeralis* in Europe.

In both Africa and India, large "robber flies" (Asilidae) of the genus *Hyperechia*, that much resemble different *Xylocopa* species and that are sometimes held as examples of "aggressive mimicry" in relation to these bees, devour the latter and other smaller Hymenoptera, while the larvae of these *Hyperechia* tunnel in wood containing the cells of *Xylocopid* bees and feed upon their young (see Poulton, E. B., Trans. Ent. Soc. London, 1924, p. 121-133, Pl. XI, and Proc. Ent. Soc. London, 1925, pp. XII-XIII, Pls. B and C; also Proc. Ent. Soc. Lond., I, 1-2, 1926, and 44-47, 1927).

*Xylocopa orpifex* Smith has been studied by Davidson (Ent. News, 4, pp. 151-153, 1893) and by Nininger (Pomona Coll. Journ. Ent. and Zool. VIII, pp. 158-168, Pls. 1 and 2, 1916) in Southern California. Davidson found the Bombyliid fly (*Argyroamoeba simson* Fab.) heavily parasitizing this bee in the larval stage, and the Chalcid wasp *Monodontomerus montivagus* Ashm. also parasitic upon it. Nininger, who published more at length upon *orpifex*, ascertained that the bee tunnels wood (choosing sound wood) very slowly, in one case less than an inch was excavated at the end of six days. The latter author describes the life history of *Spogostylum delila* Loew., another of its Bombyliid parasites which he found one season infesting about 10 per cent of the bee's cells. He also mentions the Tenebrionid beetle (*Aphanotus brevicornis* Lec.) and a Phycitid moth as feeding on the bee bread, and when this was consumed, upon the young of the bee. *Xylocopa varipuncta* as occurring in Southern California, was found by Nininger to have a life cycle of slightly over 3 months. The mite of the genus *Trichotarsus* was found to destroy a small percentage of the larvae and also to infest the adults.

*Lithurgus albofimbriatus* Sichel.

This is a very swift black bee related to the leaf-cutters (*Megachile*). It was originally described from Tahiti (Sichel, Reise d. Novara, Zool. II, p. 1, 1867, Hymen. p. 151, ♀.) and is known also from Suva, Fiji. It is a comparatively recent immigrant, the first specimen having been taken in about 1900 (Perkins, Proc. Haw. Ent. Soc. I, p. 112, 1906) at Waialua, Oahu; it is now widely distributed in the lowlands of that



island and has boring habits rather similar to *Xylocopa*. The first record of its nesting habits in the Archipelago was made by Mr. Swezey (Proc. Haw. Ent. Soc. III, p. 98, 1915), who found a nest in the pithy base of a dead date-palm leaf on Coconut Island, Kaneohe Bay, Oahu. It is not infrequently associated with *Xylocopa*, in that it may share the same post for its tunnels, even entering by those of the larger bee, as noted by Illingworth (l. c. 140, 1915). It feeds at flowers of several kinds, including morning-glories (Bridwell, l. c. p. 288), and is also fond of the blossoms of *Hibiscus mutabilis*, an ornamental *Malvaceae*, visiting these in a very hurried manner so that one must be quick to catch it.

There are five species of the genus *Megachile* in the islands, mainly lowland insects that with the exception of the very common urban *M. schauinslandi* Alfken (1898), make cells of leaf and petal discs.

*Megachile palmarum* Perk. is sometimes "seriously destructive to many shade and ornamental plants about Honolulu" (Perkins, Proc. Haw. Ent. Soc. I, 85, 1906). Perkins (l. c.) found the common grain and flour beetle, *Tribolium ferrugineum* (Fabr.) to be an enemy of this bee in its cells. The little Chalcid, *Melittobia hawaiiensis* Perkins, is parasitic on at least one species of *Megachile* in Hawaii. *M. schauinslandi* is very abundant in Honolulu; it is blackish with a band of rich brown across the body; it may often be seen busily inspecting holes in electric power poles, in woodwork, etc., in which to make its nest, partitioning off a suitable hollow and finally sealing it up with a resinous material. It occurs on several of the islands and is also known from China and India.

Two of the four typical *Megachile* have proven of exotic origin.

While bees of the genus *Megachile* are an occasional nuisance by their partial defoliation of plants and by building nests in keyholes, etc., they are important pollinators of flowers of useful plants (see Sladen, Pollination of Alfalfa by Bees of the Genus *Megachile*, Can. Ent. 50, pp. 301-304, 1918) and though occurring as a rule, in fewer numbers than the honey bee (*Apis*) are far more active and energetic than the latter.

A very readable account of the life-history of a leaf-cutter bee (*Megachile decipiens*, a large species of the eastern United States) has been written by E. G. Reinhard, in "Hobbies," VI, No. 9, March, 1926, (published by the Buffalo Society of Natural Sciences).

For a treatise on the species occurring in Hawaii, see Timberlake in Proc. Haw. Ent. Soc. IV, p. 551-557, 1921.

The common hive bee, *Apis mellifera* Linn., has been introduced into the Hawaiian Islands, where it is kept under domestication, and has also escaped to the mountains and nests there in hollow trees and suitable crevices between lava. It is a very hardy insect and in some places far outnumbers the native bees at such flowers (or nectar glands) as those of *Acacia koa*, the Algaroba (*Prosopis juliflora*), the Ohia lehua (*Metrosideros polymorpha*), and *Scaevola*, being the last to disappear therefrom upon the approach of unseasonable weather. The bee-moth, *Meliphora grisella* Fab., whose larva eats the wax of the combs, has followed it into the wilderness.

## WASPS

### SPHEGIDAE

#### *Sceliphron caementarium* (Drury).

This thread-waisted wasp is an immigrant from the United States and is now abundant on the principal islands of the Archipelago. Of this insect, Swezey (Proc. Haw. Ent. Soc. I, 16, 1906) says, in part, referring to a collecting trip in February and March to the island of Hawaii: "No adults were seen but the nests of this mud-dauber wasp were common, and they always contained larvae or pupae, which shows that this species is continuing the habit of hibernation which it had in the States, where it hibernates as larvae in the cells of its mud-nest."

While it seems to prefer the lowlands, its mud cells are often found to an altitude of at least 2,000 feet plastered against the rocky banks alongside the mountain trails of Oahu. As is well known it stores spiders in its cells, and if one of the latter cannot be filled before late afternoon it is plugged with a thin mud disc, which on the following morning is removed, the storing

completed, and the cell plugged with a thick permanent mud wad. This has previously been observed by Dutt (Mem. Dept. Agric. India IV, 203, 1912) with *S. madraspatanum* in India.

*Sceliphron* is parasitized\* in its early stages by *Chrysis* (*Pentachrysis*) *extraniens* Rohwer, (Chrysididae), a Cuckoo-wasp of a brilliant blue or green color first discovered in the Islands in 1914, on Oahu, and described by Rohwer in Proc. Haw. Ent. Soc., V, p. 67-69, 1922. The tiny Chalcid wasp *Melittobia hawaiiensis* Perk. also parasitizes the larva of this mud-dauber, as it does that of several other wasps (see Swezey, Proc. Haw. Ent. Soc. I, 121-123, 1907). Recently (Dec., 1926) Swezey found the *Chrysis* parasitized in the cocoon stage by this *Melittobia*. Many spider-stored cells fail to produce adult *Sceliphron*.

#### PEMPHREDONIDAE

##### *Stigmus inordinatus* Fox.

Perkins (Fauna Hawaiiensis, Vol. II, Pt. VI, Supplement, p. 605, 1910) records one specimen having been taken in Honolulu. None has been found here since. The species of *Stigmus* are very small blackish insects that provision their nests in hollow brambles, etc, with Aphids (plant lice).

#### MIMESIDAE

Here occur two endemic genera *Nesomimesa* and *Deinomimesa*, each represented by five species, all slender, black forest-loving insects that usually tunnel in the ground, but have occasionally been seen entering burrows in dead trees (Perkins, Fauna Hawaiiensis, I, 8, 1899).\*\* Perkins (l. c.) further states that the prey of these island species so far as known consists entirely of Tipulidae (Diptera). This habit of catching flies seems unusual however, among such wasps in view of the fact that at least several continental Mimesidae prey upon Homopterous bugs, while subsequent observations in the Hawaiian Islands point to this group of insects as being the normal host for the wasp, which is often seen examining ferns, *Pipturus* and other plants for bugs.

\* Or perhaps the *Chrysis* grub devours some of the stored spiders.

\*\* Bridwell (Proc. Haw. Ent. Soc. III, 275, 1917) found *N. antennata* nesting in dead *Eriogon* stems.

