NOTES ON FUMIGATION OF ORCHIDS

By E. R. SASSCER and H. F. DIETZ, *Washington, D. C.*

(Withdrawn for publication elsewhere)

PRESIDENT R. A. COOLEY: Do you wish to discuss this paper or ask questions?

MR. T. J. HEADLEE: Mr. Chairman, I might inquire whether the cattelyæ fly in the orchid leaf is killed by this process.

MR. E. R. SASSCER: We haven't checked up on that. I have about reached the conclusion that we cannot kill any of these insects with plant fumigation. I would not recommend this fumigation to control any insect imbedded in the plant.

PRESIDENT R. A. COOLEY: I will call for Mr. McConnell's paper, "*Mira saltator* Lindm, as a Parasite of the Hessian Fly."

EUPELMINUS SALTATOR LINDM. AS A PARASITE OF THE HESSIAN FLY

By W. R. McCONNELL, *Cereal and Forage Insect Investigations, U. S. Department of Agriculture*

During the course of our studies of the parasites of the Hessian fly we have reared another parasite as yet unrecorded in American literature. As is commonly the case with a parasite of an introduced insect, its determination has been a troublesome matter because of the inaccessibility of the type and the lack of properly identified representatives.

Specimens were submitted to Mr. A. B. Gahan, of the National Museum, who regarded them as identical with a parasite described from Russia by Lindemann (1) under the name *Euryscapus saltator*. He placed it in the genus *Mira*, with which *Euryscapus* has commonly been regarded as synonymous. Since the title of this paper was submitted, Mr. Gahan has studied this species further and has written regarding it as follows: "I have been fortunate enough to find in the collection here part of a specimen labelled *Euryscapus saltator* in what I believe to be Lindemann's own handwriting. It was in the box of *Pleurotropis epigonus* and other European parasites of the Hessian fly. We know that specimens of some of Lindemann's species were sent to Riley and there seems to be no reason to doubt that this broken one is authentic, whether the label is Lindemann's or not. Only the

thorax remains but this is enough to prove that the specimen was a wingless Eupelmine similar to the species in this country and not a *Mira*. What is left of the specimen agrees perfectly with your specimens, so far as I can see, so there seems to be no reason to think that the determination of our species is not correct. The name *Mira* should not be used for the genus, however, since *Mira* as now understood is not a Eupelmine." Still later Mr. Gahan wrote regarding the generic position of this parasite: "*Eupelminus* is the generic name applied to a lot of Eupelmines which are wingless or with rudimentary wings. I really do not think that this is generic but for the present it will probably be better to use the name since it does identify the species to some extent. The name to be used then will be (*Mira*) *Eupelminus saltator* Lindm."

The opinion has also been expressed by Mr. Gahan that this is the same parasite which Mr. W. J. Phillips of the Bureau of Entomology has reared from the galls of various species of *Harmolita* (*Isosoma*).

While our knowledge of this species as a parasite of the Hessian fly is by no means complete, yet it seems worth while to place upon record the fact of its occurrence in this country together with the facts we have accumulated regarding its life-history. The biological data are based on experiments conducted in the laboratory at Hagerstown, Md., chiefly during the season of 1916. The writer has been aided in the collection of material upon which the field records are based by Messrs. P. R. Myers and P. H. Hertzog. Mr. Myers has also given very valuable assistance in rearing the field puparia and has carried out some experiments on the parthenogenesis of this species.

DISTRIBUTION

Lindemann's specimens were reared from puparia which he collected at Moscow and in various governments of central Russia. He states that he has never found the species abundant, but it is probably widespread in Europe, and was undoubtedly introduced into this country at an early date in infested straw. There are apparently no other records in literature.

We have reared it from the following nine localities in Pennsylvania: Carlisle, Andersonburg, State College, Danville, Montoursville, Linden, Butler, Greenville and Linesville; from Hagerstown and Brad-dock Heights in Maryland; and from Strasburg and Woodstock in Virginia. Mr. Phillips has reared it from *Harmolita* material from Michigan, Indiana, Ohio, New York, Pennsylvania and Virginia, and probably from other states.

