

***Cotesia erionotae* (Wilkinson) (Hymenoptera: Braconidae), for
Biological Control of Banana Skipper, *Erionota thrax* (L.)
(Lepidoptera: Hesperiiidae) in Papua New Guinea**

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Abstract—The banana skipper, *Erionota thrax*, a pest of Southeast Asian origin, became established in Papua New Guinea (PNG) in 1983. It subsequently defoliated banana plants throughout most of mainland PNG and, by 1991, had spread to New Britain. The larval parasitoid, *Cotesia* (= *Apanteles*) *erionotae*, was introduced from Guam into quarantine in PNG, where host specificity tests were conducted by exposing larvae of four species of indigenous Lepidoptera (3 Papilionidae, 1 Hesperiiidae) to adult *C. erionotae*. The behavioural response of gravid female parasitoids and the failure of parasitoids to develop in the these Lepidoptera indicated that, if *C. erionotae* was released, it would not attack any of the species other than *E. thrax*. *C. erionotae* was subsequently released in five mainland Provinces between March and October 1990 and on New Britain between June and October 1991. The parasitoid has since become established in the Central, Western, Morobe and West New Britain Provinces, attacking up to 67% of larvae of *E. thrax*. At all sites where *C. erionotae* has become established, populations of *E. thrax* have declined. Five species of parasitoid have been recorded from eggs of *E. thrax* in PNG. Prospects for biological control of *E. thrax* by *C. erionotae* in PNG appear to be promising.

Introduction

The history of spread into the Pacific by the banana skipper, *Erionota thrax* (L.) from Southeast Asia, was discussed by Waterhouse & Norris (1989). Where abundant and without natural enemies, the larvae of *E. thrax* defoliate banana

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plants by feeding and by constructing leaf rolls in which the larvae shelter (Ostmark 1974). After this pest had become established in Guam, Mauritius and Hawaii, biological control was achieved by introducing from Thailand an egg parasitoid, *Ooencyrtus erionotae* Ferriere and a larval parasitoid, *Cotesia* (= *Apanteles*) *erionotae* Wilkinson (Waterhouse & Norris 1989).

E. thrax was first recorded in Papua New Guinea in 1983 and by 1987, it had spread to the northwestern Provinces where larvae caused serious damage to banana plants (Arura 1987). By 1989, the pest had spread throughout most of mainland Papua New Guinea. As a preliminary to a biological control program for *E. thrax* in Papua New Guinea, the damage caused by its larvae, their abundance, host plants, distribution and indigenous natural enemies were studied. Three parasitoids, *Ooencyrtus erionotae* Ferriere, *Ooencyrtus* sp. and *Anastatus* sp., attacked eggs while *Brachymeria* sp. and an unidentified tachinid attacked pupae of *E. thrax* but only *O. erionotae* influenced abundance of the pest (Sands et al. 1991).

Materials and Methods

(i) Culture of *E. thrax* and *C. erionotae*

A culture of *C. erionotae* was established in quarantine at the Department of Agriculture and Livestock, Laloki Research Station, Central Province, Papua New Guinea, from pupae from Guam. This species had been introduced into Guam from Thailand in 1974 for biological control of *E. thrax* (Waterhouse & Norris 1989).

Larvae of *E. thrax* collected from the field or reared from field collected eggs were maintained individually, either unparasitized or after exposure to parasitoids, in plastic tubes (110 × 41 mm) fitted with a ventilated lid. Each larva was provided with a fresh piece of rolled banana leaf every three days until it pupated, parasitoids spun cocoons or the larva died. Any larvae of *E. thrax* that pupated were removed and held in ventilated cages until adults or parasitoids emerged.

Parasitoid larvae that emerged from hosts and spun cocoons on leaf portions, were retained in the tubes until eclosion of adults, for rearing, testing or release. Adult *C. erionotae* were provided with honey streaked on waxed paper. To induce oviposition by *C. erionotae*, individual 2nd or 3rd instar larvae of *E. thrax* were introduced on a camel hair brush through a gauze sleeve into a ventilated acrylic cage (190 × 120 × 100 mm) holding 5 to 15, 3-day old *C. erionotae* (mixed sexes). Parasitoids were attracted to one end by illuminating the cage with a light and then tapping the cage until one parasitoid alighted on the exposed larva. After oviposition was completed (5 to 175 seconds later) the brush was gently tapped (to remove any parasitoids) and the larva withdrawn with it from the cage (to avoid multiple parasitization) and returned to a larval rearing tube containing a leaf portion.

