THE COCONUT TREEHOPPER, *SEXAVA* SPP., AND ITS PARASITES IN THE MADANG DISTRICT.

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Note by Author.—

THE following article was written in 1941, for publication in the *New Guinea Agricultural Gazette*. The Japanese invasion of New Guinea early in 1942 prevented publication.

Later in 1941, several hundred adult *Sexava* spp, † infested by the Strepsipteron were taken to Manus, where they were liberated on palms at Pak Island, Mokareng plantation, and near Lorengau. Nymphal and adult *Sexava* collected in Manus were then placed in the cages which had been occupied by the parasitized individuals, and a high percentage of parasitism was obtained. The caged *Sexava* were taken to Rabaul and kept under observation. Hosts which had been attacked as adults all died before the next generation of triungulins emerged, death usually occurring about a week after the cephalothorax of the parasite could be seen protruding from the abdomen of the host. Egg production by hosts was definitely inhibited. When the parasite attacked nymphs, its life-history appeared to be longer. From memory, the shortest period from parasitism to emergence of the triungulins was about 50 days. The Japanese invasion prevented the breeding of another generation.

In 1945, the author, who was with the Army in New Guinea, visited and inspected Pak and Mokareng. No sign of the parasite could be found. This was a great disappointment, as there had seemed good reason to expect successful establishment of the parasite, and good control of the host.

Some years later, in a paper by Richard M. Bohart (*A Revision of the Strepsiptera with Special Reference to the Species of North America*, Univ. of Calif. Pubs. in Entomology, Vol. 7, No. 6, pp. 91-160) is was noted that the possibility exists that members of the family Myrmecolacidae, which parasitize ants, may be the males of Stichotrematidae. Bohart quotes Hofeneder as attributing this suggestion to Ogloblin. If this should prove to be the case, a study of the ants of Manam Island, which is very small, might be rewarding. If a myrmecolacid parasite were found in an ant species on Manam which does not occur at Pak, it would appear likely that successful introduction of *Stichotrema* to Manus would call for simultaneous introduction to the ant species also.

THE Madang District of New Guinea has always been free from serious attack by the Coconut Treehopper, *Sexava* spp., while in the Western Islands, Manus, New Britain, New Ireland and Lavongai these insects have frequently caused severe defoliation of coconut palms. Hence, it is obvious that some controlling factor or factors are at work to prevent, except in isolated instances, severe outbreaks of the pest. Therefore, when the writer was instructed to make an entomological patrol of the Madang District, one of the main objects in view was to attempt to obtain information regarding such controlling factors.

During the course of the patrol, which occupied between three and four months, the route followed led around the volcanic islands of Kar Kar and Manam, and along the Madang Coast from Awar Plantation to Madang. Awar is opposite Manam Island,

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† Recently Dr. C. Willemse (Holland) revised the taxonomy of the Mecopodidae and Conocephalidae damaging coconuts in the Territory of Papua and New Guinea. As a result of the revision, one new genus and four new species were described. Their names and distribution are :—

Eumossula gracilis Willemse—New Ireland District (Masahet and Mahurl Islands of the Lihir Group) ; New Britain (Keravat) ; Morobe District (Bubia).

Segestidea hanoverana Willemse—New Ireland District (New Hanover and Tatau Island in Tabar group).

Segestidea insulana Willemse—Manus District (Pak Island, Lou Island, Lorengau) ; New Ireland District (Masahet Island).

(Refer to Willemse, C., 1957. Notes on Medopodidae, Orthoptera, Tettigonoidea. Tijdschrift voor Entomologie, 100, 1 : 35-42.)

Pseudoniscara szentia Willemse—Gulf District.

(Willemse, C., 1958. Natuurhistorisch Maanblad 47, 9-10 : 122-125.)

Species found in the Madang District have not been included in the above-mentioned revision.

and about 140 miles west of Madang by land. Also, a call was made at Muschu Island, about 14 miles west of Wewak, and 200 miles by sea west of Madang. On Manam, which is an active volcano, and where the soil is poor, there are no European plantations, but on Kar Kar, which has very fertile soil of volcanic origin, and on the New Guinea coast, European plantations are scattered along the road. Both Manam and Kar Kar have large native populations, whose groves of coconut palms and bananas provide collecting grounds for *Sexava* spp.

Distribution of Tettigoniids.

