

Fruit-Piercing Moths of Micronesia



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Dean/Director: Dr. Jeff D.T. Barcenas.

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Introduction

Fruit-piercing moths are found all over the world and represent a group of specialized lepidopterans that feed on the cellular sap of various fruits. They do this with great dexterity by using their modified proboscis to penetrate the fruit, macerate the internal pulp, and withdraw the liberated fluids. Fruits attacked by these insects soon become dry and pulpy and lose their edible appeal. In addition, the initial wound invariably serves as an entry point for secondary infection organisms which cause further spoilage. Heavy infestations of fruit-piercing moths can be particularly troublesome to the home gardener and economically threatening for commercial fruit growing ventures. For these reasons, several species of fruit-piercing moths are considered serious pests throughout much of their range.

Fruit-piercing moths may be categorized as either "primary" or "secondary" fruit-piercers depending on their ability to penetrate the fruit. This characterization reflects the extent to which the proboscis tip has been modified for such purposes. Moths that can penetrate the skin and pulp of fruits are termed primary fruit-piercers whereas those incapable of puncturing skin but able to reach the pulp via existing holes and other entry points are known as secondary fruit-piercers. However, these two terms are not mutually exclusive. Indeed, a moth may act as a primary fruit-piercer on one type of fruit and a secondary fruit-piercer on another, depending on the strength of its proboscis and resilience of the fruit skin.

The proboscis of a primary fruit-piercing species is highly sclerotized and frequently barbed. There may be a formidable array of spines, backward projecting hooks and stout bristles. These modifications allow easy penetration of all but the toughest skinned fruits and rapid maceration of the underlying pulp. In contrast, the proboscis of a secondary fruit-pierc-

ing species has reduced sclerotization and is much weaker. Barbs, hooks and spines are always absent although in certain species the dorsal tip of the proboscis is equipped with a dense array of stiff bristles that assist in macerating pulp cells. In less well-adapted species these structures are reduced to a sparse collection of rudimentary, hair-like processes with no obvious function.

Primary fruit-piercing moths are unquestionably more important economically than their secondary counterparts because they initiate puncturing and penetration of undamaged fruit. However, since the latter group frequently uses existing holes and cause secondary infections, secondary fruit-piercing moths probably play a greater role in transmitting diseases between pierced fruits.

Between 1987 and 1990, University of Guam scientists surveyed the distribution and pest status of fruit-piercing moths in Micronesia. Information was gathered from the Western Caroline Islands of Yap and Palau; the Mariana Islands of Guam, Rota, Tinian and Saipan; and the Eastern Caroline Islands of Chuuk, Pohnpei and Kosrae. The surveys revealed that several species of primary and secondary fruit-piercing moths were common and widespread throughout the region, although not all species were observed on all visited islands. Furthermore, certain species that posed a serious problem on some islands were minor pests on others. The results of these surveys are presented here with notes on the biology, pest status, and natural enemies of two of the more important primary species found on Guam. Deficiencies in our current knowledge and future research needs are also highlighted. We hope this summary will be both informative and of practical value to farmers and fruit growers throughout Micronesia and to the scientific community at large.

Primary Fruit-Piercing Moths

Four primary fruit-piercing moths currently occur in Micronesia. They are *Othreis fullonia* (Clerck), *Pericyma cruegeri* (Butler), *Platyja umminia* (Cramer) and *Ercheia dubia* (Butler). All four species belong to the family Noctuidae and originated from Asia. Although their route of entry into Micronesia is unclear, it is undoubtedly linked to human activities. All are nocturnal feeders and inflict moderate to severe damage to a variety of citrus and soft fruits at certain times of the year. Their distribution and pest status within Micronesia, together with known aspects of their biology, preferred host plants and natural enemies, are given below.

***Othreis fullonia* (Clerck)**

O. fullonia was probably the first primary fruit-piercing moth to establish in Micronesia and is certainly one of the most widespread (Fig. 1). It was first recorded on Guam in 1936, but was probably here long before then. This species is one of the largest fruit-piercing moths found in Micronesia with a maximum wing span approaching 10 cm (Plate 1). It is a powerful flyer capable of sustained flight over considerable distances. This attribute has allowed it to successfully establish on remote oceanic islands.

Host Plants

In their native surroundings the larvae of *O. fullonia* feed exclusively on vines of the Menispermaceae family. The preferred genera of this family seem to be *Anamirta*, *Diplocisia*, *Cissampelos*, *Cocculus*, *Cyclea*, *Pachygone*, *Stephania*, *Tiliacora* and *Tinospora* (Plate 2). Historically, the general absence of these plants in Micronesia probably presented a natural bar-

rier to the moth and prevented it from establishing in the area until about 200 years ago. During this period, many new plants were introduced into the Pacific region by the first European settlers. Among these were several Asiatic species of *Erythrina* (Plates 3-5). These fast growing trees belong to the Fabaceae family and, aside from their ornamental appeal, were favored for their shade, windbreak and living fence post properties. They were widely used on early coffee, cacao and citrus plantations throughout the region. Unfortunately, they were also adopted as the larval host plant by *O. fullonia*, an event that opened up the Pacific islands to this invader and resulted in its present distribution along the tropical and subtropical belt from Africa to French Polynesia (Fig. 2).

Why two taxonomically unrelated groups of host plants are utilized by *O. fullonia* for oviposition and larval development remains a mystery. Attraction to a common plant chemical or group of chemicals, possibly the tetracyclic *Erythrina*

type alkaloids, may be the most likely explanation. The moth demonstrates a clear preference for the primary host plants, and in situations where both primary and secondary host species co-exist, will always select the former providing it is suitably abundant. This preference does not appear to be related to the nutritional value of the host plant since larvae reared separately on leaves of *Cocculus* sp. (Menispermaceae) and *Erythrina variegata* demon-

Table 1: Larval Development Times of *Othreis fullonia* on Different Host Plants

DEVELOPMENT STAGE	DEVELOPMENT TIMES (DAYS)			
	<i>Erythrina variegata</i>		<i>Cocculus</i> sp.	
	Mean	Range	Mean	Range
First Instar	5.4	4-9	5.0	4-6
Second Instar	3.0	2-4	3.2	2-4
Third Instar	2.6	2-3	3.8	3-4
Fourth Instar	3.4	3-4	4.8	4-6
Fifth Instar	5.8	3-9	6.8	5-11
Sixth Instar	7.0	6-8	8.0	8-8