*Nesomimesa antennata* (Smith) is widespread on the uplands of Oahu and has been taken on the summit of Konahuanui, the highest peak in the Koolau range. Swezey, and later Bridwell, have observed this wasp preying upon native leafhoppers of the Cixiid genus *Oliarus*. The males are often so numerous as to fairly swarm, even in drizzling weather, over the Staghorn ferns (*Gleichenia dichotoma* Hook.) that in many places cover large areas on the mountain slopes; the females are far less in evidence, for they are generally engaged in nesting activities. I have found their burrows, that are steep and several inches deep, at the upper end of Manoa Valley, at an altitude of about 1,400 feet. The wasps nest in small colonies in the rich soil that is more or less covered with dead and living ferns and which thus somewhat conceal the little heaps of earth that mark each burrow; the latter is often difficult to follow inasmuch as it penetrates among many fine rootlets. Probably each burrow has several cells; these are stored sometimes with more than one species of *Oliarus*, and also with the larger Australian *Siphanta acuta* (Walk.) (*Pockillopterinae*), a triangular green insect that when mature suggests a very large and awkward burden for the slender wasp; the prey is not killed but paralyzed almost to immobility, so that the tender grub may feed safely upon it; the full-fed wasp grub has an elongate, medium-sized head with distinct antennal cornicles and with the body mostly clothed with quite short, erect hair. When kept under dry conditions, which may happen in nature, the grub occasionally shrinks somewhat so that it assumes a rather hunched position with the head resting upon the breast (Fig. 2).

*Nesomimesa hawaiiensis* Perkins occurs at suitable elevations on Hawaii and has habits comparable to those of its Oahuan relative. At Pahala, where sugar cane is grown to a maximum elevation of about 3,000 feet, and where some years ago it suffered from an epidemic of the foreign sugar-cane leafhopper, *Perkinsiella saccharicida* Kirk. (*Delphacidae*), this wasp left its mountain home to prey extensively on the pest, and which it did, in many cases at least, to the exclusion of other species of leafhoppers. A small colony of these wasps nested in a bank at an elevation of about 1,850 feet, and their tunnels terminated in several cells. The rather loosely-made cocoons are usually spun

among the remains of the leafhoppers. (Fig. 3, for *N. antennata*.) The parasitic flies of the genus *Pipunculus* also profited by this excess of leafhoppers; years later, however, the introduced *Perkinsiella* enemies so prevailed as to reduce it almost to the vanishing point and both *Nesomimesa* and *Pipunculus* were forced to operate above the plantation, eking out a more difficult existence among the ferns and native trees that harbored their comparatively scarce natural prey.

The habits of *Dinomimesa haleakalae* Perk. have to some extent been observed by Timberlake (Proc. Haw. Ent. Soc. IV, 330, 1920) on Mt. Haleakala, Maui, at an elevation of about 5,000 feet. The wasp stores both immature and adults of the Jassid genus *Nesophrosync*, in their horizontal burrows dug in low banks along the trail.

#### TRYPOXYLONIDAE

The two species of *Trypoxylon*, slender red and black insects, as well as the three *Pison* are not endemic to the Hawaiian Archipelago. None has been in the islands very long, though the fact that they may be domiciliary in their native country, using any convenient hollow for a nidus and storing such cosmopolitan prey as spiders, makes their presence here very normal.

*Trypoxylon bicolor* Sm. an Oriental species, first made its appearance at Hilo, on the island of Hawaii, between 1897 and 1900 (see Perkins, Fauna Hawaiiensis II, 606, 1910). On the island of Oahu, it is more likely to be found in the mountains, where it commonly nests in hollow twigs, old beetle borings, etc., partitioning off generous cells with dish-shaped discs of mud. It also nests in furniture, as noted by Perkins, thus accounting probably for its distribution to the other islands. The cocoon of this and of the following smaller species is slender and of delicate texture with the rounded base darkened and stiffened by the larval meconium. The cocoons are sometimes parasitized by the tiny Chalcid, *Melittobia hawaiiensis* Perkins.

*Trypoxylon philippinensis* Ashm. is a later arrival to the Archipelago than *bicolor*, though now well distributed. It seems more of a household insect than the latter, making its nest in

odd places, as glass tubes, in the folds of pamphlets, etc.; more normally it utilizes hollow twigs, and so the trimmed hedge of the Night-Blooming Cereus *Hyllocereus undatus* (Haworth) offers many such nesting places in its dried and more or less pith-free stems.

Interesting studies have been made in the genus *Trypoxylon*. Glass tubes have been substituted for hollow twigs (Howes, in *Tropical Wild Life in British Guiana*, 1917,) so that their habits could be studied more readily. In certain species the male guards the entrance to the nest while the female is out foraging.

*Pison hospes* Sm., the largest of the three species, occurs also in Australia, in Samoa and in Fiji. While often abundant about houses it is not uncommon at middle elevations in the mountains, sometimes modifying old *Sceliphron* nests on rocky banks to suit its need. *Pison iridipennis* Smith is common about Honolulu and has been found nesting in the old twig tips of the Night-Blooming Cereus; it is reported from Australia and also occurs in the Philippines. *Pison argentatum* Shuck. has a very great range, inhabiting Africa, Madagascar, Mauritius, the Philippines, and probably elsewhere on the continents. It makes dainty little cells of mud, fitting them in some angle or corner. The larvae of the three species form a stiff cask-like cocoon of fine particles of clay. The Chalcid wasp *Melittobia hawaiiensis* parasitizes the young of *Pison*.

A key for determining the three species of *Pison* in Hawaii has been published by Bridwell (*Proc. Haw. Ent. Soc.* IV, 123, 1919.)

#### LARRIDAE

*Notogonidea subtessellata* (Smith); (= *N. luzonensis* Rohwer), one of the commonest and most widespread Philippine Larrids, was introduced, as a few cocoons, in Honolulu in 1921. Being a very active insect with plenty of its larval food, *Gryllus* crickets present, it soon became established and later spread of itself to the major islands of the group. It is now a familiar insect in some of the cane fields of the islands and along the more open forest trails at rather low elevation. It is treated more in detail in Bull. 14, Ent. Ser. 137-138, 1919, of the Experiment station, H. S. P. A. (= *Notogonidea luzonensis* Roh.)

*Larra luzonensis* Rohwer.

This is a polished black wasp with red hind femora, that measures about 13 millimeters in length. It is not to be confused with the field-cricket wasp, *Notogonidea subtesselata*, just referred to and that is a distinctly more active Larrid of nearly similar size but more grey black, with the legs and head all blackish. *Larra luzonensis*, the mole-cricket parasite, was introduced from the Philippines by Pemberton in June and July, 1925; and on September 3, 1926, it was found abundantly—for its type of wasp—in parts of the Waialua Agricultural Company and Ewa Plantation Company, Oahu, where it had been liberated. On October 3, a single female was observed on a screen window of one of the beach hotels in Honolulu and it was probably one of the progeny of a Manoa Valley, Honolulu, liberation of 1925.

Late in the afternoon of October 25, one of the first few days whose cooling atmosphere heralded the coming of the tropical winter, I had occasion to climb the peak of Tantalus directly behind the city of Honolulu and 2,000 feet above sea level. The ascent, now that automobiles carry one over an excellent road to an altitude of about 1,650 feet, has by this route almost lost its power of drawing perspiration and is a matter of but a few minutes toil. At a quarter to five, with the sun's rays no longer on the moist, clayey foot-path where I was traveling, I noticed quite in the middle of it a half-grown mole cricket (*Gryllotalpa africana*) lying prone on the ground yet not having the appearance of being dead. In stooping to pick up the limp creature, a nearby buzz announcing the departure of *Larra luzonensis*, the perpetrator of the deed, was heard, and sure enough the wasp's pearly white egg was found glued mainly a little to one side of the mid-ventral line in the incision between the underside of the pro- and mesothorax. The cricket recovered its activity in a short time and was brought to the laboratory so that the wasp's development could be followed. To sum this up briefly: The egg hatched early on October 30; on the following day the larva's turgid and hardly segmented body had doubled in size; November 3, the grub seems to have moulted, for it is now well segmented and large enough to be visible from the upper side

of the *Gryllotalpa*; November 4, *Larva* is growing rapidly and its head appears to be inserted within the body of its host from under the prothoracic shield; the victim, which has eaten several times of a piece of sugar cane shoot and which up to now has been vigorously active, is (10 A. M.) slowing up, and when examined again at 3:00 o'clock in the afternoon lay dead and limp, with the wasp grub, its head freed, just completing the moult which brings it into the final, strongly segmented, tuberculate and chewing stage. The moult skin has receded as far back as the eighth segment and the operation has evidently exhausted the soft white larva which remains inactive for some time; at the end of half an hour or so it bestirs itself and attacks the defunct cricket with renewed zest, inserting the head at the old wound under the prothoracic shield, sucking up the remaining juice and tissues and finally devouring the harder parts to the extent that by the afternoon of November 5, only a mandible and a claw or two remain and the first weak silken strands for the cocoon have been spun. At 7:30 A. M., November 6, the larva had almost completely enclosed itself in a moist, oblong soil cocoon, there remaining but a pin-hole at one extremity, while at the other the unfinished portion revealed a larger aperture at which the artisan could be seen at work. Before 9:00 A. M., the cocoon though very thin-walled, to all external appearances was completed; it lay in the earthen trough that I had made for it and was suspended by a number of silken threads in a cylinder of soil it had formed from the sides of this trough. Thus it is protected from excessive moisture. The cocoon remains soft and flexible for some time so that the grub's movements within can be followed; it is mouthed a good deal and very rapidly, and a portion often pulled in and pushed out again. Eventually it becomes hard and brittle, the main body remaining a dark earthy color, the cephalic end as a cap, resuming a much paler shade. It measured 14.5 millimeters in length and produced an adult female on December 14, making a life-cycle of 50 days.