(ii) Host specificity studies

C. erionotae was tested to determine whether it would attack *Cephrenes augiades websteri* Evans, an indigenous hesperiid related to *E. thrax*, or some

Papilionidae (*Papilio aegeus ormenus* Guerin-Meneville, *Troides oblongomaculatus papuensis* Wallace and *Ornithoptera priamus poseidon* Doubleday), selected from species of commercial value. Since female *C. erionotae* preferred 2nd or 3rd instar larvae of *E. thrax* for oviposition, 3rd instar larvae of each species were exposed using the same method as for *E. thrax*. Exposure of each larva to be tested, was followed by exposure of a larva of *E. thrax* in the same tube of parasitoids to determine whether or not normal oviposition would occur. After exposure to parasitoids, larvae of Lepidoptera that were tested were held in cages with fresh leaves of their natural food plants or, in the case of *C. augiades websteri*, on a small potted coconut palm until they pupated or died.

(iii) Release and establishment of *C. erionotae*

Observations on the seasonal abundance of *E. thrax* and its natural enemies were conducted prior to, and after, the release of *C. erionotae*, from January 1989 to February 1990. In a banana plot at the Laloki Research Station, immature stages of *E. thrax* (max. 30 per stage) were randomly sampled within a 1 hour period, brought to the laboratory and maintained in ventilated tubes (50 × 25 mm for eggs, 110 × 41 mm for larvae) until parasitoids emerged, larvae pupated or adults eclosed.

The first release of *C. erionotae* was made at Laloki on 31 March 1990. Leaf rolls containing parasitized larvae were attached by staples to leaves of banana plants bearing 3rd instar larvae of *E. thrax*. Following establishment of *C. erionotae*, parasitoid cocoons and adults were distributed to localities infested with *E. thrax* in the Central, Morobe, Western, Western Highlands and Eastern Highlands Provinces, between July and October 1990 and to West New Britain in June and October 1991. *C. erionotae* was first released in Madang Province in March 1992.

Results

Details of the biology of *C. erionotae* are shown in Table 1 and results of host specificity tests in Table 2. During specificity tests a display by parasitoids was observed whenever 3-day old mated female *C. erionotae* prepared to oviposit. Wasps alighted near the anterior end of a larva of *E. thrax*, erected their wings vertically over the thorax and held antennae at a distinctive, near vertical angle before oviposition. This display was only observed on larvae of *E. thrax* and never on other species of Lepidoptera tested (Table 2). In one exposure, a parasitoid palpated a larva of *C. augiades websteri* but, if it oviposited, no parasitoids developed, the larva pupated normally and an adult *E. thrax* emerged. No ovipositional behaviour by the parasitoids was observed on larvae of any Papilionidae tested. We found it necessary to restrict exposure of each *E. thrax* larva to oviposition by only one parasitoid before it was withdrawn. If permitted, oviposition by more than one parasitoid resulted in high mortality of host larvae.

Abundance of eggs of *E. thrax*, egg and larval parasitization and rainfall for the period January 1989 to February 1991 are shown in Fig. 1. Establishment of

Table 1. Biology of *Cotesia erionotae* at 25.8 + 1.2°C.

	\bar{x}	Range	No replications
Development time (days)			
Oviposition to pupation	16.6	12-24	ex 57 hosts
Pupation to adult eclosion	5.9	5-7	ex 31 hosts
Adult longevity	5.6	3-14	10♀♀
Pre-oviposition	3.6	3-4	10♀♀
no per host			
Pupae	108.0	22-189	ex 31 hosts
Adults	78.3	21-152	ex 31 hosts
no			
Ovariole cycles	1.4	1-3	10♀♀

Table 2. Larvae of Lepidoptera tested as hosts for *Cotesia erionotae*.

