

THE NATURAL ENEMIES OF BAGWORMS ON OIL PALMS IN SABAH, EAST MALAYSIA

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Abstract: Three species of bagworms, *Mahasena corbetti* Tams, *Metisa plana* Wlk. and *Cremastopsyche pendula* Joannis, are major pests of oil palms in Sabah. Parasites recorded from these and other Psychids during 1969 and 1970 were: *Apanteles* sp., *Aulosaphes* sp., *Echthromorpha agrestoria* Swed., *Xanthopimpla* sp., *Sympiesis* sp., *Pediobius* sp., *Eozenillia equatorialis* Towns., *Palexorista solennis* (Wlk.) and *Sarcophaga* sp. from *M. corbetti*; *Apanteles metesae* Nixon, *Eupelmus catoxanthae* Ferr. and *Eozenillia psychidarum* Bar. from *M. plana*; *Aulosaphes psychidivorus* Muesebeck and *A. metesae* from *C. pendula*; *Xanthopimpla pedator* Fabr., *E. equatorialis* and *Brachymeria* sp. from *Clania tertia* Templ.; *Sericopimpla flavobalteata* Cam. from *Cryptothelea cardiophaga* Westw.; and *Parasierola* sp., *Brachymeria* sp. and *Pediobius lividiscutum* (Gahan) from? *Pteroma* sp. *C. tertia* and *C. cardiophaga* were also attacked by *A. psychidivorus*. *Paraphylax rufipes* Cam. was a common secondary parasite of bagworms. *Brachymeria* sp., *B. deensis* Cam. and *B. lugubris* Wlk. were reared from *E. equatorialis*; *E. catoxanthae*, *P. lividiscutum* and *Brachymeria* sp. from *A. metesae*; and *Brachymeria* sp. from *E. psychidarum*.

Apanteles angaleti Muesebeck and *Anastatoidea brachartona* Gahan emerged in cages with *M. corbetti*. *A. psychidivorus*, *P. lividiscutum* and *E. sp.? equatorialis* were reared from *M. corbetti* bags formed of leaves from an unknown host plant. A *Fislistina* sp. was obtained from *Eumeta* sp. on cocoa. Two predators, *Callimerus bellus* Gorh. associated with *M. corbetti*, and *Sycanus* sp. with *C. pendula*, were very scarce.

Pathogens isolated from dead bagworms were *Paecilomyces fumoso-roseus* (Wize) Brown and Smith, from larvae of *M. plana*, *C. pendula*, *C. tertia* and *C. cardiophaga*, and a possible nonoccluded virus and an *Aspergillus* sp. from those of *M. corbetti*.

Although several species of bagworms (Lep., Psychidae) occur on oil palms (*Elaeis guineensis* Jacq.) in Sabah, East Malaysia, only three of them, *Mahasena corbetti* Tams, *Metisa plana* Walker and *Cremastopsyche pendula* Joannis are, at the present time, of major economic importance as pests (Sankaran, 1970). In W. Malaysia *M. corbetti* has long been known to be a pest of coconut palms, while the other 2 species have caused severe outbreaks on oil palms. Native parasites play an important role in checking these bagworms but experience in W. Malaysia has shown that the use of broad-spectrum, residual, contact insecticides has hampered the beneficial work of these parasites, leading to fresh pest outbreaks (Wood, 1968). Our knowledge of the parasites of these bagworms was more or less confined to Indonesia and W. Malaysia. With the introduction and rapid extension of oil palm cultivation in E. Malaysia bagworms have become serious since 1966. Their indigenous parasites and other natural enemies were investigated in Sabah by the authors during 1969 and 1970 with a view to the introduc-

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tion of additional species from other areas as suggested by Simmonds (1967). A search for promising bagworm parasites has been taken up by the C.I.B.C. W. Indian Station in Trinidad.

This paper deals with the natural enemies of oil palm bagworms recorded in Sabah during 1969 and 1970. The same or other species of bagworms were collected on various other economic plants in order to rear out parasites, if any, to ascertain the host-range and host-plant associations of the species concerned.

PARASITES AND PREDATORS OF OIL PALM BAGWORMS

No egg-parasite of any species of bagworm has so far been obtained in Sabah. It seems unlikely that these would occur because the eggs remain well protected within the mother's hardened pupal skin, which itself is enclosed in a bag.

Several species of larval and pupal parasites obtained are listed under their hosts.

Mahasena corbetti Tams

Several species of larval parasites were reared from this bagworm but with most levels of parasitism were low. A Tachinid larval parasite, *Eozenillia equatorialis* Townsend, and an Ichneumonid, *Echthromorpha agrestoria* Swed., which emerged from the pupal cases, were by far the most important species recorded but appeared to be incapable of building up their populations to bring about any substantial reduction of the pest in an outbreak.

HYMENOPTERA

Braconidae

Apanteles sp.: Cocoons of this solitary parasite were found in 4 of 45 small larval bags collected at Sg. Manila near Sandakan in September 1969. In January 1970 a single parasite emerged from one bag in a lot of 469 young larvae collected at Mostyn Estate. There has been no previous record of any *Apanteles* sp. parasitising *M. corbetti*.