A large number of species of *Tettigoniids* was found on coconut palms throughout the district, including what appear to be two distinct species of *Sexava*. The distribution of these two species, the identity of which is not known, is rather interesting. One of them, alluded to as species A, occurs in Kar Kar, Manam and along the mainland coast, and specimens recently have been received from Maprik, an agricultural station south of Wewak, while species B occurs only on the mainland. From Madang to Sarang, which is about 35 miles north and west by sea, only species A was found. From Sarang north-west to Bogia (80 miles by sea from Madang) both A and B were seen, the numbers of A diminishing as one moved westward. West of Bogia, as far away as Awar, only species B was found, and this was also the only species seen at Muschu Island, 200 miles west of Madang by sea. As the patrol did not cover territory east of Madang, no information was obtained as to the species of *Sexava* present in that area. However, specimens from the Huon Gulf, 200 miles by sea south-east of Madang, which are preserved in the insect collections of the Agricultural Department, appear to correspond with species B. Hence, speaking generally, it seems that species B is the typical species of the New Guinea coast, and species A of the islands of Manam and Kar Kar, though the record of species A from Maprik does not fit in.

The most obvious differences in external characters between species A and species B are summarized below in the table.

Species A seems to correspond very closely to an unnamed species of *Sexava* in our collections, a specimen of which was received from Takar, Netherlands East Indies.

Strepsipterous parasites of Sexava spp.

As was mentioned above, one of the main objects of the patrol was to acquire information regarding any factors tending to control *Sexava* spp. The first day in the field revealed the presence of such an influence in the form of an internal parasite of the tree-hopper, belonging to the Order Strepsiptera. This was a most interesting discovery, as it was believed that insects of this Order had not previously been recorded as parasites on species belonging to the Order Orthoptera, to which *Sexava* spp. belong. Neither Imms nor Tillyard, in their standard textbooks, mention Orthoptera as host of Strepsiptera. Moreover, later observations showed that the reproductive rate of the parasite far surpassed that known in other Strepsiptera, a conservative estimate of the number of eggs and larvae in one mature female being 750,000. This figure has no great claims to accuracy, as the difficulty of counting the eggs in their early stages of development is great, but it is thought that the tendency has been rather to underestimate than to overestimate the numbers. Counting was carried out by making a homogeneous mixture of the body

COMPARISON OF SPECIES.

Species A.	*Species B.*
Large. Body-length to tip of elytra: male—approximately 3½ inches. Female—approximately 4 inches.	Small. Body-length of male approximately 2¾ inches. Female approximately 3¼ inches.
Antennae with transverse black bands.	Antennae uniformly brown.
Distal half of elytra wide.	Distal half of elytra narrow.
Thorax without median red stripe, overlapping portion of left elytron unicolorous with rest of body.	Thorax with dorsal median red stripe, overlapping portion of left elytron straw-coloured.
Three or four black spots situated latero-ventrally on the proximal portion of the hind femur. Hind tarsi and distal portions of hind tibiae brownish-black.	No such markings. Ventral portion of hind femur coloured red.

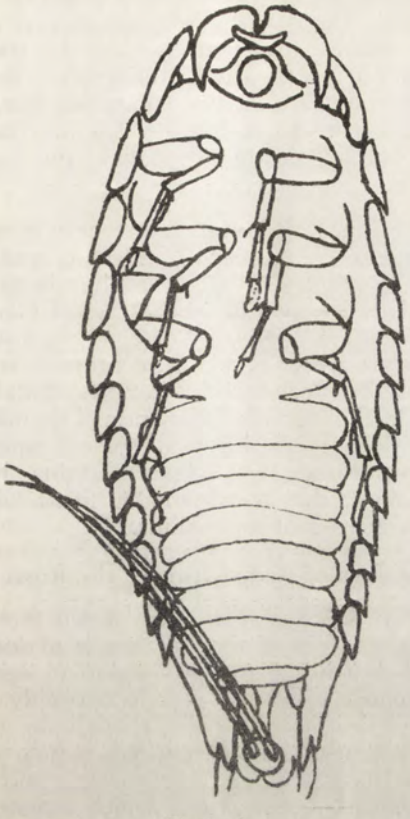

Figure 1
Triungulin Larva of Strepsipteron, Ventral View. (x800)

contents of a mature parasite in glycerine and water, and counting the number of eggs and larvae in a series of single drops of the mixture. The final figure was calculated by multiplying the average number per drop by the total volume of the mixture and dividing by the volume of one drop.

