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Biological Control of the Fruit Piercing Moth, *Othreis fullonia* (Clerck) (Lepidoptera: Noctuidae) in the Pacific

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Abstract—Adults of the fruit piercing moth *Othreis fullonia* are serious pests of ripening fruit in most islands of the western Pacific, eastern Australia and parts of Southeast Asia. In some countries egg parasitoids are abundant, contributing to biological control of the moth but few natural enemies of larvae are effective. In Papua New Guinea, *O. fullonia* is not sufficiently abundant to be considered a pest due, it is believed, to the activity of natural enemies, particularly egg parasitoids.

The most active hymenopterous egg parasitoids from Papua New Guinea, a *Telenomus* sp. and an *Ooencyrtus* sp. have been established in Western Samoa in 1988 and in Fiji in 1990 respectively. The abundance of eggs of *O. fullonia* and the number hatching have declined in Western Samoa since establishment of *Telenomus* sp. The contribution by egg parasitoids to biological control of *O. fullonia* in the Pacific is discussed.

Introduction

In the Pacific region, eastern Australia and parts of Southeast Asia the noctuid moth, *Othreis fullonia* (Clerck) (Catocalinae), is a pest of ripening tropical fruit, in particular carambola, persimmon, lychee, guava, longan, citrus and stone fruit (Banziger 1982, Sands & Schotz 1991). Adults of both sexes damage ripening fruit by piercing the rind with their specialised proboscis, macerating the pulp, withdrawing juice and by introducing micro-organisms that cause decomposition and fruit fall (Sands & Schotz 1989). *O. fullonia* occurs on most islands of the western Pacific, in tropical Australia, parts of Asia and in Africa (Waterhouse & Norris 1987). Larvae of *O. fullonia* feed only on forest vines (Menispermaceae) in Australia, Asia and Africa whereas, on the Pacific islands and in Papua New Guinea, larvae frequently feed on certain *Erythrina* spp. (Fabaceae) (Sands & Schotz 1991).

Many of the Pacific natural enemies of *O. fullonia* were listed by Waterhouse & Norris (1987), based on the extensive work of Cochereau (1973, 1974, 1977) in New Caledonia. Cochereau (1974) found that a tachinid, *Winthemia caledoniae* Mesnil, and an egg parasitoid, *Ooencyrtus cochereaui* Prinsloo & Annecke, were important natural enemies of *O. fullonia* in New Caledonia. In Papua New Guinea

where the moth is present but is not regarded as a pest, parasitoids are responsible for significant egg mortality (Sands & Broe 1991) and probably contribute to biological control of the moth (Waterhouse & Norris 1987). One Papua New Guinean parasitoid, a *Telenomus* sp., has been established in Western Samoa since 1988. Several other species of egg parasitoid are known from the Pacific region, but their importance as natural enemies of *O. fullonia* has not been assessed (Sands & Liebregts 1992).

Methods and Results

(i) Parasitoids and predators of larvae and pupae

In New Caledonia the indigenous tachinid, *Winthemia caledoniae,* was shown by Cochereau (1977) to be an important parasitoid of *O. fullonia* larvae. Other *Winthemia* spp. are known from Fiji, Tonga (*W. pacifica* Malloch: Cantrell 1989) and Western Samoa but they are uncommon and not specific to *O. fullonia.* Natural enemies of larvae and pupae (listed by Waterhouse & Norris 1987), including *Polistes* spp. (Vespidae), are either generalist predators or parasitoids likely to have a broad host range. In addition, a larval/pupal parasitoid, *Echthromorpha agrestoria* (Swederus)(Ichneumonidae) and a larval parasitoid *Exorista sorbillans* (Wiedmann) (Tachinidae) attack *O. fullonia* in Australia. A predator, *Oechalia schellenbergi* (Guérin) (Pentatomidae) attacks 3rd instar *O. fullonia* in Western Samoa. In Australia and elsewhere in the Pacific this species attacks other lepidopterous prey (G. F. Gross pers. comm.). Another predator, *Gminatus wallengreni* (Stäl) (Reduviidae) has been observed to complete development on larvae of *Eudocima salaminia* (Cramer) in Australia and is likely to also attack *O. fullonia.*

Unidentified midges, *Forcipomyia* spp. (Ceratopogonidae) suck juices from larvae of *O. fullonia* in Vanuatu and Western Samoa and attack larvae of the related *E. salaminia* in Australia (Sands & Broe 1992).

