BULLETIN

OF THE

AMERICAN MUSEUM OF NATURAL HISTORY.

VOLUME XXIII, 1907.

59.57, 96: 11.51

Article I. — THE POLYMORPHISM OF ANTS, WITH AN ACCOUNT OF SOME SINGULAR ABNORMALITIES DUE TO PARASITISM.

BY WILLIAM MORTON WHEELER.

PLATES I–VI.

The study of sex determination among organisms — a subject obviously included under the greater problem of the origin of variation, since sexual dimorphism is the most striking and constant form of intraspecific variability both in animals and plants — and the related but much more restricted problem of polymorphism, have of late attracted the attention of many biologists. A perusal of some of the literature bearing on these subjects, however, has convinced me that the simplicity of the questions involved may have been overestimated. That this is especially true of polymorphism as manifested in the social insects, will, I believe, be evident from a consideration of the facts recorded in the following paper. At any rate, it will not be a difficult task to show that we are still very much in the dark concerning the fundamental causes of the differentiation of one sex into several distinct phases, and, while it may be urged that the problem of polymorphism as it is presented by the social insects, may be more complicated than that of sex, on purely *a priori* grounds the opposite view would seem to be the more probable, for polymorphism is undoubtedly not only a more restricted phenomenon but one of much more recent phylogenetic and ontogenetic development, and hence presumably dependent on conditions both more specialized and more amenable to observation and experimentation. While the observations recorded in this article suggest both the need of experiment and some of the points at which the problem is open to this method of investigation,

they indicate with equal force that the causes of polymorphism may be so recondite as to give little encouragement to the crude physiological methods at present available. In other words, much water will have to flow through the biological mill before we possess sufficient knowledge of the physiological chemistry of such small organisms as the insects, to enable us to determine the exact nature of the subtle influences that decide whether an ant or bee shall become a queen or a worker.

The following observations relate to some of the unusual or pathological individuals occasionally found in ant colonies, and referable, with more or less probability, to trophic disturbances induced by specific parasites. The inferences from these cases have a value approaching those derived from experiment, since the phenomena make their appearance only under very definite circumstances.

PART I. OBSERVATIONS.

1. The Parasitism of Orasema and other Chalcididæ on ants.

A. Orasema viridis Ashmead.

This beautiful Chalcidid is abundant in Texas in the nests of *Pheidole kingi* André subsp. *instabilis* Emery, but only from May to September. For this reason I failed to notice it till May 25, 1903, about six weeks before I moved from Austin to New York, although during my four years' residence in Texas I had examined hundreds of *instabilis* nests during the autumn, winter, and early spring months. I was so much impressed with the peculiar behavior of the *Orasema* and the ants that I devoted to the subject every available moment of the short remainder of my sojourn in Texas, but the necessary preparations for my departure, the intense heat, which sets in during the month of May, and a peculiar misunderstanding of the conditions under which the *Orasema* develops, seriously interfered with the progress of my work. It was only after I had left Texas that the study of preserved material led me to what I believe to be a correct interpretation of the life history of the insect.

Before describing the *Orasema* and its development it will be necessary to say something about the host. *Ph. instabilis* is a common ant in central Texas and certain parts of Mexico, at least as far south as the State of Morelos, where I have taken it near Cuernavaca. It forms populous colonies which prefer to nest under stones in sunny places. In central Texas

it is often found in bottom lands and waste places where the soil is rich and supports an open growth of grasses and especially of Crotons (*Croton texensis* and *C. monanthogynus*). It is a harvesting species and stores the flat chambers of its nests with innumerable seeds collected from all the plants in the neighborhood. Like other harvesting ants, however, it does not confine itself to a vegetable diet, but eagerly seizes on any insect food that may fall in its way.

In common with other members of the great genus *Pheidole*, *instabilis* presents four phases known as the soldier, worker, female and male respectively. The soldier is 4–4.5 mm. long. The shape and extraordinary proportions of its head are shown in Plate I, Fig. 1, and Plate V, Fig. 63 *o*. Its gaster is black and shining, the mandibles and clypeus are dark brown, the remainder of the head, thorax and appendages reddish brown.

The head is subopaque and elaborately sculptured as shown in the figure. The worker (Pl. I, Fig. 7, and Pl. V, Fig. 63 *c*) is only 1.5–1.8 mm. long. It is shining throughout, and of a dark brown or black color with yellowish appendages. The female (Pl. I, Fig. 8 and Pl. V, Fig. 63 *a*), which measures 5.5–6 mm., is dull black, with the legs, antennæ, mandibles and anterior half of the head yellow. The wings (removed in the specimen figured) are yellowish hyaline with pale veins. The male (Pl. I, Fig. 9 and Pl. V, Fig. 63 *e*) is a much smaller and more graceful insect than the female, measuring only 4–4.3 mm. Its head and gaster are black, its thorax and appendages sordid yellow, the former with pale sutures. Its wings resemble those of the female.

While *instabilis* agrees with its congeners in having the four phases just described, it differs from all except a small group of North American species of *Pheidole* in presenting in every well-developed colony a series of individuals intermediate in size, structure, and sculpture between the soldier (Pl. I, Fig. 1) and the worker (Pl. I, Fig. 7). This series, which is very complete in large colonies, is represented in Plate I by a few selected individuals (Pl. I, Figs. 2–5 and Pl. V, 63 *r*). The occurrence of such intermediate forms, though well-known in some other genera of ants, like *Solenopsis* and *Camponotus*, is so unusual in the genus *Pheidole* as to call for the special explanation which I shall attempt to give in the sequel. It is also an interesting fact that the organs are not always reduced in size in strict correlative proportions as we descend the series of intermediate individuals from the soldier to the worker. As shown in Plate I, Figs. 5 and 6, for example, the antennal scape may be of the same length in two individuals which differ considerably in the size of the head. Or, again, as shown in figure 4, the scape may be longer in one individual than in others with larger (Pl. I, Fig. 3), or smaller heads (Pl. I, Figs. 5 and 6).

The acme of the colonial activities of *Ph. instabilis* is attained during the latter part of May and the first weeks of June. Then the nest is full of eggs, larvæ, pupæ, and callows of all the castes and presents a bewildering appearance, owing to the fact that the brood is not assorted according to ages, as in many ants, but lies jumbled together in the different chambers and galleries. The functions of the workers and soldiers are clearly distinct. The former are far and away the more numerous, and notwithstanding their diminutive size, may be said to manage the affairs of the colony. They collect the seeds and dead insects and drag them to the nest. They excavate the galleries, feed the brood and carry even the huge female larvæ and pupæ from chamber to chamber and assist the callows in escaping from their pupal envelopes. The soldiers act as carvers, or trenchers of the tough insects and hard seeds brought in by the workers. Their powerful mandibles admirably fit them for this office and for guarding the nest. They are often seen to form a stationary cordon about the brood and the callows in the chambers. They are never seen to eat the seeds or insects which they cut up for the other members of the colony but are fed on liquid food regurgitated by the workers. They are very stolid and inactive, very rarely leave the nest and never assist in carrying the larvæ and pupæ about. Their heads are so large in proportion to their bodies that, when dropped on their backs on a smooth surface like that of glass or polished wood, they are often unable to right themselves and may die standing on their heads. The intermediates are much more active and may be seen to leave the nest, collect food, carry larvæ and, in short, perform all the duties of the workers which they approach in their smaller size and smoother sculpture.

The larvæ of all the castes are provided with several pairs of flexuous, anchor-tipped dorsal hairs, by means of which they may be temporarily fixed to the earthern walls of the chambers or to the rough surfaces of the stone covering the nest. While in this position they are fed by the workers with bits of crushed seeds or insect fragments in the same way as the larvæ of the Ponerine ants. At least the younger larvæ of the males and females, however, appear to be fed largely, if not exclusively, with regurgitated liquid food.

Ph. instabilis is very common at Austin in the bottom and along the banks of a small limestone cañon, known as Shoal Creek. There, during May and June, 1903, I found a great number of colonies. Several of them were confined in artificial nests of the Fielde pattern and one was kept under observation till the latter part of September. I also preserved whole colonies in alcohol after killing them in water heated to 80° C.

Fully half of the colonies examined were found to contain the peculiar parasites which Dr. W. H. Ashmead has kindly identified for me as *Orasema*

viridis Ashm., a Chalcidid fly originally described from specimens collected at large by Mr. E. A. Schwarz near San Diego, Texas.

The genus *Orasema*, which belongs to the subfamily Eucharinæ, was originally established by Cameron on *O. stramineipes* from Panama, in the 'Biologia Centrali-Americana'.[1] According to Ashmead,[2] this genus is characterized by the possession of 10-jointed antennæ in both sexes, and in having the right mandible two-toothed, the left with a single tooth, and both mandibles acute and falcate at their tips. The genus appears to be largely restricted to tropical and subtropical America but extends somewhat further north in the western than in the eastern portion of the United States.