On November 7, the wasp was found abundant on a small section of the Tantalus trail at the margin of a little wood, where the first parasitized mole cricket had been taken, and it also occurred to an elevation of at least 1,800 feet. On this



quiet sunny afternoon three immigrant aculeate wasps prevailed along the path; the nervously active *Anoplius luctuosus* seeking her spider prey, the glossy little cockroach hunter, *Dolichurus stantoni* hurrying over the ground in her darting gait, and *Larra luzonensis* less animated yet very alert, whether on the hunt or when sunning herself on a wooden step-rung of the pathway. This particular locality is evidently a chosen spot for mole crickets, of which three living specimens were found upon the surface of the ground; the first scarcely half grown was walking away in an unnaturally sluggish manner and an examination showed that it was but recovering from the sting of its enemy, for a *Larra* egg had been glued to its breast, the second cricket, a mature one, was obviously ill though not parasitized, while the third, also full grown, was making off in all haste as though fearing an attack; this one was cautiously placed near a *Larra*, that upon seeing it followed and finally pounced upon it, the twain thus unfortunately disappearing down a comparatively large burrow nearby.

On November 2, 1926, the first Hawaiian males of this species were secured, numbers occurring on *Scaevola* bushes at the head of Manoa Valley where they were sharing the scale-insect honey dew with *Apis mellifera*, *Polistes* and *Crabro* spp., and with their countrymen, *Notogonidea subtessellata*. Fewer female *Larra luzonensis* were seen there.

Fresh females of this wasp were taken January 15, 1927, at 1,800 feet on the Mt. Tantalus trail.

This insect seems to prefer the damper places, as the sides of irrigation ditches or recently watered areas where mole cricket (*Gryllotalpa africana* (Beauv.)) burrows are present. In such localities the superficial burrows of its prey are often perforated by a neat round hole oftentimes the work of *Larra* made in her subterranean search for her cricket victim. The wasp bids fair to be an efficient check of this occasional pest, as it has fewer enemies to contend with here than in the Philippines.

*Silaon rohweri* Bridwell.

This tiny and very active little wasp, described by Bridwell (Proc. Haw. Ent. Soc. IV, 398-400, 1920), is presumably an Ameri-

can immigrant into the Hawaiian Islands. It was discovered in 1919 by Bridwell at Waianae and at Ewa Coral Plain, Oahu, hot, arid districts that form habitats for wasps of this genus. Subsequently it was found in the City of Honolulu, and at Waimanalo, on the windward side, and in January, 1926, was taken at Lahaina, Maui, by Swezey. The wasp generally flies only a few inches above the ground, and so swift are its movements that it often escapes observation. It has a fondness for the flowers of a little mat-like *Euphorbia*. Bridwell, who first studied the life-history of this species, found it nesting in the borings of the *Cerambycid* beetle, *Neoclytarlus cuphorbiae* Bridwell, in dead stems of an *Euphorbia* bush. The nests are stored with paralyzed nymphs of a Lygaeid bug of the genus *Nysius* that occurs plentifully on *Portulaca* or "purslane;" the cells being partitioned off with bits of coral, tiny shells, mud, dried leaves, and other odds and ends. The writer observed this Larrid nesting in a twig at Ewa Coral Plain, and in Cactus twigs in Honolulu. One nest contained 5 cells stored with a total of 17 bugs. The egg (Fig. 4) is laid more or less across the bug's breast, so that the end of the rostrum usually overlies it. It is slightly less than a millimeter long, and pearly, semi-transparent white. It hatches in less than 2 days; as far as could be ascertained the larva moults twice before pupation; the second moult shows it with the mandibles four-toothed, some fine short hairs upon its body, and with moderate lateral folds and thoracic tubercles. It is now in the chewing stage and more rapidly devours its prey (Fig. 5). In one instance observed, one of these grubs in consuming the strongly-pigmented eye of the bug became almost suddenly suffused with purplish. The cast skins of the larva form an adhesive mat upon which part of the body rests and help keep its seat upon the bug. Growing rapidly it chews up the greater part of each victim and in about a week's time from hatching begins spinning the tough typical larriform cocoon (Fig 6). Though working with steady, swift movements the building of this structure, strand by strand and grain by grain, is a slow operation. It forms the middle girdle which it augments from above and below, reversing itself frequently, at length, when the cask is nearing completion it may sometimes be seen with its head and thorax in the cocoon and ducking out

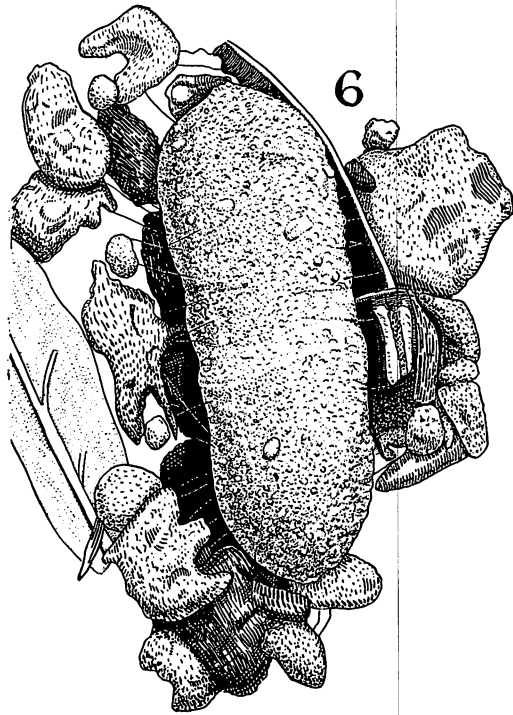
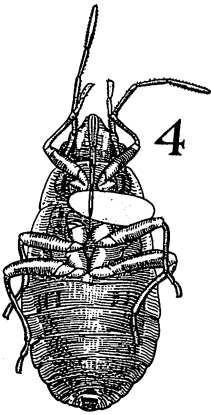
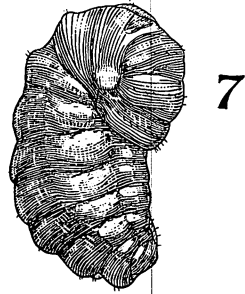
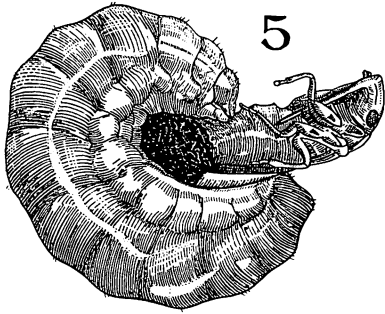


Fig. 4. Nymph of Nysius bug bearing egg of *Silaon rohweri* on venter. Ewa Coral Plain, Oahu. March, 1920.

Fig. 5. Three-fourths grown (last stage) larva of *Silaon rohweri* and its food. Ewa Coral Plain, Oahu. March, 1920.

Fig. 6. *Silaon rohweri*; cocoon. Ewa Coral Plain, Oahu. March, 1920.

Fig. 7. *Silaon rohweri*; resting larva. Ewa Coral Plain, Oahu. 1920.

of sight, much as a person might stoop within a large barrel. Adults were not produced until more than two months after oviposition, for it was found upon dissection of a cocoon or two that the larvae passed through a short resting stage, remaining with the head and thorax curved into the body so that the head was quite invisible (Fig. 7). Metabolism must have been taking place very slowly in such larvae, as the pulsation of the dorsal vessel, in the single case then noted, was only 3 or 4 beats per minute.