(ii) Egg mortality of *Othreis fullonia*

In countries where detailed studies were undertaken (Western Samoa, Tonga, Fiji), single eggs and egg masses were collected from the field for production of larvae, parasitoids or to record mortality. Quantitative estimates for parasitization were made using the methods described by Sands & Liebregts (1992).

Indigenous parasitoids attack eggs of *O. fullonia* in most Pacific countries (Sands & Broe 1991) (Table 1), contributing to varying levels of egg mortality in *O. fullonia.* Three genera are well represented, *Ooencyrtus* (Encyrtidae), *Telenomus* (Scelionidae) and *Trichogramma* (Trichogrammatidae), but their specific identity and effectiveness as biological control agents differ from one island group to another. *Ooencyrtus* spp. and *Trichogramma* spp. are usually gregarious, whereas *Telenomus* spp. develop as solitary parasitoids in the eggs of *O. fullonia.* Occasionally other hyperparasitoid genera (e.g *Anastatus* sp. [Eupelmidae]), are reared from eggs of *O. fullonia.* The taxonomy of *Ooencyrtus* spp. from *O. fullonia* in the region remains largely unresolved. Two species, *O. cochereaui,* from New

Table 1. Egg parasitoids of *Othreis fullonia* in the Pacific.

Country	Parasitoid(*)		References
New Caledonia	*Ooencyrtus cochereaui* (=*Ooencyrtus* sp.)		Prinsloo & Annecke 1978; Cochereau 1974 1977; Waterhouse & Norris 1987; Maddison 1982
	Trichogramma chilonis Ishii		
	Telenomus sp.		
Papua New Guinea	*Ooencyrtus* sp.	(LPL531)	Sands & Liebregts 1992
	Ooencyrtus sp.	(LPL643)	
	Telenomus sp.	(LPL530)	
Vanuatu	*Ooencyrtus* sp.	(LPL515)	Sands & Broe 1992
	Telenomus sp.	(LPL519)	
Fiji	*Trichogramma* sp. nr *papilionis* Nagarkatti		Kumar & Lal 1983
	Ooencyrtus sp.	(LPL684)	
	Ooencyrtus sp.	(LPL531)	Ex. PNG, established
	Telenomus sp.	(LPL668)	
Hawaii	*Trichogramma chilonis*		Heu et al. 1985
	T. ostriniae Pang & Chen		
Western Samoa	*Ooencyrtus crassulus*		Sands & Liebregts 1992
	Ooencyrtus sp.	(LPL531)	Ex. PNG, failed to establish
	O. cochereaui		Ex. New Caledonia, failed to establish, Waterhouse & Norris 1987
	Telenomus sp.	(LPL530)	Ex. PNG, established, Sands & Liebregts 1992
	Trichogramma sp.	(LPL522)	
American Samoa	*O. crassulus*		Prinsloo & Annecke 1978
	Trichogramma sp.	(LPL628)	Sands & Broe 1992
Guam	*Ooencyrtus* sp.	(LPL528)	Sands & Broe 1992
	Telenomus sp.	(LPL527)	
	Trichogramma sp.	(LPL565)	
Tinian, Saipan, Rota	*Trichogramma* sp.	(LPL645)	
	Ooencyrtus sp.	(LPL646)	
	Ooencyrtus sp.	(LPL647)	
Tonga	*Telenomus* sp.	(LPL678)	Crooker 1979
	Trichogramma sp.	(LPL581)	Sands & Broe 1992
Australia	*Ooencyrtus* sp.	(LPL603)	
	Ooencyrtus sp.	(LPL665)	
	Telenomus sp.	(LPL535)	Sands & Broe 1992
	Trichogramma sp.	(LPL618)	

*LPL numbers are CSIRO registrations for unidentified species

Caledonia and *O. crassulus* Prinsloo and Annecke, from Western Samoa have been described (Prinsloo & Annecke 1978) but more than 10 species from the region have yet to be described (Table 1). In New Caledonia, *O. cochereaui,* parasitized 20 to 80% of eggs and similar levels by *O. crassulus* have been observed in Western Samoa (Sands & Liebregts 1992). Another important, undescribed *Ooencyrtus* sp. (LPL531) from Papua New Guinea, failed to become established following several releases in Western Samoa. However, this species recently be-

came established in Fiji where its effectiveness has yet to be evaluated (S. N. Lal pers. comm.). Other indigenous *Ooencyrtus* spp. are known to attack eggs of *O. fullonia* in Guam, Vanuatu, Fiji and the Mariana Is.

