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Contemporary Hawaiian Insect Fauna of a Lowland Agricultural Area on Kaua'i: Implications for Local and Island-wide Fruit Fly Eradication Programs[1]

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ABSTRACT: We sampled the insect fauna of a 900-ha, lowland agricultural area on the northeast shore of Kaua'i to identify native and beneficial species that could be potentially impacted by USDA fruit fly control measures. Of the 283 species currently identified, only 24 species (< 10%) are endemic to Hawai'i, and most of these are common species occurring on all the major islands. Stream and riparian systems, more than any other habitat, appear to still harbor the greatest number of endemic species. Lack of adequate taxonomic and distributional information for some species presents a major obstacle in the development of safe eradication technologies in lowland agricultural areas. Twenty-five species represent biological control agents purposefully introduced to suppress noxious pests, and numerous other inadvertent immigrants functioning as predators, pollinators, and in nutrient recycling should also be considered in any impact assessment. This survey suggests that the expansion of control measures to other agricultural areas and different habitats should consider the likely presence and potential impact on endemic species.

THE HAWAIIAN INSECT fauna is characterized by two distinct patterns: (1) remarkable phylogenetic and ecological diversification in geologic time, and (2) unusually large numbers of alien species acquired in the recent past (Howarth 1990). Our current understanding of the relationship between these two patterns exists only at the regional level, with an estimated 20–32% of the fauna of Hawai'i composed of alien species (Zimmerman 1948*a*, Howarth 1990) compared with only 1–2% of the North American fauna (Sailer 1978, Danks 1988), as a continental example. This diversity of both native and alien species makes the conservation of Hawaiian insects a most critical and challenging issue (Howarth 1985, Stone and Stone 1989).

The local, lowland insect communities in Hawai'i have been shaped predominantly by agricultural practices, including patterns of land use, pesticide application, and importation of biological control agents (Gagné 1988). Future agricultural activities, particularly efforts to suppress or eradicate certain pest species, should consider the composition of the local insect fauna and address the potential impacts on the native biota. Recently, a 4-yr pilot project to evaluate preharvest control procedures for fruit flies in Hawai'i has been implemented by the USDA-ARS (USDA 1989). Four control methods, (1) sanitation, (2) corn-border sprays with malathion bait, (3) male annihilation with attractants and bait sprays, and (4) parasitoid release, are aimed at reducing or eliminating infestation levels in a papaya production center along the northeast side of the island of Kaua'i. A requisite for evaluating the effects of these control procedures on insects other than the target fruit flies is a knowledge of the entomofauna of the study area, particularly beneficial and native species.

An arthropod survey of this USDA study area was conducted to gather baseline information on the presence and distribution of nontarget arthropods that might be impacted by the fruit fly control procedures. In this

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paper, we present the results of the survey and discuss the endemic Hawaiian species and beneficial insects observed to occur in the study area and the implications for both a local and island-wide eradication program.

MATERIALS AND METHODS

Study Area

The study site, Moloa'a, is a 900-ha agricultural area on the northeast side of Kaua'i (Figure 1). Elevations range from sea level, where it is bounded by the Pacific Ocean along the coast, to 150 m, along the Moloa'a Forest Reserve in the Anahola Mountains inland. Mean temperatures range from ca. 20°C (January) to 26°C (August), and monthly rainfall ranges from 1 cm (June) to 18 cm (December) (Armstrong 1983).

This area is predominately old sugarcane and pineapple fields and is presently used primarily for ranching and crop cultivation, with ca. 100 ha of papaya (*Carica papaya* L.), eggplant (*Solanum melongena* L.), watermelon (*Citrullus lantanus* (Thund.) Matsum. & Nakai), cucumber (*Cucumis sativus* L.), and tomato (*Lycopersicum esculentum* Miller) (USDA 1989).

With the exception of ferns and beach-strand vegetation, there are very few native plants in the study area. The coastal area is bounded by a 100- to 200-m belt of alien ironwood (*Casuarina equisetifolia* L.), and riparian areas are dominated by strawberry guava (*Psidium cattleianum* L.) and Java plum (*Syzygium cumini* (L.)). Lantana (*Lantana camara* L.), cats-claw (*Caesalpinia decapetala* (Roth)), Brazilian pepper (*Schinus terebinthifolius* Raddi) and koa haole (*Leucaena leucocephala* (Lam.) de Wit) is the predominant alien vegetation in fallow fields. Two streams, Moloa'a and Pāpa'a, traverse the study area for 6.4–8.0 km and have their headwaters at between 180 and 300 m in elevation in the Anahola Mountains. Vegetation along the banks of these streams includes sensitive plant (*Mimosa pudica* L.), basket grass (*Oplismenus hirtellus* (L.)), napier grass (*Pennisetum purpureum* Schumach.), and honohono (*Commelina diffusa* Burm.), all alien species.

Ten sampling stations were established covering all major vegetation zones, including upland and lowland guava forest, the coastal ironwood zone, abandoned fields, and cultivated fields. At each of these stations, arthropods were sampled using the following collecting methods: pitfall traps, malaise traps, yellow-pan traps, bait traps, light traps, and Berlese funnels. In addition to these stationary traps, ca. 250 hr were spent manually sampling all vegetation zones using sweep nets, beating sheets, and visual inspection of the plants and substrates. Several microhabitats were also sampled separately, including streams, stagnant pools, dung, carrion, and fungi.

Representative specimens of all species were curated and identified and are housed in a permanent collection at the Kaua'i Agricultural Experimental Station.

RESULTS

To date, 283 species of insects have been identified from the Moloa'a samples (Appendix). This does not represent the total number actually collected, however, because an additional 30–40 species, primarily Thysanoptera, sternorrhynchus Homoptera, and Microlepidoptera have not been identified. All of these groups have at least some genera with endemic species that potentially occur in the study area. An additional 20–30 noninsect arthropods (arachnids, millipedes, centipedes, amphipods, and isopods) with potentially native species also await identification and are not dealt with in this paper.