Regarding the identity and host-relations of the parasite, it was later found that a Strepsipteron had been found parasitizing *Sexava nubila*, Stal, and *Sexava* sp. in the Schouten Islands and Admiralty Islands respectively (Pierce, 1918). For this species, named by Hofeneder *Stichotrema dallatorreana*, a new super-family, Stichotrematoidea, was erected. As the species recently found throughout the Madang District has been found in localities adjacent to the Schouten Islands, and runs down to the Stichotrematoidea in Pierce's key to the super-families, it is probably identical with *S.dallatorreana*, Hofeneder. The triungulin larva also corresponds closely to that described by Pierce. The record of the parasite from the Admiralty Islands is regarded as doubtful. Specimens of the insect have been forwarded to the British Museum for identification.

As yet, no detailed study has been made of the biology of the parasite, though it is hoped that some headway may be made in this direction at a later date. However, by piecing together observations made in the field and information gleaned from available literature, it is possible to obtain a reasonable picture of the bionomics of the insect. Among the literature, Kirkpatrick's notable work on the bionomics of *Corioxenos antestiae* has proved particularly helpful.

Bionomics of the Strepsipteron.

The species apparently is parthenogenetic, the female being capable of reproduction without fertilization by a male. Approximately 500 parasitized *Sexava* spp. were dissected during the course of the patrol, and no male puparia were found. The female insect in the adult stage is a crescent-shaped, soft sac, with a strongly-chitinized cephalothorax, and a portion of brown, persistent larval cuticle ventrally. The general body colour is white in the early stages, becoming grey-black as the larvae inside the female body darken. Body-length of a well-developed female is about 4 cm. with a dia-

Figure 2
Triungulin Larva of Strepsipteron, Lateral View. Legs omitted (x800)

meter of 1 cm. The parasite spends the bulk of its life inside the body of the host, the only stage which exists in the open air being the minute, heavily-chitinized triungulin larva.

The triungulin larva (Figs. 1 and 2) is dark-brown, heavily chitinized, body-length 0.13 mm., body-width at widest point 0.05 mm. with two strong anally-situated spines, 0.06 mm. long, which enable the larva to spring into the air. On each side of the head there are one large and two small ocelli, ventrally are situated a pair of powerful, sharply-pointed mandibles, while the tarsi of the first pair of legs are provided with large adhesive pads. This type of larva is very hardy, capable of withstanding adverse weather conditions, and surviving for extended periods without food. No first-hand observations of the species have been made, but it is probable that they behave in a manner somewhat similar to the triungulins of *Corioxenos antestiae*, whose behaviour has been fully described by Kirkpatrick. This author states that the larvae attach themselves to any moving object which passes them, deserting it when they find that it is not their host. On finding a suitable host, they remain attached to it until its next ecdysis, when they are capable of penetrating into the body cavity.

Within a short time after entering the body of the host, the triungulin sheds its appendages and heavily-chitinized integument, the second-instar larva being translucent, vermiform and lightly chitinized. Nutriment is absorbed from the blood of the host through the integument, and after several ecdyses the larva pupates, and penetrates one of the abdominal pleura or sterna of the host, portion of the strongly-chitinized cephalothorax protruding slightly from the host's body. The adult insect is partly enclosed in the larval skin, the presence of which on the ventral surface causes a puckering and curving of the abdomen. Two spiracles lead into the main tracheal trunks, which branch internally into a maze of tracheae, supplying the insect with air. A crescent-shaped opening in the cephalothorax gives access to the brood-canal, formed between the larval skin and the ventral surface of the body of the female, and three transverse rows of genital tubes permit the emergence of fully-developed triungulins into the canal, from which they emerge into the open air through the crescent-shaped opening. As the triungulins within the body of the mother approach maturity, they darken, those near the periphery maturing first, and hence becoming visible through the translucent skin of the female, giving the body a grey-black appearance.

Emergence of the larvae has been observed to take place throughout the day, and probably continues at night, as has been described by Kirkpatrick in the case of *Corioxenos antestiae*. The rate of emergence of the larvae is very rapid, a continual stream having been seen to issue from the female for considerable periods. They propel themselves by springing off the anal spines, emerging two or three at a time. During heavy emergence, the brood-canal is filled with a seething mass of triungulins.