The female *O. viridis* (Pl. I, Fig. 10, and Pl. V, 63 *m*) measures 2.5–3 mm. and is deep metallic green with the clypeus and thoracic dorsum more golden and the gaster blue or violet. The head, thorax and petiole are uniformly and densely punctate, the gaster very smooth and shining. The legs are honey-yellow, excepting the middle portions of the femora, which are metallic green, and the terminal tarsal joints, which are black. The antennæ are black, with the basal joints yellow, as are also the mandibles, tongue, and palpi. The wings are very clear and iridescent. The epinotum and scutellum together form a rounded cone through which the thorax reaches a greater vertical diameter than it does elsewhere. The male (Pl. I, Fig. 11, and Pl. V, Fig. 63 *n*) is distinctly smaller than the female (2.3–2.5 mm.) and differs in having a much longer petiole, a much shorter and smaller gaster, and longer and thicker antennæ, with the basal joints black instead of yellow.

On opening a large *instabilis* nest a dozen or more of these superb insects may be seen lying on their sides or creeping about among the ant-brood (Pl. V, Fig. 64). It is also easy to recognize their pupæ, white when young or nearly ready to hatch, of a dull blue-green color when mature, scattered among the larvæ and pupæ of their hosts. Such nests present a splendid appearance, reminding one of a jewel casket in which the sapphires and emeralds are represented by the *Orasema*, the pearls by the larvæ and pupæ, the opals by the iridescent wings of the parasites and of the male and female ants, the garnets and bits of jet by the glistening black and red seeds and the red heads and black bodies of the soldiers.

As soon as the nest is disturbed, the workers seize the *Orasemæ* and their pupæ and, even at the risk of neglecting their own brood and callows, carry them bodily to a place of safety. In artificial nests this great fondness for the *Orasema* may be witnessed at one's leisure. The adult parasites are not only carried about and continually licked and fondled, but are also fed

[1] Vol. I, 1883–1900, pp. 104, 105, pl v, fig. 20, pl. vi, fig. 18.
[2] Classification of the Chalcid Flies or the superfamily Chalcidoidea. Mem. Carnegie Museum, No. 4, 1904, pp. ix, 225–551, pll. xxxi-xxxix.

by regurgitation as if they were workers. They usually submit to these effusive attentions passively, but at times they may be seen to struggle and disengage themselves from the embraces of their hosts. When fully mature both sexes of the *Orasema* become highly phototropic and endeavor to escape from the dark nest to the open air and sunshine. The ants, however, redouble their attentions and carry them back to the dark chambers. Although usually aided by the workers in hatching from their pupæ, the *Orasemæ* themselves often remove the pupal envelopes from their antennæ by rubbing them with their fore legs, and, though fed by the ants, they sometimes visit and partake of the sugar in artificial nests. They spend much of their time in lying on their sides among the ant larvæ and pupæ. While the workers thus appear to be infatuated with their beautifully sculptured and brilliantly colored parasites, the latter are not sufficiently hypocritical to feign any interest in their hosts. They are, in fact, interested only in the ant brood and, as I shall show, only in a certain portion of the brood.

As several successive broods of *Orasema* pupæ appeared and hatched in my artificial nests, I was sure that the larval stages must also be present. These stages, it would seem, should be readily detected, but for a long time I was completely misled in my search for them, and even after I had found them, I was deceived by their appearance. This arose partly through certain prepossessions based on analogy with what I had read about other Chalcidids, and partly through the confusion produced by the high degree of polymorphism in the *Pheidole*. As nearly all Chalcidid larvæ are internal parasites in other larvæ, I was under the impression that the *Orasemæ* also start their life cycle within the larvæ of their hosts, and certain peculiarities in the *Orasema* larvæ merely tended to strengthen this prepossession. The great number of larval and pupal forms of the ant added to my confusion, especially as some of their larvæ differed in shape according to their feeding. Thus for a time I regarded certain small, spherical, sexual larvæ, fed with regurgitated liquids, as the young larvæ of *Orasema*. It was not till after I had left Texas and had nothing but preserved and stained material at my disposal that I succeeded in gaining a clear idea of the early larval stages of the parasite.

I have not seen the eggs of *O. viridis* after oviposition, but only the very young larvæ. Dissection of the female shows that, as we should expect in a parasite, the eggs are extremely numerous and minute. The mother insect, when she comes to oviposit, exercises a very careful selection among the ant brood. In the first place she has nothing to do with the *instabilis* larvæ but directs her attention to the pupæ. In the second place she selects, as a rule, only the pupæ of the soldiers, males, and females. The small worker pupæ would not furnish sufficient food for her larvæ. In the third place she selects

only pupæ at the very critical moment when they have just been stripped of their larval skin by the workers and are, therefore, little more than semipupæ, for obviously at this moment the cuticle is thinner and will be more easily pierced by the young *Orasema* larva than during the preceding or succeeding stages. And in the fourth place, she does not lay her eggs at random anywhere on the body of the semipupa but carefully selects one of four regions near the head. Usually she places the egg on the sternal surface just beneath the still very short, incurving legs of the semipupa but occasionally it is placed on the back of the neck between the head and the prothoracic segment, or on the right or left side of the neck beneath the corresponding prothoracic leg. These regions would seem to be singularly appropriate, both because the cuticle of the semipupa is extremely thin and readily punctured by the parasitic larva at these points, and also because the egg or resulting larva, especially when it is covered with the overlapping appendages of the semipupa, is not so readily brushed or licked off by the *instabilis* workers. I believe that the danger of detaching the egg is very great and this, together with the other special requirements above enumerated, may account for the fact that comparatively few of the great number of *Orasema* eggs ever complete their development.

Further reflection shows still greater appropriateness in the time and place selected for oviposition by the mother *Orasema*. In the sexual semipupæ of *instabilis*, and especially in those of the soldiers, the small anterior end of the body is destined to grow very rapidly and to undergo extraordinary changes in structure. For this purpose carefully elaborated liquid substances of a very high nutritive value are suddenly propelled into the anterior portion of the body of the semipupa, which therefore appears tense, clear, and transparent in this region, while the abdominal region is full of opaque, nonmetabolized fat cells. The parasitic larva is thus situated from the first at a point where it has ready access to a rich food supply and is able to grow with surprising rapidity.

The instinct that leads the mother *Orasema* to oviposit with such precision is not, however, infallible. As the number of soldier and sexual pupæ in an *instabilis* colony is always very limited compared with the number of worker pupæ, the *Orasema*, impelled, apparently, by the need of getting rid of her eggs, sometimes oviposits on the latter, although even in such cases also, she chooses the cervical and sternal region. The interesting consequences of this instinct aberration will be considered in a later paragraph.

Several of the youngest *Orasema* larvæ seen are represented in Plate II, Figs. 30–35. They are extremely small — less than .1 mm. in length — and of a dark brown color. The head is distinct and furnished with short,

acute mandibles; the body consists of a number of sharply marked segments, of which the anterior are longer and broader, the posterior smaller and often telescoped into one another so that it is difficult to ascertain their exact number. There are probably three thoracic and ten abdominal segments. The terminal segment bears a pair of hair-like cerci. Were it not for the absence of legs, these larvæ might be regarded as campodeiform and likened to the youngest stages of such parasites as the Stylopidæ and Meloidæ. Several of my preparations show these larvæ attached to the necks of worker semipupæ or pupæ, as represented in Plate II, Fig. 13. Twice I have seen a pair of these larvæ attached symmetrically on the sides of the same pupa. In other cases they were found on the nuchal or sternal surfaces.

So different are these minute, sharply segmented and dark brown larvæ from those of other Chalcidid larvæ, of which I have seen descriptions or figures, that I should never have regarded them as belonging to the life-cycle of *O. viridis*, had I not seen stages like those represented in Plate II, Figs. 14 and 15. These figures represent semipupæ of *instabilis* soldiers with undoubted *Orasema* larvæ .3 mm. in length attached, in the one case to the sternal surface between the pro- and mesothoracic segments, in the other to the nuchal surface. In Plate II, Fig. 14, the larva has its long axis at right angles to that of its host; in Fig. 15 the parasite and host are similarly oriented. The dark brown segments of the younger larva are represented in both cases by dark bands on a yellowish white background. The cerci have disappeared. The larvæ have plunged their mandibles into their host and have begun to absorb its juices, and this has led to a separation of the more heavily chitinized sclerites and great expansion of the intervening membranes.

Succeeding stages in the growth of these larvæ are shown in Plate II, Figs. 16, 17 and Plate V, Fig. 66. All of these represent female semipupæ of *instabilis*, and in each the *Orasema* larva, which is attached as in Fig. 14, has attained a length of .7–.9 mm. In Plate II, Fig. 17, which is drawn from a stained and mounted specimen, the parasite is somewhat shrunken through dehydration and clearing, but in Fig. 16, from an alcoholic specimen, the skin of the larva is smooth and tense. The fact that all traces of the dark bands have disappeared is probably due to the intervention of an ecdysis between this stage and the one represented in Figs. 14 and 15. It was stages like Figs. 16 and 17, which were first seen in my artificial nests and led me to an erroneous interpretation. The parasite in this stage was yellowish and semitransparent, while the semipupa to which it was attached was opaque, waxy white and more or less shriveled. The larva, moreover, seemed to make its appearance very suddenly, and this, coupled with the fact that the ants kept licking it till its surface glistened with saliva, led me to

suppose that it had reached its full growth within the ant-larva and was just breaking through the integument on the nuchal or sternal side. I saw the workers, which evinced the greatest interest in this phenomenon, pull the larva away from the semipupa and throw aside the latter, now reduced to a sickly mass, though still retaining enough of the contents of the abdomen and of its original form to be recognizable as a pupa, notwithstanding the fact that the head, as shown in Fig. 16, was much smaller than in the corresponding stages of the nonparasitized soldiers and females.