Species*	No host larvae				Parasitoid		
	exposed	pupated	dead	parasitised	display	probing	development
<i>Cephrenes augiades</i>	21	19	3	0	-	+(1)	-
<i>E. thrax</i>	23	2	9	13	+	+	+
<i>Papilio aegaeus</i>	10	8	2	0	-	-	-
<i>E. thrax</i>	11	2	4	5	+	+	+
<i>Troides oblongomaculatus</i>	11	10	1	0	-	-	-
<i>E. thrax</i>	14	2	6	6	+	+	+
<i>Ornithoptera priamus</i>	9	8	1	0	-	-	-
<i>E. thrax</i>	11	7	0	4	+	+	+

**E. thrax* exposed to the same parasitoids as the preceding species tested. Five *E. thrax* unexposed to parasitoids maintained until pupation in each test.

C. erionotae at the release site at Laloki was followed by a rapid decline in abundance of *E. thrax* with no stages recorded in December 1990, 9 months after first release of the parasitoids. Seven months after first release, 67% of larvae were found to be parasitized. Monitoring near the release site was discontinued after February 1991 due to scarcity of *E. thrax*. By that date an outbreak of *E. thrax* 3 k from the release site, was experiencing high parasitization by *C. erionotae* which had dispersed from the release site.

In a survey carried out in March 1992, *C. erionotae* was found in the Central, Morobe, Eastern Highlands, West New Britain and Western Provinces. At all sites where parasitoids were present, numbers of *E. thrax* were very low and in some localities, no stages at all of the pest could be located.

Two egg parasitoids of *E. thrax*, *Ectopiognatha* sp. nr *major* Perkins (Encyrtidae) and a *Telenomus* sp. (Scelionidae) were reared, bringing to five the

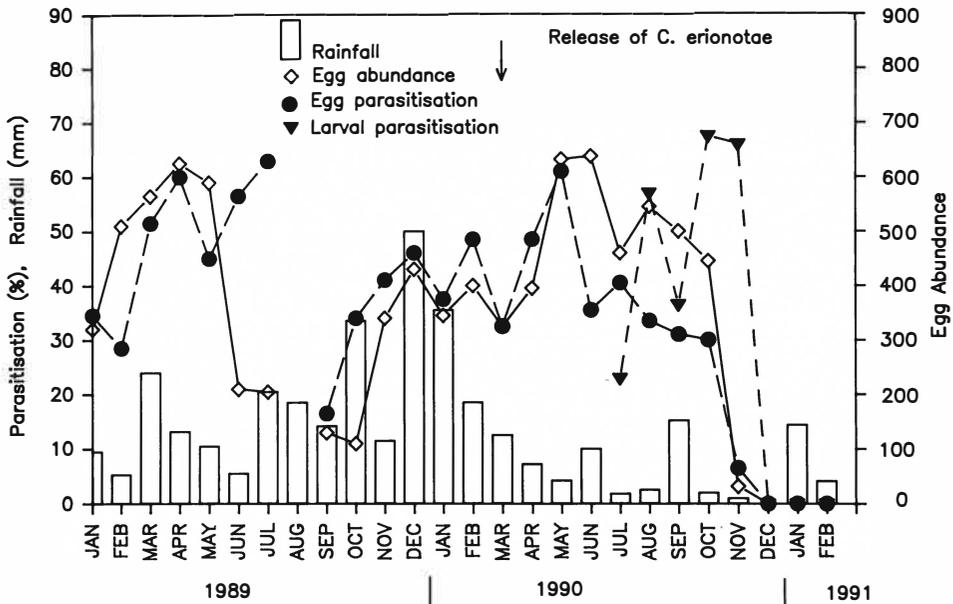


Figure 1. Egg abundance, egg and larval parasitization of *Erionota thrax* on bananas, and rainfall at Laloki Research Station, before and after release of *Cotesia erionotae*.

number of egg parasitoids recorded. *O. erionotae* and *Anastatus* sp. continued to be the predominant species. Other natural enemies of *E. thrax* observed included a bug, *Platynopus melacanthus* Boisduval (Pentatomidae), a predator on larvae at Laloki and a parasitic fly, *Palexorista* sp. (Tachinidae), which was a common larval parasitoid in West New Britain.