The species has not been an abundant parasite of the Hessian fly during our investigations. The greatest number were found in a field

at Greenville, Pa., in 1915, where 6.67 per cent of the puparia were parasitized by it.

Hosts

Eupelminus saltator is a primary parasite of the Hessian fly, attacking externally both larval and pupal hosts inside the puparium. We have repeatedly demonstrated the primary nature of its attack by rearing it experimentally from puparia known to be free from other parasites. It may, however, become a secondary parasite of the fly, since a puparium from which an individual emerged was opened and found to be filled with cocoons of *Polygotus*, from one of which it had issued.

Lindemann mentions that he had reared this parasite from *Harmolita hordei*. Mr. Phillips has kindly furnished a list of eight species of *Harmolita* from the galls of which he has reared it. These are *H. tritici*, *H. vaginicola*, *H. maculata*, *H. albomaculata*, and four new species of the same genus. He is certain that they have come from the galls of *Harmolita*, but is not sure whether they were primary or secondary there. There is little doubt, however, that this species is ordinarily primary, but when other parasites are abundant it can just as easily become secondary.

THE ADULT

This parasite belongs to the family Encyrtidæ, subfamily Eupelminæ, and can easily be distinguished from its nearest relative among Hessian fly parasites, *Eupelmus allynii* French, by its indistinct parapsidal grooves and poorly developed wings. No males are known, but the females are further distinguishable from those of *E. allynii* by their well exerted ovipositor. The wings are small and do not function. The tip of the anterior wings is bent upward at a right angle so that the apical portion is held in a vertical position; the posterior wings are shorter, very narrow, and are turned upward at the tip. While the adults are unable to fly, they are remarkably good leapers.

They normally emerge through a rounded hole near the posterior end of the puparium. Before beginning to oviposit they rest and feed for a period of two to five days, this preoviposition period probably averaging about three days. In cages they will feed on sugar solution, and they have been observed also to puncture the host with the ovipositor and feed at the wound. In one case the same puparium was punctured several times and feeding observed to take place after each puncture. This puparium, after being kept in a cage for some weeks, was found to contain a dead fly pupa, and there is little doubt that the host was killed by the feeding punctures.

When ready to oviposit the female walks back and forth over the

infested stems or stubbles with antennæ bent forward and downward and kept in constant vibration. When a suitable location is found, the abdomen is contracted longitudinally, the tip bent downward and the ovipositor pushed into the stem. If no puparium is present, the ovipositor is promptly withdrawn, but when a host is found oviposition may require several minutes. They oviposit only during daylight, and preferably during bright weather.

A female may lay as many as five eggs in a day, and probably more. She may rest from oviposition for a day or two at a time. Females have lived in cages and oviposited over a period of 3 to 24 days, and other females which never oviposited have lived as long. The maximum number of stages reared from a single female was 39, but it is necessary to make allowance for considerable mortality, and it seems probable that a female may lay at least a hundred eggs. On the other hand, some females seem to be unable to oviposit. These are small individuals which for one reason or another have had an insufficient amount of food during the larval period.

Unfertilized females are thelyotokous. Mr. P. R. Myers has reared this species through five successive parthenogenetic generations and the writer, starting with a different female, has carried them through six such generations without the appearance of a male in any case. The sixth of these generations appeared during the past summer, but the individuals were small in size and never oviposited. This was undoubtedly due to a scarcity of good host material upon which they could develop, and not to the lack of fertilization.

THE EGG

The eggs (Fig. 8, 1) are deposited on the outside of the host larva or pupa inside the puparium, and cling lightly to the host. They are white in color. The chorion is thin and elastic, with a smooth and shining surface. They are ellipsoidal in form with a large pedicel at the cephalic pole and a slender flagellum at the caudal pole. They measure 0.374 mm. in length by 0.133 mm. in greatest width, taking the average of five eggs. The pedicel is about half as long as the egg and is usually folded back along the side of the egg, its tip being recurved forward, but it may be bent and twisted in various ways. The flagellum at the posterior pole is about half as long as the pedicel and usually lies against the posterior surface of the egg. It is very slender and structureless, and, as Marchal (2) has suggested for *Platygaster* and related genera, it probably results from the degeneration of the follicular cells surrounding the posterior pole of the ovarian egg.