#### CRABRONIDAE

The Hawaiian species all belong to the genus *Crabro*, in the wide meaning, and are large-headed, stoutly built little wasps, prevailing black in color. They prey upon flies, and either burrow in the ground, as is the case with the dry-land forms, or else, as with others that inhabit the humid mountains, generally utilize beetle borings, etc., in timber, or even hollow twigs, or make their own borings in decaying branches and stems. The lowland *Crabro* have ants to contend with, while the mountain forms suffer much as nestlings from fungous diseases; but mould, even in dry regions often destroys the cell provender and hence the waspling.

At the present time with so many species of immigrant flies here, the prey of some of these wasps is very indiscriminate. Perkins (Fauna Hawaiiensis I, p. lxxxvi, 1913) states that: "Many of the species are extraordinarily numerous in individuals, and we have seen around a dead cow, on which flies were abundant, a swarm of one or two species of *Xenocrabro* almost as large as that of their prey." So also do species like *Xenocrabro unicolor* (Smith) (see Bridwell, Proc. Haw. Ent. Soc. IV, 331-332), and *Hylocrabro tumidoventris* prey to some extent on *Ceratitis capitata* Wied., the Mediterranean Fruit Fly. Green-bottle flies (*Lucilia*), flesh flies (*Sarcophaga*), and house flies (*Musca vicina* Macq.) are also commonly stored. At higher elevations in the native forest endemic Diptera are more likely to serve as the prey for these wasps, Perkins (l. c.) having found *Nesocrabro* carrying off native *Sarcophagid* flies of the genera *Dyscritomyia* and *Prostethochaeta*. *Nesocrabro stygius* (Blkb. and Cam.) inhabits the mountains of Oahu, and while

usually perhaps forming cells in the ground, was once taken by Bridwell (Proc. Haw. Ent. Soc. III, 275, 1917,) nesting in fallen wood.

*Nesocrabro compactus*, var. *lanaiensis* Perk. has been found by Perkins to form its burrows "in trodden pathways and bare banks in the forest."

At Kilauea, Hawaii, elevation 4,000 feet, I have taken *Hyllocrabro tumidoventris* (P.) var. *leucognathus* (P.) with a de-legged flies. *Xenocrabro hawaiiensis* (P.) has been observed by hood were searching earth banks—presumably for similar long-legged flies. *Xenocrabro hawaiiensis* (P.) has been observed by Swezey, at Kona, Hawaii, where it nested in a rotten log and provisioned its cells with *Sarcophaga pallinervis* Thoms., and Perkins (Fauna Hawaiiensis, Introduction, p. lxxxvi) has found this wasp preying, among other flies, upon the Linnobiid *Dicranomyia*. Of *Xenocrabro atripennis* (P.) Perkins says (l. c. p. lxxxvi), "Even the common housefly is not exempt, and at the Volcano-house hotel on Hawaii, *X. atripennis* has often been seen entering the rooms and taking the flies on the window panes." *Oreocrabro abnormis* (B. and C.) is rarely encountered; the first specimen, a male, was taken by Blackburn on Mt. Konahuanui, in the eighties, a very few were subsequently captured by Perkins, while Swezey bred both sexes of this wasp from cells found in the decaying wood of *Elacocarpus* and stored with *Dyscritomyia* flies. Scarce as this insect seems, it has, nevertheless, a wide range on Oahu, for more recently (November 12, 1926) Swezey, while collecting at an altitude of about 2,000 feet on Mt. Kaala, Waianae range, captured a female in her nest in a "Kukui" (*Aleurites moluccana*) log, its presence being indicated by the quantity of sawdust on the ground beneath the burrow. The latter, which contained at least three cells was provisioned mainly with the Mexican lantana gall-fly (*Eutreta xanthochaeta* Ald.), an insect introduced to help destroy the obnoxious Lantana bush, and with the two endemic Diptera, *Dyscritomyia* sp. and *Caenosia dexioides*. As usual, these flies were stored headfirst in the cells. There was one egg and one wasp larva in the nest. On January 16, of the following year, Swezey captured another female *abnormis* and

discovered another nest of this species in a dead *Osmanthus* (native olive) branch. It was provisioned mainly as in the first nest, the fly *Eutreta xanthochaeta* predominating over native *Sarcophagidae* and *Lucilia sericata*; two good cocoons occupied the remainder of the nest, one producing a male wasp on February 12.

*Melanocrabro discrepans* Giffard, is a handsome black species with some yellowish white abdominal markings and infusate wings that inhabits the mountains of Kauai. In February, 1927, the writer found it nesting in an old stump along the Summit Camp trail, at an altitude of perhaps 1,800 feet. The short tunnels seemed to be their own work and it was evidently a colony of long standing. The cells were stored, as far as could be ascertained, with flies of the family Dolichopodidae.

Flies of the genus *Pipunculus* sometimes fall victims to Hawaiian Crabronids (*Hylocrabro tumidoventris*), as do these and Tipulidae as well, in other countries (see Scott H., Notes on the Nesting-Habits and Prey of Two British Species of Crabronidae, Ent. Mo. Mag. 3rd Series, XI, p. 156-160, 1925).\*

*Crabro* may not be particularly skillful at capturing her prey; she poises briefly before her intended victim and makes a dart-like pounce, frequently missing, but sooner or later seizes a fly. Thus have I seen the common lowland *Xenocrabro distinctus* (Sm.) reddened by the soil in which she nests, capture the housefly, grasping it in her legs. One of these flies was caught in mid-air. Once firmly seized, the wasp sets about stinging it, letting go her hold of any support, and frequently falls on her side in her concern. In this connection may be mentioned the hunting operations of *Crabro*, sp. near *vicinus* Cress., a rather slender wasp that occurs well up in the Sierra Nevada Mountains of California: "At the end of July, 1925, at an altitude of about 7,500 feet, near Lake Tahoe, as the sun was leaving the forest floor, I noticed numerous restless *Anthomyid* flies,

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\* Perhaps worthy of note in this connection is the fact that *Nesocrabro stygius* (Kirby) in its compact build, nearly transparent wings, and the slightly greenish sheen of the abdomen, bears a superficial likeness to its endemic Sarcophagid prey. Perkins (l. c. lxxxvii) has noted that: "Some of the species of *Nesocrabro* emit a shrill noise, when on the wing, which much resembles the note of the Tachinids they are seeking."

apparently all of one species swarming on a sunny boulder, the latter being pleasantly warm. Here and there among the flies and apparently causing them no concern basked a few of their wasp enemies. After a sufficient warming up these would fly upwards a short distance, would poise in air, draw back as if taking aim, and then make a slanting dart at a fly. Misses were frequent but nevertheless many flies were caught in the curled grasp of *Crabro*, the wasp sometimes stinging her captive on the boulder or else immediately flying off with it. These insects were thus active for at least forty-five minutes after the sun had left the boulders for greater heights, the last wasp disappearing at 6:57 P. M."

In soil-nesting forms the tunnel may give off as many as ten cells; those *Crabro* that nest in decayed wood—the soft *Elaeocarpus* tree being a favorite with such aculeates as *Crabro*, *Odynerus* and *Nesoprosopis*, on Oahu—seem to make fewer cells; each cell is well stuffed with flies whose heads usually point away from the entrances; some of the victims may twitch feebly, while others appear motionless; an egg of comparatively large size—3 millimeters long in the case of *Xenocrabro distinctus*—is laid at the throat of one of the more interior of the flies and the chamber stoppered with soil or with sawdust, as the case may be. The cocoon of *Crabro* (Fig. 8) is of distinctive form; the remains of the prey littering the sides and bottom of the cell. The pupa (Fig. 9, for *H. tumidoventris* (P.)) is stout and with lateral, abdominal finger-like processes. But these insects do not always transform into pupae soon after the cocoon is spun; there may be a resting stage (Fig. 10, *Hylocrabro tumidoventris*) over a considerable period, and comparable perhaps to the larval hibernation of most solitary wasps in temperate regions. The larva turns somewhat yellowish, becomes more wrinkled, better segmented, and assumes a curved, quite motionless posture; furthermore, its metabolism becomes much retarded, so that the dorsal vessel pulsates far more slowly than when the larva is active or when it straightens out considerably before pupation (Figs. 11 and 12).

The Hawaiian *Crabro* are noticeable, generally speaking, for their comparative tameness and they frequently alight upon one's hands or clothing.