Effect of parasitism on the host.

As is the case with other known Strepsiptera, the effect of the parasite is to inhibit, partly or wholly, the production of eggs by the female *Sexava*, and it probably also renders the male infertile, though the testes remain intact. A parasitized female treehopper usually has few or no eggs, and it is not known whether those which remain are fertile. Kirkpatrick has shown, in the case of *Corioxenos antestiae*, that, though the testes of the male host appear normal and produce living spermatozoa, a parasitized male is incapable of fertilizing a female.

Degree of parasitism in Madang District.

The highest degree of parasitism seen during the patrol, based on the percentage of parasitized adults, was on Manam Island, with Kar Kar second and the Madang coast a rather poor third. Not only was the rate of parasitism highest on Manam, but the number of parasites to each host was higher than in other areas. (Dissections were confined mainly to adult *Sexava* spp. and sixth and seventh instar nymphs, though one fifth instar nymph was found to be parasitized. Supplies of the nymphal stages were very small, the natives in the district being unskilled in collecting them, owing to the prevailing ignorance of the treehopper and its life-history.) Stunting of the ovaries and the digestive system of the host was much more obvious on Kar Kar and Manam than on

the mainland, where parasitized females frequently had numbers of well-developed eggs in the ovaries. On the islands, it was rarely that one found even a few eggs in a parasitized treehopper, while the digestive system was often much reduced in size.

The greatest number of parasites found in one host was in a female in Baliau Village, Manam, which contained one mature Strepsipteron attached to the abdominal wall, and 80 larvae in various stages of development. At Dugulaba Village, Manam, one male *Sexava* contained eight mature parasites attached to the abdominal wall, and a female from the same locality had seven. From five to 10 parasites are commonly found in one host at Manam. On Kar Kar, the greatest number of parasites in one host was 16, one mature and the rest in the larval stage. Below is a table showing the percentage of parasitism in Manam, Kar Kar and the Madang coast, based on adult hosts only.

Locality.	Males.		Females.		Total.	
		Per Cent.		Per Cent.		Per Cent.
Manam	74/122	— 61	92/158	— 58	166/280	— 60
Kar Kar	49/123	— 40	56/110	— 51	105/233	— 45
Madang coast	79/368	— 21.5	122/544	— 22.4	201/912	— 22

Projected transfer of parasites to other districts.

As no evidence of hyperparasitism has been found, and as the triungulin larvae of the parasite, which are the only stage existing outside the body of the host, are very hardy, no great difficulty is anticipated in establishing the Strepsipteron in other parts of the Territory. Hence arrangements are being made to collect parasitized treehoppers on Manam Island, where the parasite is most vigorous and successful, and take them to suitable areas elsewhere in the Territory. While attempts are being made to establish the parasite in the field, it is hoped that fuller investigation of its bionomics will be possible. Because Manam is not a port of call for regular shipping lines, and Government transport has been restricted by the exigencies of war, some delay in carrying out this programme is inevitable, but it is hoped that within the next 12 months considerable progress will have been made.

Other species of Tettigoniids attacked by the parasites.

In areas where both are present, the two species of *Sexava*, A and B, seem to be equally susceptible to attack by the Strepsipteron, and, in addition, the parasite has been found in three other species of Tettigoniidae. Two species on Kar Kar were attacked, and one on Manam, but the percentage of infestation was very low, there being only a single record of attack on each species at Kar Kar, while on Manam two adults of a single species were found to be parasitized. The species of parasite in each case is thought to be the same as that which attacks *Sexava* spp., though the size of the adult female is reduced in small hosts.

Tachinid parasite of Sexava spp.

All along the Madang coast, from Awar to Sek, the presence of a Tachinid parasite of *Sexava* spp. was noted, five per cent. of the adults and 10 per cent. of the 6th and 7th instar nymphs being affected. The larvae, in what is presumed to be their first instar, are enclosed in a delicate sac, in which they lie in the abdominal cavity of the host, the head pointing inwards. Anally, the sac is attached to a chitinous funnel, the narrow end of which opens onto the pleural portion of the abdominal wall, thus admitting air to the pair of large spiracles of the larva. The adult fly has not been bred out, and little is known of the life-history of the parasite or its effect on its host, though it is hoped that further knowledge may be obtained at a later date.

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