PRELIMINARY STUDIES ON THE BIOLOGY OF *ORASEMA ASSECTATOR* KERRICH (HYM., EUCHARITIDAE), PARASITIC ON *PHEIDOLE* AND CAUSING DAMAGE TO LEAVES OF TEA IN ASSAM.

By G. M. Das

Tocklai Experimental Station, Cinnamara, Assam.

(Plate X.)

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A peculiar type of damage to the tea leaf, termed ' sewing blight ', has been known for a long time but the identity of the causal agent and how the damage was caused was unknown until 1954, when some 40 acres of tea on an estate about seven miles from Tocklai, Assam, were severely affected (Das, 1954). This is the only occasion on record on which such an extensive area has been affected by this so-called blight.

The characteristic symptoms are a series of incisions in several rows along the length of the leaf, giving the appearance of stitches made by a sewing machine (Pl. X, fig. 1). Examination of freshly damaged leaves revealed the presence of eggs, one in each slit. A few small wasps were caught while ovipositing in the leaf tissues but no further observations on them were possible, as DDT was applied to prevent further oviposition; they were later (1955) submitted to the Commonwealth Institute of Entomology and identified as a species of the genus *Orasema* (Eucharitidae). This species has now been described as *O. initiator* Kerrich (1963).

In 1962, a small area of tea at the Borbhetta Field Station was similarly affected, and this gave an opportunity to study the life-history and habits of the insect concerned, which has been found to represent another species, now described as *O. assectator* Kerrich (*op. cit.*). The results of the investigations of its biology are recorded in the present paper.

Nature of the damage caused to tea.

The damage to the leaf of the tea bush is caused by punctures made for oviposition by the wasp. The tissues surrounding the punctures dry up and turn brown, leaving a minute cavity in the middle. The growth of the shoot is checked, and after a few days the affected leaves may present a crinkled appearance. In all cases before 1954, the leaves affected by sewing blight and showing such brown puncture marks were collected after the eggs had hatched; obviously it was not possible to ascertain the cause of the damage.

The affected leaves are known to wither quicker than the healthy ones after plucking, and there can be no uniform withering in the process of manufacture as all leaves on a shoot are not affected, and many shoots may be entirely free from oviposition punctures. The tea manufactured from the affected shoots is said to " lack briskness and good tea character ". However, oviposition is usually extremely localised, being found on a few shoots on scattered bushes or in small patches of tea.

Host of *Orasema assectator.*

The parasitic habits of the genus *Orasema* are not fully known. Wheeler (1907) stated that *Orasema viridis* Ashm. oviposited upon the larvae and semi-pupae of the ant, *Pheidole instabilis* Emery, but he did not observe the eggs. He observed that the larva of *O. viridis* developed as an ectoparasite upon the pupa of the ant. Commenting upon Wheeler's observations, Smith (1912) assumed that the eggs of *Orasema* are deposited not in the ant nest but upon plants. His assertion that the planidium is first endoparasitic in the larva of the ant and then emerges to complete its development as an ectoparasite upon the pupa is correct. Wheeler & Wheeler (1937) observed that the planidia of *O. costaricensis* Wheeler & Wheeler and *O. sixaolae* Wheeler & Wheeler are endoparasites of the larvae of species of *Pheidole* and *Solenopsis*, respectively. They could not find the second- and third-instar larvae of either parasite, although they found mature larvae of *O. costaricensis* in the ant nest.

In August 1962, a small area of tea at the Borbhetta Field Station, consisting of clonal mother bushes in which the shoots were not plucked but were allowed to grow for vegetative propagation, was affected as a result of oviposition by *O. assectator*. Twenty-five adults of this species were collected from bushes while they were depositing eggs in young leaves. They were brought to the laboratory and placed in vials containing fresh young tea shoots. Two of them deposited a small number of eggs the same day, and all were found dead the following morning.

There were 569 bushes in the affected area, but oviposition occurred in varying degrees in only 126 of them, of which nine had most of the young leaves punctured while on each of the remainder only a few young leaves were affected. The wasps deposited eggs only on those bushes that had nests of an ant, an undetermined species of *Pheidole*, in the soil beneath them. Oviposition was higher where the nests were bigger or more numerous. On examination of the nests, the *Orasema* larvae were found to be at first endoparasitic in the larva and then ectoparasitic on the pupa of the ant, and mature larvae and pupae of the parasite were found scattered amongst the immature stages of the host.