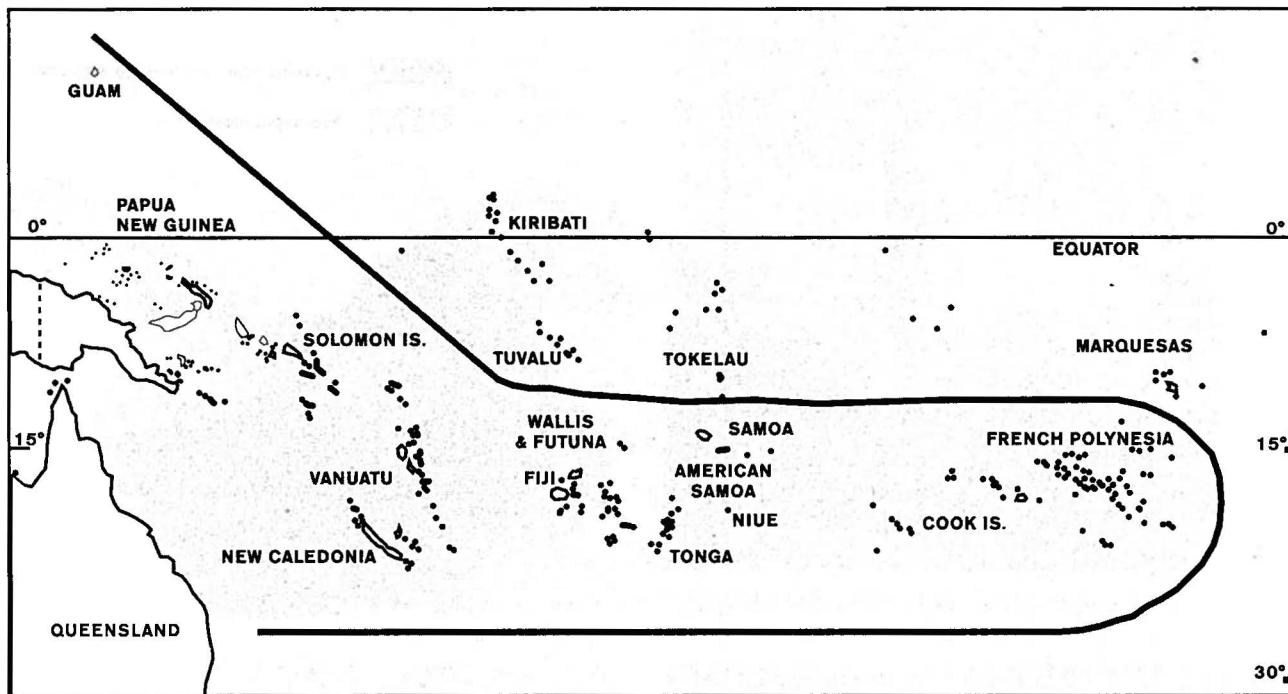


Figure 1: Distribution of *Othreis fullonia* in the Pacific (Reproduced from Waterhouse and Norris, 1987.)

strate similar growth rates (Table 1).

common there. It has not been observed on Yap or Chuuk.

Pest Status

Although widespread throughout Micronesia, the abundance and pest status of *O. fullonia* varies significantly between islands. It is considered to be a major pest on Guam, Tinian, Saipan and Kosrae, but is of minor importance on Rota, Palau and Pohnpei despite being relatively

Adult Food Preferences

The heavily armed and thickly sclerotized proboscis of *O. fullonia* (Plate 6) enables it to penetrate and feed on many different fruits including several tough-skinned citrus varieties (Table 2, Plates 7-12). When allowed a choice, the moth prefers sweet, aromatic fruit (e.g., ripe banana, mango, papaya, pomegranate, guava) over those with low sugar content (e.g., tomato, bell pepper and eggplant).

Table 2: Fruits Pierced by Adult *Othreis fullonia*

Apple	Apricot	Banana	Bell Pepper
Breadfruit	Cactus	Carambola	Cashew nut
Coffee	Custard Apple		Eggplant
Fig	Grape	Grapefruit	Guava
Jackfruit	Kiwi	Lemon	Litchi
Longan	Mandarin	Mango	Melon
Nectarine	Orange	Papaya	Passion fruit
Peach	Persimmon	Pineapple	Plum
Pomegranate	Pummelo	Soursop	Sweetsop
Tangerine	Tomato		

Life Cycle

In Micronesia *O. fullonia* lay eggs on their host plants year round, although production peaks during the wetter months when there is ample food for the developing larvae. The eggs are laid singly or in clusters of up to several hundred, usually on the underside of *Erythrina* leaves (Plates 13-15). The eggs normally require 2-4 days to hatch. The emergent larvae measure about 0.5 cm in length and are clear, green colored with a black spot at the base of each body hair (Plate 16). They are avid feeders and grow to full size in 2-3 weeks, molting every few days as they do so (Plates 17-18). The later larval instars are spectacularly colored with two conspicuous lateral "eye spots" on the second and third abdominal segments (Plates 19-23). Pupation occurs in a cocoon protected by