This survey was not intended to be exhaustive, thus the list we present is only a representative sample. For example, although Lepidoptera is probably the most diverse group in the study area, it represents only 10% of the total number of species collected and identified. Even among the species-poor, ground-inhabiting fauna, the number of species per collecting effort probably did not

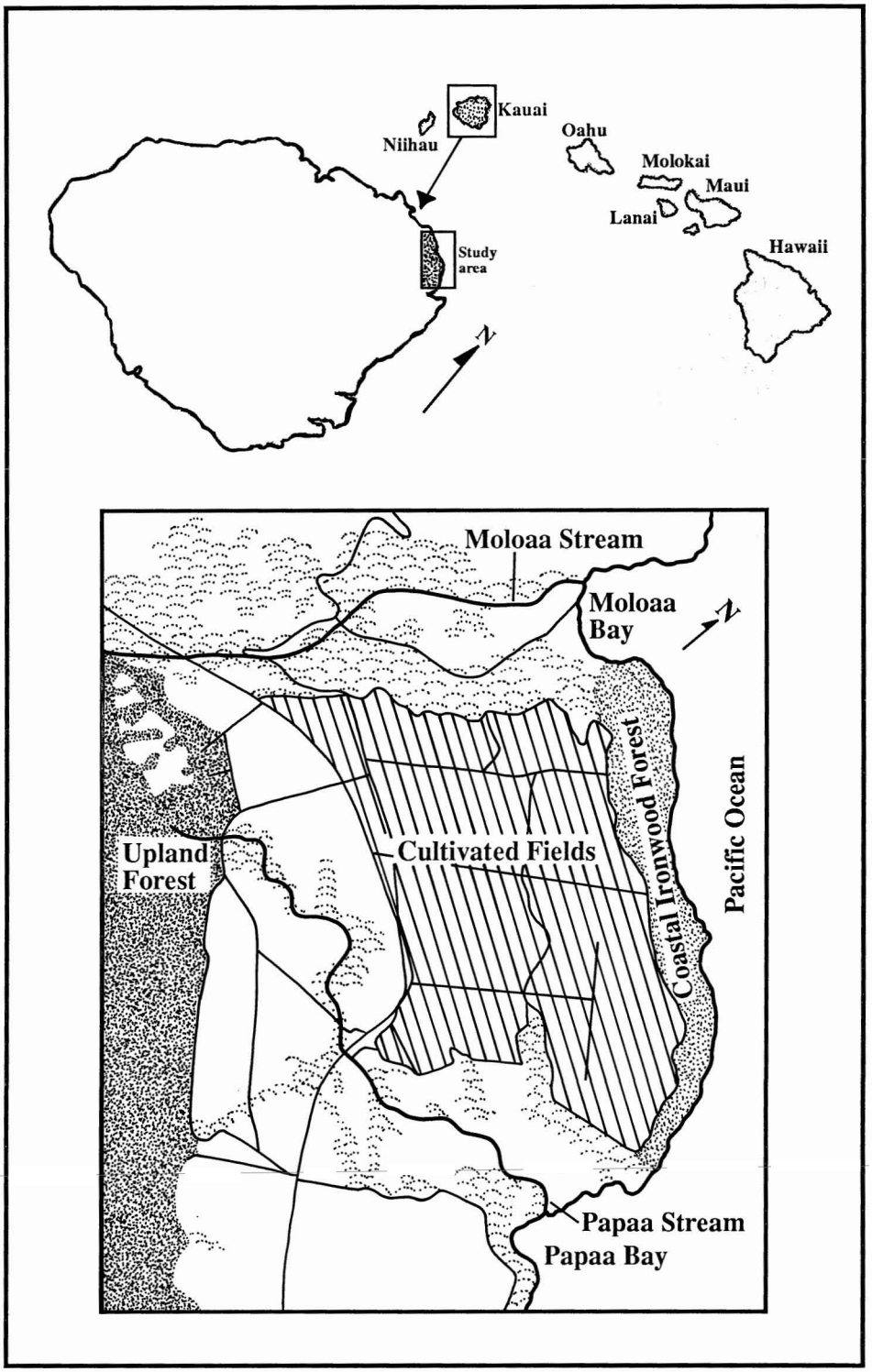

FIGURE 1. Location and map of Moloa'a study area, showing major habitat types.

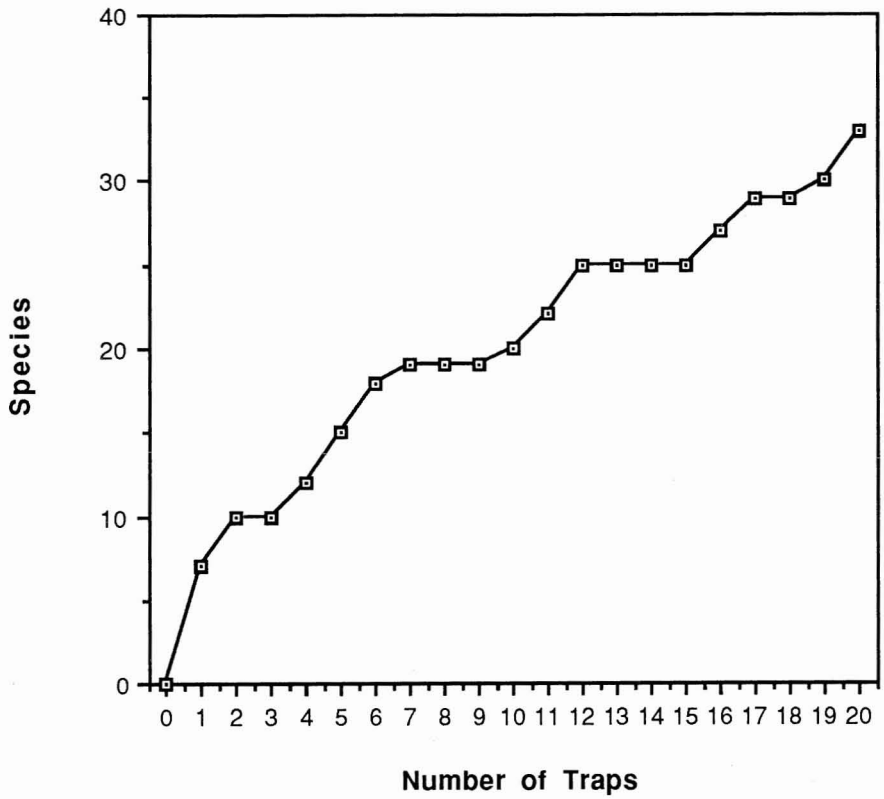

FIGURE 2. Cumulative number of ground-inhabiting arthropods in cultivated and fallow fields in Moloa'a, in relation to the number of pitfall traps set.