At least three *Telenomus* spp. attack eggs of *O. fullonia* in the Pacific region. All are biparental, solitary parasitoids. One undescribed *Telenomus* sp. (LPL530) from Papua New Guinea has become established in Western Samoa, where it is contributing to biological control of the moth (Fig. 1) (Sands & Liebregts 1992). Most other *Telenomus* spp. do not contribute to significant egg mortality of *O. fullonia* in the region, with the possible exception of a species from Guam (R. Muniappan pers. comm.). The species causing low mortality are probably principally parasitoids of other hosts. Similarly, although several *Trichogramma* spp.

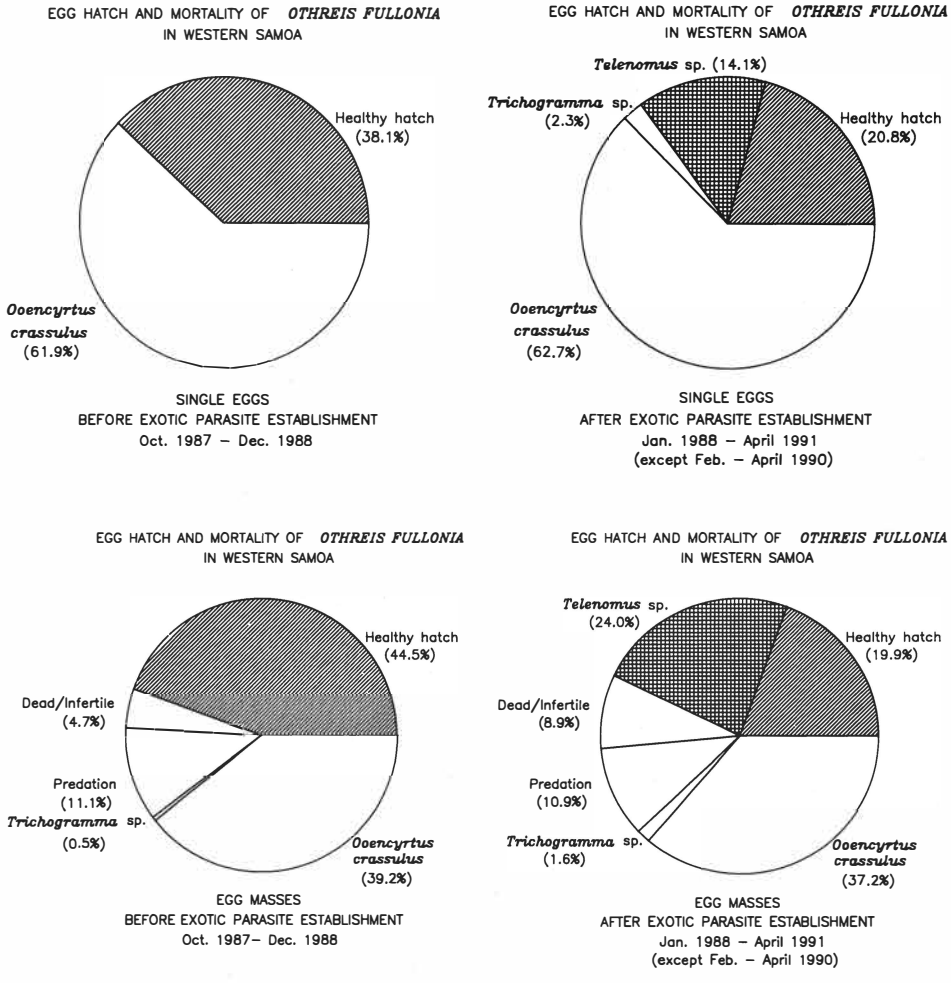

Figure 1. Egg hatch and mortality of *Othreis fullonia* in Western Somoa.

occur in the region (Waterhouse & Norris 1987), their attack on eggs is very variable and does not appear sufficient to reduce abundance of *O. fullonia* to uneconomic levels.