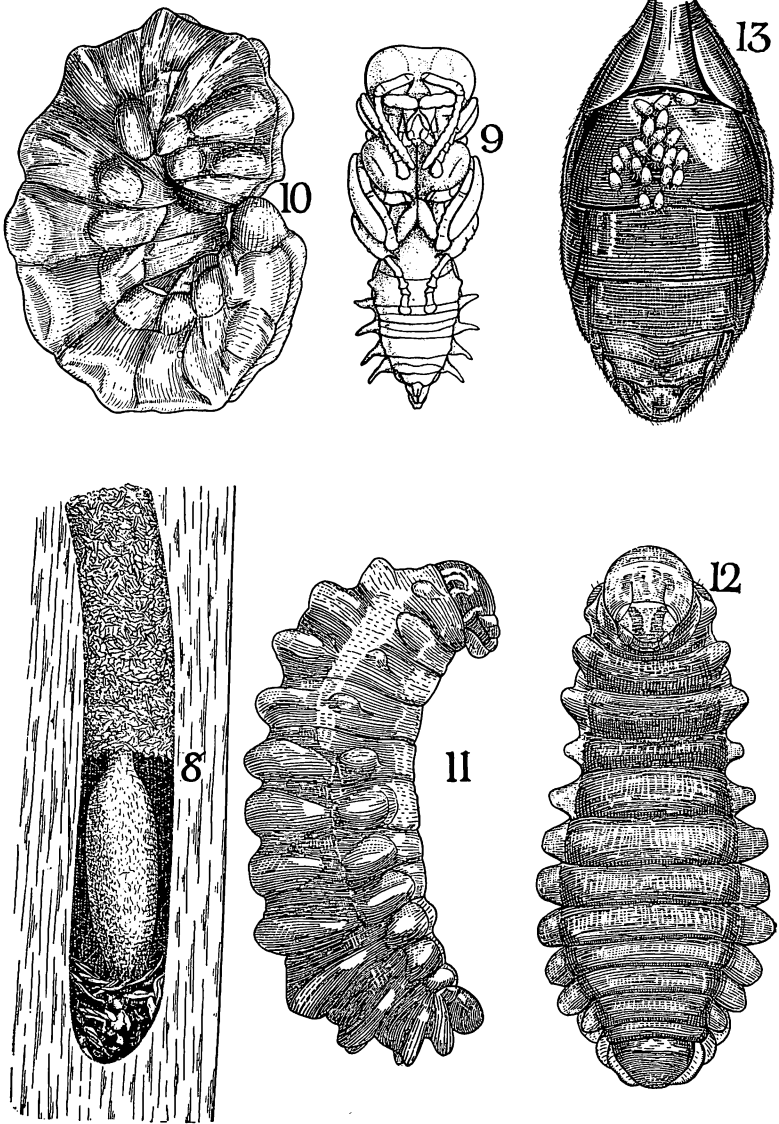


Fig. 8. Cell and cocoon of *Hylocrabro tumidoventris*, var. *leucognathus* (P.), in trunk of fallen *Acacia koa*. Kilauea, Hawaii. November, 1919.

Fig. 9. Pupa of *Hylocrabro tumidoventris*. Mt. Konahuanui, Oahu. October, 1919.

Fig. 10. *Hylocrabro tumidoventris*; resting larva.

Fig. 11. *Hylocrabro tumidoventris*, var. *leucognathus*, unrolled after resting period. Kilauea, Hawaii. April, 1920. Lateral view.

Fig. 12. *Hylocrabro tumidoventris*, var. *leucognathus*, unrolled after resting period. Kilauea, Hawaii. April, 1920. Ventral view.

Fig. 13. *Xenocrabro unicolor*, showing colony of mites on second ventral abdominal segment. Mt. Kaala, Oahu. December, 1919.



Mites (Acari) are often found upon these and other wasps, and figure 13 portrays a few upon the venter of *Xenocrabro unicolor*.

Crabronidae in other parts of the world may have a considerable diversity of prey among their genera,—some capture Hemipterous bugs, one species preys on ants, other small ones prey on book-lice (Psocidae), and on Aphids. Kohl (Die Crabronen der palaearktischen Region, 1915, Vienna) devotes a considerable part of his monograph to the habits of these wasps. See also Hamm, on the Biology of the British Crabronidae. (Trans. Ent. Soc. London, 297-331, 1926.)

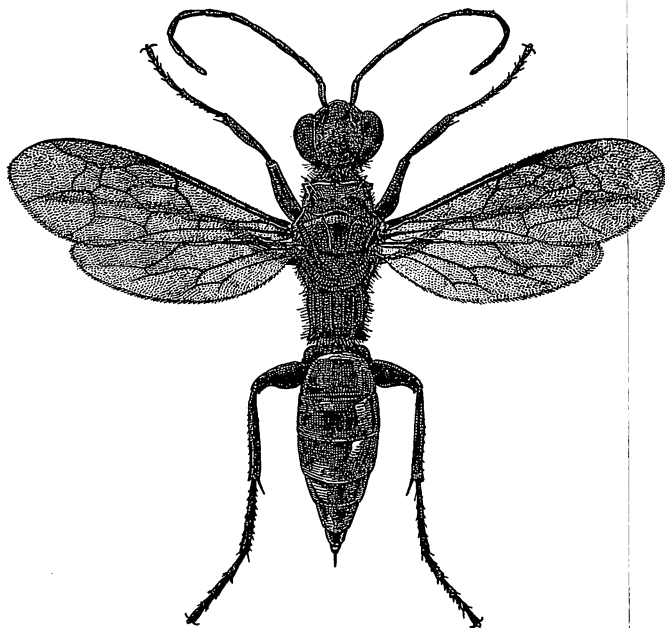


Fig. 14. Philippine-Hawaiian Cockroach Wasp, *Dolichurus stantoni*.

AMPULICIDAE

*Dolichurus stantoni* (Ashmead)

This polished black little cockroach wasp (Fig. 14) was introduced from the Philippines in 1917. It soon spread to the mountain summits of Oahu where, with the immigrant American spider wasp *Anoplius luctuosus* (Cresson), helps augment

the scant Aculeate fauna of our islands. It also occurs in drier regions and has spread of itself to the islands of Hawaii, Maui, and Kauai. According to one observer it has greatly reduced the number of small roaches in the uplands of Oahu, where such species as *Cutilia soror* (Brunn.) and *Allacta similis* (Sauss.) serve as its prey. These roaches are stung to a state of feeble resistance and shorn of part of their antennae, dragged to a newly-found crack or porosity in a lava rock, etc., an egg laid along one of the middle coxae, and the "nest" plugged with grains of lava and other debris. But one roach is supplied to each grub. The pupa is enclosed in a stout cocoon; the former as seen from the figure (Fig. 15) is of somewhat Mephistophelian aspect. A more detailed account of the biology of this



Fig. 15. *Dolichurus stantoni*; male pupa.

insect is given in Bull. 14, Ent. Ser., (Philippine Wasp Studies, 1919,) of Exp. Station, H. S. P. A.

#### PSAMMOCHARIDAE

*Anoplius luctuosus* (Cr.), a blue-black spider wasp of Western United States, was first taken in the Hawaiian Islands in 1910 (Swezey, Proc. Haw. Ent. Soc., II, 187, 1912.) It proved very adaptable to insular conditions, spreading rapidly to the other islands and is now found from sea-level to far up the mountains; in fact, it is one of the wind-borne insects usually

met with at the summit of Mauna Loa, Hawaii, elevation 13,625 feet.

It almost invariably seems to nest in the ground; Bridwell, however, (Proc. Haw. Ent. Soc. III, 275, 1917), observed one nesting in rotten wood in the mountains. The female digs short burrows, sometimes several close together, and provisions each with a paralyzed spider, not confining her attention to one species of Arachnid, however,—she often captures the jumping spiders (Attidae)—and upon whose abdomen she lays an egg. The full-fed larva weaves a tough brown cocoon. Though very numerous here, *Anoplius* does not seem to have noticeably affected the spider fauna of the Hawaiian Islands.

#### SCOLIIDAE

##### *Scolia manilae* Ashmead

This black and yellow wasp is native to the Philippine islands, where it has a wide distribution in the more open lowlands. It measures from about 8 to 12 millimeters and is one of the smallest species of the genus. Introduced into the Hawaiian Islands as an enemy of the *Anomala orientalis* beetle by Mr. F. Muir in 1916, it has done the work so well that this white grub, once very destructive in certain cane fields on Oahu, is now reduced almost to a nonentity. *Scolia* also preys upon the grub of the Chinese Rose-Beetle (*Adoretus sinicus* Burm.), but as the wasp dislikes to operate in grassy areas such as lawns, where the *Adoretus* very commonly breeds, it is thus not nearly so efficient an enemy of this beetle. The wasp, while a very successful parasite, is not, at least in the female sex, so powerful a flier as some other exotic Aculeates, as *Notogonidea*, *Dolichurus* and *Anoplius*; for that reason it was deemed necessary to transport it to other of the Hawaiian Islands. There it soon became established but is noticeably more abundant on the drier than on the more humid plantations.