Aulosaphes sp.: Twelve cocoons of an *Aulosaphes* sp. were obtained from a larval bag in a lot of 47 specimens collected at Giram Estate in June 1969. Many of these cocoons were empty or had imperfectly developed adults. In November a single adult emerged from a bag and a group of 6 cocoons was found in another bag collected at the same estate. This species is different from *Aulosaphes psychidivorus* Muesebeck, which is a common parasite of several genera of Psychids in Sabah.

Ichneumonidae

Echthromorpha agrestoria Swed.: In December 1969 this large Ichneumonid was reared for the first time from female pupal cases of *M. corbetti* collected at Mostyn Estate. In one field 11 specimens in a collection of 95 were found parasitised. The parasite adults emerged from the hardened pupal skins of the hosts. In unparasitised individuals such pupal skins contain female moths. Therefore, it seems that parasitism actually occurs in the late larval or pupal stage but the parasite completes its development only after the host reaches the imaginal stage but is still enclosed in the pupal skin. The hardened pupal skin of the host is lined internally by a thin, parchment-like membrane.

Xanthopimpla sp.: A single specimen was reared from a female pupal case of *M.*

corbetti in a lot of 71 bags collected at Giram Estate in August 1969. A pupa of the same parasite was found in another specimen which was dissected in the field. This is also a new record of an Ichneumonid from *M. corbetti*.

Eulophidae

Pediobius sp.: A single specimen was obtained from a larval bag among 404 specimens of various stages of *M. corbetti* collected at Mostyn Estate in April 1969. The Commonwealth Institute of Entomology, London, has retained the specimen, commenting that this is a peculiar species, not represented in the British Museum collection.

Sympiesis sp.: Eighteen parasites emerged from three larval bags of *M. corbetti* collected at Giram Estate in November 1969. On opening the bags, empty pupal skins of the parasite were found in them. Species of *Sympiesis* are generally parasitic on coleopterous, dipterous and lepidopterous leafminers. The only other record of a *Sympiesis* sp. parasitising a Psychid (*Cryptothelea crameri* West.) is from Ceylon (Thompson, 1954).

DIPTERA

Tachinidae

Eozenillia equatorialis Townsend: This was the only important dipterous parasite of *M. corbetti* in Sabah. It was frequently reared from fully grown larvae collected in all the plantations visited in eastern Sabah but was scarce in the Beaufort area on the west coast. Rarely two or three parasites but generally only one emerged per host. In two instances, final stage larvae of this Tachinid passed through a pupal period of 9 and 11 days, respectively. In the laboratory, adult parasites fed on dilute honey lived for a maximum of 5 days. Puparia have been found in larval bags collected almost throughout the year. However, parasitism never increased along with the host's population when outbreaks occurred at Mostyn Estate. This Tachinid appears to exercise some measure of control of *Mahasena* only when the bagworm population remains at low levels on oil palms and other alternative host plants. At the time of an outbreak at Mostyn Estate in November and December 1969 parasitism was hardly 1-2%. In the same estate, *E. equatorialis* and another Tachinid, *Palexorista solennis* (Walker), together accounted for only 12.6% parasitism in a collection of 400 bags in April 1969 although the bagworm population here had increased earlier during an outbreak. In the Lormalong Scheme, 200 bags were collected in the same month, out of which only 7 had parasite puparia.

In April 1970 up to 55 percent parasitism of *Mahasena corbetti* on *Albizzia* sp. was recorded in areas around Kota Kinabalu, and at Pamol Estate 80% of the bagworms in a small sample was found parasitised by *E. equatorialis* in September. In both areas the bagworm population was low. Some specimens of *E. equatorialis* in the insect collection of the Agricultural Research Center, Tuaran, were earlier determined as *Exorista psychidarum* Bar. Several specimens reared from *M. corbetti* by the authors and submitted to the Commonwealth Institute of Entomology, London, were identified as *Eozenillia equatorialis* Towns. *E. equatorialis* and *E. psychidarum* are very closely allied but distinct species and have been confused in the past. The true *E. psychidarum*, of which the holotype is in the British Museum, has the eyes completely bare, and *E. equatorialis* has the eyes densely haired. There are also differences in the male genitalia (R. W. Crosskey, pers. com.).

Exorista (= *Zenillia*) *quadrifaculata* Bar. is a parasite of *Cryptothelea variegata* Sn. in India and Malaya (Thompson, 1945), *M. corbeti* in Malaya and Thailand (Thompson, 1946a; Meksongsee, 1963) and unidentified Psychids in Ceylon, India, Malaya and Sumatra (Thompson, 1946b). Crosskey (1967a) has synonymised this species with *Nealsomyia rufella* (Bezzi).

Eozenillia? equatorialis Towns.: A single specimen of this doubtful species was reared from a larval bag collected at B. A. L. Estates in June 1969.

Palexorista solennis (Walker): This was obtained in small numbers from larval bags of *M. corbeti* collected at Mostyn and Giram Estates on several occasions in both years. The puparium can be easily distinguished from that of *E. equatorialis* by its hairy surface, brown color, more or less parallel sides and by the very prominent posterior spiracles, which have three raised slits, resembling a group of three mussels. The puparium of *E. equatorialis* is dark brown with a smooth and shining surface, and with an asymmetrical swelling on one side. *P. solennis* is the commonest Oriental species of *Palexorista*, distributed from India through the Far East and New Guinea to Samoa and is polyphagous, parasitising several Lepidoptera (Crosskey, 1966; 1967a and b). The species has been recorded from the toon shoot-borer *Hypsipyla robusta* Moore in India (CIBC, unpublished record).