Shutting my eyes to the correct interpretation of the above stages as indicating that the larva was ecto- instead of entoparasitic, I stained and mounted *in toto* whole series of soldier and female larvæ and young pupæ in the hope of finding the *Orasema* larvæ prior to their eruption. This search proved, of course, to be futile, and I was baffled until I accidentally found the crucial stages represented in Plate II, Figs. 13 to 15.

The growth of the parasite, after it has plunged its mouthparts into the integument of its host, must be extremely rapid. I doubt whether the stages above described require more than a couple of days for their completion. Such rapid growth, however, is not surprising when we consider the accessibility and high nutritive value of the food on which the larva subsists.

As soon as the full-grown *Orasema* larva has been separated from its prey, it begins to pupate. Occasionally the ants are either unable or neglect to detach the parasite. In such cases, two of which are shown in Plate II, Figs. 18 and 19, the larva begins to pupate *in situ*. It undergoes an ecdysis in which it is undoubtedly assisted by the workers, and then appears as a short, thick-set semipupa, slightly constricted just in front of the middle of its body. Another ecdysis seems to follow almost at once, leaving the semipupa covered with a peculiar envelope studded with large blisters, or pustules. These are arranged segmentally in regular rows along each side of the body but are absent in the middorsal and midventral regions. I am unable to assign any function to these singular organs, which in *O. viridis* disappear with the semipupa stage. On focussing through the pustulate envelope the semipupa is seen to present the appearance of Fig. 20 (Pl. II). The imaginal head, with its large eyes and antennæ, is embedded in a hood-like prothoracic mass; the legs and wings are clearly indicated. A little later the pustulate envelope is shed and the complete, pure white pupa of the *Orasema* is seen enclosed in a thick membrane (Pl. II, Fig. 22) which, in the intersegmental regions of the abdomen, is thrown into prominent transverse welts. The color, which now gradually deepens, becoming first blackish and then metallic green, is dimmed by the rather opaque, white pupal envelope (Pl. II, Fig. 23). Soon after this stage is reached, the

insect hatches. The changes from the stage represented in Fig. 21 to that of Fig. 23 can hardly require more than three or four days. If this and my estimate concerning the rate of development in the earlier stages is correct, we must suppose that *O. viridis* completes its entire life-cycle, from the egg to the imago, in less than a week or ten days. Similarly rapid developments are known to occur in other Chalcidids, as I infer from the following statements in an interesting paper published some years ago by Howard[1]: "Ratzeburg has shown that in Europe *Pteromalus puparum* occupied on one occasion from June 11 to July 14 to undergo its entire transformation from egg to adult — thirty-seven days; but in this country Webster has recorded an instance (Insect Life, I, 225) in which the eggs of the same parasite were laid August 9, the adult insect developing August 27 — seventeen days later. Hubbard has noted (Fourth Report U. S. Ent. Com., p. 103) that the egg of *Aletia xylina* gives forth the adults of *Trichogramma pretiosa* on the seventh day after it was stung by its parents. *Euplectrus comstockii* has been shown by Schwarz to develop from egg to adult in Alabama in mid-summer in seven days."

There can be little doubt that in a state of nature the male and female *Orasemæ* leave the nest very soon after hatching and mate in the open fields. This is indicated by their strong positive phototropism. The fertilized females then seek out fresh *Pheidole* nests in which to lay their eggs. In one of my artificial nests, however, which was kept from June 19 to September 20, three successive broods of *Orasema* were noted, the last disappearing about a week before the latter date. In this case, unless the offspring arose from parthenogenetic eggs, the males and females must have mated in the nest. Both in this and other cases it was found that the adult *Orasemæ*, after they had remained in the nest for several days, were killed and dismembered by the workers, as though the parasites had at last been recognized as predatory aliens. This slaughter, however, may have been due to other causes, since the workers also killed and dismembered their own females and ultimately reared only workers and intermediates, probably because these required less nourishment. Such conditions point to a deterioration of the colony and are frequently observed in artificial nests inadequately furnished with food. Similar behavior on the part of workers may be seen in other species of ants when the food supply becomes insufficient or is no longer palatable. Under these circumstances I have seen *Camponotus ferrugineus* workers kill and dismember their soldiers and *Myrmica brevinodis* workers do away with their males.

Before concluding this account of the relations of *O. viridis* to *Ph.*

[1] The Biology of the Hymenopterous Insects of the Family Chalcididæ. Proceed. U. S. Nat. Mus., XIV, 1892, pp. 567–588.

instabilis, it will be necessary to return to the worker semipupæ on which the *Orasema* occasionally deposits her eggs. In such cases the young larvæ of the parasite must be very inadequately fed and probably soon die and fall off, leaving their hosts in a depleted condition but still able to pass on to the pupal stage. Now in all the nests infested with *Orasema*, and only in these, I have found a number of peculiar pupæ like those represented in Plate II, Figs. 24–26 and Plate V, Fig. 65 *s*, and differing from the normal worker pupæ (Fig. 27) in several important characters. They are smaller, of a waxy white color, with more decided intersegmental constrictions and are broad behind and very narrow anteriorly. The head is remarkable for the very small size of the brain and eyes and the situation of the latter on distinct stalks. The mandibles, too, are abortive. The resemblance of the head to depleted female pupæ, like the one represented in Fig. 16, is very striking. The thorax is extremely slender and the gaster has a high fold on each side, and in balsam preparations (Pl. II, Fig. 26 and Pl. V, Fig. 67 *i*) is seen to contain a number of large urate masses in the *corpus adiposum*. In many specimens the gaster is concave ventrally, with its tip turned upward and forward. Although these singular pupæ are carefully cleaned by the workers and kept with the normal individuals, they never succeed in hatching. After lying in the chambers for many days without even acquiring a deeper color of the body or pigment in the eyes, they are either carried to the refuse heap or eaten by the workers. I am convinced that these extraordinary pupæ, which may be called *phthisergates*, have arisen from worker semipupæ that have had part of their juices sucked out by *Orasema* larvæ, so that only enough formative material was left to produce pupæ with very defective head and thorax and hence quite unable to develop as far as the imaginal instar. It is interesting to note that these microcephalic, microphthalmic, and stenonotal characters represent merely greater diminution of the similar characters of the normal workers as compared with the more macrocephalic, macrophthalmic, and eurynotal soldiers and females. The theoretical bearings of these conditions will be considered in the latter part of this article. The depleted semipupæ of the *instabilis* females and males, which like the phthisergates are incapable of further development, may be called *phthisogynes* and *phthisanērs* respectively.

In this connection the question naturally suggests itself: are the intermediates between the *instabilis* workers and the soldiers due to similar depletion in their semipupal stages? In other words, do the intermediates arise from soldier semipupæ that have been partially exhausted by *Orasema* larvæ prematurely torn from their hosts by the workers? I am inclined to answer this question in the negative, for reasons to be given in the sequel.

After finding *O. viridis* so common in the nests of *Ph. instabilis* I was

naturally led to look for it in the company of other Texan species of *Pheidole*. This search soon revealed the fact that the parasite can make its home also with other ants of this enormous genus. June 16, I found a single female *viridis* in a flourishing colony of *Ph. dentata* Mayr at Alice, Texas, which is only about ten miles east of San Diego where the types of the parasite were originally captured by Schwartz. *Ph. dentata*, it should be noted, is a carnivorous species with sharply separated soldier and worker castes, as represented in Plate III, Figs. 37 and 38. June 21, I again found at New Braunfels, Texas, a colony of this same *Pheidole* containing a few female pupæ of *O. viridis*. In this colony, which was kept for some weeks in an artificial nest, four phthisergates made their appearance. One of these is represented in Plate II, Fig. 28. They differed considerably in form from the *instabilis* phthisergates and had slightly pigmented eyes. These organs, however, as well as the head and thorax were notably reduced as compared with those of the normal worker pupa, which is essentially like that of *instabilis* (Pl. III, Fig. 27).