Several other Scolioid wasps of the genus *Tiphia* have been brought to the Hawaiian Islands, but for reasons unknown never became established here. Perhaps it is because the Tiphias do not, as *Scolia* does, paralyze their prey to permanent tranquility, and thus the chance for the parasitized grub of rub-

bing off the wasp's eggs are present, and, too, the fact that they usually breed much more slowly than *Scolia* may be part of the explanation.

A fuller account of *Scolia manilae* is given in Bull. No. 14, Ent. Ser., Haw. Sugar Planters' Experiment Station, 1919. See also Swezey, Hawaiian Planters' Record, XVII, 50-55, 5 figs. 1917, and Muir, Ann. Ent. Soc. Amer. XII, 171, 1919.

#### EUMENIDAE

The fact that there is so large a number of Odyneri peculiar to the Hawaiian Islands, that most of these wasps—in common with other endemic Aculeates—are distinctive for the four principal islands, and that many live in a special environment, indicates that nature has found their forebears a very plastic lot. Certain ones, as *Odynerus nigripennis* (Holm.) and *Nesodynerus rudolphi* (D. T.), are so constituted that they flourish in the dry lowlands as well as in the humid mountains; the majority, however, are fairly well restricted to certain biological zones, and this condition as well as the differences in size between many species certainly go a long way towards insuring a proper distribution among them of their caterpillar prey. A few of the lowland forms nest in the ground, the others with very rare exceptions utilize ready-made cavities, such as holes and cracks in lava rock and old beetle borings in wood, or to some extent themselves bore into this decaying material; the one true architect that has been identified builds free cells of mud.

The more widely distributed kinds may prey upon a variety of moth caterpillars of the Microlepidoptera type, while those limited to particular districts are more likely to select fewer species. In very dry regions it is mainly following the scant seasonal rainfall (not invariably annual) that these wasps, and their caterpillar prey that feed upon the refreshed vegetation appear. The egg of the Odyneri is suspended by a filament from the wall of the cell, the larva is comparatively obese and when fully fed spins a sort of silvery sheet more or less appressed to the cell walls; the pupa is much like a cramped or mummified adult.

Dr. R. C. L. Perkins, particularly in his "Introductory Essay on the Fauna" (Fauna Hawaiiensis I, 1913) has treated the Hawaiian *Odyneri* at length, and it is my purpose here merely to give a few of my observations—to which those of others may be added—on several of these species of wasps.

*Odynerus oahuensis* D. T.

This is a fat, rather dull black wasp with some red markings, a rather uncommon insect that inhabits the mountains of Oahu. It is distinguished for its architectural ability, standing alone in this respect among the Hawaiian *Odyneri* whose nesting habits are known. Nor does this habit appear common among *Odynerus* in other parts of the world.

It is usually extremely difficult to follow the line of flight of our Hawaiian wasps to their nests, for with their swiftness and generally black color they are soon lost to our eyesight, while the often rugged and wooded nature of the country which many of these wasps inhabit permits of no rapid nor long-impeded movements on the part of the observer. Rather are their cells discovered by accident or while one is searching for various wood-inhabiting insects. While collecting on a steep ridge at the head of Manoa Valley, Honolulu, in February 1920, a female *Odynerus oahuensis* was seen resting on the crown of a Pandanaceous vine (*Freycinetia arnotti* Gaud.) and holding beneath her in her mandibles, a bright, pale greenish moth caterpillar. She was soon lost to view in a low flight down the slope among ferns and vines, but I took up my position at the point where I saw her disappear, eating my lunch there in expectation of seeing her pass by; this was realized, however, only more than an hour later when she flew quickly out of a mere shell of a rind-fragment of a *Freycinetia* stem (ie-ie vine) that happened to be suspended in the shade on a piece of dead and curled frond of a fern. This shell contained two cells of *oahuensis* (Fig. 16) besides an old egg-cocoon of a spider; one cell was sealed, the other was still being stored. I detached the piece of *Freycinetia* and soon thereafter noticed the architect searching vainly for her cells; on my approaching the latter to near their former site she alighted on my hand with a small green cater-

pillar and then plunged for one-half her length into the cell, remained thus for less than a minute and took wing, returning 25 minutes later with very small green caterpillar about 4.25 millimeters long. The cell which she was provisioning thus rather slowly was half filled with small caterpillars upon which a young wasp grub was feeding. Thus it seemed to be a case of "progressive provisioning" necessitated when food is scarce (see Bequaert, Vespidae of the Belgian Congo, Bull. Am. Mus. Nat. Hist. N. Y., August, 1918, p. 220, re *Synagris*). The *oahuensis* larva fed to repletion after I gave it a mutilated Phycitid larva (*Cryptoblabes aliena* Swezey) 7 millimeters long; it successfully spun a cocoon, and in about two and a half weeks thereafter this cell and its mate produced male wasps. The pupa becomes quite active in its late development so that it may then move its legs and open and shut its jaws.

The wasp also nests in curled-up leaves, but its small group of cells are occasionally found suspended from some earthen bank alongside a trail, by a fine rootlet (Fig. 17) and where they are with some difficulty distinguished from the little lumps of soil naturally adhering to roots in similar situations.

Evidently *Odynerus oahuensis* does not always prey upon the same species of caterpillar but conforms to the material the locality affords. Thus, I have seen her extracting from unopened flower heads of *Acacia koa* Gray that had fallen to the ground presumably because of the damage they had received, the fat, dirty whitish caterpillar of the Tortricid moth, *Adenoneura rufipennis* Walshm., and identified by Mr. O. H. Swezey as an insect hitherto only known to attack the green seed-pods of this leguminous tree. These little caterpillars were only 3 or 4 millimeters in length and so a considerable quantity would be required to store a cell. In hunting for these larvae the wasp flies low over the ground alighting every now and then, examining the flower heads, rejecting many but on finding one containing a larva she lets go all else in curling herself around the sphere, bites into it and finally pulls out her prize. Cloudy weather, so very frequent in the Hawaiian mountains, seemed not to interfere with her operations. One or two species of *Coelopenecyrtus* parasites have been bred from the cells of this wasp (Perkins, Fauna Hawaiiensis, I, p. xcvi).

1913). In August, 1909, Swezey reared *Eupelmus paraxestops* Perkins, from the larva of *O. oahuensis* taken on Tantalus, Oahu,

*Odynerus eucharis* Perkins

This insect much resembles the former in appearance and habitat and occurs rather sparsely in the mountains behind Honolulu. It is uncommon, probably in the sense that most of the rare Odyneri are, in that they occur generally as colonies, within certain altitudes, and are more or less periodical in appearance, whether it be a matter of seasons or of interference by parasites. At an altitude of about 1,700 feet, a couple of wasps were observed flying about a broken bough of a koa tree and entering it by means of some old boring. Examination showed the wood to be much tunneled by the large mountain termite, *Neotermes connexus* Snyder, and in whose outer, deserted flattish tunnels were three or four old nests of *Odynerus eucharis*, several cells to each, that were partitioned off with earth and contained remains of cocoons and some dried caterpillars of fairly large size, besides a dead wasp. This is all that was learned of the nesting habits of the species.

*Odynerus pseudochromus* Perkins

This red and black wasp is perhaps the commonest of the higher upland species that inhabits Oahu. It seems generally to nest in hollow twigs, also in various beetle borings, as those of Anobiids (Bridwell, Proc. Haw. Ent. Soc., IV, 393, 1920) which it partitions with mud or disintegrated lava into several cells; these are stored with various micro-lepidopterous caterpillars, Bridwell (Proc. Haw. Ent. Soc., IV, 123, 1919) having found one nest provisioned with the larva of the Ohia Tortricid *Eccoptocera foetorivorans* (Butler). Figure 18 represents a portion of a fragile, hollowed-out root suspended from a bank that has been utilized by the wasp as a single-cell nest, plugging the upper extremity and lateral hole with disintegrated lava rock mixed with saliva. Figure 19, A to E, shows, illustrated to the same scale, the larval mandibles of the wasp grub in its five stages; it will be noticed that as in general with other wasp grubs of this nature, the jaws in the last instar are of necessity

much the stoutest and most fitted for chewing their prey. The slightly spinose pupa is illustrated in figure 20.

*Odynerus pseudochromoides* Perkins

Very like the last species but less abundant is *Odynerus pseudochromoides*. It is occasionally seen in company with other species on forest trails where flying to a particular spot it selects disintegrated lava rock for plugging up its nest, which in the only case observed was a pair of old cells of *Odynerus oahuensis*. The cells had been capped with mud (Fig. 17) and in due time yielded a pair of *O. pseudochromoides*.