Sarcophagidae

Sarcophaga sp.: A *Sarcophaga* sp. was occasionally obtained from larval bags collected at Mostyn and Giram Estates.

Sarcophaga antilope Boettch. and *S. peregrina* R.-D. have been recorded as parasites of *M. corbeti* in Malaya (Thompson, 1946a).

HYPERPARASITES

Three species of hyperparasites, *Brachymeria* sp. (not in British Museum), *B. deesensis* Cam. and *B. lugubris* Walk. were reared from the puparia of *E. equatorialis*. These emerged by cutting circular holes in the puparia while the Tachinids from unparasitised puparia emerged by splitting open their anterior ends. Nine of 25 puparia (36%) obtained from *Mahasena* bags at Ranau in November 1969 were found to have been attacked by *Brachymeria*.

In Indonesia, *B. lugubris* is a secondary parasite of the coconut leaf-moth *Artona ca-tloxantha* Hmps. through the Tachinid *Ptychomyia remota* Aldr. (van der Vecht, 1950).

PARASITES OF UNCERTAIN STATUS

Apanteles angaleti Muesebeck: A single specimen of *A. angaleti* emerged in a laboratory cage with 47 larvae of *M. corbeti* collected at Giram Estate in June 1969. At that time the host relationship of *Apanteles* with *M. corbeti* was uncertain. Since another *Apanteles* sp. was later found to be parasitic on young larvae of *M. corbeti*, *A. angaleti* may also prove to be a primary parasite of this bagworm. Nixon (1965) mentions *Sylepta derogata* F. and *Pectinophora gossypiella* Saunders as hosts, and Pakistan, India and Sumatra as the distribution of *A. angaleti*. Like *M. corbeti* these two hosts also live in protected situations.

Anastatoidea brachartoniae Gahan: A single specimen of this Eupelmid emerged in a

laboratory cage with 24 larvae of *M. corbetti* collected at Sg. Manila in June 1969. *A. brachartoniae* has been recorded as a parasite of *Psyche vitrea* Hmps. in Ceylon (King, 1933). In Indonesia it occasionally attacks the prepupae and pupae of *Artona catoxantha* but is more often a hyperparasite of the Tachinids *Ptychomyia remota* and *Cadurcia leefmansi* Bar. and of *Apanteles artonae* Rohw. and *Goryphus* spp. (van der Vecht, 1950).

PREDATORS

In a larval bag of *M. corbetti* collected at Mostyn Estate in August 1969 a freshly emerged adult and a larva (in a cocoon) of a predator, *Callimerus bellus* Gorb. (Coleoptera, Cleridae), were found. The presence of a second, empty, cocoon within the same bag indicated that the adult beetle might have emerged from it. *Callimerus arcufer* Chpm. is a predator of bagworms in West Malaysia (Wood, 1968). It has also been recorded feeding on *Artona catoxantha* and on the parasite *Ptychomyia remota* in Malaya (Corbett and Miller, 1933). There is no record of *C. arcufer* from Sabah.

Once an unidentified Chrysophid larva was found within a bag collected at Sg. Manila. This carried on its back small bits of dried, oil palm leaves, apparently derived from the *Mahasena* bag, and is suspected to be a predator of the bagworm. In the laboratory it attacked the small larvae of *M. corbetti* and pupated but did not complete its development.

OTHER INSECTS FOUND ASSOCIATED WITH *M. CORBETTI*

On several occasions maggots of a phorid fly, *Megaselia* sp., were found feeding on dead larvae of *M. corbetti* at B.A.L. and Giram Estates. These were probably saprophytic. Two adults of the Hemerobiid *Micromus timidus* Hagen emerged in a cage with larvae of *M. corbetti* collected at Giram Estate. A full-grown nymph of an Aso-pine predator, *Caniheconidea* sp., was collected on an oil palm infested by *M. corbetti* and the nettle grub *Setora nitens* Walk. at Giram Estate. It fed on a larva of *S. nitens* in the laboratory and developed into an adult. The bug later attacked the larvae of *M. corbetti* and *C. pendula* which were provided for it. It fed on a larva of *M. corbetti* continuously for about 5 hours until the prey was sucked dry.

Specimens of a bagworm species collected on oil palms were much smaller than and different in appearance from those of *M. corbetti*. They lacked the large pieces of oil palm leaves characteristic of the bags of *M. corbetti*. However, a single male moth which emerged from one of such bags collected at B.A.L. Estates, Tawau, was identified by the C.I.E. as *Mahasena corbetti*. Since *M. corbetti* has been reported to feed on other alternative host plants it seems likely that these unusual specimens had actually fed on some other (possibly wild) plants in the oil palm fields and then migrated to the palms. It would be interesting to obtain a series of specimens of male moths from such bags and compare them with *M. corbetti* to confirm their identification. The three species of hymenopterous parasites and a Tachinid obtained from larvae of this species are listed:

HYMENOPTERA

Braconidae

A. psychidivorus: Empty and inhabited cocoons of this parasite were obtained from larval bags collected at Beaufort in April, May and July, at B.A.L. Estates and at Merotai in May and at Pamol Estate in June 1969. Parasitism was 17 % in a collection of 155 bags from Beaufort in May. In July 6 larvae in a small sample of 18 received from the same area were parasitised. Twelve females and 2 males of *A. psychidivorus* emerged from one of the bags and these adults fed on dilute honey lived up to 6 days in the laboratory.

