Introductions for Biological Control in Hawaii 1997–2001

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Abstract. Introductions and releases of natural enemies for the biological control of agricultural and forest pests in Hawaii are discussed for the period 1997-2001. Sixteen insect and five fungal species were introduced, released, or redistributed by the Hawaii Department of Agriculture for the control of six weeds (*Clidemia hirta*, *Coccinia grandis*, *Miconia calvescens*, *Myrica faya*, *Senecio madagascariensis*, and *Ulex europaeus*) and four insect pests (*Aleurocanthus woglumi*, *Bemisia argentifolii*, *Pentalonia nigronervosa*, and *Sipha flava*).

Key words: biological control, Hawaii

In its role as the state's lead agency for classical biological control, the Plant Pest Control Branch of the Hawaii Department of Agriculture (HDOA) has maintained a program for the introduction and release of beneficial organisms for the past 100 years. This paper, the latest in a series, provides information on the status of some pests and their introduced natural enemies, and a list of natural enemies released for biological control in Hawaii from 1997 through 2001 (Table 1). All introductions are thoroughly studied and screened under quarantine following established protocols, and must be approved by the state Board of Agriculture and the United States Department of Agriculture's (USDA) Animal and Plant Health Inspection Service before they can be released in Hawaii. Unless otherwise referenced, information presented here is from HDOA records.

Weed Control

Clidemia hirta (L.) D. Don (Melastomataceae) (Koster's curse, clidemia)

A native of the American tropics, *C. hirta* is a densely branching shrub, growing up to four m in height and thickly covered with hairs (Simmonds 1933, Wester and Wood 1977). It rapidly invades habitats, thriving both in open areas and in deep shade. Discovered on Oahu in 1941 (Krauss 1954), by the late 1980s, the total area throughout the state infested with clidemia was estimated to exceed 100,000 ha (Smith 1992). Although considered to be under at least partial control, the weed continues to be a threat to native forests in Hawaii.

Insectary propagation of the noctuid defoliator *Antiblemma acclinalis* Hübner continued, and additional releases were made on Kauai and Oahu. Although established on Oahu, there is no indication that populations of this moth have persisted on Kauai or on Maui, where the moth was first released in 1996.

From October 1998 through June 1999, in collaboration with the U.S. Army and USDA Forest Service, shipments of the microlepidopterans *Carposina bullata* Meyrick (Carposinidae) and *Mompha trithalama* Meyrick (Momphidae) from Trinidad-Tobago were resumed. Having been liberated previously on Oahu, first releases of *C. bullata* and *M. trithalama* on the island of Hawaii were made in November 1998 and February 1999, respectively. Whereas *M. trithalama* appears to be established on both Oahu and Hawaii, no

recoveries of *C. bullata* have been made on either island.

Coccinia grandis (L.) Voigt (Cucurbitaceae) (ivy gourd, scarlet-fruited gourd)

Previously limited to Hawaii and Oahu, in recent years, infestations of this noxious vine have appeared on Maui and Kauai. Releases of the sesiid moth *Melittia oedipus* Oberthür continued on Oahu until August 1999, after which insectary production ceased. First releases of this agent, from material field-collected on Oahu, were made on Kauai, Maui, and Hawaii, beginning in February 2001. At present, *M. oedipus* is considered to be well established only on Oahu and Hawaii.

Two curculionid weevils, *Acythopeus burkhartorum* O'Brien and Pakaluk (a gall-forming species) and *A. cocciniae* O'Brien and Pakaluk (a leafminer), introduced from East Africa in 1992, were approved for release from quarantine by the Board of Agriculture in June 1998. However, it was not until more than a year later (August 1999) that federal approval finally was granted. Thereupon, *A. burkhartorum* was released on Oahu, liberation of *A. cocciniae* following in November of that year. Both species were released on Hawaii in December 1999. First release of *A. cocciniae* on Kauai occurred early in 2001. Adults of both species feed on leaves. *Acythopeus cocciniae* oviposits in older leaves; heavy larval mining destroys much of the mesophyll. Eggs of *A. burkhartorum* typically are laid in the bases of leaf petioles and tendrils of terminal shoots, initiating the formation of galls, which act as energy sinks, diverting nutrients from plant growth and reproduction. Whereas *A. cocciniae* is well established on both Oahu and Hawaii, establishment of *A. burkhartorum* on Oahu is marginal, apparently restricted largely to sites in heavy shade, and the single release of this species on Hawaii evidently has failed to establish a viable population. Bird predation on galls is implicated as a factor limiting the increase and dispersal of *A. burkhartorum* populations. On Oahu, *C. grandis* now is under heavy attack by both the moth and leafmining weevil, suffering extensive dieback in areas formerly heavily infested.