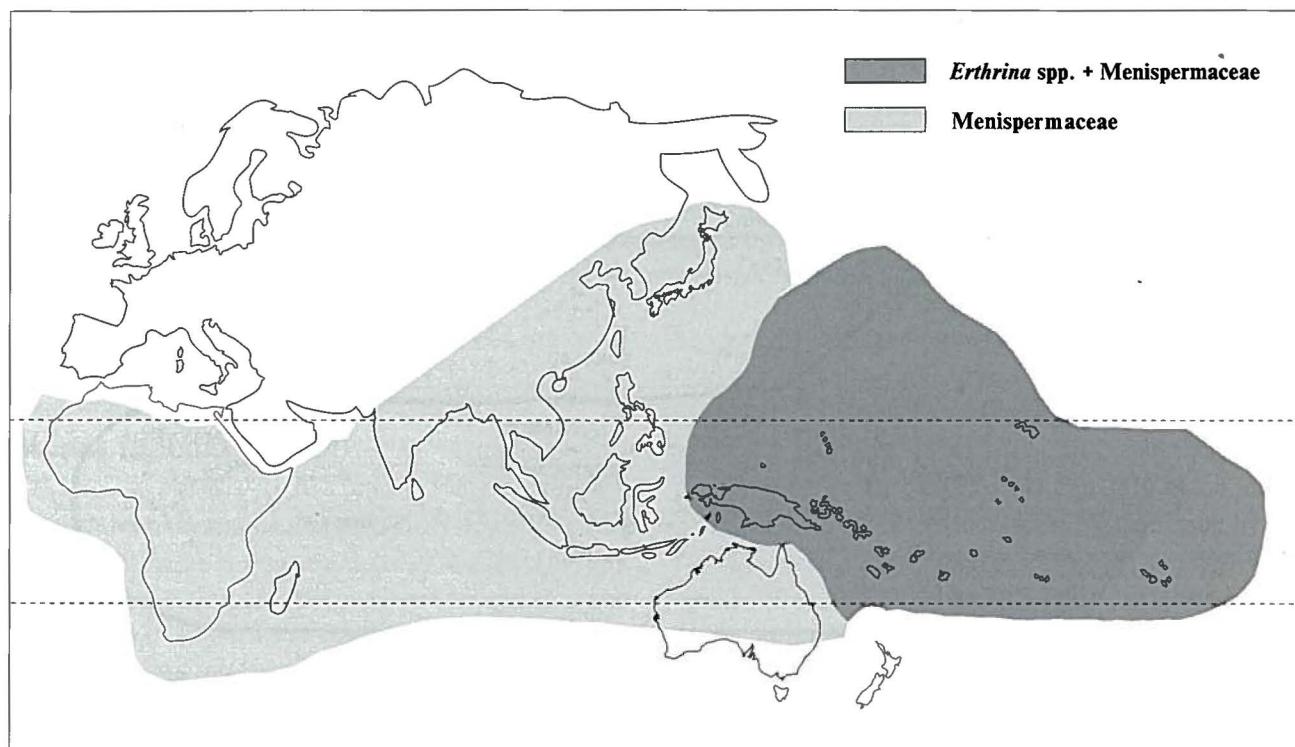


Figure 2: World Distribution of *Othreis fullonia* in Relation to Its Larval Host Plants.

Erythrina leaves drawn together with silk (Plate 24). Adult moths emerge some 10-11 days later. Newly emerged females begin to lay eggs within 4-10 days. The entire life cycle is completed within 4-6 weeks.

Control Measures

A number of control measures have been suggested but few are effective and economical. The simplest and perhaps earliest form of control involves hand catching and destroying feeding adults. This is, of course, of little practical value to a large-scale fruit growing operation. In such cases, covering the ripening fruit with a protective bag may be a viable option but is labor intensive. Alternatively, fruit may be prematurely harvested, but at the risk of diminished quality and lower market returns. Another alternative involves illuminating fruit trees at night with yellow-green light (wavelength 580 nm). While this is an effective means of repelling the moths, it is prohibitively expensive to install and run. Moreover, many less well-developed islands in Micronesia have limited electric power availability, while some have none at all.

The application of chemical insecticides to fruit trees is generally discouraged for public health reasons, although it may be effective in the short-term. Chemical insecticides are

expensive and do little to reduce local adult moth populations unless also applied to larval host plants. Unfortunately, larval host plants are frequently located several miles from the foraging grounds of adult moths, making implementation extremely difficult. Other chemical control measures include the use of lures, baits, poisons and repellents, but are also relatively ineffective.

Complete eradication of host plants is among the most effective and obvious means of controlling fruit-piercing moths. This technique may be feasible on certain Micronesian islands where relatively few *Erythrina* trees exist (e.g., Tinian). However, total eradication from all of Micronesia would be virtually impossible at present in light of the many traditional uses and values (agricultural, medicinal and ornamental) of these trees. In addition, islands unwilling to comply with eradication efforts would continue to serve as a source of moths to those islands attempting to eradicate it.

Natural Enemies

Because of the many problems involved in controlling *O. fullonia* by conventional means, recent efforts have focused on using the insect's natural enemies to provide less expensive and sustainable suppression. Several predatory and parasitic organisms that attack specific developmental stages

PHOTO CREDITS:

Plate 16 by James McConnell;

Plate 35 by C.A. Kimmons;

Remaining photos by G.R.W. Denton and R. Muniappan



Plate 1: Adult *Othreis fullonia*

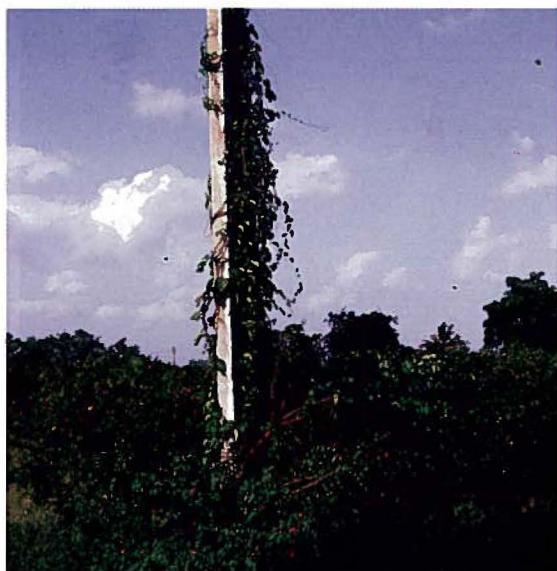


Plate 2: The Vine *Tinospora* sp. (Menispermaceae): Host Plant of *O. fullonia*



Plate 3: Coral Tree, *Erythrina variegata*



Plate 4: Coral Tree in Flower



Plate 5: Close-up of Coral Tree Branches Showing Feeding Damage by *O. fullonia* Larvae

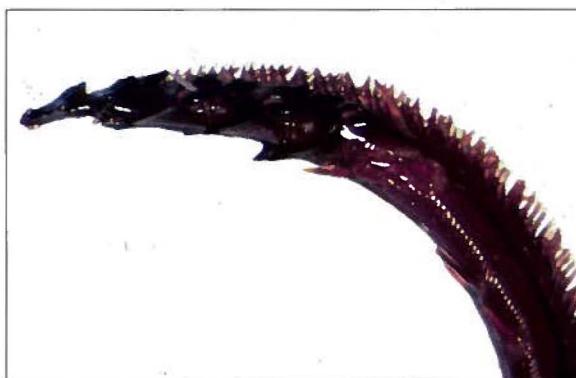


Plate 6: Proboscis of Adult *O. fullonia*



Plate 7: Adult *O. fullonia* Feeding on Guava



Plate 8: Adult *O. fullonia* Feeding on Pomegranate



Plate 9: Damage Caused by *O. fullonia* to Carambola



Plate 10: Damage Caused by *O. fullonia* to Citrus Fruits



Plate 11: Damage Caused by *O. fullonia* to Strawberry Guava



Plate 12: Damage Caused by *O. fullonia* to Soursop



Plate 13 (left): Single Egg of *O. fullonia* on
Erythrina variegata Leaf



Plate 14 (left, below): Egg Mass of *O. fullonia* on
Erythrina variegata Leaf

Plate 15 (immediately below): Egg Mass of *O. fullonia*
Showing Freshly Laid Eggs (left) and Developing Larvae
(right)