reach an asymptote at the end of the sampling period (Figure 2). In addition, there is undoubtedly a seasonal change in species composition, and opportunistic collecting during the year after the survey indeed produced numerous additional species, particularly Lepidoptera. Despite these caveats, however, the survey provided critical information on the occurrence of native and beneficial species potentially affected by the testing in the study area.

Endemic Species

The great majority (>90%) of species collected were not endemic to Hawai'i (Figure 3). We do not anticipate this proportion to change substantially with the identification of the remaining material or additional collecting. Twenty-four endemic species in six orders and 15 families were collected from the Moloa'a study area:

1. *Forcipomyia hardyi* Wirth & Howarth Diptera: Ceratopogonidae

This species is common on all the islands at elevations up to 1200 m (Wirth and Howarth 1982). It breeds in a variety of moist habitats, including the bases of cabbage plants and wet leaves and trash on the forest floor (Williams 1944, Hardy 1960). This was the most common endemic insect collected in the survey and was abundant (>1000 specimens) in some samples from crop fields. Wirth and Howarth (1982) pointed out the importance of related species in the pollination of some tropical crop plants and suggested that *F. hardyi* may be involved with the pollination of native composites as well as mangoes and other alien plants.

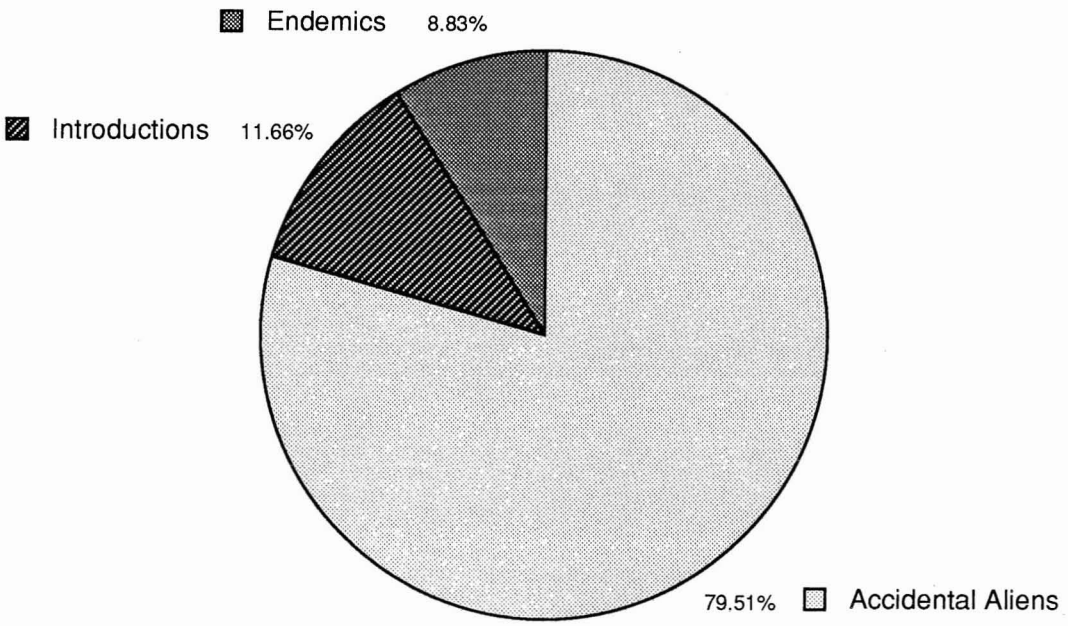

FIGURE 3. Proportions of 283 species identified from Moloa'a, in three categories: endemic, purposefully introduced beneficials, and accidental aliens.

2. *Forcipomyia brevis* (Johannsen) Diptera: Ceratopogonidae

This species has been recorded previously only from O'ahu and Lana'i, but probably occurs on all the islands (Hardy 1960). Illingworth (1929, 1934) found the larvae of *F. brevis* abundant in the axils of pineapple leaves, where they feed on accumulated organic matter. This species appeared frequently (> 500 specimens) in several trapping stations in Moloa'a.

3. *Limonia hawaiiensis* (Grimshaw) Diptera: Tipulidae

This species is very common in the lowlands on all the major islands (Hardy 1960). Nothing is known of its breeding habits and although we found no direct evidence that it breeds in the Moloa'a area, the abundance of specimens (> 50) in malaise traps suggests that it does.

4. *Limonia stygipennis* (Alexander) Diptera: Tipulidae

This is one of the most common crane flies along mountain streams on all the major islands (Hardy 1960). A single specimen was collected in a malaise trap along Pāpa'a stream.

5. *Limonia kauaiensis* (Grimshaw) Diptera: Tipulidae

This is also a common species in the mountains on all the major islands (Hardy 1960). *Limonia kauaiensis* is unique among crane flies in that the larvae are leaf miners. It has been reared from *Cyrtandra* spp. (Swezey 1915). Less than 10 specimens were collected from malaise traps along Moloa'a and Pāpa'a streams.

6. *Paraphrosylus acrosticalis* (Parent) Diptera: Dolichopodidae

This species occurs along the seashore on most of the major islands, but nothing else is known of its biology (Hardy 1964). Half a dozen specimens were collected in yellow-pan traps placed near the beach in Moloa'a Bay.