Miconia calvescens DC. (Melastomataceae) (miconia, velvet tree)

An attractive plant sporting meter-long leaves with purple undersides, miconia was introduced from tropical America into Hawaii as an ornamental in the late 1950s or early 1960s (Medeiros et al. 1997; Meyer 1998). However, its pestiferous nature was not widely recognized until the 1990s. Miconia has invaded forests on Kauai, Oahu, Maui, and Hawaii, in which it thrives even in heavy shade, growing rapidly to heights in excess of 10 m and shading out desirable species. Each plant may produce millions of seeds that are spread widely by birds. Exploration in South America during 1998 led to the introduction of several candidate control agents. Unfortunately, the small numbers of each species introduced failed to propagate in quarantine, and all of the colonies were lost.

A fungal pathogen from Brazil, *Colletotrichum gloeosporioides* (Penz.) Sacc. f. sp. *miconiae* Killgore et al. (Coelomycetes: Melanconiales), introduced into quarantine in 1996, received final approval for release in July 1997. First release occurred on Hawaii that month, and on Maui the following November. Establishment was confirmed on Hawaii in 1998. The fungus produces an anthracnose disease in miconia, causing premature leaf drop and stem dieback. It is expected to be quite effective under wet and windy conditions.

Host-range testing of another fungus from Brazil, *Pseudocercospora* sp. (Hyphomycetes: Hyphales), introduced in 1998, revealed that it was not host specific. The causal agent of a leaf spot disease, in addition to miconia and other melastomes, it was found to infect three species of Myrtaceae: the endemic *Metrosideros polymorpha* Gaud. and two introduced species, *Syzygium malaccense* (L.) Merr. and Perry and *Psidium cattleianum* Sabine.

Myrica faya Aiton (Myricaceae) (firebush, firetree, faya tree)

A native of the Azores, Canary, and Madeira Islands, this invasive tree was introduced into Hawaii as an ornamental late in the 19th century (Little and Skolmen 1989; Wagner et al. 1990), and subsequently redistributed in reforestation programs. A nitrogen fixer, the species moved rapidly into pastures, disturbed forest, and other areas, displacing other, valuable vegetation. By the 1940s, it was recognized as one of Hawaii's most serious weeds. At present, firetree infests a total area in Hawaii exceeding 34,000 ha (Whiteaker and Gardner 1992); infestation is most widespread on Hawaii. Two species of microlepidoptera, a tortricid and a gracilariid, from the weed's native region had been released in 1956 (Weber 1957) and 1991 (Markin 2002), respectively, had become established, but had no measurable impact on the weed.

In September 1997, a fungal agent, *Septoria hodgesii* Gardner (Coelomycetes: Sphaeropsidales), originally isolated from *Myrica cerifera* L. in North Carolina, was granted final approval for release from quarantine. First releases were made the following month at sites on Hawaii. Establishment of *S. myricae* at all release sites was confirmed in August 1998. The fungus produces necrotic lesions on foliage, leading to premature leaf drop and retarded growth of the plant. To date, there is no indication of its effectiveness in controlling *M. faya*.

Senecio madagascariensis Poiret (Asteraceae) (fireweed)

A native of southeastern Africa, this biennial herb, which is toxic to livestock, invades pastures where it competes aggressively with valuable forage grasses. A single plant may produce up to 18,000 seeds (Sindel et al. 1998). Spread occurs mainly through wind-blown seed; seeds also may be dispersed in hay and grain products, on clothing and vehicles, and by livestock, birds and other animals. The weed was first discovered on Hawaii in the early 1980s. It is now also established on Kauai, Maui, and, most recently, Oahu. Eleven insect agents were introduced from Africa late in 1999 and successfully colonized under quarantine. Colonies of most of the agents were destroyed in 2001 due to lack of host specificity or negligible control potential. However, two species, an arctiid moth, *Secusio extensa* (Butler), the larvae of which are defoliators, and a tephritid fly, *Sphenella* sp., which, in the larval stage, attacks the flower heads, have shown promise, and continue to undergo host-range testing.

Isolates of the fungus *Puccinia lagenophorae* Cooke (Basidiomycetes: Uredinales), which causes a rust disease of *S. madagascariensis*, were introduced from Australia, South Africa, and Madagascar in the latter part of 1999. Initially considered to have good potential to control the weed, the pathogen was determined not to be host-specific (Killgore et al. 2001).

Ulex europaeus L. (Fabaceae) (gorse)

Another rust fungus, *Uromyces pisi* (DC.) Otth f. sp. *europaei* Wilson and Henderson, was obtained from England, and first released on Hawaii in February 2000 for control of this spiny shrub. Infection causes dieback of spines and branches. Although the rust survived for a time on infected gorse plants introduced into the field, there is no evidence to date that it has become established. Future releases are planned, employing different inoculation methods and, perhaps, new isolates of the pathogen.