Plate 16 (bottom): *O. fullonia* Larvae Emerging from an
Egg Mass

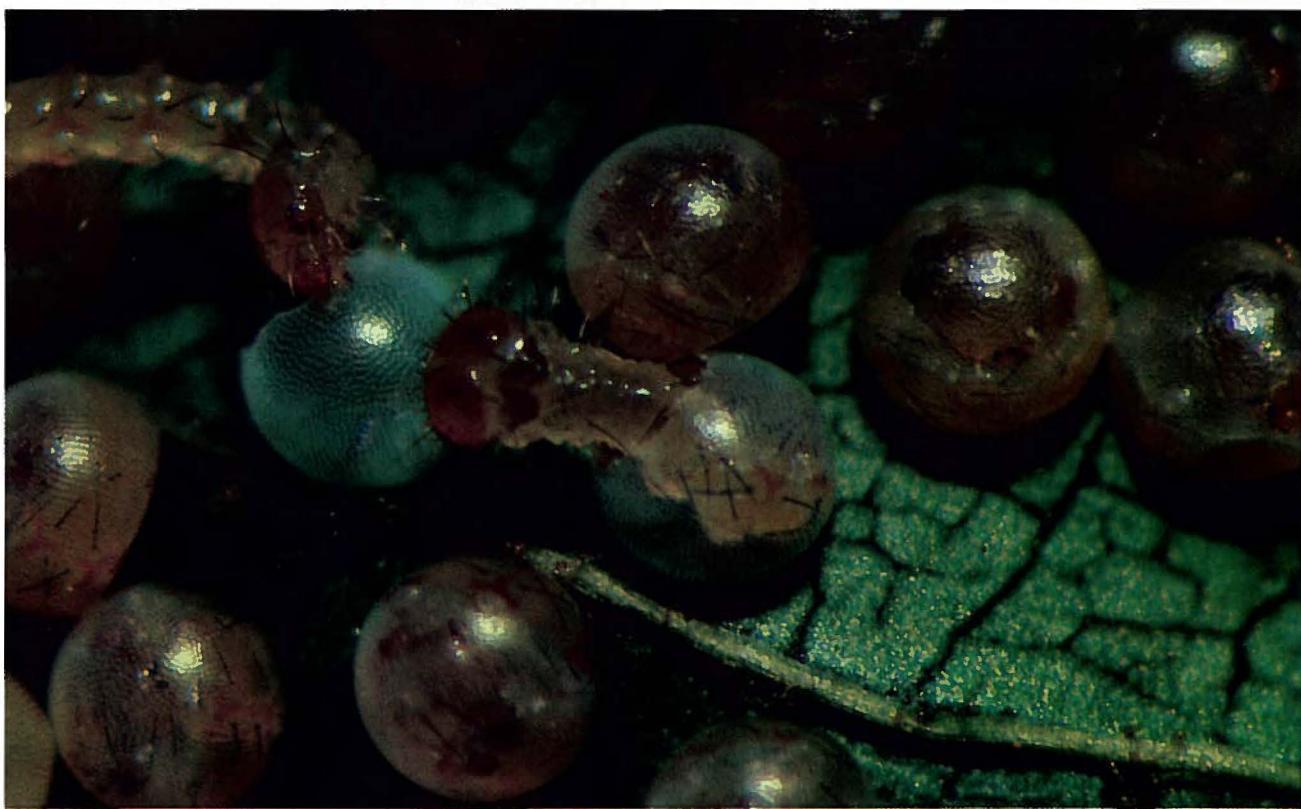
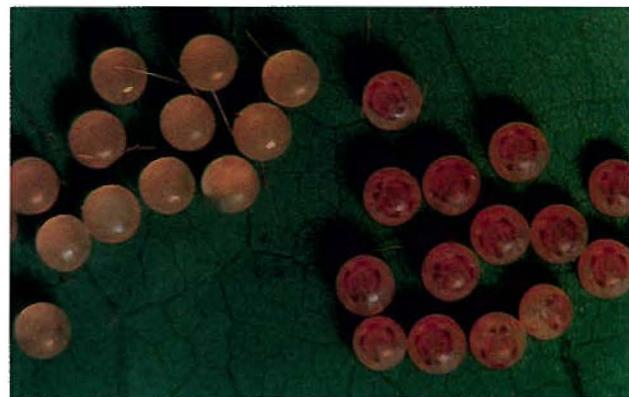




Plate 17: Second Instar Larva of *O. fullonia* on *Coccus* sp. Leaf



Plate 18: Third Instar Larva of *O. fullonia* Feeding on *Erythrina variegata* Leaf



Plates 19-23: Color Variations of *O. fullonia* Larvae



Plates 20



Plates 21



Plates 22



Plates 23



Plate 24: Pupae of *O. fullonia*



Plate 25: Fungus Infected Eggs of *O. fullonia*



Plate 26: Parasitoid Wasp, *Telenomus* sp., Ovipositing on the Eggs of *O. fullonia*



Plate 27: Developing Larvae of *Telenomus* sp. in *O. fullonia* Eggs (note purple rings on egg shells)



Plate 28: Parasitoid Wasp, *Ooencyrtus* sp., Ovipositing on the Eggs of *O. fullonia*



Plate 29 (above): Developing Larvae of *Ooencyrtus* sp. in *O. fullonia* Eggs



Plate 30 (above, right): Parasitoid Wasp, *Trichogramma* sp., Ovipositing on the Eggs of *O. fullonia*

Plate 31 (right): Parasitoid Wasp Emergent Holes in *O. fullonia* Eggs (a = *Telenomus* sp., b = *Ooencyrtus* sp., c = *Trichogramma* sp.)

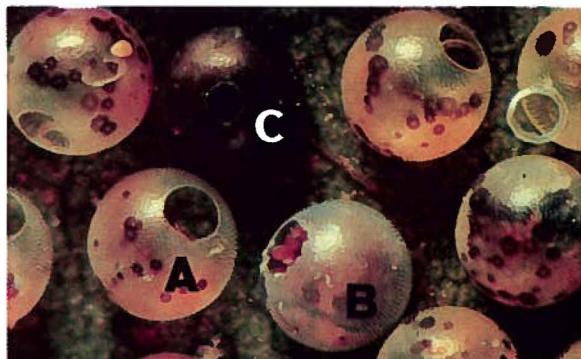


Plate 32 (below): Emergent Male *Telenomus* sp. Searching for a Hatching Mate





Plate 33: Ants Predating on *O. fullonia* Eggs



Plate 34: *O. fullonia* Eggs Damaged by Bug Attack

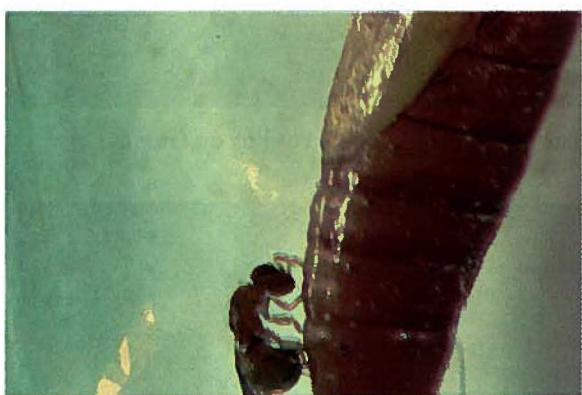


Plate 35: Parasitoid Wasp, *Trichospilus diatraeae*,
Ovipositing on the Pupa of *O. fullonia*