It is note-worthy that *A. psychidivorus* has not been obtained from the larval bags of *M. corbetti* which were covered by pieces of oil palm leaves as described earlier.

Ichneumonidae

Paraphylax sp.: A single specimen emerged from a larva in a collection of 42 bags from B.A.L. Estate. The Commonwealth Institute of Entomology has commented that this was "assuredly secondary."

Eulophidae

Pediobius lividiscutum (Gahan): Two specimens were obtained from larvae collected at Beaufort. According to the C.I.E. this species has been reared from *Artona catoxantha* in the Malay Peninsula in 1924 and 1934 and the specimens were then misdetermined as *P. detrimentosus* Gahan in 1940, under the generic name *Pleurotropis*.

DIPTERA

Tachinidae

Eozenillia? equatorialis Townsend: A single specimen emerged from a larva collected at B.A.L. Estate in May 1969.

Metisa plana Walker

The following parasites were recorded:

HYMENOPTERA

Braconidae

Apanteles metesae Nixon: This was the only important parasite obtained during the period. In April 1969 a sample of 260 *M. plana* was collected at Mostyn Estate. About 4 % of the bags contained *Apanteles* cocoons, most of which were empty. When the area was visited in August, the *Metisa* larval population had greatly increased during the next generation. The numbers of specimens collected in four fields and the percentages of parasitism (in brackets) were 168(25), 307 (18.6), 73 (71) and 110 (60), respectively. In September 13 larvae of 31 from B.A.L. Estate were parasitised. On a third visit to Mostyn Estate in November 18 larval bags of 73 from a different field contained cocoons of *A. metesae*. At Papar parasitism by *A. metesae* was 66 % in June 1970.

Eupelmidae

Eupelmus catoxanthae Ferriere: This was reared from male pupae of *M. plana* but parasitism was negligible. *E. catoxanthae* has been recorded from the Limacodid *Parasa lepida* (Cram.) in Malaya (Lever, 1964).

DIPTERA

Tachinidae

Eozenillia psychidarum Bar. : In May and July 1969 puparia of this Tachinid were found in a few larval bags of *M. plana* collected at B.A.L. Estate. In June a puparium was found in a pupal cocoon of *M. plana*. Most of these puparia were empty or aborted. A parasite which did emerge was identified as *E. psychidarum*, which has been recorded from an unidentified Psychid in Sumatra (Thompson, 1946b). This is the first record of a Tachinid parasitising *M. plana*.

HYPERPARASITES

Three species of hyperparasites, *E. catoxanthae*, *Pediobius lividiscutum* and *Brachymeria* sp., were reared from cocoons of *A. metesae* collected at Mostyn Estate. Some 50 *Apanteles* cocoons which were isolated from *Metisa* bags in August 1969 were kept under observation in the laboratory. Since they failed to produce any emergents they were dissected in November. They contained dead larvae and pupae and imperfect adults of *Apanteles* and of the first two species of hyperparasites.

According to van der Vecht (1950) *E. catoxanthae* has been reared from pupae of *Artona catoxantha*, puparia of *Ptychomyia remota* and *Cadurcia leefmansii* and from pupae of *Apanteles artonae* in Indonesia.

In April 1970 about 80 % of the *Apanteles* cocoons obtained at B.A.L. Estates were found to be attacked by the three hyperparasites.

A *Brachymeria* sp. was obtained, on one occasion, from a puparium of *E. psychidarum* in a bag of *M. plana*.

***Cremastopsyche pendula* Joannis**

This bagworm infests oil palms as well as *Albizzia* sp. and *Delonix regia*.

PARASITES

Two Braconids, *A. psychidivorus*, and *A. metesae*, were obtained from larval bags of *C. pendula*. The former occurred both as a solitary and as a gregarious parasite (up to 4 cocoons per host were seen) while *A. metesae* was invariably a solitary species, its cocoon occupying the whole bag of the host larva. With both, the parasitised hosts were always young and medium-sized larvae.

In May 1969 parasitism by *A. psychidivorus* was 12 % and that by *A. metesae* 2 % in a lot of 650 bags collected at Pamol Estate. At Papar *Apanteles* had parasitised 16 % of the bagworms on oil palms and 4 % on *D. regia* in June 1970. *A. psychidivorus* has been reared from *C. pendula* at Tuaran, while *A. metesae* has been reared from the same bagworm collected at Beaufort, B.A.L. Estates and Merotai. According to Nixon (1967) *A. metesae* has been recorded from Vietnam "ex. *C. pendula*?"

E. catoxanthae and *Paraphylax rufipes* Cam. (Ichneumonidae) were reared from *C. pendula* on *D. regia* at Papar. These together with *Apanteles* were obtained from 33.5 % of the bagworms on oil palms in the same area in May 1970. It is possible that these two species are secondary parasites.