*Odynerus paludicola* Perkins

A rather small and rare, shining black wasp with a few red markings that inhabits the mountains of Oahu. It will be noted, by watching its actions, that we are considering a nervous and fidgety insect; in fact, it runs along dead twigs as if distracted, and at once stands out in contrast—when gathering nesting material—to the more deliberately moving *Nesodynerus rudolphi*

EXPLANATION OF PLATE XVI.

Fig. 16. Cells of *Odynerus oahuensis* in rind fragment of *Freycinetia* vine, adhering to dead fern frond. Manoa, Honolulu, 1,300 feet. February, 1920. Slightly enlarged.

Fig. 17. Cells of *Odynerus oahuensis*, that were appropriated by *Odynerus pseudochromoides* and from which a pair of the latter issued. The cells are suspended from a rootlet. Manoa Cliff Trail, Oahu. August, 1920. Slightly enlarged.

Fig. 18. Portion of a dead and hollowed rootlet occupied by the nest of *Odynerus pseudochromus*. Manoa Cliff Trail, Oahu. December, 1919.

Fig. 19. Larval jaws of *Odynerus pseudochromus*. Five successive stages to last stage of the same specimen. C-D in moult. All to the same scale. Mt. Kaala, Oahu. December, 1919.

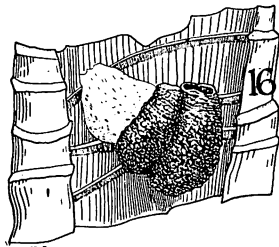
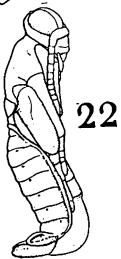
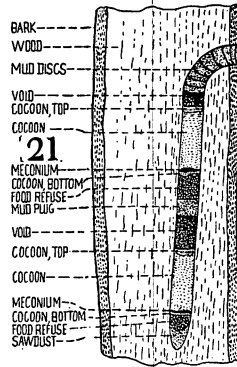
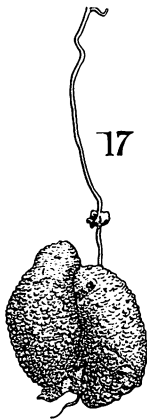
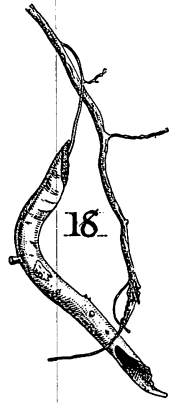
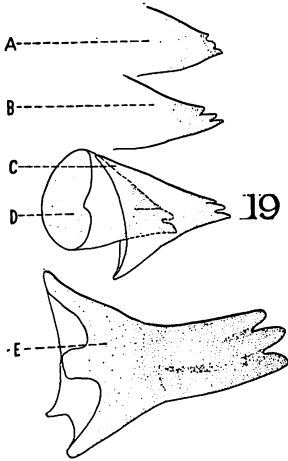
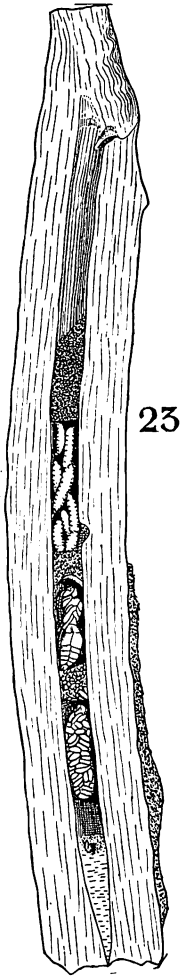
Fig. 20. Pupa of *Odynerus pseudochromus*. Castle Trail, Oahu. 2,000 ft. December, 1919.

Fig. 21. Nest of *Odynerus paludicola* in boring of Anobiid beetle in dead *Acacia koa* limb. Semi-diagrammatic. Manoa Cliff Trail, August, 1920.

Fig. 22. Pupa of an Eupelmid wasp parasitic on the larva of *Odynerus paludicola*. Manoa Cliff Trail, Oahu. August, 1920.

Fig. 23. Nest of *Odynerus orbis* in beetle boring in *Myoporum* twig. Dry forest, Kilauea, Hawaii, 4,000 feet. November, 1919.





that is so common on the forest trails. In the case observed, *paludicola* nests in the deserted borings of *Holcobius glabricollis* Sharp, an Anobid beetle whose cylindrical tunnels seem exactly to fit the wasp. The cells are stored with the larva of *Hyposmocoma alliterata* Walshm. (Hyponomeutidae), a tiny case-bearer abundant on the bark of the koa. A similarly provisioned nest was found by Swezey in old Cerambycid beetle borings in Ohia lehua (*Metrosideros polymorpha*), at Pupukea. This *Hyposmocoma* case is disc-like and flattish and before the occupant pupates, is secured to the tree trunk whence it is pried free by the hunting wasp, bitten open and the morsel extracted, stung to imperfect paralysis and carried to the nest. Three nests were examined, of which two had a couple of cells while the third but a single one. Fig. 21 is a semi-diagrammatic illustration of a two-cell nest in longitudinal section; worthy of notice is the number of mud, or perhaps disintegrated lava discs that plug up the entrance, as also the voids or empty chambers before the cells. The egg of *paludicola* is about 2 millimeters in length, almost equalling in size some of the stored caterpillars, of which 27 were found in one cell; the wasp larva spins a cocoon appressed to the cell walls and above the food-refuse as figured, but it voids its intestine for the last time, in the base of the cocoon as a solid meconium. This wasp, in common with many other Hawaiian aculeates, suffers in the larval state from the attacks of small wasp parasites; in this case, from *Eupelmus chloropus* Perkins, which in the instance noted was reared to the number of about a half dozen, from the inner of two cells. Figure 22 illustrates the pupa of this little parasite.

#### *Odynerus threnodes* Perkins

*Odynerus threnodes* and *O. dubiosus* are very closely related and occupy much the same lowland region on Oahu. Both are small black wasps of the same nervous temperament as *O. paludicola*. One or both of these species occur in the city of Honolulu, and on the low and dry Ewa Coral Plain, where they may be observed searching dead twigs in a hurried manner, running along one this way and that, and eventually locating and dissecting a fat little caterpillar out of a small bundle of silk-

spun debris, stinging and bearing it away.\* In one spot, small holes an inch or two in diameter above but widening as they penetrated the large piece of flat coral stone retained a bit of moist soil, and to which regularly these little wasps in company with other *Odyneri* paid visits for cell materials.

*Odynerus unicus* Perkins

This all-black wasp occurs in the mountains of Oahu, and at Pupukea, in the Koolau Mountains, was found utilizing the old borings of native longicorn beetles in a *Bobeia* tree.

*Nesodynerus rudolphi* (D. T.)

This wasp is not infrequently seen in Honolulu itself but it is more at home from low to moderate elevations in the mountains, where chiefly because of its deep iridescent blue wings it often attracts attention when gathering soil on the moister parts of the trails. It nests in holes in rotten trees, also in porosities in rocks and utilizes as well, the old mud-cells of *Sceliphron*, the spider wasp. Bridwell (Proc. Haw. Ent. Soc., IV, 1919, 122-123) records this species nesting in old *Sceliphron* cells and storing these with *Amorbia emigratella* Busck (Tortricidae) caterpillars. I have also seen this wasp—as in *O. oahuensis*—examining the fallen and unopened flower-head of *Acacia koa* for caterpillars. Perkins (Fauna Hawaiiensis) also gives the prey of *rudolphi* as *Crociosema plebeiana*, *Eccoctocera foetorivorans*, *Heterocrossa* and *Thyrocopa*. It is parasitized in the grub stage by a Chalcidoid (?) wasp, a grub of which was once found feeding externally upon its larva.

*Odynerus orbus* Perkins

An entirely black species of moderate size that inhabits the region about Kilauea Volcano, 4,000 feet elevation, Hawaii. In the "dry forest" (Kipuka Puauulu) at Kilauea, *orbus* was found nesting in deserted cylindrical beetle borings in Naio or Bastard Sandalwood (*Myoporum sandwicense* Gray). Figure 23 shows the larger of two nests. Commencing first with a plug (of

\* *Odynerus dubiosus* Smith as well as some other species have been observed by Swezey hunting for the sugar-cane bud-worm (*Ercumetis flavistriata* Walshm. and other Tineid caterpillars (Bull. No. 6, Div. Ent. H. S. P. A. Experiment Station, 31-32, 1909).

decayed wood or frass of the beetle larva), there follows a large void space, then a thick plug, then the cell stored with whitish or pinkish little Tortricid moth larvae, following this is a second cell containing an *orbus* pupa, while the third compartment has a large *orbus* larva filled to distension with the pupa of *Coelopenencyrtus orbi* Timberlake (Proc. Haw. Ent. Soc., IV, pp. 422-4, 1920,) a little wasp, two adults of which were also found in a stored and sealed cell of another *orbus* nest in *Myoporium*.