The nests of several other species of ants were also found in the affected area, but none of these was found to be a host of *Orasema*. Some of the affected bushes were infested with the aphid *Toxoptera aurantii* (Boy.), which is attended by a species of *Crematogaster*. This ant constructs small nests, composed of a few leaves, on bushes, but no larva or pupa of *Orasema* has been observed in them.

Biology and habits of *O. assectator.*

Oviposition.

Pairing has not been observed. A female started depositing eggs in the laboratory about two hours after emergence. In the field, after hovering over the bushes, the wasp alights on a young leaf and moves to the underside of the leaf or to a bud. It depresses its abdomen, inserts its ovipositor in the leaf and makes an incision in which it deposits an egg. The time taken is about 9 seconds. It then moves a short distance forward and deposits another egg in the same manner. The process goes on until the wasp reaches the edge of the leaf, when it moves laterally a very small distance, turns back, and starts depositing eggs in another line. A few eggs may also be deposited on the upper side of such leaves as are bent downwards.

Incisions are made more or less in a straight line along the length of the leaf; there may be as many as 12 rows and 500 eggs in a leaf (Pl. X, fig. 1). Oviposition lines may also be broken, slightly curved, or occasionally oblique. The incisions are about 0·3 mm. long and spaced 0·3 mm. apart when freshly

made in a young leaf. Clausen (1940) states that the oviposition incisions of *Schizaspidia* sp. in the large leaves of *Eugenia* and *Medinilla* in Malaya are in serpentine rows, and Ishii (1932) found that in the Philippine Islands another Eucharitid, *Losbanos uichancoi* Ishii, makes them in two parallel lines.

The female of *O. assectator*, after depositing eggs in one leaf, moves to another and continues egg-laying. The exact number of eggs usually laid by a female is unknown but it appears to be very high. A female emerging in the laboratory deposited 355 eggs in 2 hr. 20 min., after which it died. The reproductive capacity is said to be high in all species of Eucharitidae, ranging from approximately 1,000 in *Stilbula tenuicornis* (Ashm.) (cited as *Schizaspidia*) to 15,000 in *Kapala terminalis* Ashm. and *Stilbula cyniformis* (Rossi) (Clausen, 1940).

On bright days oviposition occurs mostly in the morning and to some extent in the afternoon, but during the hottest part of the day very few wasps are seen on the tea bushes.

The egg.

The egg (Pl. X, fig. 2) is exceedingly minute, ellipsoidal in form, with a slender anterior stalk, which is about half as long, the whole being 0·14–0·16 mm. in length. It is translucent white when freshly laid but gradually assumes an amber colour, turning almost black before hatching. Hatching of the eggs took place after 5–6 days in the laboratory in August, when the average temperature was 29·1°C. and the average relative humidity 75·4 per cent.

The planidium.

The early first-instar larva is a dark-coloured planidium about 0·16 mm. long (Pl. X, fig. 3), with an ovoid, strongly sclerotised head, curved and acute mandibles, sub-ellipsoidal body invested with segmental plates joined by transparent membranes, the posterior segments being narrow and telescopic, so that it is difficult to ascertain their exact number, the last bearing a pair of stout bristles and also a sucker.

After emergence from the egg, the planidium remains on the surface of the leaf until it finds a suitable carrier. It may occasionally move a small distance by means of a looping movement as described by Clausen (1923) for *Stilbula tenuicornis*. Very often it remains in an erect position awaiting the arrival of a carrier, and attaches itself to any moving object that approaches.

The carrier.

It could not be ascertained how the planidium gains access to the ant nest in the ground. The workers of the host ant do not visit the tea bushes for foraging and the only possibility of their serving as a carrier is when the planidia fall to the ground, where they may attach themselves to the workers and be carried into the nest. On occasions several planidia have been found attached to young tea leafhoppers, *Empoasca flavescens* (F.), or young tea thrips, *Scirtothrips dorsalis* Hood, which become sluggish in movement and may fall to the ground, when they are carried by the workers into the nest, where the planidia could transfer to the ant larvae.