The pyralid moth *Pempelia genistella* (Duponchel), released in large numbers on Hawaii in 1996 (Culliney and Nagamine 2000), but eluding all attempts at recovery until recently, now is considered provisionally established. Its contribution to gorse control is not considered to be significant.

Insect Pest Control

Aleurocanthus woglumi Ashby (Homoptera: Aleyrodidae) (citrus blackfly)

First discovered on Oahu in July 1996, this whitefly, the 28th to become established in the state, is known now to be established on most of the main islands (there have been no reports from Niihau or Lanai). Records of *A. woglumi* in Hawaii before 1996 (e.g., Mound and Halsey 1978; CABI/EPPO 1992) are erroneous. The species is widespread and polyphagous, having been recorded from plants in at least 35 families (Mound and Halsey 1978). *Citrus* spp., however, are the primary hosts, and the only hosts apparently supporting long-term survival of populations (Steinberg and Dowell 1980).

Initial surveys on Oahu by HDOA personnel revealed low rates of parasitization of *A. woglumi* by the adventive aphelinid *Encarsia nipponica* Silvestri. Exploration in Central America in the summer of 1998 resulted in the introduction of two other parasitic Hymenoptera, *Amitus hesperidum* Silvestri (Platygasteridae) and *Encarsia perplexa* Huang and Polaszek (at first misidentified as *E. opulenta* [Silvestri]). The former parasitoid is most effective at high host densities whereas the latter species has a higher searching capacity, and is an efficient regulator of whitefly populations at their lower densities (Nguyen and Hamon 1993). These agents were first released on Oahu in the spring of 1999, with releases on neighbor islands following in 2000 and 2001. Just before their release, in March 1999, surveys on Oahu had found an additional species, *E. smithi* (Silvestri) (introduced from Japan in 1974 for control of the orange spiny whitefly *Aleurocanthus spiniferus* [Quaintance]; Nakao and Funasaki 1976), and an already established *E. perplexa* (thought to have been introduced with the blackfly) parasitizing *A. woglumi* at low rates within limited sites (M.W. Johnson, University of Hawaii, personal communication). Although *A. hesperidum* had been recovered from Oahu, its current status is unknown as further recoveries have not been made owing to extremely low host densities. The Guatemalan strain of *E. perplexa* is well established on Oahu and Kauai and providing apparently excellent control of the pest.

Bemisia argentifolii Bellows and Perring (Homoptera: Aleyrodidae) (silverleaf whitefly)

This polyphagous pest, which induces physiological disorders in tomato and squashes, remained under inadequate control. Surveys found occasional parasitism by the adventive parasitoids *Encarsia luteola* Howard and *E. nigricephala* Dozier (Kumashiro et al. 2002), and *Eretmocerus* spp., but this was insufficient to regulate whitefly populations at non-economic densities. In June 1998, four additional *Encarsia* species, *E. hispida* De Santis, *E. lutea* (Masi), *E. mineoi* Viggiani, and *E. pergandiella* Howard, held under quarantine since 1992, were released on Oahu. Two months later, first releases were made on Hawaii. Insectary production of the parasitoids was terminated in December 2000. Thus far, establishment has been confirmed only for *E. lutea* on Oahu.

Pentalonia nigronervosa Coquerel (Homoptera: Aphididae) (banana aphid)

This aphid, originally from southeast Asia, but now largely pantropical in distribution, was first recorded from Oahu in 1922 (Timberlake 1924). It is reported now from most of the main islands (there have been no reports from Niihau or Molokai). Apart from the feeding injury it causes to banana and other hosts, its main significance as a pest stems from the fact that it is the sole known vector of banana bunchy-top virus (Waterhouse and Norris 1987). In Hawaii, the pest was found to be attacked by generalist aphid parasitoids and predators, but these had little negative impact on its numbers. A coccinellid beetle, *Scymnus* sp., introduced from Thailand in December 2000, and now undergoing propagation and host-range testing under quarantine, may prove to be an effective control agent if it is found to be specific to aphids, none of which is native to Hawaii.