*Odynerus nigripennis* (Holmgren)

This large, wholly black species is found on the islands of Oahu, Hawaii and Maui, and occurs from sea level to at least 4,000 feet in the mountains. Prior to the recent advent of *Pachodynerus simplicicornis* (Sauss.) to these islands it was the most abundant Odynerid about cities and towns, nesting in stone walls, old mud-dauber (*Sceliphron*) nests, etc. It seems to be losing ground before this very adaptable competitor, for it was comparatively scarce in 1926, in Honolulu, if not elsewhere as well. It suffers much also from the attack of Chalcid wasps. Swezey (The Sugar Cane Leafroller, etc., and Natural Enemies, Bull. 5, Div. of Ent. Experiment Station, H. S. P. A., 50-53, 1907), who gives an account of the life-history of this beneficial insect, has found it preying upon the caterpillars of various species of *Omiodes*, including the sugar cane leafroller (*Omiodes accepta* (Butl.), on *Hymenia recurvalis* (Fab.), *Amorbia emigratella* Busck and *Mecyna aurora* (Butl.). The wasp larva may remain in the quiescent stage in its cocoon for six months or more (Swezey, l. c.). In the mountains it catches the caterpillars of some of the native Geometrid moths, as *Scotorythra caryopis* Meyr. Occasionally the prey of *nigripennis* has been parasitized internally by a Tachinid fly (*Frontina archippivora*) which may successfully complete its transformations in the wasp's cell. Five species of Chalcidoidea wasps have been found to parasitize the larva of this Odynerid; they are as follows: *Melittobia hawaiiensis* and *peles*\* Perkins, and *Coelopenencyrtus mauiensis* Timberlake, *C. odyneri* Timberlake and *C. swezeyi* Timberlake.

\* *M. Peles* was also reared from the nest of another species of native *Odynerus* found by Swezey on Mt. Kaala, Oahu, November, 1926.

The white-banded *Odynerus radula* (Fabr.), the representative of *O. nigripennis* on Kauai, often nests in old mud-dauber cells on stone walls, etc. In breaking open such cells I have found a great deal of mortality among these wasps and *Pison hospes*, a spider catcher, that were unable to make their way through the mud walls.

At Eleele, on the island of Kauai in February, 1927, I have seen the little red-marked *Odynerus blackburni* Kirby, fairly swarming about a fence built of lava rock (Plate XVII) in whose porosities they nested and often retired in dull weather and presumably also for the night—head facing outwardly. Comparatively few females were seen provisioning their nests; the tiny caterpillars used for this purpose are probably *Cryptoblabe aliena* Swezey (Phycitidae) of trash-feeding habit. The cells are stoppered with the moistened red soil of the locality. This wasp also utilizes the deserted cells of the *Sceliphron* mud-dauber. *Odynerus kauaiensis* Perkins, another lowland wasp with a white-banded abdomen, was also found resting in lava rock porosities and no doubt frequently nests therein.

*Pachodynerus simplicicornis* (Sauss.)

This thick-set, yellow-winged and yellow-banded black wasp that is now so predominant in the lowlands, is a recent immigrant from the warmer parts of the American mainland, to which this subgenus is peculiar. Mr. W. M. Giffard first discovered it in the Hawaiian Islands, in Honolulu during the fall of 1911 (Giffard, Proc. Haw. Ent. Soc., II, 199-202). It was found partitioning the mud cells of *Sceliphron caementarium* and provisioning them with caterpillars of *Cryptoblabe aliena* Sw. It may exist almost in swarms about buildings and is a very common wasp around plantations, and also in such localities as the Ewa Coral Plain, where the porous coral affords it excellent nesting places. It is frequently seen on the blossoms of *Crotalaria* and has the habit common among *Odyneri* in parts of the United States but not observed in the Archipelago among native species, of congregating in some numbers on plants to pass the night. Mr. O. H. Swezey made some observations on this insect at Hana, Maui, October 16, 1926. He found them flying in hundreds about the eaves and walls of the plantation



Wall of porous lava rock along edge of field of sugar cane. Eleele, Kauai. Nesting site of *Odynerus blackburni*.

store in search of holes for nesting. Upon examining some of the cells he found them stored with the larvae of *Crociosema lantana* Busck, a tortricid moth imported from Mexico to destroy the undesirable lantana plant that covers so much of our lands. *Pachodynerus* from this standpoint is an undesirable insect. But it also stores the larva of the injurious Tortricid, *Amorbia emigratella*. In its mainland home it has some effective enemies, important among which is a Rhipiphorid beetle that parasitizes its cells.

#### POLISTES

*Polistes aurifer* Sauss., *Polistes hebraeus* Fab., and *Polistes macaensis* Fab. are the common "yellow jackets" throughout the islands, and build the familiar, social paper nests under eaves, palm leaves, in open buildings, etc.

*Polistes aurifer* is probably an immigrant from California, the other two being of Asiatic origin. All are caterpillar-hunters and therefore useful insects, though effective stingers. They hunt armyworms and leafrollers, etc., in the lowlands and cane fields, and in the mountains, among other larvae, those of *Scotorythra* on *Acacia koa*, etc., trees. These they skin and chew into a pulp with which to feed themselves and their young. The caterpillar of the Pyralid moth *Pyralis mauritialis* Boisd. feeds in old *Polistes* nests (Swezey, Proc. Haw. Ent. Soc., II, No. 3, p. 138, 1910).

*Polistes aurifer* in Hawaii is very commonly parasitized (stylopsized) by insects of the Order Strepsiptera, that may be found partly protruding from between the abdominal segments of the host.

A good popular account of *Polistes hebraeus* is given by R. Veitch (see The Hornet in Fiji, Agric. Rep. No. 2, Colonial Sugar Refining Company, Ltd., Sydney, April, 1917).

#### *Vespa occidentalis* Cresson

This yellow and black "hornet" has been found on the north-western highlands of the island of Kauai, being first taken at Kokee, by A. Kusche in January, 1919. A year later Messrs. Rock and Agee when in the Alakai Swamp, at an elevation of between 3,500 and 4,000 feet, took a single queen benumbed with cold and clinging to the underside of a fallen post, where she was evi-

dently hibernating. Subsequently it has been taken in this same humid region, as follows: Kaholuamano, April, 1920 (A. Kusche); Olokele Canyon, Milolii, and Nualolo, August, 1925 (O. H. Swezey). Thus, it has spread over many square miles, Swezey having found it especially common on the Nualolo ridge, where it was flying very actively about Ohia trees. He also noted a nest of this wasp in the ground. In February, 1927, it was found along the Summit Camp trail some miles back of the town of Lihue. This fierce insect will probably be of no benefit to the endemic fauna.

The natural habitat for *Vespa occidentalis* is Western United States, and the common prey for many species are flies.

#### BETHYLIDAE

These include small to very small blackish or brownish wasps that are parasitic upon the larvae of beetles and of moths. The genus *Sierola* is enormously developed in the Hawaiian Archipelago, Fullaway (Bishop Museum, Occasional Papers, VII, p. 57-159, 1 pl., 1920), having described 171 species and subspecies therefrom, and in many cases has recorded their caterpillar host. Many of the forest forms may be obtained by sweeping bushes and trees. *Sclerodermus* is a much smaller genus, with the females generally apterous.\* Their hosts are usually the larvae of boring moths, and so these wasps are to be found in dead wood, under bark and in twigs where these caterpillars occur. Bridwell (Proc. Haw. Ent. Soc., IV, p. 21-38, 1919, and 291-314, 1920) has given us some very excellent accounts of the biology of *Sclerodermus* and other Bethylidae and has experimented with them with interesting results.

Swezey, in "A Preliminary List of the Hymenopterous Parasites of Lepidoptera in Hawaii" (Proc. Haw. Ent. Soc., III, p. 101, 1915) lists several Bethylidae and their moth caterpillar hosts.

*Epyris extraneus* Bridwell is an immigrant from the Orient; it is a comparatively large species that preys on the larva of the common trash-dwelling tenebrionid beetle, *Gonocephalum seriatum* (Boisd.) (see Williams, Proc. Haw. Ent. Soc., IV, 55-63, 2 pl., 1919).

\*Timberlake (Bull. 31, Bishop Mus., p. 19-21, 1926) gives a key to the majority of Hawaiian species of *Sclerodermus*.