7. *Medetera atrata* Van Duzee Diptera: Dolichopodidae

This species was previously recorded only from O'ahu. Although nothing is known of

the Hawaiian species, elsewhere *Medetera* larvae live under bark as predators (Hardy 1964). A single specimen was collected in Moloa'a.

8. *Chrysotus pallidipalpus* Van Duzee Diptera: Dolichopodidae

Hardy (1964) noted that this is an abundant species in the lowlands on all the major islands. Nothing is known of its biology, and only two specimens were collected.

9. *Orthocladius* sp. nr. *williamsi* Diptera: Chironomidae

The related species *O. williamsi* is known from O'ahu and Hawai'i. Williams (1944) reared *O. williamsi* on felt-like algae and "wet trash"; nothing else is known about related species in Hawai'i. This species occurred in moderate numbers (ca. 20) during manual sampling and in yellow-pan traps in crop fields.

10. *Bradysia molokaiensis* (Grimshaw) Diptera: Sciaridae

This is the most common sciarid on all the major islands and is commonly attracted to lights in large numbers (Hardy 1960). Although nothing is known of the biology of *B. molokaiensis*, the larvae of this family commonly breed in decaying plant and animal matter and fungi, and some species in Hawai'i may be destructive to crop roots. This species was abundant (> 700 specimens) in light traps throughout the study area.

11. *Neoscatella kauaiensis* Wirth Diptera: Ephydridae

Found only on Kaua'i, this species is most abundant on algae-covered rocks in open, swift streams, although it is also found in slower waters (Hardy and Delfinado 1980). Several adults of this species were collected at a plunge pool in Moloa'a stream.

12. *Neoscatella cilipes* Wirth Diptera: Ephydridae

This species is found on all the major islands except Lana'i, and can be abundant in swift streams (Hardy and Delfinado 1980). The adults congregate around algae-covered rocks, where the eggs are laid and larvae develop. Both adults and larvae of *N. cilipes* were collected from Moloa'a stream.

13. *Celerio calida calida* (Butler) Lepidoptera: Sphingidae

This species is known from Kaua'i, O'ahu, and Moloka'i. It feeds on *Acacia koa*, *Bobea elatior*, *Coprosma*, *Gardenia*, *Metrosideros*, *Pelea*, and *Scaevola* (Zimmerman 1958*a*). Several specimens were collected from light traps set in stream gulches, but it is doubtful that this species breeds in Moloa'a.

14. *Hyposmocoma* sp. nr. *saccophora* Walsingham Lepidoptera: Cosmopterigidae

Larvae of an unidentified species of *Hyposmocoma* were collected from rocks in both Moloa'a and Pāpa'a streams. This genus contains over 350 endemic species in the Hawaiian Islands, with several species still abundant even in disturbed, lowland habitats (Zimmerman 1978). The larvae of *Hyposmocoma* occupy diverse habitats including rocks, bark, logs, lichens, leaves, and ferns. None of the 101 species from Kaua'i whose habits are known occur on rocks; however, the cases of the larvae from Moloa'a are similar to those of *Hyposmocoma saccophora* Walsingham from O'ahu, which is found on rocks (Zimmerman 1978) possibly in streams (Mitchell 1951). The specimens from the Moloa'a streams undoubtedly represent an undescribed species related to *H. saccophora*, possibly species no. 25 noted by Zimmerman (1978).

15. *Hyposmocoma* sp. A Lepidoptera: Cosmopterigidae

A single larva of different unidentified species was collected from a pitfall trap placed in a fallow field. The larva bore a soft case covered with debris, which places it in the subgenus *Hyposmocoma*, but more accurate identification is not possible.

16. *Megalagrion heterogamias* (Perkins) Odonata: Coenagrionidae

This species is found only on Kaua'i. Perkins (1913) found nymphs numerous among saturated, decaying leaves at the base

of a rock wall. A few adult specimens were collected along streams, but breeding in Moloa'a is unconfirmed.

17. *Megalagrion vagabundum* (Perkins) Odonata: Coenagrionidae

This species is also a Kaua'i endemic, and Perkins (1913) found it widespread in the mountains. Several adults were collected, and we found nymphs of what may be this species among the moss on boulders in Pāpa'a stream.

18. *Saldula exulans* (White) Heteroptera: Saldidae

This is the most common Hawaiian saldid species and occurs on all major islands. Cobben (1980) noted that it occurs in a variety of habitats at both high and low elevations. In Moloa'a, however, this species is restricted to boulders in the middle of streams. *Saldula exulans* is a generalist predator as both nymph and adult, and adults are usually flightless. Both nymphs and adults were collected, indicating that this species does indeed breed in Moloa'a.

19. *Nysius kinbergi* Usinger Heteroptera: Lygaeidae

This species is common on most of the major islands. In the lowlands it breeds principally on *Erigeron canadensis* (Beardsley 1977), but it has also been collected on *Euphorbia*, *Dubautia*, *Amaranthus*, *Geranium*, and *Dodonaea* (Usinger 1942). A series of eight individuals was collected from a pasture area, which suggests a breeding population in Moloa'a.

20. *Microvelia vagans* White Heteroptera: Veliidae

This is an extremely common predatory species occurring on all the major islands (Zimmerman 1948*c*). Both nymphs and adults were collected from the surface of stagnant pools and quiet eddies along streams in Moloa'a.

21. *Kilauella* sp. Psocoptera: Elipsocidae

The genus *Kilauella* Endlerlein is endemic to the Hawaiian Islands. Zimmerman (1948*b*) listed only seven species, and the genus has not been recorded from Kaua'i. Thornton (1981), however, in a preliminary review of the Hawaiian psocid fauna, indicated that there are 145 species of *Kilauella*. It is likely, then, that this represents one of these undescribed species. It was collected in small numbers, both nymphs and adults, from small trees of *Metrosideros polymorpha* growing along a road cut near Moloa'a stream.