Plate 36: Praying Mantis Feeding on Adult *O. fullonia*



Plate 37: Adult *Pericyma cruegeri*
(upper = male, lower = female)



Plate 38: Royal Poinciana
Defoliated by *P. cruegeri* Larvae



Plate 39: Royal Poinciana (Flame Tree) in Flower



Plate 40: Adult *P. cruegeri* Feeding on Guava



Plate 41: Adult *P. cruegeri* Feeding on Eggplant.

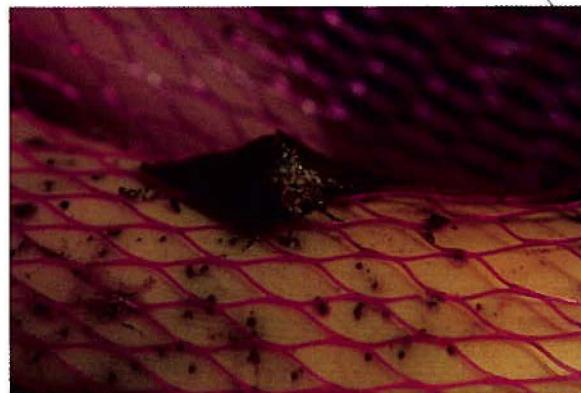


Plate 42: Adult *P. cruegeri* Feeding on Banana



Plate 43: Damage Caused by *P. cruegeri* to Banana



Plate 44: Adult Proboscis of *P. cruegeri*



Plate 45: Caterpillar of *P. cruegeri*
on Flame Tree Leaf



Plate 46: Adult *Platyja umminia*
(upper = female, lower = male)



Plate 47: Adult *Ercheia dubia*



Plate 48 : Proboscis
of Adult *P. umminia*

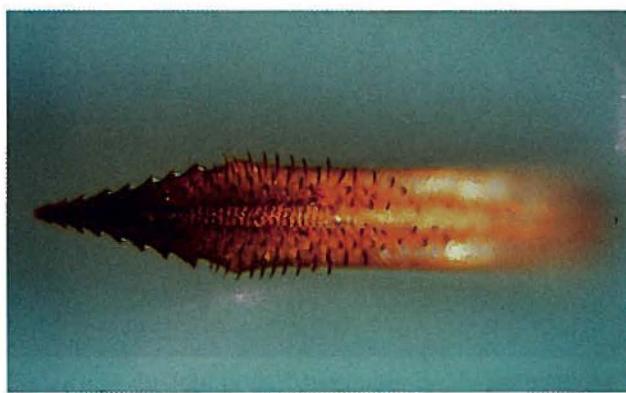


Plate 49: Proboscis of Adult *E. dubia*



Plate 50: Secondary Fruit-Piercing Moth, *Achaea janata*,
the Primary Piercer, *O. fullonia*, and Others Feeding on
Guava



Plate 51: Adult *P. umminia*, *Anomis flava*, *P. cruegeri* and *Parallelia palumba* Feeding on Guava



Plate 52: Adult *E. dubia*, *P. cruegeri* and *A. flava* Feeding on Guava



Plate 53: Larva and Adult of Secondary Fruit-Piercing Moth, *Ophiusa coronata*, Feeding on Guava



Plate 54: Secondary Fruit-Piercing Moth, *Anua tongensis*, Feeding on Guava



Plate 55: Secondary Fruit-Piercing Moth, *Thyas regia*, Feeding on Guava



Plate 56: Secondary Fruit-Piercing Moth, *Grammodes geometrica*, Feeding on Guava



Plate 57: Secondary Fruit-Piercing Moth, *A. janata*, Feeding on Guava



Plate 58: Secondary Fruit-Piercing Moths, *A. janata*, *Platysenta illecta*, and *A. flava* (partially hidden at bottom) Feeding on Guava



Plate 59: Proboscis of Adult *O. coronata*



Plate 60: Proboscis of Adult *Dysogonia absentimacula*



Plate 61: Secondary Fruit-Piercing Moth, *Mocis undata*



Plate 62: Proboscis of Adult *Mocis frugalis*



Plate 63: Secondary Fruit-Piercing Moth, *Ericeia inangulata*



Plate 64: Proboscis of Adult *E. inangulata*



Plate 65: Proboscis of Adult *A. flava*



Plate 66: Secondary Fruit-Piercing Moth,
Parallelia palumba



Plate 67: An Unidentified Secondary Fruit-Piercing Moth

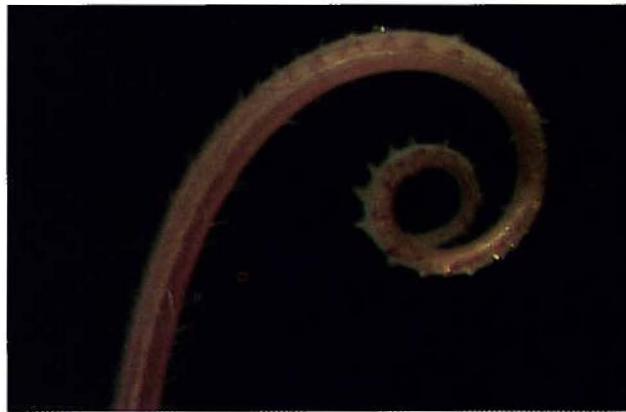


Plate 68: Proboscis of Unidentified Secondary
Fruit-Piercing Moth

during the moth's life cycle have been identified on Guam and other islands within Micronesia. Some of these natural enemies, particularly the predators, attack a variety of other insects and are therefore of limited value as biological control agents. In contrast, many moth parasitoids are host-specific and may be excellent candidates for such purposes.