A little later in the month (June 24), I came upon a colony of a hitherto undescribed *Pheidole* (*Ph. sciophila* sp. nov.), containing a number of imagines and pupæ of *O. viridis*. This ant, like *Ph. dentata*, has no forms intermediate between the soldiers and workers. It is a rare species, nesting under stones in rather damp, shady places in the vicinity of Austin. These observations prove that *O. viridis* is not confined to a single host ant but has international relations with a number of species of the genus *Pheidole* in central and southern Texas. It may be expected to occur also in the nests of *Ph. crassicornis*, *Ph. hyatti*, *Ph. morrisi*, etc. Still another observation goes to show that the parasite is not confined to Texas, but is also probably widely distributed through Mexico. In my collection there is a female specimen of *O. viridis* taken August 4 at Tuxpan, in the state of Jalisco, by Mr. J. F. McClendon. As this specimen was found in a bottle containing a mixed lot of ants comprising three species of *Pheidole*, besides some species of other genera, I am unable to refer it to a particular host.

B. Orasema coloradensis Ashmead.

During August, 1903, while collecting ants in Colorado, I came upon a second species of *Orasema*, which Dr. Ashmead has identified for me as *O. coloradensis*, in the nests of two very different species of ants. One of these is a larger and usually darker form of a small *Solenopsis*, which I take to be *S. molesta validiuscula* Emery, the other *Pheidole vinelandica* Forel.

O. coloradensis (Pl. I, Fig. 12 and Pl. V, Fig. 68 *m*) is of about the same size as *O. viridis*, but is readily distinguished by its longer, lower, and

smoother thorax, and less prominent scutellum and epinotum. In coloration it is like the Texan species, except that the thorax is less golden above and the mesopleuræ are more shining. In the male the petiole is shorter and the tibiæ are more or less infuscated. The mature pupæ of the two species are very readily distinguished by the character of the last pupal envelope. In *coloradensis* (Pl. IV, Figs. 53 and 54) this is pustulate like the semipupal envelope of *viridis*, the pustules appearing on the abdomen as dilatations in the transverse intersegmental welts above described for *viridis*. Then, too, the pupal skin of the Colorado species has a series of large pustules extending along the middorsal line of the epinotum and abdomen and about the front of the pronotum where they are completely absent in *viridis*.

O. coloradensis was first noticed August 3, in a colony of *S. validiuscula* (Pl. V, Fig. 68) at Manitou. The ants with their brood were confined in a bottle for the purpose of rearing some of their numerous male and female pupæ. The tiny workers were seen to spend much time shampooing an adult female *Orasema*. Later other females and a few males hatched in the nest and were cared for by the ants like members of their own species. In the course of a few days two of the *Orasemæ* were found dead on the refuse heap, one having been decapitated and shorn of its legs and wings. This led me to wonder whether the *Solenopsis* workers which are themselves parasitic and feed on the larvæ and pupæ of other much larger ants of the genera *Formica, Myrmica, Cremastogaster*, etc., are quicker than the species of *Pheidole* to recognize the *Orasemæ* as aliens after they have been reared. August 11, while collecting near Broadmoor, south of Colorado Springs, I found two more infested *Solenopsis* colonies. This *Solenopsis* was paler than the form taken at Manitou, and in this respect approached the typical *molesta*. In one of these colonies I counted twenty pupæ and adult *Orasemæ*. At the same time I noticed that there were very few male and female pupæ of the ant. The other colony, which contained nearly as many of the parasites, was living in cleptobiosis with a large colony of *Formica ciliata* Mayr. As *S. molesta* has only one form of worker, and this of minute size compared with the males and females and since, moreover, the males and females of *O. coloradensis* are of about the same size as the corresponding sexes of the ant, I infer that the larvæ of the parasite must feed exclusively on the sexual forms, while the tiny workers enjoy complete immunity from their attacks.

In the same locality in which I saw the *Solenopsis* nests above described, and on the same day, I found two colonies of *Pheidole vinelandica* containing the same species of *Orasema*. One of these colonies was taken alive and placed in a Fielde nest. A careful examination of the worker brood revealed the presence of a single phthisergate with somewhat pigmented eyes and

very similar in shape to those of *Ph. dentata* above described. This phthisergate had neither hatched nor changed its appearance by August 29 — 15 days later. It eventually disappeared (eaten by the workers?). The colony was kept for several weeks but as no second brood of *Orasema* appeared, it was abandoned. August 20 I found near Beaver Ranch, southeast of Colorado Springs, a third infested *vinelandica* colony. This two was kept in an artificial nest, but the observations revealed nothing that has not been recorded for *Ph. instabilis* and *O. viridis*. According to Forel, *Ph. vinelandica* occasionally produces intermediates between the typical soldiers and workers, but although I have collected many colonies of this ant in different parts of the United States, I have seen only the typical soldiers and workers.

The foregoing observations prove that *O. coloradensis*, like *O. viridis*, does not confine its depredations to a single host ant. It may be said to be even more catholic in its habits, since it not only infests a species of *Pheidole* but also attacks ants belonging to the very different genus *Solenopsis*. The number of colonies observed was not sufficient to show which of these genera represents the original and more frequent host, but, judging from analogy with *O. viridis* and the next species to be considered, there can be little doubt that this is *Ph. vinelandica*. *O. coloradensis* probably occurs also in the nests of *Ph. pilifera* var. *coloradensis* and *Ph. ceres*, both common ants in the neighborhood of Colorado Springs and other localities of about the same altitude.

C. Orasema wheeleri Ashmead.

A third species of *Orasema*, which Dr. Ashmead will describe as *O. wheeleri*, was found July 14, 1902, on Keesy's Ranch at Fort Davis, Texas, in the nest of *Pheidole ceres* Wheeler. This ant is a small, dark colored species which makes obscure nests in the shade of the cotton-woods (*Populus fremonti*) and garners the woolly seeds of these trees. The *Orasema* was seen in only one of the nests, and though about a dozen pupæ were found among the ant brood, only a single mature specimen, which happened to be a female, could be secured. It measures 2.7 mm. and closely resembles *O. viridis*, especially in the shape of the scutellum and epinotum, but the thorax is broader and stouter. The last pupal envelope, like that of *viridis*, is without pustules, though it has strong intersegmental welts in the abdominal region.

I have examined many colonies of *Ph. ceres* near Fort Davis and in various Colorado localities without finding any intermediates between the soldiers and workers. In the single colony infested with *O. wheeleri*, how-

ever, there were several of these annectant forms. As this could hardly be a mere coincidence, we must assume that there is some connection between the existence of intermediates and the presence of the parasites.

D. Other Chalcidid Ant-Parasites.

From the observations recorded in the above paragraphs we may safely conclude that the remaining *Orasema* species, of which quite a number have been described by Cameron, Howard, and Ashmead, are parasitic on ants and have life-cycles analogous to that of *O. viridis*. Still other genera, however, of the enormous family Chalcididæ, contain ant-parasites and these, though very imperfectly known, may be passed in review before I proceed with an account of a very different type of parasitism. For the sake of convenience we may distinguish three groups of cases, first the ant-parasites of the sub-family Eucharinæ exclusive of *Orasema*, second those belonging to other subfamilies, and third, the cases too imperfectly known to be referred to any particular genera.

Among students of the Chalcididæ the opinion seems to have been gaining ground that the Eucharinæ, which according to Ashmead's recent synopsis (l. c. pp. 266–270) comprise some 25 genera, are largely, if not exclusively ant-parasites. Ashmead says that in this group "are found some of the most singular looking and wonderfully shaped Chalcids known, the structure of the thorax, and particularly of the scutellum, being most wonderfully and curiously modified and developed; and this development, in connection with the brilliant metallic green and blue colors of its members, makes the group the most striking and attractive of any in the subfamily. Some of the species are now known to be parasitic upon ants and probably the whole group attacks these insects. In temperate regions the family is poorly represented, but in tropical countries, where ants most abound and flourish in enormous colonies, these insects are not rare and seem to have reached a very highly specialized development." This extraordinary specialization, which at once reminds us of that obtaining in other highly myrmecophilous and termitophilous groups, like the Paussidæ among beetles and the Termitoxeniidæ among Diptera, etc., is clearly shown in the figures of some of the more striking Eucharine genera reproduced in this article (Pl. IV, Figs. 56–62).

The first to describe a Eucharine parasite on ants was Forel.[1] On opening the huge cocoons of one of the Australian bull-dog ants (*Myrmecia forficata*) he found several metallic green and coppery pupæ about a cm. long, which a year later were described and figured by Cameron[2] as those

[1] Un parasite de la Myrmecia forficata Fabr. Extr. C. R. Soc. Ent. Belg., I Fev. 1890, 3 pp.
[2] Hymenopterological Notes. Mem. Lit. Phil. Soc. Manchester (4), IV, 1891, pp. 182–194, 1 pl.

of *Eucharis myrmeciæ*. These pupæ, according to Forel, were "couvertes d' aspérités et de boursoufflures," probably analogous to the pustules above described for the pupa of *Orasema*. He concluded that the *Eucharis* attacks the *Myrmecia* larvæ, but after what I have said of *Orasema* it is more probable that the Chalcidid attacks the semipupa or pupa of the ant after the cocoon is spun and encloses both host and parasite.

In the same paper in which the *Eucharis* is described, Cameron describes a member of another genus, *Chalcura bedeli*, which was taken in nests of the Algerian *Myrmecocystus viaticus*.