22. *Psocus* sp. A Psocoptera: Psocidae
23. *Psocus* sp. B Psocoptera: Psocidae

Although *Psocus* is a cosmopolitan genus, Zimmerman (1948*b*) listed 14 endemic Hawaiian species, most known only from a single island. There is presently no key to the Hawaiian species, and Thornton (1981) indicated that there are at least 35 undescribed species, so we believe that assigning names to the specimens from the study area is not prudent.

The Psocoptera, in particular *Psocus*, are some of the most abundant native Hawaiian insects and are probably the principal prey for numerous endemic predators (Zimmerman 1948*b*). Small series (< 10 individuals) of both species were collected from *Metrosideros polymorpha*.

24. *Anisolabis eteronoma* Borelli Dermaptera: Carcinophoridae

Although Zimmerman (1948*b*) listed this species as an immigrant, *A. eteronoma* is now considered to be endemic to the Hawaiian Islands (Brindle 1981). It is known from all the major islands except Moloka'i and Lāna'i and has been taken under logs, cow dung, and in leaf litter under mango trees (Brindle 1981). Six adult specimens were collected from pitfall traps in riparian areas in Moloa'a.

We reiterate that these endemics represent only a sample, and there are conspicuous absences. For example, the coconut leafroller, *Hedylepta blackburni* (Butler) (Lepidoptera: Pyralidae), although a native, feeds on introduced palms and can be so abundant as to be pestiferous (Zimmerman 1958*b*). Species in another pyralid genus, *Mestolobes*, are commonly collected in lowlands, although their larval habits are completely unknown

(Zimmerman 1958*b*). Clearly, additional collecting would produce additional endemic species. This is exemplified by the fact that nearly a year after the completion of the survey an undescribed species of plant bug in the genus *Cyrtopeltis* (Heteroptera: Miridae) was discovered on beach naupaka (*Scaevola sericea*) in the study area (Asquith 1993).

DISCUSSION

Conventional wisdom among many Hawai'i entomologists is that below 600 m elevation, there are few native insects remaining. Our survey seems to support that view, although the more than 24 species collected during our survey show that at least some native taxa have survived or recolonized lowland areas. Unfortunately, there are no adjacent, undisturbed lowland areas with which to compare Moloa'a, but undoubtedly there were once many more than 24 species of native insects inhabiting lowlands on windward Kaua'i than there are now.

Abundant anecdotal evidence suggests that the loss of native species in the lowlands has been accelerated during historical times, in large part because of the land use and pest control methods of agriculture, both Polynesian and European. The historical monocultures of sugarcane and pineapple did not entirely preclude native insects, however. Williams (1931) listed at least 25 native species commonly collected in sugarcane fields in the early 1900s. At that time, however, agricultural fields were commonly adjacent to native forests, whereas Moloa'a is today buffered from native forest by a wide zone of guava and other exotics, making the recolonization of the area by native insects more difficult.

Despite this buffer zone, however, there is clearly some exchange between the native vegetation in the Anahola Mountains and the Moloa'a study area. Several of the native species, such as *Celerio calida calida* and *Limonia kauaiensis*, for example, are clearly transients, because they require certain host plants that do not occur in Moloa'a. Both these species were found only in riparian areas, and it is likely that the stream valleys act as conduits for the movement of species such as these from higher elevations into the agricultural area. Even some of the resident aquatic insects in the lower reaches of the streams have likely recolonized those areas in historic times after the decline of the agricultural monocultures. On the other hand, the occurrence of flightless, ground-inhabiting species such as the earwig *Anisolabis eteronoma* suggests that some terrestrial endemics have maintained viable populations in the lowlands.

In addition to corridors for movement, nine of the 24 endemics are associated with the streams. Hawaiian streams have a particularly small aquatic fauna and any impact on aquatic species is likely to have a disproportionately large effect on the community compared to the terrestrial system. In addition to the importance of stream species as unique entities, their role as food for the four species of endemic fish in Moloa'a is unknown, yet it should also be considered (Timbol et al. 1990).

Many of the nonaquatic species require certain host plants that are typical of higher-elevation forest. The three species of Psocoptera, for example, all had breeding populations on a few individuals of *Metrosideros polymorpha* growing in the study area. Although this native tree is common and often the dominant species at elevations from sea level to 2500 m, its native insect fauna varies with elevation. Although alien insects, particularly ants, may usurp native species, Gagné (1979) found few *Metrosideros*-specific endemic insects on trees near sea level. This suggests that some species may be at the lower limit of their natural elevational distribution in Moloa'a, regardless of the condition of current habitat.

If fruit fly eradication proceeds in Hawai'i, it is likely to be integrated and flexible, with different technologies used in lowland agricultural areas and in more pristine, high-elevation rainforest (USDA 1985). Agricultural environments could receive the harsher technologies such as aerial application of insecticides because of the high density of fruit flies and the perceived low impact on nontarget arthropods. Our survey, however, demonstrates the potential for large numbers of

endemic species to exist in these areas. Indeed, there are numerous endemic genera that are restricted to lowlands, and most Hawaiian insects currently considered to be in danger of extinction are lowland species that survive in small pockets of suitable habitats (Gagné 1988, Howarth 1990). As feasibility testing continues on Kaua'i, lowland agricultural and urban centers should not be considered low-impact areas without first determining the composition of their insect communities.

Introduced Beneficial Species

The Moloa'a study area is typical of many lowland agricultural ecosystems in Hawai'i in that most of the native species have been eliminated or displaced. Most environmental assessments in the state concentrate on these threatened native species; however, many *introduced* arthropod species also have critical functional roles to play in the maintenance of ecological stability. It is important to document the distribution, abundance, and possible susceptibility of these nonnative species as well as the endemics in examining possible impacts of fruit fly control measures.

POLLINATORS. Although flies, beetles, and many other kinds of insects may be involved in plant pollination, the European honey bee (*Apis mellifera* L.) is probably the most efficient general pollinator and is manipulated for this purpose in agricultural systems throughout the world. At Moloa'a, there are at least two apiaries containing managed honey bee hives and probably several feral colonies as well. Crops grown in or near Moloa'a that are known to benefit from honey bee pollination include avocado, carambola, citrus, coconut, cucumber, guava, lychee, loquat, mango, melons, papaya, and squash.