PREDATOR

In June 1969 a female of a *Sycanus* sp. was found on an oil palm heavily infested by *C. pendula* at Pamol Estate. It readily attacked the larvae of *C. pendula* (but not those of *M. corbetti*) in the laboratory and lived for 12 days. Stationary bags of *C. pendula* (those containing moulting larvae and pupae which were immobile) were ignored by the predator and only moving larvae were attacked. A cluster of 48 eggs was laid by the bug on the lid of plastic rearing cage. Forty-one eggs hatched after 20 days. The tiny nymphs fed on freshly hatched larvae of another bagworm (? *Pteroma* sp.) but not on full-grown larvae of *C. pendula* which were offered to them in glass tubes.

Two Scelionid parasites, *Gryon* sp. and *Telenomus* sp., emerged from two clusters of eggs closely resembling those of *Sycanus* collected on oil palm leaves at Mostyn and Giram Estates, respectively.

***Clania tertia* Templ.**

An Ichneumonid larval parasite, *Xanthopimpla pedator* Fabr. and the Braconid *A. psychidivorus* were obtained from this bagworm in small numbers, the former only from material collected at Beaufort and the latter from other plantations as well. On one occasion a single specimen of a *Xanthopimpla* sp. (which appears to be different from *pedator*) emerged from a larva collected at Beaufort. This is similar to the species listed under *M. corbetti*.

This bagworm species was found on guava at Tuaran, where *E. equatorialis* and a *Brachymeria* sp. were reared from 19 % of the larvae collected in July 1970.

X. pedator is a solitary parasite. Parasitised larvae become dark in colour, their skin shrinking and gradually drying up from the hind end. Parasitism was about 6 % in two samples of 124 and 67 bags collected in May and September 1969 respectively, and nearly 11 % in another of 55 specimens collected in November. The adults emerged by severing the head capsules of the host larvae, which remained adhering to the hosts' bodies inside their bags.

A. psychidivorus also attacks *C. tertia* infesting other host plants. In July 1969 a total of 142 individuals emerged from a single bag collected on a coffee plant at Tuaran.

E. equatorialis was reared from *C. tertia*. In June 1970 parasitism was 41 % on oil palms at Papar and 11 % at Beaufort.

***Cryptothelea cardiophaga* Westw.**

This bagworm was very common on oil palms in most of the localities surveyed. It also infested various other host plants, such as citrus, coffee, cocoa, guava, mango, pepper, an unidentified ornamental palm, *Annona muricata*, *Araucaria cunninghamii*, *Cassia* sp., *Grevillea* sp., *Hibiscus* sp., *Lagerstroemia indica*, *Nephelium lappaceum*, *Peltophorum pterocarpum*, *Samanea saman* and *Thuja orientalis*.

A. psychidivorus, *Sericopimpla flavobalteata* Cam. and *P. rufipes* (most probably secondary) were reared from *C. cardiophaga* collected on oil palms. Parasitism by the last two species was 30.5 % at B.A.L. Estates in August 1970.

? *Pteroma* sp.

Larvae of this species collected on oil palms at Tuaran were found parasitised by a Bethyloid, *Parasierola* (= *Perisierola*) sp. and a *Brachymeria* sp. The former is gregarious; up to 7 parasites per host have been recorded. It has also been reared from larvae collected at Beaufort, Pamol and Sabah Palm Estates. Parasitism was 14% in a collection of 166 bags taken at the last two estates in June 1969. On one occasion *Pediobius lividiscutum* was reared from this bagworm at Tuaran.

Stephens (1962) has recorded a *Perisierola* sp. attacking small larvae of *Oiketicus kirbyi* Guild. in Costa Rica.

A Tachinid puparium was obtained once from a bag collected at Tuaran in May but this actually harboured a *Brachymeria* sp.

UNIDENTIFIED BAGWORM

E. equatorialis and a *Palexorista* sp. were reared from two specimens of this species collected on oil palms at Ulu Dusun and B.A.L. Estate in May and June 1969 respectively.

PARASITES OF BAGWORMS COLLECTED ON OTHER HOST PLANTS

C. tertia

On *Annona muricata*: *A. psychidivorus*; on coffee: *A. psychidivorus* and *Paraphylax* (= *Aphadnus*) *rufipes* (Hym., Ichn.), all from Tuaran. *P. rufipes* appears to be a secondary parasite.

C. cardiophaga

On citrus: *Sericopimpla flavobalteata*, *Goryphus* sp. and *Paraphylax* sp. Once, a *Brachymeria* sp. emerged in a cage with this bagworm. On cocoa and coffee: *P. rufipes* (most probably secondary), all from Tuaran.

? *Pteroma* sp.

On paddy: *Parasierola* sp.; on coffee: *Goryphus* sp., both from Tuaran.

? *Acanthopsyche* sp.

On tea: *Paraphylax* sp., Kundasang.

Eumeta sp.

On cocoa: *Fislistina* sp., Tuaran

? *Eurukuttarus* sp.

On cocoa: *Pediobius lividiscutum*, Tuaran.