Wasmann in his 'Verzeichniss', published in 1894,[1] cites as the only Chalcidids known to occur with ants the two preceding species described by Cameron and a *Chalcura* sp. which was "bred from cocoons of *Formica rufa* at Prag (Polak)."

Another Chalcidid belonging to the subfamily Eucharinæ and closely related to the preceding, was accidentally detected in some alcoholic material of *Camponotus ligniperdus* var. *novæboracensis* Fitch, collected August 12, 1904, on a bare slope of the Porcupine Mountains in northern Michigan by Mr. Otto McCreary and sent me for identification by Dr. Charles C. Adams. Two of the worker cocoons, measuring respectively 6.5 and .7 mm., were found to contain pupal parasites, which Dr. Ashmead has identified for me as *Pseudochalcura gibbosa* Provancher. In one of the cocoons, represented in Plate II, Fig. 29, there were two pigmented and therefore nearly mature pupæ, lying face to face near the anterior pole, while the remains of the ant pupa, which they had consumed, were crowded against the black meconial spot at the posterior pole. The other cocoon contained four unpigmented pupæ. It would seem that the Chalcidid larva must attach itself to the *Camponotus* larva and wait till it has spun its cocoon, before devouring the host. As the ant is an unusually large species compared with the parasite, several of the latter can obtain sufficient nourishment even from a single worker and need not, like *Orasema*, attack the still larger intermediate, soldier, and female brood.

I have received with some miscellaneous ants (*Formica fusca* var. *neorufibarbis*, *Myrmica brevinodis*, etc.) collected by Mr. H. Viereck, on the summit (11,000 ft.) of the Las Vegas Range, New Mexico, a single male specimen of a *Eucharis* (Pl. IV, Fig. 62), which is in all probability an ant parasite, although I am unable to refer it to its precise host.

In the discussion following a paper read several years ago by Ashmead before the Entomological Society of Washington,[2] Howard called attention

[1] Kritisches Verzeichniss der Myrmekophilen und Termitophilen Arthropoden. Berlin, 1894.

[2] Notes on the Eucharids found in the United States. Proc. Ent. Soc. Wash., II, 1890–92, pp. 354–358.

to the fact "that in the collection of St. Vincent Chalcids sent to Professor Riley from Cambridge University there is a specimen of *Kapala furcata* Fabr. which bears in its jaws a medium sized red ant." Events have shown that Howard was probably correct in supposing this peculiar Chalcidid to be an ant parasite. Dr. O. F. Cook informs me that he has bred a specimen of an allied genus, *Isomeralia coronata* Westwood (Pl. IV, Figs. 58 and 59), from a cocoon of the Guatemalan kelep (*Ectatomma tuberculatum* Oliv.), and Dr. Ashmead tells me that in his opinion *Kapala floridana* (Pl. IV, Figs. 56 and 57) is probably parasitic on the Florida harvester (*Pogonomyrmex badius* Latr). He also assures me that the type of *Pseudometagia schwarzi* was taken in an ant-nest near Washington, D. C.

To the foregoing observations on Eucharinæ I am able to add some notes on a parasite belonging to another subfamily of Chalcididæ. As stated on p. 2, I failed to find *Orasema* in nests of *Pheidole instabilis* except during the summer and late spring months. At other seasons I often took a species of the subfamily Asaphinæ, namely, *Pheidoloxenus wheeleri* Ashmead (Pl. III, Fig. 36), an exquisite little Chalcidid which runs about in the dense throng of *Pheidole* workers like one of their number. It is not easily detected, as it resembles the workers in its small size (1 mm.) and in being subapterous or practically wingless. Its head is very wide, with a concave occiput and 9-jointed antennæ inserted near the oral border. These appendages are very robust, and have a club-shaped funiculus terminating in a broad flat joint. The epinotum is very short, the wings are represented only by the tegulæ and minute vestiges of the alar membranes. The surface of the body is smooth and shining. The head is deep metallic blue, with green cheeks and yellow mandibles; the antennæ are yellow at the base, with the large apical and adjacent transverse joints black. The thorax is green with golden reflections, the epinotum more blue green, the tegulæ violet. The abdomen is metallic green with a broad violet band across the posterior portion of each of the basal segments. The legs are fuscous, with yellow knees, tarsi and trochanters.

I have not been able to learn anything concerning the development of this insect. According to Ashmead the vast majority of Asaphinæ are parasites "upon plant lice, Aphididæ, and upon the bark lice, Coccidæ," but this cannot be the case with *Pheidoloxenus* since this insect is a regular myrmecophile, and *Ph. instabilis* does not, like our northern species of *Lasius*, cultivate aphids and coccids in its nests. During the autumn and winter months I have occasionally seen the *instabilis* workers carrying small pink larvæ about in the chambers. These were certainly not a portion of the ant brood, but whether they were the larvæ of *Pheidoloxenus* or not, I have been unable to determine. On one or two occasions I have seen as many as six or eight

of the little Chalcidids in a single nest. A careful search will probably show that they are even more abundant.

In the literature I find the following scattered references to Chalcidid ant-parasites:

Fritz Müller, according to Sharp,[1] mentions a South American Chalcidid which attacks the larvæ of *Azteca instabilis* in its nests in the Cecropia trees. When the parasite pupates it suspends itself, by its posterior end, from the walls of the chambers like a butterfly chrysalis.

Wasmann[2] cites an observation of Brauns who found a Chalcidid in one of the nests of a South African subspecies of *Pheidole megacephala.* When the nests were disturbed the workers were seen to carry the parasites, which probably devour the brood, to a place of safety.

A larva found by Rupertsberger attached to a large *Myrmica* larva, and mentioned by Wasmann in his 'Verzeichniss' (*l. c.*, p. 169) as possibly an Ichneumonid, was probably a Chalcidid.

Perhaps no single group of parasitic insects has greater surprises in store for the future investigator of habits and development than the Chalcididæ. This is indicated not only by the fragmentary materials collated in the preceding paragraphs, but more especially by the splendid researches of Bugnon,[3] Marchal,[4] and Silvestri,[5] on the extraordinary polyembryony of the Encyrtinæ. These and future researches in the same direction may be expected to bring about many radical changes in the present taxonomy of the enormous family Chalcididæ.

2. The Parasitism of Mermis in Ants.

Five years ago (June 3, 1901), I found at New Braunfels, Texas, on a shady hill that slopes to the lovely sources of the Comal River, two medium-sized colonies of *Pheidole dentata* var. *commutata* Mayr. They were under stones about sixty feet apart. One contained ants of the typical dark variety of the species, while both the soldiers and workers of the other colony were decidedly paler. On lifting the stones my attention was arrested by several very large and conspicuous individuals with huge gasters, moving about among the workers and soldiers of normal dimensions. Unfortunately I failed to preserve any living specimens at that time but collected instead a

---

[1] Cambridge Natural History. Insects, Vol. I, 1895, p. 550.

[2] Die Psychischen Fähigkeiten der Ameisen. Zoologica, Heft 26, 1899, pp. 1–132, Taf. i–iii.

[3] Recherches sur le Développement postembryonnaire, l'anatomie et les mœurs de l'Encyrtus fuscicollis. Recueil Zool. Suisse, V, 1891, pp. 435–534, pl. xx–xxv.

[4] Recherches sur la Biologie et le Développement des Hyménoptères Parasites. I, La Polyembryonie Spécifique ou Germinogonie. Arch. Zool. Expér. (4), II, 1904, pp. 257–335, pl. ix–xiii.

[5] Sviluppo dell' Ageniaspis fuscicollis (Dalm.) Thoms. Rendic. R. Accad. Lincei, XV, 1906, pp. 650–657.

EXPLANATION OF PLATES.

Plate I.

Fig. 1. — *Pheidole kingi* André var. *instabilis* Emery. Soldier, Austin, Texas.
Figs. 2–6. — Series of intermediate forms (desmergates) between the soldier and worker of *Ph. instabilis.*
Fig. 7. — Typical worker of same.
Fig. 8. — Deälated female of *Ph. instabilis.*
Fig. 9. — Male of same.
Fig. 10. — *Orasema viridis* Ashmead. Female. Austin, Texas.
Fig. 11. — *Orasema viridis.* Male.
Fig. 12. — *Orasema coloradensis* Ashmead. Female. Colorado Springs, Colorado.

Plate II.