During April and May in the laboratory the eggs hatched in about three days. In the process of hatching the larva breaks through the chorion near the base of the pedicel and slowly crawls out.

THE LARVA

The larva when first hatched is about 0.4 mm. long, slightly depressed, widest in the metathoracic region, and tapering to a rather acute abdomen. The head is com-

paratively large, convex anteriorly, and slightly narrower than the prothorax. The body color is grayish white, with very pale brownish head and large brownish black mandibles, which are simple curved hooks. The body and head are provided with long hairs, as is the mature larva.

The mature larvæ (Fig. 8, 2) vary greatly in size, but average about 2.75 mm. in length. They are white, with dark brown mandibles. The body is of the usual chalcidoid form, somewhat spindleshaped and concave ventrally. Head short, convex, without tubercles, slightly higher than wide, and partially immersed in the prothorax. Antennæ not jointed, cylindrical, with bluntly rounded apex. Mandibles simple, curved, heavily chitinized hooks, with dorsal and ventral articular processes (Fig. 8, 5). The labrum and the region dorsal to it form a concavity (Fig. 8, 3), the central part of the labrum being heavily chitinized (Fig. 8, 4, *b*) and bearing teeth on its ventral edge. These teeth are triangular and a little over 0.003 mm. long. They are irregular in number and arrangement, varying in number from 6 to 9 and are separated by interspaces usually at least as wide as the height of the teeth. The lateral regions of the labrum are very thinly chitinized and the mandibular processes (Fig. 8, 4, *c*) are difficult to see. The maxillæ (Fig. 8, 3) are thin and transparent and separated from the labium by a shallow notch. Each maxilla bears a cluster of three very small tubercles which probably represent the palpus. The labium is also thin and transparent and bears two pairs of very small tubercles probably representing the labial palpi. The head bears 8 long hairs; one pair submedian on the dorsal posterior part of the epicranium; one pair between and slightly below the level of the antennæ; another pair in the same plane posterior to the above; and a fourth pair ventral to the last and a short distance posterior to the mandibles. In addition there is a pair of small hairs dorsal to the labrum.

The body consists of the usual 13 segments. Spiracles are present on the last two thoracic and first seven abdominal segments. Prothorax with 7 pairs of long hairs; 3 dorsal, 1 lateral and 3 ventral. Mesothorax with 6 pairs of hairs: 2 dorsal, 1 lateral, and 3 ventral. Metathorax with 4 pairs of hairs: 1 dorsal, 1 lateral and 2 ventral. The thoracic hairs are all long except the dorsal metathoracic pair. Abdominal segments 1-9 each bear a pair of subdorsal hairs and a pair of lateral hairs. Segments 5-9 have in addition a pair of ventral hairs. Segment 10 bears 4 short bristles on the dorsal lobe and 2 on the ventral lobe. The abdominal hairs are all much shorter than those on the head and thorax, but increase in length on segments 8 and 9.

The young larvæ soon attach themselves to the host by means of the mandibles and use the tip of the abdomen to help anchor the body. They crawl with a leech-like movement, and when disturbed frequently retain their hold on the host by means of the mandibles and sway the body about the head as a fixed point.

EXPLANATION OF FIGURE 8)

Fig. 8, 1. Egg x 230, *a* Pedicel, *b*, Flagellum. 2. Mature larva, lateral view x 50, *a* Antenna. 3. Head of larva, ventral view x 216, *a*, Labrum, *b* Mandible, *c* Maxilla, *d* Maxillary palpus, *e* Labium, *f* Labial palpus. 4. Labrum, cephalic view x 960, *a* Toothed region, *b* Heavily chitinized concave area, *c* Mandibular process, *d* Angle of mouth. 5. Mandible, ventral view x 750, *a* Ventral articular process. 6. Pupa, lateral view x 40. 7. Adult female, dorsal view x 40. 8. Adult female, lateral view x 40. All figures have been reduced one-half. Drawings 6-8 have been made by Miss E. H. Hart.