The natural enemies of *O. fullonia* can effectively be divided into the following four major categories:

1. Egg Parasitoids

The egg parasitoids of *O. fullonia*, on a worldwide basis, include certain types of fungi (e.g. *Fusarium* sp.) and several small wasps. In Micronesia, the fungi are relatively unimportant and probably account for no more than 5 percent destruction of the total number of eggs laid (Plate 25). Microhymenopteran egg parasitoids, on the other hand, are among the more effective biological control agents throughout the region. On Guam, they collectively destroy around 60-80 percent of all single eggs laid and between 80-90 percent of those eggs laid in clusters of two or more. These tiny wasps lay their eggs inside *O. fullonia* eggs, and complete their life cycle at the expense of the developing moth larvae. At least ten such species of wasps are known to exist on Guam, although only three, *Telenomus* sp., *Ooencyrtus* sp. and *Trichogramma* sp., have any significant impact on *O. fullonia* populations (Plates 26-30).

Representatives of all three genera are important egg parasitoids throughout Micronesia and elsewhere in the world, although their relative effectiveness varies both in time and space. For example, temporal changes in the relative effectiveness of *Ooencyrtus* sp. have been shown to occur on Guam with proportionately fewer numbers of *O. fullonia* eggs parasitized by this species during the dryer months. Such seasonal variability probably reflects the wasp's inability to tolerate dry conditions compared to the other two genera. Clear spatial differences in the relative effectiveness of each parasitoid have also been demonstrated in Micronesia. For example, *Telenomus* sp. and *Ooencyrtus* sp. are the most important egg parasitoids of both single eggs and egg masses on Guam, Rota, Tinian and Saipan. *Trichogramma* sp. predominates in Pohnpei and Kosrae.

Female wasps of all three species use their ovipositor to mark the host egg immediately after egg deposition. Such markings, whether physical or chemical, are recognized by the individual that made them and enable it to avoid parasitizing the same egg twice. Whether members of the same spe-

cies are able to detect and interpret one another's markings is unknown. Our laboratory observations suggest that they cannot. What does seem clear, however, is that such signals are not decipherable on an inter-specific level. Eggs in the field are frequently subject to attack by more than one species of wasp. In such cases the wasp species that initially parasitized the egg is usually the one that successfully develops. In the rare instance, when more than one species develop in the same egg, usually only one species successfully emerges.

Typically, eggs parasitized by *Trichogramma* sp. turn gray to black as the parasitoid develops, while those containing *Telenomus* sp. usually remain white and are covered with several small purplish rings (Plate 27). These rings may or may not be present on eggs parasitized by *Ooencyrtus* sp.

All three parasitoids require a development time of 10-12 days and can develop both in fertile and infertile *O. fullonia* eggs. Usually, only one individual of *Telenomus* sp. will emerge from a single egg, whereas 2-3 *Ooencyrtus* sp. individuals per egg are frequently encountered. As *Trichogramma* sp. is the smallest of the three wasp genera, 8-12 individuals per egg are typical, although as many as 18 have been observed.

Each parasite makes a characteristic emergence hole that allows identification of the parasitoid long after it has left the egg. On Guam, *Telenomus* sp. make a cleanly cut, circular hole 0.39-0.45 mm in diameter. In contrast, the emergence hole of *Ooencyrtus* sp. is ragged-edged and roughly circular, measuring 0.32-0.37 mm in diameter. There may frequently be more than one emergence hole per egg, and more than one wasp may use the same hole to escape. *Trichogramma* sp. makes a small, circular, finely serrated-edged hole 0.20-0.26 mm in diameter (Plate 31). Usually only a single emergence hole is cut, although two or more have occasionally been observed.

Female wasps are sexually mature when they emerge and immediately begin searching for new hosts. They mate within the host egg prior to emerging (*Trichogramma* sp.) or mate directly upon emergence (*Telenomus* sp., see Plate 32). They live for one or two months but, during that time, can parasitize literally hundreds of *O. fullonia* eggs. Male wasps, by comparison, survive only for a few days after emerging.

2. Egg Predators

Notable egg predators encountered in Micronesia are ants (Plate 33), and one or more unknown species of hemipteran bug. The ants detach whole eggs from *Erythrina* leaves and

carry them back to their nests for food, leaving little evidence of their activity. In contrast, eggs attacked by hemipteran bugs typically display a series of tears in the shell that radiate outwards from one or more penetration points (Plate 34).

The general absence of residual signs makes the quantification of ant egg foraging activities difficult. Preliminary studies on Guam suggest that mean egg losses due to ant predation may range from 10-30 percent of the total egg population. Ant impact on *O. fullonia* populations may, therefore, be highly significant. In comparison, hemipteran egg predators on Guam destroy around 3 percent of the total number of eggs laid at any one time. Their impact on moth populations elsewhere in Micronesia is not known. Limited field observations have shown considerable inter-island differences in bug predation levels ranging from <1 percent in Rota, Saipan and Pohnpei, to around 40 percent in Tinian.

3. Pupal Parasitoids

Although little information is available regarding the identity and effectiveness of pupal parasitoids of *O. fullonia* in Micronesia, the general consensus is that they constitute a relatively minor group of natural enemies in the western Pacific. Two pupal parasitoids have been identified on Guam, the euphorid wasp, *Trichospilus diatraeae* Cherian and Margabandhu (Plate 35), and the brachonid wasp *Brachymeria* sp. Unfortunately, neither are specific to *O. fullonia* and readily attack other lepidopteran pupae.

4. Larval Predators

Several known larval predators of *O. fullonia* in Micronesia include the hornet, *Polistes olivaceus* (De Geer), the praying mantis, *Hierodula patellifera* (Serville) (also attacks adult moths, see Plate 36), and a variety of birds. However, their general impact on *O. fullonia* populations throughout the region is not known.

Pericyma cruegeri (Butler)

Pericyma cruegeri is a native of Malaysia and is distributed throughout Southeast Asia, Papua New Guinea and Northern Australia. Its Micronesian distribution is limited to Guam, Rota and Palau. It also occurs on Kauai in the Hawaiian Islands. *P. cruegeri* is a relatively small moth with a wingspan measuring a little under 4.5 cm (Plate 37). Commonly known as the poinciana looper, *P. cruegeri* was first observed on Guam in July 1971 and is thought to have been accidentally introduced to the island during the late 1960s.

Host Plants

As its common name suggests, the larvae of *P. cruegeri* feed on the foliage of poinciana trees, specifically the royal poinciana tree, *Delonix regia* (Bojer) Rafinesque, and the yellow poinciana tree, *Peltophorum pterocarpum* (DC) Backer. They also feed on another local leguminous plant, *Prosopis insularum* (Guillume) Bret. (= *Leucaena insularum* var. *guamensis* Fosberg and Stone). On Guam, royal poinciana trees, or "flame" trees as they are called, appear to be the preferred larval host plant. Annual population explosions of *P. cruegeri* during the rainy season result in the severe defoliation of these magnificent trees over much of the island (Plates 38). After defoliating the trees, the larvae spin down from the branches on silken threads. Thousands of larvae may be seen crawling underneath and near the trees search-

ing for food. On Guam, many royal poinciana trees have been cut down by people who dislike *P. cruegeri* larvae crawling in their yards.