Unidentified bagworms

On *Acacia auriculiformis*: *Eupelmus catoxanthae* and *Brachymeria* sp., B.A.L. Estates.

On cashew-nut tree: *A. psychidivorus*, Tuaran.

On guava: *A. psychidivorus*, Tuaran.

PATHOGENS ASSOCIATED WITH OIL
PALM BAGWORMS

In March 1969 about 120 bags of *M. corbeti* were collected at Sg. Manila. The majority of these contained dead larvae. Since these were suspected of having died of some disease, specimens preserved in distilled water and Dubosq Brasil Bouin's fluid were sent to the Insect Pathology Unit, Oxford. The preliminary diagnosis made by IPU indicated that there was no evidence of any virus infection but that there were many microorganisms in the specimens.

In April specimens of *M. plana* collected at Mostyn Estate developed a fungal infection and died in the laboratory at Tuaran. Some specimens of *C. pendula* collected at B.A.L. Estate also showed the same fungus. In June several specimens of *C. pendula* were found to be attacked by this fungus at Pamol and Sabah Palm Estates near Sandakan. Laboratory colonies of two other bagworm species, *C. tertia* and *C. cardiophaga*, originating from the Klias Scheme at Beaufort and B.A.L. Estates, respectively, showed symptoms of the fungal disease and eventually died. Specimens of the three last species were sent to Dr. E. Müller-Kögler, Institut für Biologische Schädlingsbekämpfung, Darmstadt, Germany. He placed the infected larvae in moist chambers, allowed the fungus to develop and then successfully isolated it and built up a culture. It was reported to grow well on malt extract (2-3%), peptone (0.5%), agar (2-3%). The fungus was identified by him to be a *Paecilomyces* sp. Later, Dr Agnes H. S. Onions, Commonwealth Mycological Institute, Kew, examined the fungus and identified it specifically as *Paecilomyces fumoso-roseus* (Wize) Brown and Smith. A culture of this fungus is kept at Kew under the designation "IMI 143085" (E. Müller-Kögler, personal communication).

P. fumoso-roseus was originally found by Wize on larvae of *Cleonus punctiventris* Germ. in the Ukraine and its other known insect hosts include *Hylemyia floralis* Fall., *H. brassicae* Bch. and *Melolontha melolontha* L. This fungus is of widespread occurrence, chiefly as a parasite of insects but also capable of growing on other substrata. *Isaria fumoso-rosea* Wize and *Spicaria fumoso-rosea* (Wize) Vassiljevski are synonyms of *P. fumoso-roseus* (Wize) Brown and Smith (Brown and Smith, 1957). The fungus appears to exist in different strains.

Investigations by Sekiguchi (1959) in Japan have shown that *P. fumoso-roseus* is suitable for use in the biological control of the peach fruit moth *Carposina sasakii* Mats. (*niponensis* Wlsm.)

In November a large number of dead larvae and also some dead pupae of *M. corbeti* were examined at Mostyn Estate. Some of them had a blackened skin and showed signs of liquefying internally, emitting a foul smell. These were sent to the Insect Pathology Unit which later reported in its preliminary diagnosis that the specimens showed a "possible non-occluded virus." At the time of collection the bags had become very wet owing to heavy rains in the Tawau area.

In laboratory cages young larvae of *M. corbeti* started making their bags with small pieces of dried oil palm leaves from their mother's bag. Most of the larvae which used the green leaves for bag construction were attacked by a fungus, *Aspergillus* sp.

DISCUSSION

The present investigations have shown the existence of several natural enemies of bagworms infesting oil palms and certain other economic plants in Sabah. However, the native parasites of the three major oil palm bagworm species, *M. corbeti*, *M. plana* and *C. pendula*, are not able to prevent the serious outbreaks of these three pests which have occurred since 1966 following a rapid increase in the area under oil palms. While *Apanteles metesae* parasitises a high percentage of the larvae of *M. plana* in some fields it is attacked by at least two important species of hyperparasites which reduce its efficiency.

There is a striking similarity between the natural enemy complexes associated with these bagworms in West Malaysia and East Malaysia. Although the two areas are separated by a vast stretch of the South China Sea most of the oil palm pests and their natural enemies are common to them. This is because the insect pests of oil palms in the entire Malay Archipelago are all native species which already existed on other palms and several other alternative food-plants prior to the introduction of the oil palm. They have gradually transferred to oil palms over the last three decades or so. The bagworms have also attracted to their new host plant (oil palm) a number of their own parasites and predators.

A. metesae is the commonest parasite of *M. plana* on oil palms in West Malaysia. Other, less important parasites include: *Brachymeria* sp., *Elasmus* sp. nr. *hutsoni* Ferr., *Eupelmus catoxanthae*, *Fislistina* sp., *Goryphus inferus* Szep., *Lienella varius* Walk., *Pediobius anomalus* Gah., *P. detrimentosus* Gah. and *Syntomosphyrum zygaenarum* var. *nigricoxis* Ferr. Parasites of *C. pendula* include: *Apanteles* sp. nr. *hasorae* Wilk., *Aulosaphes psychidivorus*, *Brachymeria* sp., *E. catoxanthae*, *Eurytoma* sp., *Goryphus* sp. nr. *inferus* Szep., *G.* sp. ? *varibalteatus* Cam., Genus near *Paraphylax*, *Paraphylax rufipes*, *P. anomalus*, *P. detrimentosus* and *Tetrastichus* sp. (Wood, 1966 and 1968; C.I.B.C. unpublished records). In January 1962 Rao (1962) recorded 14% parasitism of *C. pendula* by *Apanteles* sp. (later identified as *metesae* by Nixon) at Layang Layang, Johore.