Larval development.

First-instar larva.—From examination of ant nests beneath affected bushes, it appears that on reaching the nest the planidium transfers to the last-instar larva of the ant and penetrates its body (Pl. X, fig. 4). The posterior end of the body becomes fixed to the integument in the entrance hole. Critical examination under the microscope revealed the presence of a (chitinous ?) sac surrounding the planidium. Wheeler & Wheeler (1937) observed that the planidia of *O. costaricensis* and *O. sixaolae* penetrate the bodies of the larvae of *Pheidole* and *Solenopsis*, respectively, through a rounded opening cut in the cuticle. The

posterior end of the planidium is protruded from the hole and the cuticle around the hole becomes thickened to form a collar, which according to Clausen (1940) is probably respiratory in function. Young larvae of the ant have rarely been found parasitised by *O. assectator*.

The planidium of *O. assectator* may penetrate at any part of the body of the ant larva, and often more than one planidium (up to six) has been found embedded in one larva. The planidium thus embedded makes no growth until the prepupal stage of its host is reached, when feeding and some growth commences, the segmental plates becoming slightly separated (Pl. X, fig. 5). As soon as the host pupa is formed, the parasite larva, by then distended, emerges, takes up its position on the sternum of the host's thorax, punctures the cuticle of the latter at one side, between the second and third pairs of legs, and commences feeding. Only in one instance was a parasite larva found established on the dorso-lateral aspect of the thorax of the host, and it died without moulting. Unless some extended growth of the planidium has taken place before its host larva moults, the planidium is thrown away with the cast skin.

Although often several planidia may be found embedded in an ant larva, usually only one planidium makes extended growth. In rare instances two planidia may start developing, but in no case has more than one parasite larva been found established on an ant pupa.

When planidia collected from the field were placed on the larvae of the host ant in the laboratory, all remained attached to the cuticle and when the ant pupae were formed the planidia were detached with the cast skins and were unable to re-establish themselves on the host.

Once established on its host, the parasite larva never changes its position and continues feeding at the same puncture throughout its subsequent instars.

The advanced first-instar larva, soon after it has commenced feeding as an ectoparasite, has distended body segments and is 0·45–0·5 mm. long (Pl. X, fig. 6). There are 12 segments, the first and second sclerites being closely apposed, with only a faint line of demarcation, the third to ninth more or less widely separated, and the last three in contact. The last segment bears a pair of spines. As feeding continues, the body becomes distended ventrally and the head is not visible from its dorsal aspect.

Three or four days after the larva has taken up position on the venter of the thorax of the host, the first ecdysis takes place, the cast skin remaining attached to the side of the second-instar larva, near its posterior end, unless removed by ant workers or otherwise.

Second instar larva.—The second-instar larva is white, somewhat oval in shape, highly convex dorsally, without distinguishable body segments (Pl. X, fig. 7). Moulting has not been observed and the duration of the second instar is not known.

Third-instar larva.—The third-instar larva has an elongate, sub-cylindrical body, rounded at each end, broadly so anteriorly; when it has completely sucked the contents of the host, or just after, it is 1·5–2·2 mm. long. The head is ventral and the mouth-parts are slightly sclerotised and pinkish in colour, the mandibles being short and acute. The body consists of 11 segments with rows of pustulate protuberances, similar to those in *O. costaricensis* (Wheeler & Wheeler, 1937).

The third instar develops extremely rapidly, the contents of the host being completely consumed in 4–5 days. The remains of the host are found attached to the sternum of the thorax of the parasite larva, unless removed by worker ants. After a further 4–5 days the mature larva moults to form a pupa. During this period little change takes place except that the intersegmental furrows deepen, a slight constriction appears between the third and fourth segments, and fifth to

eighth segments are slightly enlarged. Wheeler (1907) observed an additional moult in *O. viridis* before the prepupa was formed, but no such moulting has been found in *O. assectator*, although several mature larvae were under constant observation.