Royal poinciana trees flower from March to May in Micronesia and are a spectacular sight (Plate 39). Flower production is severely curtailed in trees repeatedly defoliated by *P. cruegeri* larvae during the previous wet season. In extreme cases, no flowers are produced at all.

Pest Status

Until quite recently, the fruit-piercing capability of the adult moth was unknown and only the larvae were considered pests. We now know that both larvae and adults are problematic. Adult *P. cruegeri* are abundant on Guam during the wet season. They cause severe damage to soft fruits, including banana, papaya and guava, by virtue of sheer numbers alone (Plates 40-42). We have often observed 10-20 foraging adults on a single guava fruit, far more than ever seen for any other fruit-piercing species found on Guam. Fortunately, outbreaks of this moth are highly seasonal and occur only during the mid to late wet season. Climate plays a major role in controlling the species, which does poorly during dry weather. However, at the peak of its abundance the damage caused by larvae and adults places this species among the most serious insect pests on Guam and a major pest in Rota and Palau. Its presence has yet to be confirmed on any other Micronesian Island.

Adult Food Preference

The adult food preferences of *P. cruegeri* have yet to be studied. There is little doubt, however, that this moth is capable of inflicting damage to a wide variety of fruits. Its highly sclerotized proboscis is heavily armed with tearing hooks and stout bristles rendering even tough-skinned fruits like citrus and pomegranate susceptible to attack (Plate 44).

Life Cycle

Female *P. cruegeri* lay their eggs at night on the leaflets of tender leaves. The eggs are semispherical and range from yellowish green to bluish green in color. They hatch 2-3 days after being laid. The new larvae are yellow in color and about 3.1 mm long. As with most noctuids, the first two pairs of abdominal legs are atrophied. Consequently the larvae move in a characteristic "looping" fashion and are sometimes referred to as "semiloopers" as opposed to "true loopers" (geometrids) which lack the first three pairs of abdominal legs.

The duration of the first and second instar stage is 5-6 days and 3-4 days, respectively. Second instar larvae are dark green in color with black dots on the body. The head ranges from yellow to orange in color. Third instar larvae are light green with grey and white longitudinal lines on the body. The head is orange with a dorso-median yellow patch. Fourth instar larvae are light green with five white dorsal and two black lateral longitudinal lines. Both third and fourth instars require 4-6 days to develop. The duration of the fifth instar is a little longer and ranges from 9-11 days. Larvae at this stage of development can vary from green to dark brown in color (Plate 45).

Pupation takes place on leaves with cocoons constructed out of leaflets and the rachis. Pupae are chocolate colored and often coated with a layer of thin white wax. The adult moth emerges from the pupa after a development time of 9-12 days.

Control Measures

No pesticides have been registered for the control of *P. cruegeri* on Guam. However, the larvae can be effectively controlled on small poinciana trees by spraying with biological pesticides prepared from *Bacillus thuringiensis* Berliner. On larger trees, the operation is more prohibitive in terms of cost and effort. Many local gardeners prefer to remove affected trees rather than repeatedly spray them. Such measures have little to no impact to the general population because of the abundance and widespread distribution of host trees throughout Guam. There is no effective way of controlling the species by mechanical means short of removing all host trees.

Natural Enemies

Little is known about the natural enemies of *P. cruegeri*. It appears to be relatively free from egg parasitoids throughout its range. On Guam, we have observed low rates of attack by three pupal parasitoids: the tachinid fly, *Exorista* (= *civiloides*) *xanthaspis* Wiedemann, an ichneumonid wasp, *Echthromorpha* sp., and the braconid wasp, *Brachymeria lasus* (Walker). Larval predators include the praying mantis, *H. patellifera*, the pentatomid bug, *Eocanthecona furcellata* (Wolff), and the mud dauber, *Delta* sp. However, none of these natural enemies appears to be very effective. Climate remains the dominant factor controlling population outbreaks of this species on Guam.

Platyja umminia (Cramer) and Ercheia dubia (Butler)

The primary fruit-piercing moths, *Platyja umminia* and *Ercheia dubia*, are natives of Southeast Asia (Plates 46-47). However, their geographic ranges are not yet described. The distribution of *P. umminia* within Micronesia appears to be limited to Guam at present, whereas *E. dubia* also occurs on Rota, Tinian and Saipan.

Both species are relatively recent introductions to Guam and were first noted in 1988 and 1989, respectively. Although they are both relatively common on the island during the wet season, we know very little of their biology and their

larval host plants have yet to be discovered. Similarly, there is no information on the identity and effectiveness of their natural enemies.

Preliminary field observations suggest that both moths have the potential to become major pests of Guam's fruit crops. *P. umminia* is the larger and more powerful of the two moths, and may well cover large distances between foraging excursions. Both species possess a heavily sclerotized, spear-like proboscis, the edges of which are smooth in *P. umminia* and serrated in *E. dubia* (Plates 48-49). However, both lack the barbs, hooks and spines that characterize the proboscis of *O. fullonia* and *P. cruegeri*.

Secondary Fruit-Piercing Moths

The known species of secondary fruit-piercing moths within Micronesia outnumber primary fruit-piercing moths by a little over four to one (Table 3, Plates 50-58). Their distribution and abundance throughout the region varies both between species and between islands. Among the most common and widespread species are *Achaea janata* (L.) and *Anomis flava* (Fabr.). The larvae of both species are polyphagous, an adaptation that favors their survival and proliferation in new environments. Larval host plants for many of the remaining secondary fruit-piercing species listed in Table 3 are unknown at this time.

Several species of secondary fruit-piercing moths possess relatively elaborate arrangements of hairs and bristles on the proboscis that suggest specialized feeding habits. In contrast, other species have a relatively simple, undifferentiated proboscis implying a more opportunistic way of life. The latter are most likely nectar feeders and probably do

little more than suck cellular sap from tissues previously damaged by their more specialized relatives. Examples of both are shown in Plates 59-68.

Among the more specialized feeders are *Ophiusa coronata* (Fabr.) and *Dysogonia absentimacula* (Guenee). The tip of the proboscis in each of these species is spatulate shaped and dorsally covered with a dense array of short, stout bristles resembling a long-handled scrubbing brush (Plates 59-60). Although such a design allows the moths to macerate fruit tissues in preexisting puncture wounds, it has no penetrating capability. The proboscis of *A. flava*, on the other hand, possesses a dense arrangement of relatively long hairs along much of its length, plus what appear to be rudimentary lateral spines along the distal portion of the shaft (Plate 65). This species may have primary fruit-piercing capability, at least for very soft-skinned fruits.