Egg predators include the ants *Pheidole* sp. and *Tetramorium insoleus* (Fr Smith) in Western Samoa and *Iridomyrmex glaber* (Mayr) in Australia; bugs, *Germalus montandoni* Bergroth in New Caledonia, *G. samoanus* China in Western Samoa and *G. unipunctatus* Montandon in Vanuatu and Fiji; and unidentified Neuroptera. In Western Samoa *G. samoanus* is, at times, a most important predator preying on up to 40% of eggs of *O. fullonia.*

Discussion

It is possible that geographical differences in *O. fullonia* influence the successful establishment and effectiveness of exotic parasitoids. For example, on some islands (e.g. Western Samoa, Papua New Guinea), eggs of *O. fullonia* are more often deposited in masses, whereas in other localities (e.g. Australia, Fiji, Tonga) eggs are generally deposited singly and only rarely in masses. This is particularly relevant for certain parasitoids, for example most *Telenomus* spp., which prefer to parasitize masses, whereas their attack on single eggs is not as effective (Sands & Liebregts 1992). Other biological differences include choice of larval food plants which, on all Pacific islands, are known to be mainly species of *Erythrina,* whereas in Australia, Asia and Africa, larvae of *O. fullonia* feed only on Menispermaceae.

The portion of the plant on which eggs are deposited, sometimes influences the searching behaviour of parasitoids. In Australia, an uncommon *Ooencyrtus* sp. (Encyrtidae), a parasitoid of the related fruit piercing moth, *E. salaminia,* only attacks eggs deposited on stems and stakes supporting the food plant vine, *Stephania japonica,* whereas eggs deposited on leaves of the vine remained free from attack. On the other hand, when studying the effectiveness of *O. crassulus* in Western Samoa, there were no significant differences either in the numbers of eggs deposited or parasitized by *O. crassulus* on *Erythrina variegata* var. *orientalis* and *Stephania japonica* var. *forsteri.*

Differences in the morphology of separated geographical populations of *O. fullonia* are sometimes accompanied by differences in their biology. Samoan populations of *O. fullonia* differ consistently from those from other islands further west, especially in the size of the crescentic band and chequered cilia of the hind wings in both sexes. When an attempt was made to rear *Ooencyrtus* sp. (LPL531) from Papua New Guinea in eggs from Western Samoan moths, normal development did not take place. Very few parasitoids developed, the culture could not be sustained in the laboratory and this *Ooencyrtus* sp. failed to become established in Western Samoa following its release. It is also possible that heavy competition from the endemic *O. crassulus* may have contributed to the failure of this species to become established.

The failure of *W. caledoniae* to become established in Fiji or Tonga (Waterhouse & Norris 1987) is difficult to explain, but may be due to agent/host biotype

incompatibility. This parasitic fly was released in Fiji for more than six years but has not been recovered from the field (S. N. Lal pers. comm.).

The egg parasitoids, *Ooencyrtus* sp. (LPL531) and *Telenomus* sp. (LPL530) from Papua New Guinea, *O. crassulus* from the Samoas and *O. cochereaui* from New Caledonia appear to be the most valuable agents so far known, based on their activity in their indigenous ranges. Other valuable species in these two wasp genera may occur in the Pacific, particularly in the Solomon Islands and in Micronesia. Intentional movement of the most effective species of egg parasitoid from one island group to another is likely to increase levels of egg mortality, even when competition with indigenous species occurs.

If egg parasitoids are to be introduced into countries where other *Othreis* spp. are present, some attack on related non-target species is likely to occur, since the known species are oligophagous and not specific to *O. fullonia.* This aspect of biological control programs is coming under increasing scrutiny following the suggestions by several authors, including Howarth (1991), that indigenous, non-target insect fauna have become rare or extinct following introductions of generalist biological control agents. Fortunately, in most Pacific countries, other species of *Othreis* or related genera are poorly represented. However, the situation in Australia is different where other pest species (e.g. *O. materna* L., *O. jordani* Holland) and non-pest species (e.g. *O. iridescens* [Lucas]) will be tested before these parasitoids are released.

Fruit piercing moths are powerful fliers, the adults sometimes migrating considerable distances from their breeding sites (Sands et al. 1991). This behaviour is likely to delay benefits from biological control if adults continue to migrate in numbers from areas where parasitoids are not yet established.

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