BIOLOGICAL CONTROL AGENTS. Hawai'i has been at the forefront of biological control for over a century, and many species have been introduced to the state from around the world to help control noxious pests. At least 25 control agents have been found in Moloa'a (Figure 3; Appendix), including predators and parasitoids of major Hawaiian agricultural pests (e.g., aphids, scales, leafhoppers, and others), herbivores that feed on weeds (such as lantana), and scarab beetles that help reduce dung fly populations. In addition to the purposefully introduced species, numerous other inadvertent immigrants function in similar roles.

DETRITIVORES. These species are essential for the breakdown of plant and animal refuse and the recycling of nutrients in both aquatic and terrestrial systems. The ground-inhabiting isopods, amphipods, millipedes, and Collembola in Moloa'a all appear to be immigrants and some attain phenomonally large populations. In the absence of the native ecological equivalents, these immigrants play important roles in the decomposition process. The taxonomy and habits of these species are poorly understood and the potential impact of eradication technologies on this functional group has been completely ignored.

FOOD WEB COMPONENTS. Insects and other arthropods often function as the primary food source for consumers at higher trophic levels. Endemic species of fish, a bat, and indigenous birds occur in Moloa'a, some of which are opportunistically or exclusively insectivorous. Diet breadth and selectivity of none of these species are known, and the availability of some insects may be critical for their survival. In addition, the possible consumption of poisoned prey, both fruit flies and nontargets, needs to be addressed.

CONCLUSIONS AND SUGGESTIONS

Moloa'a, with a long history of intensive agricultural use, clearly contains a predominately nonnative insect fauna. There is little information available on the composition of lowland insect faunas in Hawai'i, but areas at higher elevation, adjacent to, or containing more native vegetation, certainly have greater proportions of endemic species (Mueller-Dombois et al. 1981, Takara et al. 1983). From this perspective, then, eradication techniques in Moloa'a and similar agricultural areas are not as likely to affect large numbers of endemic species as would similar measures in a less-managed area.

The majority of the endemic Hawaiian insects that do occur in Moloa'a appear to be common in the lowlands throughout the islands. The fact that these species can utilize intensively managed areas that have included large-scale monocultures and heavy pesticide use does not suggest that they are particularly fragile species. It is unlikely that the eradication technologies presently being tested in Moloa'a will significantly affect these ubiquitous species. In addition, although half of the endemic species found were Diptera, there were no native Drosophilidae or Tephritidae, the two groups most likely to be impacted by the attractants used in male annihilation and parasite release. Preliminary observations indeed suggest that none of the endemic species are attracted to the baits currently being used in the study area. In addition, only one species, *Forcipomyia hardyi*, was found to be killed during malathion corn-border spraying (Messing et al. in press).

The relatively small numbers of endemic species in no way indicate that Moloa'a is not susceptible to impact by eradication technologies, however. On the contrary, some of the species, such as *Orthocladius* sp. and *Hyposmocoma* sp., are probably undescribed, and the distribution of these species outside the Moloa'a area is virtually unknown. This should be of great concern, considering the extremely small ranges of some Hawaiian organisms (Zimmerman 1948*a*). The impact of eradication procedures on these species cannot be ascertained without a better understanding of their taxonomy and distributions.

The susceptibility of these endemic species to the specific technologies being tested and those proposed must be determined. The expansion of feasibility testing or implementation of eradication procedures outside the Moloa'a area, particularly if in different habitats, should include similar surveys, or at least intensive searches for endemic insects.

A large number of economically and ecologically important *introduced* beneficial arthropods occur also in Moloa'a. These species are vital to the continued agricultural productivity of the area, especially in terms of crop pollinators and biological control.

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APPENDIX

Insects Collected from Moloa'a Bay Study Area, Kaua'i, Hawai'i

B, beneficial species purposefully introduced as a control agent or pollinator; E, endemic to the Hawaiian Islands; I, indigenous to the Hawaiian Islands

Coleoptera	
Anthribidae	
Araecerus fasciculatus (De Geer)	
Exillus lepidus Jordan	
Mauia subnotatus (Boheman)	
Bostrichidae	
Xylothrips religiosa (Boisd.)	
Bruchidae	
Acanthoscelides obtectus (Say)	
Carabidae	
Selenophorus striatopunctatus Putzeys	
Cerambycidae	
Ceresium unicolor (F.)	
Curtomerus pilicornis (F.)	
Cyllene crinicornis (Chevrolet)	
Sybra alternans Weid.	
Chrysomelidae	
Chaetocnema confinis Crotch	
Diachus auratus (F.)	
Epitrix hirtipennis (Melsheimer)	
Octotoma scabripennis Guérin-Méneville	B
Coccinellidae	
Coccinella septempunctata L.	B
Coelophora inaequalis (F.)	B
Curinus coeruleus Mulsant	B
Diomus debilis (LeConte)	
Diomus notescens (Blackburn)	
Olla abdominalis (Say)	B
Colydidae	
Colobicus parilis Pascoe	
Cucujidae	
Cryptolestes pusillus (Schönherr)	
Cryptomorpha desjardiosi (Guérin-Méneville)	
Curculionidae	
Athesapeuta cyperi Marshall	B
Oxydema sp.	
Elateridae	
Conoderus exul (Sharp)	
Prodrasterius collaris (Candeze)	
Simodactylus cinnamomeus Boisduval	
Hydrophilidae	
Dactylosternum abdominalis F.	
Lyctidae	
Lyctus brunneus (Stephens)	
Mycetophagidae	
Litargus vestitus Sharp	
Nitidulidae	
Carpophilus dimidiatus (F.)	
Carpophilus hemipterus (L.)	
Haptoncus mundus Sharp	
Haptoncus ocularis (Fairmount)	
Macroura sp.	
Urophorus humeralis (F.)	
Scarabaeidae	
Adoretus sinicus Burmeister	
Aphodius lividus (Oliver)	
Copris incertus Say	B
Oniticellus militaris Laporte	B
Onthophagus gazella F.	B
Staphylinidae	
Cilea sp.	
Oxytelus sp.	
Philonthus discoideus (Gravenhorst)	
Philonthus longicornis Steph.	
Philonthus sp.	
Rugilus sp.	
Tenebrionidae	
Alphitobius lateralis (Boheman)	
Gonocephalum adpressiforme Kuszab	
Trogidae	
Trox suberosus F.	
Dermaptera	
Carcinophoridae	
Anisolabis eteronoma Borelli	E
Labiduridae	
Euborellia annulipes (Lucus)	
Labidura riparia (Pallas)	
Labiidae	
Sphingolabis hawaiiensis (Bormans)	
Dictyoptera	
Blaberidae	
Diploptera punctata (Eschscholtz)	
Blattellidae	
Blattella lituricollis (Walker)	
Lupparia notulata (Stål)	