Future Research Needs

Clearly, fruit-piercing moths are serious pests throughout much of Micronesia and have greatly hindered the commercial development of tropical fruit production within the region. Currently, *O. fullonaria* is one of the most troublesome and widespread species. Indeed, it ranks among the top ten most serious pests of the Pacific region. However, over the last few decades there has been a steady influx of other fruit-piercing moth species into the area possessing similar fruit damaging potential. On Guam, two new species have established in the past ten years. Other species will likely follow given the intensity of trade and travel between Guam and Asia, and the diversity of primary fruit-piercing species that are known from neighboring countries such as India, Thailand, and Japan. It is therefore imperative that research on effective means of managing these pests be conducted and supported financially by both local and federal governments.

While there is seldom a single method of effective pest control for many pest species, biological control using host-specific natural enemies has met with considerable success in many areas of the world. Such biological solutions to biological problems are non-labor intensive and highly cost-effective in terms of long-term potential and benefits. For these reasons, we recommend that research at the University of Guam continues to focus on biological control as a primary means of controlling fruit-piercing moths throughout the region.

On Guam, the natural enemies of *O. fullonaria* substan-

tially reduce the number of egg laying adults that reach maturity. The egg parasitoids alone cause about 85 percent egg mortality in this species. This notwithstanding, the surviving adult moth population remains high enough to cause significant damage to locally grown fruits and vegetables throughout the island. Additional biological and cultural control measures are therefore warranted to augment and improve the effectiveness of existing natural enemies on Guam and throughout Micronesia.

With this in mind, the Entomology Unit within the College of Agriculture and Life Sciences at the University of Guam is focusing its attention on potentially useful larval-pupal parasitoids from other parts of the world. Plans are currently underway to introduce the host-specific euphorid wasp, *Euplectrus maternus* Bhatnagar, from India to Guam. The efficacy of this larval parasitoid in its native lands is very encouraging. Consequently, there is every good reason to believe that it will make a significant contribution to the control of *O. fullonaria* on Guam once it has become established. This program of research is financially supported by a Tropical and Subtropical Agricultural Research award, under the jurisdiction of the Cooperative State Research, Education and Extension Service (CSREES) division of the USDA.

Additional studies are also required to identify and evaluate the natural enemies of the other three species of primary

Table 3: Fruit-Piercing Moths of Micronesia

SPECIES	LARGEST RECORDED WINGSPAN (cm)	ISLAND ¹	KNOWN MICRONESIAN LARVAL HOST PLANTS
Primary			
<i>Ercheia dubia</i> (Butler)	4.0	G, R, T, S	?
<i>Othreis fullonia</i> (Clerck)	9.5	G, R, T, S, P, Po	<i>Erythrina</i> spp.
<i>Pericyma cruegeri</i> (Butler)	4.4	G, R, P	flame tree, yellow poinciana
<i>Platyja umminia</i> (Cramer) ^a	5.8 (♀) - 6.6 (♂)	G	?
Secondary			
<i>Achaea janata</i> (L.)	5.5	G, R, T, S, P, Po	castor, rose spp., crotons
<i>Achaea serva</i> (Fabr.) ^a	5.6 (♀) - 6.8 (♂)	G, T, P	sapota (chiku)
<i>Anomis flava</i> (Fabr.)	3.3	G, R, T, S, P, Po	okra, hibiscus spp.
<i>Anua tongaensis</i> Hampson	7.1	G, T	?
<i>Crysopera combinulus</i> (Walker) ^b	4.3	G	?
<i>Dysogonia absentimacula</i> (Guenee)	4.6	G	eba
<i>Ericeia inangulata</i> (Guenee) ^b	4.7	G, T, Po	?
<i>Grammodes geometrica</i> (Fabr.) ^b	4.3	G, T, S	?
<i>Hulodes caranea</i> (Cramer) ^b	7.9	G, T, P	?
<i>Mocis frugalis</i> (Fabr.) ^b	4.2	G, T, S, P, Po	grasses
<i>Mocis undata</i> (Fabr.) ^b	4.2	G, T, P, Po	?
<i>Ophiusa coronata</i> (Fabr.)	9.2	G, T	guava, Indian almond
<i>Parallelia palumba</i> (Guenee)	3.5	G	?
<i>Platysenta illecta</i> (Walker) ^b	3.3	G, T	
<i>Polydesma boarmoides</i> (Guenee) ^b	4.3	G, T, Po	?
<i>Sericia</i> sp. ^b	7.6	G, P	?
<i>Spodoptera litura</i> (Fabr.) ^b	3.9	G, R, T, S, P, Po	cabbage, other vegetables
<i>Spodoptera mauritia</i> (Boisuval) ^b	3.4	G, R, T, S, P, Po	turf-grasses
<i>Thyas regia</i> (Lucas)	9.2	G, R, T, S, Po	?

¹G = Guam, R = Rota, T = Tinian, S = Saipan, P = Palau, Po = Pohnpei.

a = sexual dimorphism apparent; b = proboscis relatively simple and undifferentiated

fruit-piercing moths currently found within Micronesia. The flame tree looper, *P. cruegeri*, is a particularly deserving candidate for further research considering the widespread damage it causes to fruits, vegetables, and ornamentals at certain times of the year. Attention should be directed towards the native habitats of this Southeast Asian species in view of the total absence of effective biocontrol agents on Guam.

The two most recent arrivals to Guam, *P. umminia* and *E. dubia*, are especially interesting because of the lack of published information on their natural enemies, life cycles,

and larval host plants. In addition, almost nothing is known about their population dynamics, food preferences, or the extent of the damage caused by each species on Guam and on other Micronesian islands. Gaining further knowledge about the biology of these pests is an essential prerequisite to the development of any future biological control program.

Successfully controlling primary fruit-piercing moths within Micronesia will improve the economic potential of tropical fruit production in the region. Indirectly, it may also improve yields of crops that serve as larval host plants for

various secondary fruit-piercing moths found in the area (Table 3). The rationale for this is that secondary fruit-piercing moths rely heavily on the puncture wounds inflicted by their primary counterparts to gain access to the fleshy interior of soft fruits and vegetables. A reduction in primary fruit-piercing moth populations would restrict the availability of

this nutritional source to secondary fruit-piercing species. This may result in lowered egg production and reduced fecundity in members of the latter group. Thus, a decline in populations of primary fruit-piercing moth may well precipitate a concomitant decrease in the abundance and pest status of several secondary fruit-piercing species.

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