Discussion

The correct generic identity of *Cotesia erionotae* (previously placed in the genus *Apanteles*) was recently clarified by Austin & Dangerfield (1992). *C. erionotae* is the only braconid known to parasitize larvae of Hesperiidae in the Australasian region (A.D. Austin, pers. comm.).

Recent concerns relating to biological control agents attacking non-target arthropods have stimulated a need to examine the host range of agents before release. Howarth (1991) for example, has claimed that several insects in Hawaii have become rare or extinct as a result of attack by introduced biological control agents. As pointed out by Waterhouse & Norris (1989), PNG has a diverse and unique hesperiid fauna that should be considered when introducing natural enemies to control *E. thrax*. Moreover, PNG has an important industry involving trade in butterflies which might be affected if any decline in their abundance resulted from attack by exotic parasitoids. For this reason, we were required by

conservation authorities to test representatives from the family Papilionidae to ensure that they would not support the development of *C. erionotae*.

The specificity of *C. erionotae* for *E. thrax* was clearly demonstrated by the pre-ovipositional display, ovipositional response and the development of parasitoids. By contrast, it was difficult to assess the host specificity of the egg parasitoid, *Ooencyrtus erionotae*, the behaviour of which was thought to be disrupted by confinement within cages (Sands, in press). Although they did not involve a wide range of Hesperidae, our studies provided evidence that *C. erionotae* is a host-specific parasitoid and is therefore unlikely to attack other Lepidoptera in the region, including species (e.g. *Cephrenes* spp.) that are closely related to the *E. thrax*. It is possible that *C. erionotae* might attack other closely-related South-east Asian *Erionota* spp. but none of these occur naturally in PNG or the neighbouring Pacific region. It is not known if *C. erionotae* will attack the related *Erionota torus* Evans, which became established in Taiwan in 1986 and where it has since become a pest of bananas (Chiang & Hwang (1991).

Since the first appearance of extensive damage to banana plants by *E. thrax* in PNG (Arura 1987), indigenous natural enemies have increased in abundance and a general decrease in the levels of damage by *E. thrax* has taken place over much of the mainland. In particular, *Ooencyrtus erionotae* and *Anastatus* sp. have increased egg mortality in *E. thrax* and a tachinid parasitoid, *Palexorista* sp., has become an abundant pupal parasitoid of *E. thrax* on New Britain (S. Embrapa, pers. comm.). Birds, particularly crows, were at times seen opening leaf rolls to feed on larvae and pupae of *E. thrax* near Port Moresby in 1990 and caused 72% mortality of these stages.

At localities where *C. erionotae* is present in PNG, the abundance of *E. thrax* has declined markedly. However, the parasitoid is unable to reach remote localities without manual assistance. In such localities, *E. thrax* continues to cause damage and at some localities in New Britain and the Western Province (for example at Lake Kutubu) defoliation by the pest averaged 60% in 1992 (M.C. Sands, pers. comm.). Despite the presence of *C. erionotae* and indigenous natural enemies, *E. thrax* has continued to extend its distribution and is likely to spread to New Ireland in the near future.

Since 1989, *E. thrax* has spread to the West New Britain Province and by March 1992, had reached Rabaul, East New Britain Province. Further movement seems to be inevitable, particularly to New Ireland and to islands further east. There is a serious risk of spread by *E. thrax* to Australia, where the value of the banana industry is annually worth more than A \$150m. Lights on board boats are considered to be a means for attracting the crepuscular adult *E. thrax* and allowing them to be carried from one island to another. A specimen in the Natural History Museum, London, was collected on board a ship in 1929, near Seram, outside of its native range. From the distinctive pattern of spots beneath the hind wings, this specimen probably came from Java. A specimen from Port Moresby, PNG in 1961 and referred to by Parsons (1991) probably travelled to PNG on board a ship since this specimen pre-dated first establishment of *E. thrax* in northwestern PNG by 22 years.

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