Blattidae
Loboptera dimidiatipes (Bolivar)
Melanozosteria soror (Brunner)
Mantidae
Hierodula patellifera (Serville)

Diptera
Agromyzidae
Liriomyza brassicae (Riley)
Anthomyzidae
Mumetopia nigrimana (Coquillett)
Calliphoridae
Chrysomya megacephala (F.)
Chrysomya rufifacies (Macquart)
Canaceidae
Canaceoides angulatus Wirth
Ceratopogonidae
Forcipomyia brevis (Johannson) E
Forcipomyia hardyi Wirth & Howarth E
Chironomidae
Orthocladius sp. nr. *williamsi* E
Chloropidae
Gampsocera hardyi Kanmiya
Gaurax bicoloripes (Malloch)
Monochaetoscinella anonyma (Williston)
Rhodesiella elengantula (Becker)
Rhodesiella sauteri (Duda)
Semaranga dorsocentralis Becker
Culicidae
Culex quinquefasciatus Say
Dolichopodidae
Chrysoma globiferum Weidemann E
Chrysotus pallidipalpus Van Duzee E
Medetera atrata Van Duzee E
Paraphrosylus acrosticalis (Parent) E
Drosophilidae
Drosophila kikkawai Burla
Drosophila nasuta Lamb
Drosophila simulans Sturtevant
Drosophila sulfurigaster bilimbata Bezzi
Scaptomyza elmoi Takeda
Ephydridae
Donaceus nigronotatus Cresson
Neoscatella kauaiensis Wirth E
Neoscatella cilipes Wirth E
Lauxaniidae
Homoneura hawaiiensis (Grimshaw)
Homoneura unguiculata (Kertesz)
Lonchaeidae
Lamprolonchaea metatarsata (Kertesz)
Milichiidae
Desmometopa tarsalis Loew
Milichiella lacteipennis (Loew)
Muscidae
Fannia pusio (Wiedemann)
Neriidae
Telostylinus lineolatus (Wiedemann)
Otitidae
Acrostica apicalis (Williston)
Notogramma cimiciforme Loew
Euxesta annonae (F.)
Piophilidae
Protopiophila australis Harrison
Platystomatidae
Scholastes bimaculatus Hendel
Sarcophagidae
Parasarcophaga sp.
Scatopsidae
Holoplagia guamensis (Johannson)
Sciaridae
Bradysia molokaiensis (Grimshaw) E?
Bradysia tritici (Coq.)
Sepsidae
Sepsis biflexuosa Strobl
Sepsis lateralis Wiedemann
Sphaeroceridae
Leptocera abdominiseta Duda
Stratiomyidae
Evaza javanensis de Meijere
Hermetia illucens (L.)
Syrphidae
Allograpta obliqua (Say)
Eristalinus arvorum (F.)
Eumerus aurifrons (Wiedemann)
Eumerus figurans Walker
Simosyrphus grandicornis (Macquart)
Syritta hackeri Klocker
Syritta orientalis Macquart
Tachinidae
Trichopoda pilipes (F.) B
Tephritidae
Acinia picturata (Snow) B
Bactrocera cucurbitae (Coquillett)
Bactrocera dorsalis (Hendel)
Dioxyna sororcula (Wiedemann)
Eutreta xanthochaeta Aldrich B
Tetreuaresta obscuriventris (Loew) B
Tipulidae
Limonia hawaiiensis (Grimshaw) E
Limonia kauaiensis (Grimshaw) E

Limonia perkinsi (Grimshaw)
Limonia stygipennis (Alexander) E

Embioptera
Oligotomidae
Oligotoma saundersi (Westwood)

Heteroptera
Anthocoridae
Cardiastethus minutissimus Usinger
Orius insidiosus (Say) B
Physopleurella mundula (White)
Cydnidae
Geotomus pygmaeus (Dallas)
Rhytidoporus indentatus Uhler
Lygaeidae
Appolonius sp.
Graptostethus sp.
Nysius caledoniae Distant
Nysius kinbergi Usinger E
Nysius sp. nr. *vinitor*
Reclada moesta White
Miridae
Cyrtorhinus lividipennis Reuter B
Fulvius perigrinator Kirkaldy
Spanagonicus albofasciatus Reuter
Talorilygus pallidulus (Blanchard)
Termatophyloides sp.
Tythus mundulus (Breddin) B
Nabidae
Nabis capsiformis Germar I
Pentatomidae
Nezara viridula (L.)
Plautia stali Scott
Reduviidae
Empicoris rubromaculatus (Blackburn)
Oncocephalus pacificus (Kirkaldy)
Scadra rufidens Stål
Zelus renardii Kolenati
Rhopalidae
Liorhyssus hyalinus (F.)
Saldidae
Saldula exulans (White) E
Tingidae
Leptodictya tabida (Herrich-Schäffer)
Teleonemia scrupulosa Stål B
Veliidae
Microvelia vagans White E