Within two or three days after the larvæ attach themselves to the outside of the host, the latter dies, soon becomes flabby, and turns to an ashy gray color. The larva slowly absorbs the contents of the host skin, increases in size and finally nothing remains of the host but the empty skin, which is usually pushed into one end of the puparium. When the host is dead or in a partly desiccated condition at the beginning of the attack, the larva may live for a time but ultimately dies.

The larval stage requires a period of 8 to 12 days for complete development. Near the end of this stage the alimentary canal becomes completely developed and the waste material accumulated in the ventriculus is voided into one end of the puparium. In less than a day after defecation occurs the larva transforms to the pupal stage.

THE PUPA

The pupa (Fig. 8, 6) is at first white, turning rather rapidly to pale reddish brown and light brown. It varies in length from 1.41 mm. to 2.50 mm., with an average for 15 individuals of 2.08 mm. The head is slightly wider than the thorax, its greatest width averaging 0.58 mm. The pupa is slightly depressed and slightly concave ventrally. The ovipositor sheath is turned upward, but does not extend dorsad of the abdomen.

The pupa stage requires 8-12 days in May and June, with an average of about 10 days. In midsummer this stage is undoubtedly shorter.

NUMBER OF GENERATIONS

In the laboratory the average time required for development from egg to adult varied greatly with the season. In May it averaged 25 days; in June, 24 days; in July, 18 days and in July-August 23 days. The shortest period of development recorded was 15 days during July. Most larvæ which develop from eggs laid during the latter part of August and September remained over winter in the condition of mature larvæ, emerging as adults the following May. The average period required for development in the overwintering generation, based on 19 individuals, was 265 days.

Five generations were reared in the laboratory in 1916 between April and September. A sixth generation overwintered, and emerged the following May. Thus it was possible to rear six generations in about a year. Under field conditions at Hagerstown, Md., hibernating larvæ were found in puparia late in the spring. Adults probably do not emerge outdoors before the middle of June at about the time puparia of the spring brood of the Hessian fly are appearing. In a season like 1916 there is time for four generations to develop during the summer, which with the hibernating generation, makes five gen-

erations a year. During a comparatively cool summer, like that of 1917, there were probably not more than three generations produced.

While up to the present time *Eupelminus saltator* has been of considerable importance in the natural control of the Hessian fly, it is also true that during the time we have had it under observation there has been no extensive outbreak of either the Hessian fly or *Harmolita*. It seems probable that when either of these hosts becomes abundant, the numbers of the parasite will increase and aid in reducing the numbers of this host. In case the alternate host becomes abundant the following season, the parasites will then be ready to turn their attention to it in increased numbers and with considerable effect. It will be necessary to keep this parasite under observation for a series of years before its real value can be correctly estimated.

REFERENCES

- (1) LINDEMANN, K. 1887. Die Pteromalinen der Hessenfliege. *In* Soc. Imp. Nat. Moscou Bull., vol. I, pp. 190-191.
- (2) MARCHAL, PAUL. 1906. Les Platygasteres. *In* Arch. Zoöl. Exp. et Gen., IV serie, T. IV, p. 507.

PRESIDENT R. A. COOLEY: The next paper is "Grasshopper Observations, Experiments and Demonstrations in Arizona, During 1917," by Mr. A. W. Morrill.

EXPERIMENTS WITH GRASSHOPPER BAITES WITH INCIDENTAL OBSERVATIONS ON THE HABITS AND DESTRUCTIVENESS OF THE DIFFERENTIAL GRASSHOPPER (MELANOPLUS DIFFERENTIALIS)

By A. W. MORRILL, *Phoenix, Arizona*

In connection with demonstration work against grasshoppers in Arizona during the past season problems were presented which led to the series of observations and tests which form the basis of this paper. It was at first believed that one or two days' work would give the desired information but the results failed to meet expectations in this respect. Although the conclusions which may be drawn from these experiments are not as definite as desired, this paper is presented in the hope that it may be of some use during the coming season in suggesting profitable lines of work to others interested in grasshopper control as well as of some direct value as a contribution to our literature on this subject. The experimental work here reported was