In West Malaysia, *M. corbeti* is parasitised by *Brachymeria euploae* Westw., *Sarcophaga antilope*, *S. peregrina*, *Palexorista inconspicuides* (Bar.) (= *Sturmia inconspicuides* Bar.), *Thrycolyga aberrans* Strobl., *T. psychidarum* Bar., *T. sorbillans* Wied. and *Nealomyia rufella* (Bezzi) (= *Zenillia quadrimaculata* Bar.) (Thompson, 1946a). There is no information as to the extent to which these parasites are responsible for keeping the bagworms under natural control.

Tricholyga (= *Thrycolyga*) *psychidarum* Bar. is now treated as a synonym of *Eozenillia psychidarum* (Bar.) (Crosskey, 1967a) which occurs in Sabah. In addition, a *Sarcophaga* sp. and the Tachinids *E. equatorialis* and *P. solennis* occur here. Three *Brachymeria* spp. are hyperparasitic on *Eozenillia* and limit the capacity of this Tachinid to increase its population. *B. euploae* in West Malaysia may also behave as a secondary parasite. Although this species has not been bred from *M. corbeti* it has been recorded from *Erionota thrax* L. in Sabah. Therefore, none of the parasites of *M. corbeti* known at present from West Malaysia is considered suitable for introduction here.

A. metesae is an important parasite of *M. plana* in both Sabah and West Malaysia. Similarly, both *A. metesae* and *A. psychidivorus* attack *C. pendula* in the two areas. Many of the other West Malaysian parasites of these two bagworms are known to occur as

hyperparasites, not only of these bagworms but also of other lepidopterous pests. These are: *Brachymeria* sp., *E. albotibialis*, *E. catoxanthae*, *G. inferus*, *G. varibalteatus*, *P. rufipes*, *P. detrimentosus* and *S. zygaenarum*. It would, therefore, be undesirable to introduce them into Sabah even if some of them definitely do not occur here. *E. catoxanthae* and *P. rufipes* have been recorded from Sabah during the present study. Further work may show that the other species are also present here.

The Reduviid predator *S. dichotomus* and the Clerid *C. arcufer* are important general predators of bagworms in West Malaysia. Eggs of *C. arcufer* are parasitised by a Myrmid, *Cleruchus* sp. (Wood, 1966). *S. dichotomus* is already present in Sabah, according to information obtained from the Commonwealth Institute of Entomology, London. It was not seen in any of the plantations surveyed. However, another *Sycanus* sp. attacks *C. pendula*. Two egg-parasites of Reduviids *Gryon* sp. and *Telenomus* sp., occur in Sabah and these and possibly other parasites appear to be, at least partly, responsible for the scarcity of Reduviids in the oil palm plantations here. *Sycanus* spp. are indiscriminate feeders, attacking parasitised as well as healthy larvae (Vayssièrè, 1958). The Clerid predator *C. arcufer* is known to attack the Tachinid *Ptychomyia remota* in West Malaysia (Corbett and Miller, 1933). Its introduction into Sabah is not recommended since it may attack the Tachinid parasites of *M. corbeti*.

Since *M. corbeti*, *M. plana* and *C. pendula* are not known to occur outside the South-east Asian region any additional parasites which are specific to them and intended for introduction into Sabah have to come from other areas in this region. However, a comparison of the known natural enemies of these bagworms in different parts of the Malay Archipelago reveals a more or less common complex. Therefore, it would be desirable to screen the parasites of other bagworms elsewhere in the world, choosing the species, as far as possible, from areas where the climate is predominantly tropical and comparable to that of Sabah.

Since there are a very large number of hymenopterous and some dipterous parasites of *Oiketicus* spp. in South America (Thompson, 1946b and C.I.B.C. card files) it will be worthwhile testing the more readily available species on *M. corbeti*, *M. plana* and *C. pendula*. The hymenopterous parasites should receive prior attention since no effective hymenopterous larval parasites of *M. corbeti* are known from Sabah. Parasites of the ever-green bagworm *Thyridopteryx ephemeraeformis* (Haw.) in the U. S. A. might also be tested. Since *Oiketicus* spp. and *T. ephemeraeformis* are polyphagous the possibilities of some of their parasites exhibiting a "host-plant relationship" have to be borne in mind. In this connection it may be noted that many of the native parasites of *M. corbeti*, *M. plana* and *C. pendula* are themselves polyphagous, attacking other bagworms and various unrelated Lepidoptera. For example, *Sarcophaga antilope* and *Eupelmus catoxanthae* attack *Parasa lepida* (Cram.) in Malaysia (Lever, 1964). *Goryphus varibalteatus* Cam. attacks the nettle-grub *Natada nararia* Moore in Ceylon (Austin 1932) and *G. inferus* Szép. is a common parasite of *Artona catoxantha* in Java (van der Vecht, 1950). *Sarcophaga peregrina* R.-D. is a larval parasite of *Dendrolimus punctatus* Walk. in China (Sun and Liu, 1958). *S. peregrina* and *Exorista sorbillans* have been recorded from *Mocis frugalis* F. in Australia (Mungomery, 1947). *E. sorbillans* parasitises the bagworm *Deborrea malagassa* Heyl. in Malagasy (Brenière and Dubois, 1965). *Echthromorpha agrestoria* attacks *Clania* sp., *Cryptothelea minuscula* Btlr., *Hyblaea puera* Cramer and *D. punctatus* (Townes, Townes and Gupta, 1961).