Fig. 13. — Phthisergate of *Ph. instabilis* with very young *Orasema viridis* larva attached to the right side of the prothorax beneath the fore leg.
Fig. 14. — Soldier semipupa of *Ph. instabilis* with *O. viridis* larva in second stage attached to the presternal region between the first and second pairs of legs.
Fig. 15. — Female semipupa of *Ph. instabilis* with *O. viridis* larva in the second stage attached to the pronotal region behind the head.
Fig. 16. — Female semipupa of *Ph. instabilis* with *O. viridis* larva in the third stage attached to the presternal region.
Fig. 17. — Female semipupa of *Ph. instabilis* with nearly mature *O. viridis* larva (shrunken by reagents) attached to the sternal surface between the middle and hind pairs of legs. From a specimen mounted in balsam.
Fig. 18. — Female pupa (phthisogyne) of *Ph. instabilis* with *O. viridis* semipupa in the pustulate stage, still attached in the position which it occupied as a larva. From a specimen mounted in balsam.
Fig. 19. — Female pupa (phthisogyne) with *O. viridis* semipupa in the pustulate stage, still attached to the sternal region. From an alcoholic specimen.
Fig. 20. — Semipupa of *O. viridis*, viewed as a transparent object, showing the head, wings, and legs developing beneath the hood-like prothoracic mass. From a specimen mounted in balsam.
Fig. 21. — Semipupa of *O. viridis* in a more advanced stage. From a specimen mounted in balsam.
Fig. 22. — Pupa of female *O. viridis* just before pigmentation, showing the prominent intersegmental abdominal welts.
Fig. 23. — Pigmented pupa of *O. viridis* nearly ready to hatch.
Fig. 24. — Phthisergate of *Ph. instabilis* viewed in profile as an opaque object. From an alcoholic specimen.
Fig. 25. — Phthisergate of *Ph. instabilis* in ventral view to show the greatly attenuated thorax, small projecting eyes, etc.

FIG. 26. — Phthisergate of *Ph. instabilis* viewed as a transparent object to show the urate masses in the gaster. From a specimen mounted in balsam.

FIG. 27. — Normal worker pupa of *Ph. instabilis* in profile. From an alcoholic specimen.

FIG. 28. — Phthisergate of *Ph. dentata* Mayr. From an alcoholic specimen.

FIG. 29. — Worker cocoon of *Camponotus herculeanus ligniperdus* var. *novæboracensis* Fitch, from northern Michigan, showing an enclosed pair of pupæ of *Pseudochalcura gibbosa* Provancher near the anterior pole, and the remains of the consumed *Camponotus* semipupa applied to the black meconial spot at the posterior pole.

FIGS. 30–35.— Six larvæ of *Orasema viridis* in the youngest stage observed, corresponding with the one shown in Fig. 13.

PLATE III.

FIG. 36. — *Pheidoloxenus wheeleri* Ashmead. Female, taken from a colony of *Ph. instabilis* at Austin, Texas.

FIG. 37. — *Pheidole dentata* var. *commutata* Mayr. Soldier. New Braunfels, Texas.

FIG. 38. — *Ph. commutata*. Worker.

FIG. 39. — Mermithergate of *Ph. commutata*, drawn to the same scale as Figs. 37 and 38; showing *Mermis* parasites in the distended gaster. The head of the ant bears occelli; the thorax is shaped like that of the soldier.

FIG. 40. — Lateral view of same mermithergate.

FIG. 41.— *Xenodusa cava* Leconte, taken from a colony of *Formica schaufussi* var. *incerta* Emery at Colebrook, Connecticut.

FIG. 42. — *Formica schaufussi* Mayr. var. *incerta* Emery. Normal worker. Colebrook Connecticut.

FIG. 43. — Pseudogyne of *F. incerta* drawn to the same scale as Fig. 42.

FIG. 44. — Pseudogyne from the same colony as Fig. 43, showing a somewhat different conformation of the thorax.

PLATE IV.

FIG. 45. — Pseudogyne of *Myrmica rubra brevinodis* Emery var. *sulcinodoides* Emery, with vestige of left fore wing, from Isle Royale, Michigan.

FIG. 46. — Thorax of same in profile.

FIG. 47. — Thorax of normal worker of *M. sulcinodoides*.

FIG. 48. — Thorax of pseudogynic *M. rubra scabrinodis* Nyl. var. *schencki* Emery, from Jeanette, Pennsylvania. This specimen has minute vestiges of both fore wings.

FIG. 49. — Lateral view of same.

FIG. 50. — Pseudogyne of *Formica rufa obscuriventris* Mayr. var. *melanotica* Emery, with well-developed mesonotum, scutellum and metanotum, from Rockford, Illinois.

FIG. 51. — Dorsal view of thorax of same.

FIG. 52. — Pseudogyne of *F. melanotica* with more convex mesonotum, from the same colony as the specimen shown in Figs. 50 and 51.

FIG. 53. — Pupa of female *Orasema coloradensis* Ashm.; dorsal view showing the arrangement of the pustules.

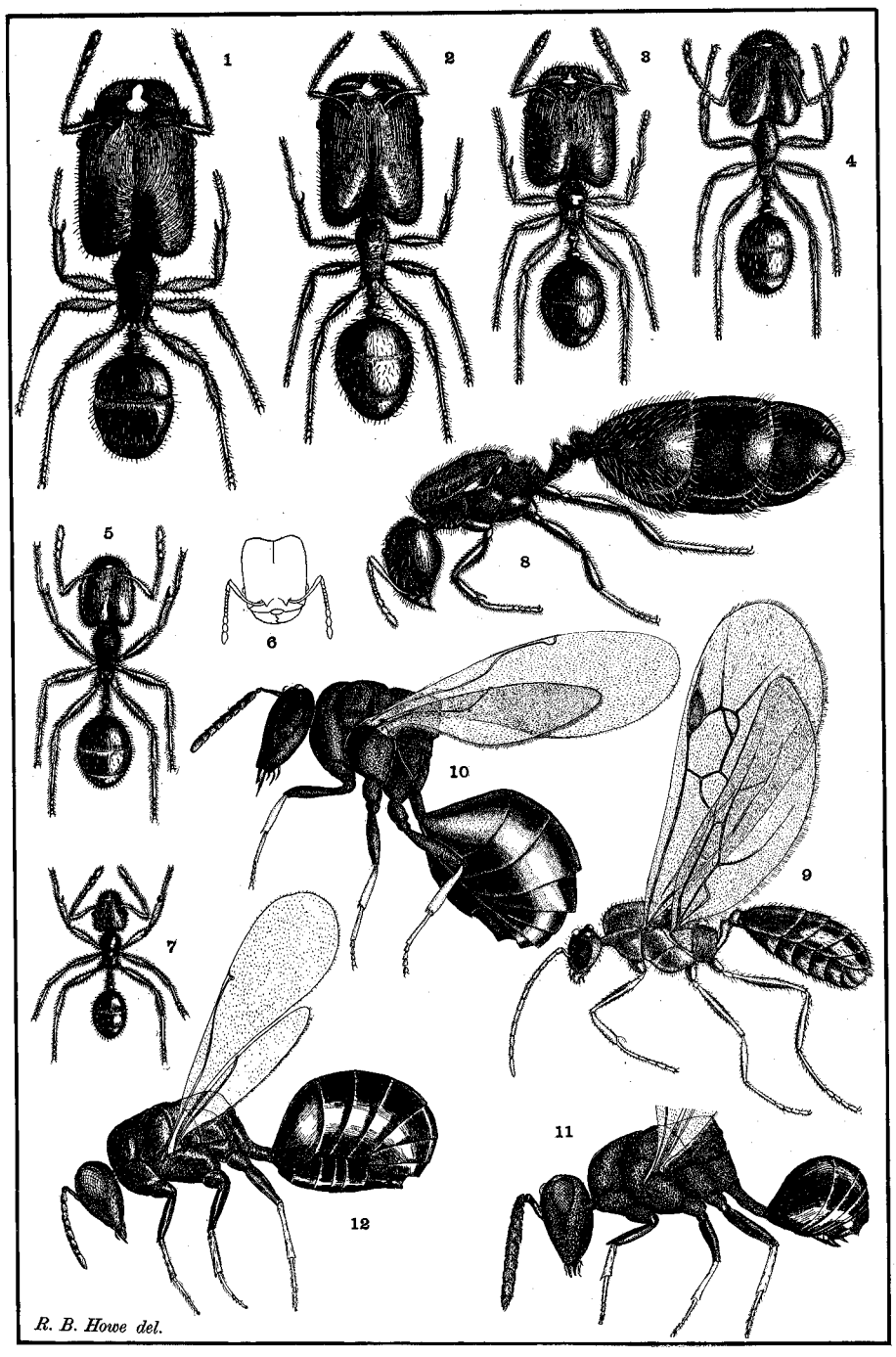
FIG. 54. — Lateral view of same.
FIG. 55. — Pupa of female *Pseudochalcura gibbosa* Prov., from northern Michigan.
FIG. 56. — *Kapala floridana* Ashmead. Female, from eastern Florida. From a specimen in the United States National Museum.
FIG. 57. — *Kapala floridana*. Male, from eastern Florida. From a specimen in the United States National Museum.
FIG. 58. — *Isomeralia coronata* Westwood. Female, from Pernambuco, Brazil. From a specimen in the United States National Museum.
FIG. 59. — Lateral view of same.
FIG. 60. — *Dicælothorax platycerus* Ashmead. Female. After Ashmead.
FIG. 61. — Scutellum of same, seen from above. After Ashmead.
FIG. 62. — *Eucharis* sp. Male, from the top of the Las Vegas Range, New Mexico (11,000 ft.).

PLATE V.