Homoptera
Cicadellidae
Acinopterus angulatus Lawson
Carneocephala saggittifera (Uhler)
Draeculacephala mollipes (Say)
Gyponana germari (Stål)
Protalebrella brasiliensis (Baker)
Spanbergiella quadripunctata Lawson
Delphacidae
Peregrinus maidis (Ashmead)
Perkinsiella saccharicida Kirkaldy
Sardia pluto (Kirkaldy)
Sogotatodes eupompe (Kirkaldy)
Flatidae
Melormenis antillarium (Kirkaldy)
Siphanta acuta (Walker)
Membracidae
Antianthe expansa (Germar)
Vanduzea segmentata (Fowler)

Hymenoptera
Ampulicidae
Dolichurus stantoni (Ashmead) B
Anthophoridae
Ceratina sp.
Xylocopa sonorina Smith
Apidae
Apis mellifera L. B
Braconidae
Agathis hawaiicola (Ashmead)
Apanteles opacus Ashmead
Aphaereta pallipes (Say)
Chelonius blackburni Cameron
Lysiphlebus testaceipes (Cresson) B
Opius dissitus Muesebeck
Opius incisi Silvestri B
Opius sp.
Phanerotoma hawaiiensis Ashmead
Ceraphronidae
Ceraphron plebius Perkins
Ceraphron sp.
Chalcididae
Anthrocephalus apicalis (Walker)
Anthrocephalus pertorvus (Girault)
Brachymeria podagrica (F.)
Proconeura, undescribed sp.
Diapriidae
Doliopria sp.
Encyrtidae
Adelencyrtus odonaspidis Fullaway
Anagyrus antoninae Timberlake
Blepyrus insularis (Cameron)
Caenohomalopoda guamensis (Fullaway)

Cheiloneurus sp.
Coccidoxenoides peregrina (Timberlake)
Copidosoma floridana (Ashmead)
Leptomastidea abnormis (Girault) B
Neodusmetia sangwani (Subba Rao)
Plagiomerus sp.
Syrphophagus aphidovorus (Ashmead)
Eucoilidae
Chrestosema magnifica (Yoshimoto)
Ganaspidium utilis Beardsley B
Eulophidae
Aprostocetus sp. A
Aprostocetus sp. B
Diglyphus intermedius (Girault) B
Eulophinae
Evaniidae
Szepligetella sericea (Cameron)
Formicidae
Hyponera opaciceps (Mayr)
Leptogenys falcigera Roger
Pheidole megacephala (F.)
Tetramorium guineense (F.)
Ichneumonidae
Barichneumon californicum Heinrick
Casinaria infesta (Cresson)
Diadegma pattoni (Ashmead)
Gotra sp.
Trathala flavoorbitalis (Cameron)
Venturia sp.
Xanthopimpila punctata (F.)
Mymaridae
Acmopolynema bifasciatipennis (Girault)
Gonotocerus marilandicus (Girault)
Pteromalidae
Cerocephalinae
Microgastrinae
Spalangia sp. B
Scelionidae
Baeini
Dyscritobaeus comitans Perkins
Telenomus despiciendus Perkins
Scoliidae
Micromeriella marginella modesta (Smith) B
Sphecidae
Liris subtesselata (Smith) B
Trypoxylon bicolor Smith
Tiphiidae
Tiphia segregata Crawford B
Torymidae
Podagrion mantis (Ashmead)
Vespidae
Polistes macaensis (F.)

Isoptera
Kalotermitidae
Neotermes connexus Snyder

Lepidoptera
Cosmopterigidae
Hyposmocoma sp. E
Hyposmocoma sp. nr. *saccophora* E
Danaidae
Danaus plexippus (L.)
Gelechiidae
Stoeberhinus testaceous Butler
Geometridae
Anacamptodes fragilaria (Grossbeck)
Semiothisa santaremaria (Walker)
Noctuidae
Anua indiscriminata (Hamson)
Bocana manifestalis Walker
Elydna nonagra (Walker)
Hypena laceratalis Walker B
Leucania striata Leech
Pseudaletia unipuncta (Haworth)
Simplicia caeneusalis Walker
Pieridae
Pieris rapae (L.)
Pterophoridae
Lantanophaga pusillidactyla (Walker) B
Pyralidae
Maruca testulalis (Geyer)
Omphisa anastomosalis (Guenée)
Salbin haemorrhoidalis Guenée B
Spoladea recurvalis (F.)
Sphingidae
Celerio calida calida (Butler) E
Tineidae
Decadarchis simulans (Butler)
Monopis monachella (Hübner)
Tortricidae
Amorbia emigratella Busck
Episimus utilis Zimmerman B

Neuroptera
Hemerobiidae
Nesomicromus navigatorum (Brauer) B

Odonata
Coenagrionidae
Megalagrion heterogamias (Perkins) E

Megalagrion vagabundum (Perkins)	E
Libellulidae	
Pantala flavescens (F.)	I
Orthoptera	
Acrididae	
Atractomorpha ambigua Bolivar	
Oxya japonica (Thunberg)	
Schistocerca nitens nitens (Thunberg)	
Gryllidae	
Acheta conspersa (Schaum)	
Cycloptilum bimaculatum (Shiraki)	
Gryllus bimaculatus De Geer	
Metioche vittaticollis (Stål)	
Myrmecophilidae	
Myrmecophila quadrispina Banks	
Tettigoniidae	
Conocephalus saltator (Saussure)	
Elimaea punctifera (Walker)	
Euconocephalus nasutus (Thunberg)	
Phaneroptera furcifera Stål	
Xiphidiopsis lita Hebard	
Psocoptera	
Ectopsocidae	
Ectopsocus fullawayi End.	
Elipsocidae	
Kilauella sp.	E
Lepidopsocidae	
Lepidopsocus fasciatus Thornton	
Lepidopsocus maculatus Thornton, Lee & Chui	
Psocidae	
Psocus sp. A	E
Psocus sp. B	E
Trichoptera	
Hydropsychidae	
Cheumatopsyche analis Banks	