Most of the hymenopterous parasites of *Oiketicus* spp. in South America have no other known hosts. These parasites include *Apanteles oeceticola* Blanch., *Balcarcia brethesi* Blanch., *Cryptus borsani* Blanch., *Cryptopteryx oeceticola* Blanch., *Iphiaulax* spp., *Pimpla (Itoplectis) psychidophagus* Blanch. and *Psychidosmicra* spp. *Pimpla tomyris* Blanch. is polyphagous, *Pimpla (Itoplectis) oeceticola* (Brethes) has been recorded from the pine shoot borer *Rhyacionia (Evetria) buoliana* (Schiff.) in Uruguay (Millan & De Santis, 1958). *Spilochalcis* spp. and *Tetrastichus pseudoeceticola* Blanch. are known to be hyperparasites though they may also be primary. Only those species that are entirely primary should be tested on the oil palm bagworms.

Oiketicus kirbyi Guild. is a minor pest of cacao in Trinidad (Kirkpatrick, 1953). Work at the C.I.B.C. West Indian Station during 1970 has already shown that eight species of parasites and a nuclear polyhedrosis virus disease of bagworms occur in Trinidad (Cruttwell, 1970).

Many of the hymenopterous primary parasites of the evergreen bagworm *T. ephemeriformis* in the U. S. A. are also polyphagous. In a study conducted in October 1960 the polyphagous *Itoplectis conquisitor* (Say) was found to be the most important parasite of the ever-green bagworm. Dipterous parasites were only of minor importance (Kulman, 1965). However more recent work by Prof. Kulman has led him to suspect that *I. conquisitor* may be a hyperparasite more often than is indicated in the literature (H. M. Kulman, pers. com.). Therefore, it would not be desirable to introduce it into Malaysia. Work on another Ichneumonid, *Sericopimpla sericata* (Kchrb.), in South Africa has shown that the initial attraction of the parasite to its bagworm host *Kotochalia junodi* (Heyl.) seems to be the bag rather than the host larva. The adults, particularly the females, are not restricted to wattle trees or other *Acacia* spp. on which the hosts occur (Smithers, 1956). It is worth investigating whether *S. sericata* would parasitise the bagworms on oil palms.

The size of the host larva (enclosed in the bag, which itself varies in size and structure according to the food-plant) is a critical factor in host selection with some of the bagworm parasites. *A. metesae* parasitises only the young larvae of *M. plana*. According to Stephens (1962), *Iphiaulax* sp. attacks all sizes of larvae of *O. kirbyi* while *Psychidosmicra* sp. attacks only small larvae. *Sarcophaga (Sarcodexia) lambens* Wied. and *Achaetoneura* sp. attack medium and large larvae. Griot and Icart (1947) have studied the bionomics of *Psychidosmicra brethesi* Blanch., *P. brasiliensis* (Brethes) and *P. australis* Blanch. These parasites do not attack larvae in bags which are larger than 1 cm. These and possibly other parasites of *Oiketicus* which prefer the young larval stages of the host may prove useful against the early stages of *M. corbetti*, *M. plana* and *C. pendula* in Sabah. In central Argentina *P. brasiliensis* has been reported to give as much as 80 % parasitism of the larvae of *O. kirbyi* in some places (Griot and Icart, 1947).

Miller (1970) has stated that many species of the Eulophid *Sympiesis* are "niche-specific" and that any trends in their habits towards host-specificity are attributable to the fact that only certain species of insects occupy the niches sought by the parasites. *S. stigmata* Girault seeks a niche usually occupied by lepidopterous case-bearing insects. A similar habit may account for the occurrence of a *Sympiesis* sp. as a parasite of *M. corbetti* in Sabah.

Mahasena theivora (Dudg.) and *Metisa plana* are minor pests of tea in north-east India (Das, 1956). Their natural enemies, if any, have not been investigated. *Mahasena graminivora* Hmps. is an unimportant pest of paddy in north-east India. A *Paraphylax* sp. and a *Lienella* sp. have been reared from this bagworm.

M. corbetti, *C. pendula*, *C. terita* and *Pteroma* spp. have been recorded from New Guinea. As suggested by Simmonds (1971) a survey for parasites of these and other bagworms in this area will be of value both to Malaysia and to New Guinea.

The entomogenous fungus *I. psychidae* and the virus (*Borrelinavirus kotochaliae* Ossofski) attacking the wattle bagworm in South Africa are also worth testing for their host specificity. If they prove to be pathogenic to *M. corbetti*, *M. plana* and *C. pendula* (or to any of these species) they could be introduced into both East and West Malaysia.

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