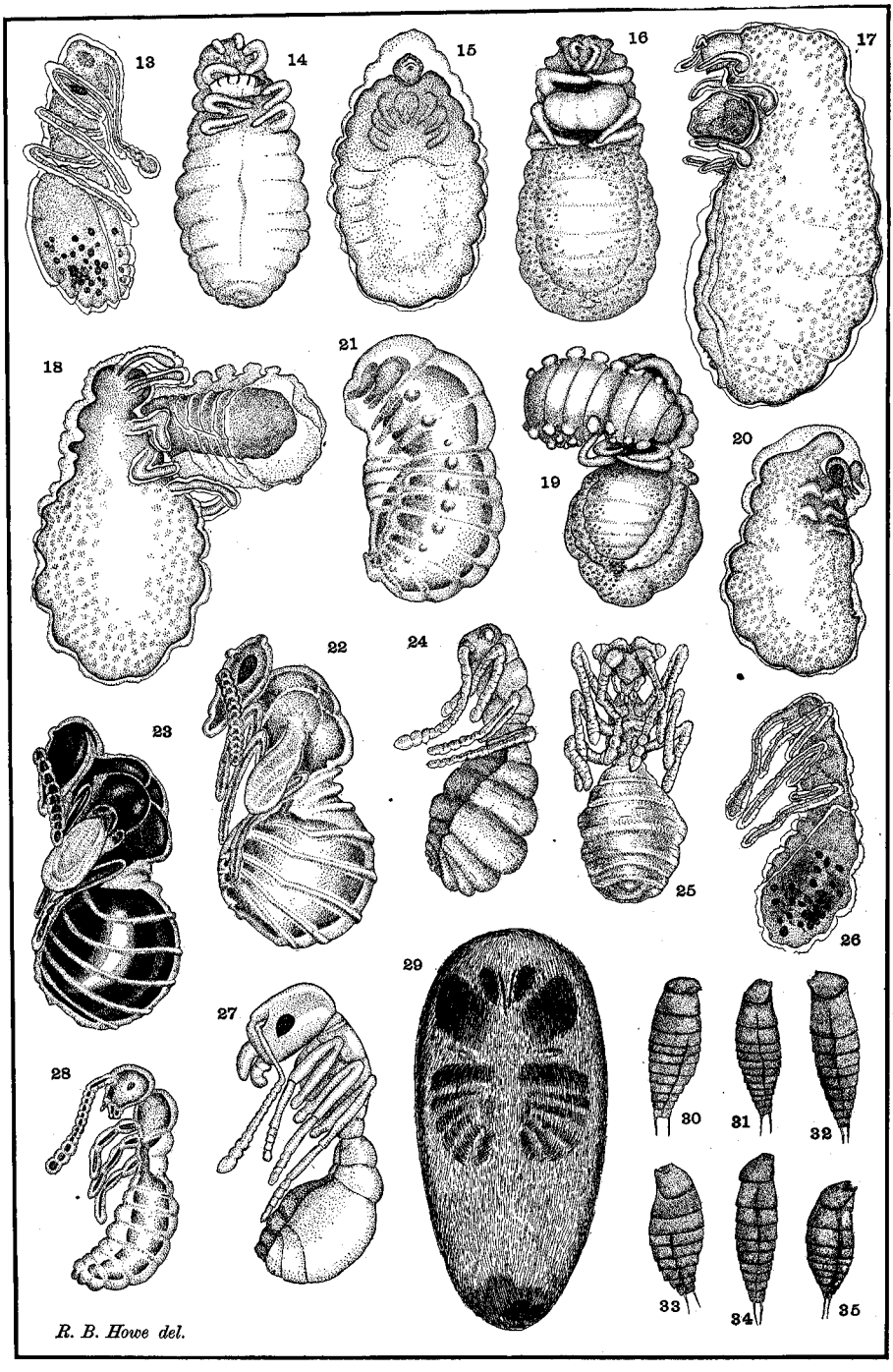
FIG. 63. — *Pheidole instabilis*; *a*, females (winged and deälated); *e*, male; *o*, soldier; *c*, workers; *r*, intermediates (desmergates); *m*, *Orasema viridis*, female; *n*, male. × 2.
FIG. 64. — Brood of *Ph. instabilis*; *a*, female larvæ and pupæ; *e*, male pupæ and semipupæ; *o*, soldier pupæ; *c*, worker larvæ and pupæ; *r*, pupæ of desmergates; *m*, *O. viridis*, adult female, *m'*, pupæ and semipupæ; *n*, male; *n'*, pupæ of same. × 3.
FIG. 65. — Brood of *Ph. instabilis*. Letters as in the preceding figure; *s*, phthisergates. × 3.
FIG. 66. — Three female semipupæ (phthisogynes) of *Ph. instabilis* bearing larvæ of *O. viridis* on their sternal surfaces. × 3.
FIG. 67. — Worker brood of *Ph. instabilis*; *c*, normal worker pupæ and semipupæ; *i*, phthisergates; *r*, intermediate (desmergatic) phthisergate. From specimens mounted in balsam.
FIG. 68. — *Solenopsis molesta validiuscula* Emery; *a*, female; *e*, male; *c*, workers; *m*, *Orasema coloradensis*, female.
FIG. 69. — Brood of *Pachycondyla harpax* Fabricius. The larvæ marked *x* each bear a larva of *Metopina pachycondylæ* Brues; *z*, detached *Metopina* larva; *v*, puparium of *Metopina*; *u*, cocoon of *Pachycondyla*.

PLATE VI.

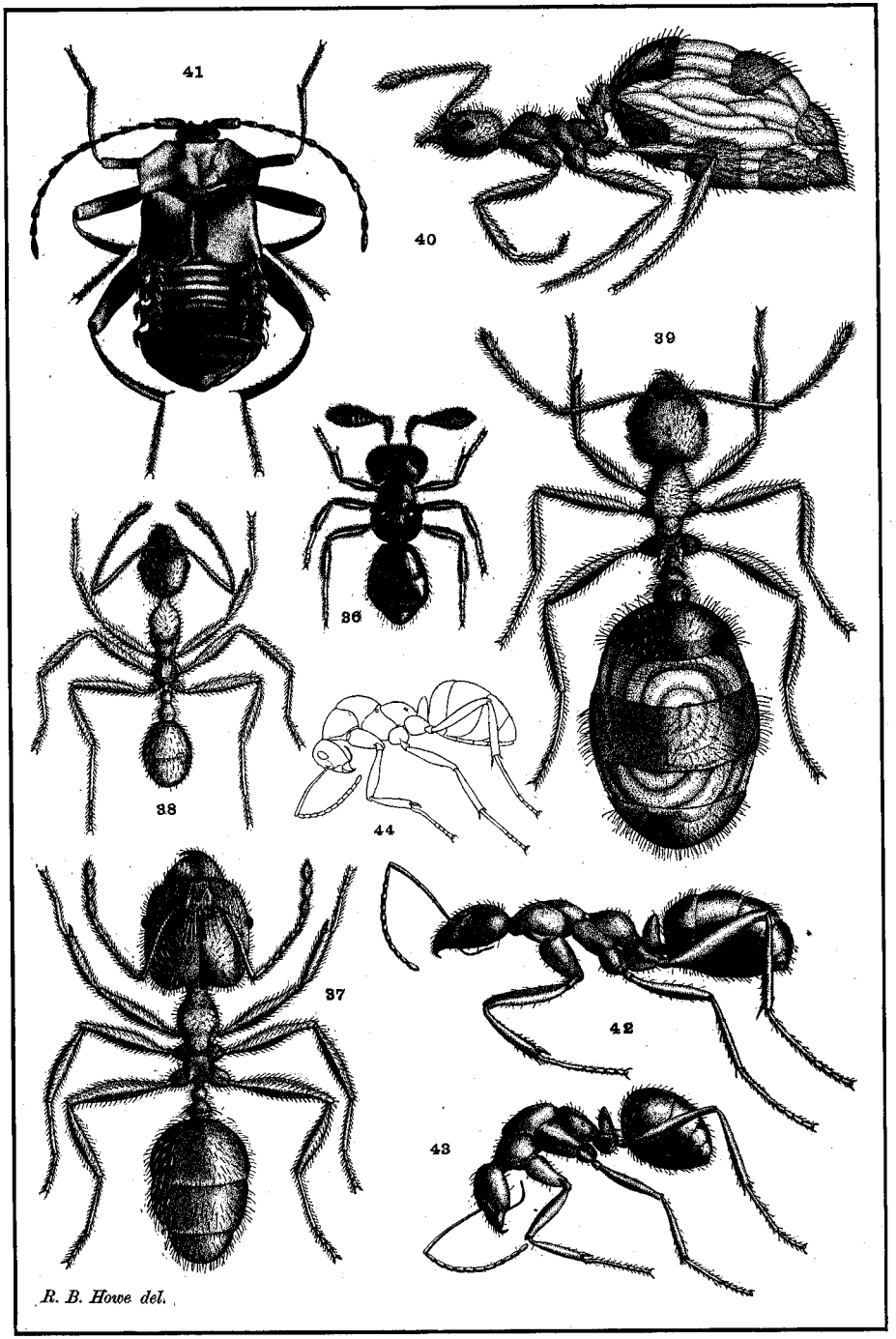
Diagram to illustrate the relationships of the typical and atypical phases of ants. The three typical phases are placed at the angles of an isosceles triangle, the excess developments to the right, the defect developments to the left of a vertical line passing through the middle of the diagram. The normal atypical phases are in ordinary, the pathological phases in italic type. The arrows indicate the direction of the affinities of the atypical phases. The phases arranged on the sides of the triangle are annectant, those radiating outward from its angles are new departures showing excess or defect characters. For definitions of the different phases see pp. 53 to 57.