Pupa.—The pupa is 2·2–2·4 mm. long, at first white, but gradually darkening and becoming metallic green. There are three pustules at the anterior region of the abdomen arising mid-dorsally from the pupal membrane. The pupal period is about five days.

The mature larvae and the pupae of the parasite remain scattered amongst those of the host and are cared for by the worker ants. As soon as the artificial nests in the laboratory were disturbed the workers seized and carried the larvae and pupae of the parasite to a place of safety as they do with their own larvae and pupae. The newly emerged adults were often prevented from escaping.

Effect on host.

An ant larva with one or two planidia embedded inside it is not much affected and in due course forms a pupa, but where several planidia are embedded in a single larva, the latter dies without pupating. When the first-instar parasite larva is established on the sternum of the thorax of the ant pupa, some development of the appendages of the host has already taken place, but soon after the parasite starts feeding, no further growth of the host takes place and it is killed.

Number of generations.

It is not definitely known how many broods the wasp has in a year. In the earlier cases that were observed of sewing blight, the leaves affected were collected from plucking tea in April and May, but in 1962 oviposition continued on clonal mother bushes from May to the end of September, while, on abandoned tea in the neighbourhood, slight fresh oviposition was noticed early in November. It appears that there are four broods in a year.

Summary.

The so-called ' sewing blight ' of tea in Assam is an effect of oviposition in the young leaves by two species of Eucharitid, *Orasema initiator* Kerrich and *O. assectator* Kerrich. The affected leaves develop brown spots round the oviposition punctures, wither prematurely and adversely affect the quality of the made tea. Normally only a small proportion of bushes is affected and these are associated with the presence of nests of an undetermined species of *Pheidole*.

An account is given of the life-history of *O. assectator*, and the developmental stages are briefly described. The eggs are laid singly in incisions made by the ovipositor on the underside of the leaf in parallel rows arranged lengthwise. The newly hatched larvae exist as free-living planidia on the leaf surface, whence they are carried by unknown means into the ants' nests in the soil beneath the tea bushes. Here the planidium transfers to the last-instar larva of the ant and penetrates its body. There it remains inactive until its host reaches the prepupal stage, whereupon endoparasitic feeding and development start. After the host pupa has formed, the parasite larva emerges, establishes itself below the thorax of its host, and remains there, feeding ectoparasitically, through two further instars, completely consuming the contents of its host. The mature larvae remain scattered in the ant's nest and pupate a few days later; both larvae and pupae are cared for by the worker ants.

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References.

D[AS], G. M. (1954). Sewing blight.—*Two & a Bud* **1** no. 3 p. 12.

CLAUSEN, C. P. (1923). The biology of *Schizaspidia tenuicornis* Ashm., a Eucharid parasite of *Camponotus*.—*Ann. ent. Soc. Amer.* **16** pp. 195–219.

CLAUSEN, C. P. (1940). Entomophagous insects.—688 pp. New York, McGraw-Hill.

ISHII, T. (1932). Some Philippine Eucharids with notes on their oviposition habits.—*Bull. imp. agric. Exp. Sta. Japan* **3** pp. 203–212 [original not seen].

KERRICH, G. J. (1963). Description of two species of Eucharitidae damaging tea, with comparative notes on other species.—*Bull. ent. Res.* **54** pp. 365–371.

SMITH, H. S. (1912). The Chalcidoid Genus *Perilampus* and its relations to the problem of parasite introduction.—*Tech. Ser. Bur. Ent. U.S. Dep. Agric.* no. 19 pp. 33–69.

WHEELER, W. M. (1907). The polymorphism of ants, with an account of some singular abnormalities due to parasitism.—*Bull. Amer. Mus. nat. Hist.* **23** pp. 1–93.

WHEELER, G. C. & WHEELER, E. W. (1937). New Hymenopterous parasites of ants (Chalcidoidea: Eucharidae).—*Ann. ent. Soc. Amer.* **30** pp. 163–175.