Sipha flava (Forbes) (Homoptera: Aphididae) (yellow sugarcane aphid)

Periodic outbreaks of this aphid continued to occur in pastures on Maui and Hawaii. An aphidiid wasp, *Lysiphlebus ambiguus* (Haliday), introduced from southwestern Europe in 1990 for control of *S. flava*, apparently never became established despite the release of more than 300,000 individuals over a four-year period (Culliney and Nagamine 2000). In July 1997, another strain of the wasp, parasitizing the closely related *Sipha maidis* Passerini, was obtained from Pakistan through cooperation of the International Institute of Biological Control (IIBC). After insectary colonization, releases were made on Oahu the following month, and on Maui, Hawaii, and Kauai later in the year. Unlike its European predecessor, the new strain became established quickly; first recoveries were made on Hawaii in May 1998, six months after the agent was first released on that island. Although the wasp now is considered well established, its potential for *S. flava* control remains unclear.

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Table 1. Releases of biological control agents in Hawaii, 1997–2001.

Target pest	Control agent introduced	Sender (affiliation)	Country of origin	Date of first release[1]	Total number released
Aleurocanthus woglumi Ashby	Amitus hesperidum Silvestri	*M. Ramadan* (HDOA)	*Guatemala*	*Ha: August 2000* Ka: March 2000 Ma: June 2000 Oa: May 1999	*Ha: 20* Ka: 112[2] Ma: 107[2] Oa: 8,565 Total: 8,804
	Encarsia perplexa Huang & Polaszek	M. Ramadan (HDOA)	Guatemala	Ha: May 2000 Ka: March 2000 Ma: June 2000 Mo: April 2001 Oa: April 1999	Ha: 52,050 Ka: 17,590 Ma: 45,800 Mo: 27,165 Oa: 5,740 Total: 148,345[2]
Bemisia argentifolii Bellows & Perring	*Encarsia hispida* De Santis	R. Burkhart (HDOA)	Brazil	Ha: August 1998 Oa: June 1998	Ha: 3,200 Oa: 18,925 Total: 22,125
	E. lutea (Masi)	R. Burkhart (HDOA)	Egypt	Ha: August 1998 Oa: June 1998	Ha: 725 Oa: 11,410 Total: 12,135
	E. mineoi Viggiani	R. Burkhart (HDOA)	Egypt	Ha: August 1998 Oa: June 1998	Ha: 4,475 Oa: 22,605 Total: 27,080

Table 1. (continued)

Target pest	Control agent introduced	Sender (affiliation)	Country of origin	Date of first release[1]	Total number released
	E. pergandiella Howard	R. Burkhart (HDOA)	Brazil	Ha: August 1998 Oa: June 1998	Ha: 3,500 Oa: 14,610 Total: 18,110
Clidemia hirta (L.) D. Don	*Antiblemma acclinalis* Hübner[3]				Ka: 653 Oa: 5,601 Total: 6,254
	Carposina bullata Meyrick[3]			Ha: November 1998	Ha: 129 Oa: 4 Total: 133
	Mompha trithalama Meyrick[3]			Ha: February 1999	Ha: 276 Oa: 153[2] Total: 429
Coccinia grandis (L.) Voigt	*Acythopeus burkhartorum* O'Brien & Pakaluk	R. Burkhart (HDOA)	Kenya	Ha: December 1999 Oa: August 1999	Ha: 100 Oa: 2,950 Total: 3,050
	A. cocciniae O'Brien & Pakaluk	R. Burkhart (HDOA)	Kenya	Ha: December 1999 Ka: January 2001 Oa: November 1999	Ha: 1,689 Ka: 1,424 Oa: 30,279 Total: 33,392

	Melittia oedipus Oberthür[3]			Ha: April 2001 Ka: February 2001 Ma: March 2001	Ha: 89[4] Ka: 132[4] Ma: 54[4] Oa: 25,319 Total: 25,594
Miconia calvescens DC.	Colletotrichum *gloeosporioides* (Penz.) Sacc. f. sp. *miconiae*	*R. Barreto* (Univ. of Viçosa)	*Brazil*	*Ha: July 1997* Ma: November 1997	
Myrica faya Aiton	*Septoria myricae* Ellis & Everh.	D. Gardner (Univ. of Hawaii)	U.S.A (N. Carolina)	Ha: October 1997	
Sipha flava (Forbes)	*Lysiphlebus ambiguus* (Haliday)	(IIBC)	Pakistan	Ha: November 1997 Ka: December 1997 Ma: September 1997 Oa: August 1997	Ha: 365,321 Ka: 23,110 Ma: 67,545 Oa: 1,939 Total: 457,915
Ulex europaeus L.	*Uromyces pisi* (DC.) Otth f. sp. *europaei*		England	Ha: February 2000	

[1]Island abbreviations: Ha = Hawaii, Ka = Kauai, Ma = Maui, Mo = Molokai, Oa = Oahu
[2]Figure includes both releases of insectary-reared stock and redistributions of field-collected material
[3]Introduced previously (see Culliney & Nagamine, 2000)
[4]Redistributions of field-collected material