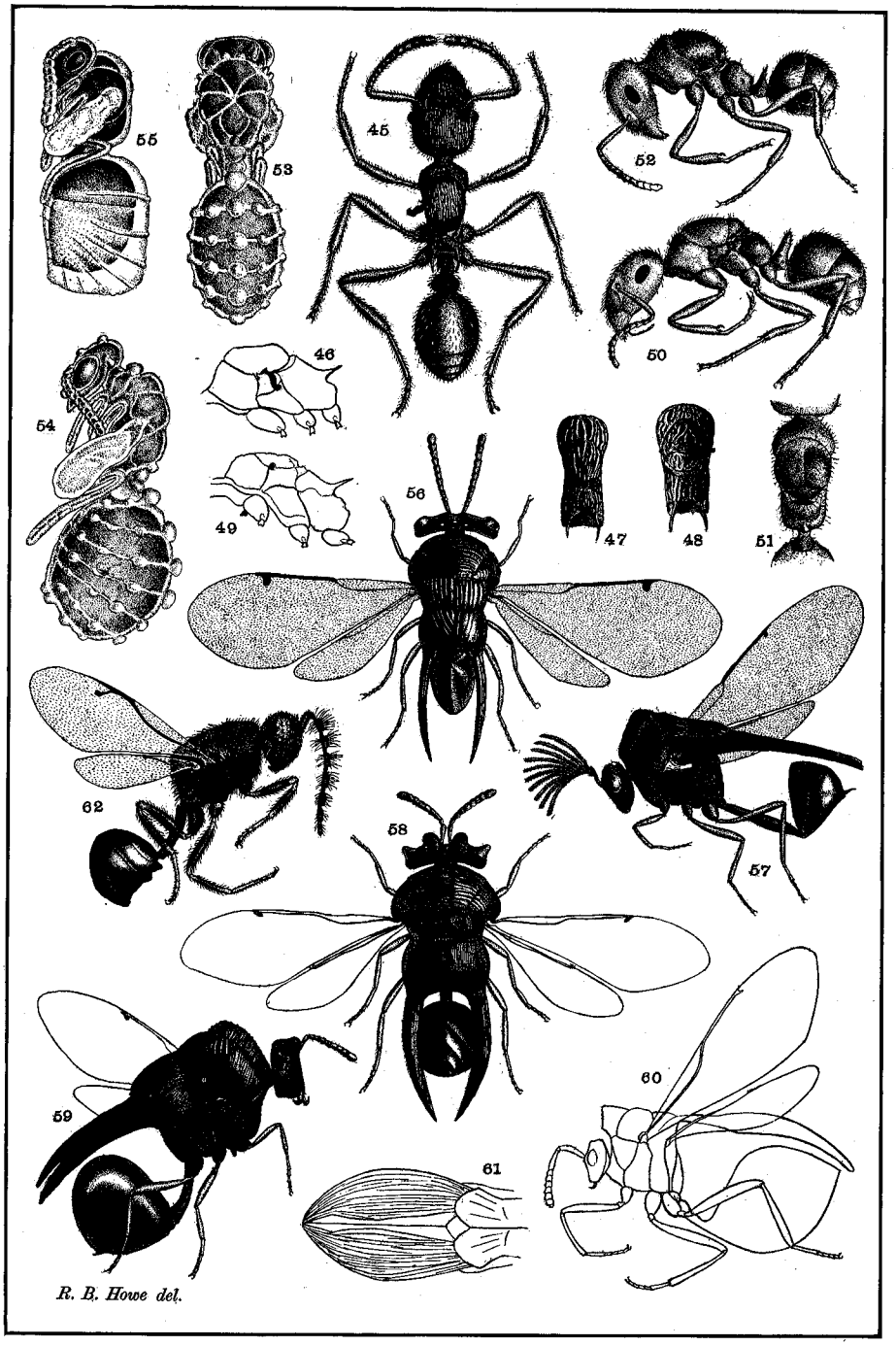
PHEIDOLE INSTABILIS AND ORASEMA.



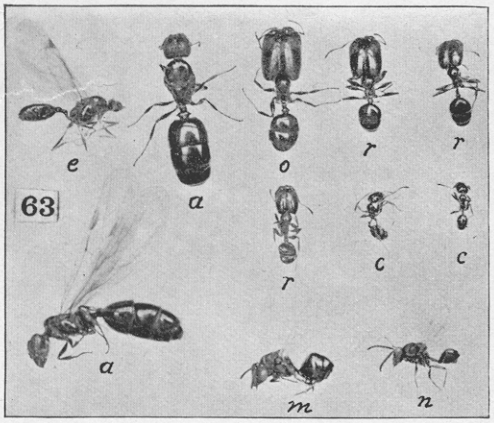
DEVELOPMENT OF ORASEMA

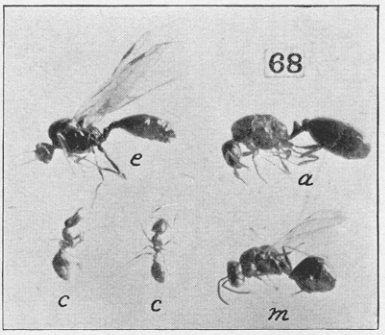


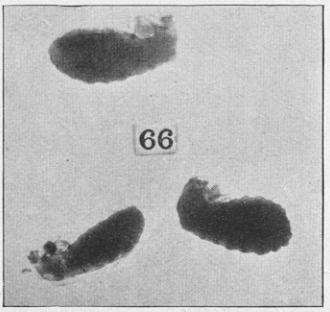
PARASITES OF PHEIDOLE AND FORMICA.

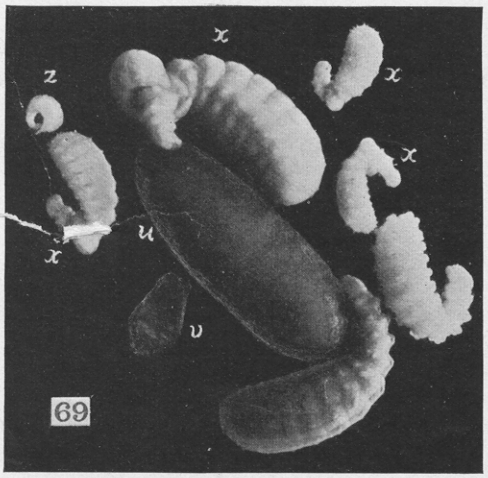


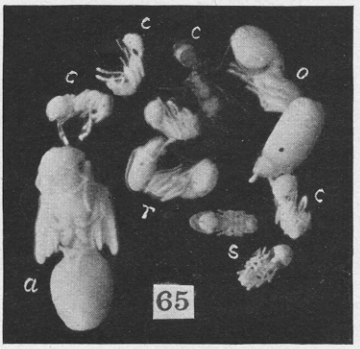
CHALCIDID PARASITES OF ANTS, ETC.

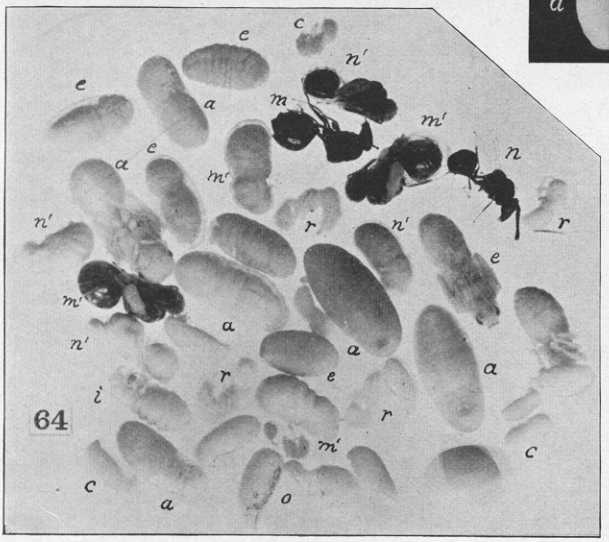


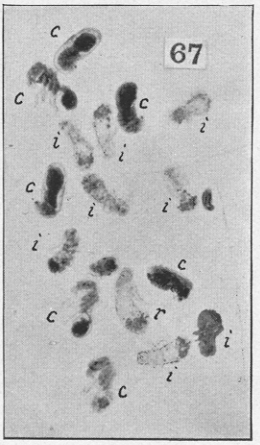












PARASITES OF PHEIDOLE, SOLENOPSIS AND PACHYCONDYLA.