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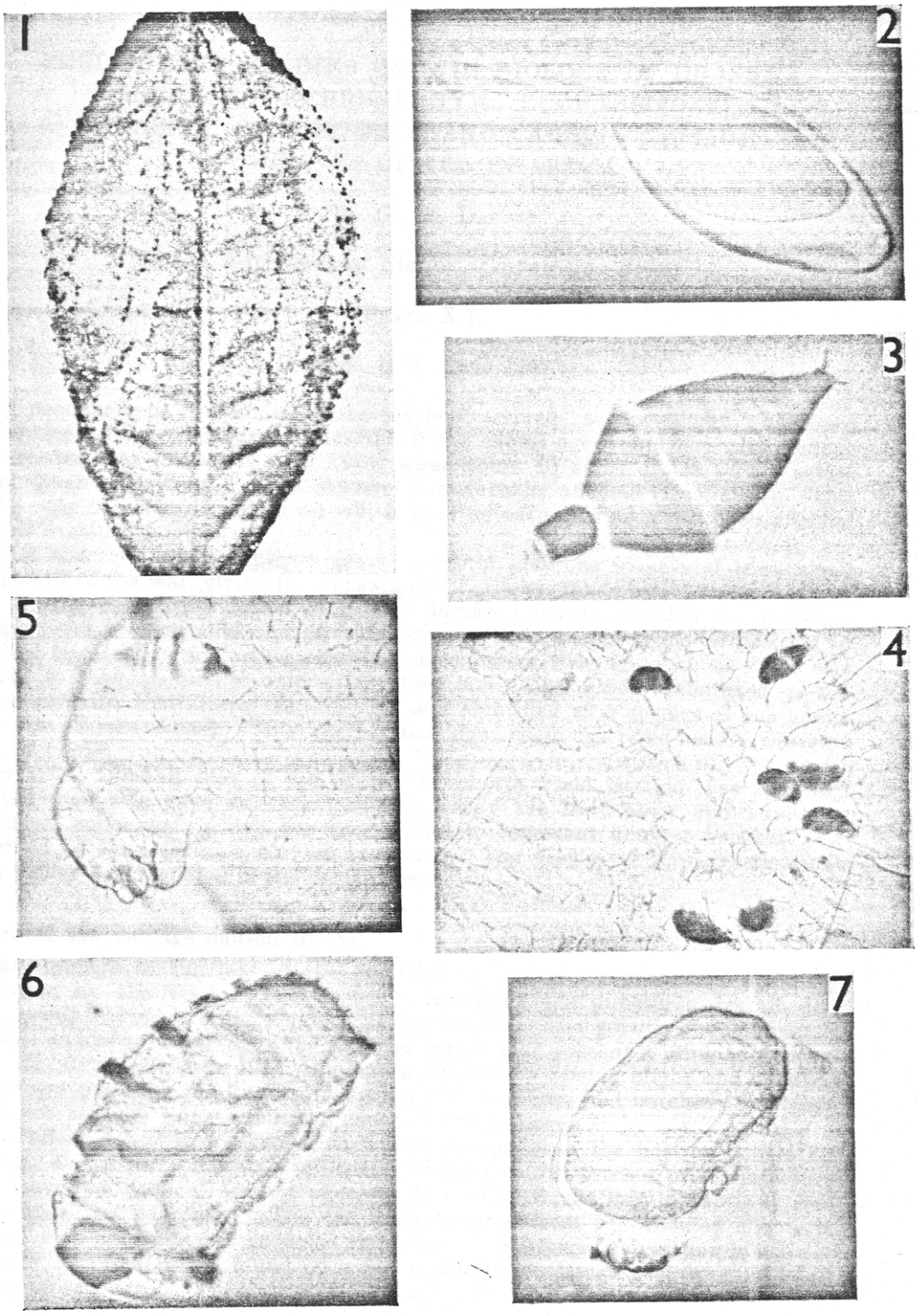

Developmental stages of *Orasema assectator*.

Fig. 1. Leaf of tea showing oviposition incisions. Fig. 2. Egg (× 475). Fig. 3. Planidium (× 315). Fig. 4. Seven planidia embedded in anterior part of larva of *Pheidole* (× 54). Fig. 5. Planidium showing extended growth within host larva (× 34). Fig. 6. Late first-instar larva after start of feeding ectoparasitically on pupa of *Pheidole* (× 110). Fig. 7. Second-instar larva (× 87).