Introductions for Biological Control in Hawaii, 1987–1996

Thomas W. Culliney and **Walter T. Nagamine**
Hawaii Department of Agriculture, Division of Plant Industry, Plant Pest Control Branch
1428 South King Street, Honolulu, Hawaii 96814, USA

Abstract. Introductions and liberations of natural enemies for the biological control of agricultural and forest pests in Hawaii are presented for the period 1987–1996. A total of 24 arthropod and 2 fungal species were released or re-released (augmentation) by the Hawaii Department of Agriculture for the control of 4 weeds (*Clidemia hirta, Coccinia grandis, Passiflora mollissima,* and *Ulex europaeus)* and 9 insect pests (*Bemisia argentifolii, Brontispa chalybeipennis, Elasmopalpus lignosellus, Frankliniella occidentalis, Heteropsylla cubana, Liriomyza* spp., *Nezara viridula, Plutella xylostella,* and *Sipha flava*).

Keywords: Biological control, Hawaii

In its role as the state's lead agency for classical biological control and foreign exploration for beneficial organisms, the Plant Pest Control Branch (PPC) of the Hawaii Department of Agriculture has maintained a program for the introduction and release of beneficial organisms for more than 90 years. This paper provides information on the status of some pests and their purposely introduced natural enemies and a list of beneficial organisms introduced and released for biological control from 1987 through 1996 (Table 1). All introductions are thoroughly studied and screened under quarantine following established protocols (Funasaki et al. 1988b, Lai & Funasaki 1990), and must be approved by the U.S. Department of Agriculture's Animal and Plant Health Inspection Service (USDA APHIS) and the state Board of Agriculture before they can be released in Hawaii.

Weed Pest Control

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

This tropical American weed has continued to be a major pest in Hawaiian forests and pastures since its first detection on the island of Oahu in 1941 (Krauss 1954). A pioneering, disturbance-adapted species, in forests it tends to displace native plants (Wester & Wood 1977). PPC has evaluated agents for the biological control of clidemia since 1952, shortly before the first phytophagous insect was introduced (reviewed by Nakahara et al. 1992). In 1986, following field and laboratory studies in Trinidad, West Indies, additional potential control agents were shipped to Hawaii. In early 1988, after further testing under quarantine, one of these, a buprestid beetle, *Lius poseidon* Napp, was approved for release. Initial releases were made on Oahu in October 1988. Later that year, a small number of *L. poseidon* was released on the island of Kauai. Beginning in 1990, beetles, field-collected on Oahu, were released on Maui and Hawaii. Establishment (sensu Clausen 1951) has been confirmed on each of the 4 islands.

A fungal pathogen, *Colletotrichum gloeosporioides* (Penz.) Sacc. f. sp. *clidemiae* Trujillo, introduced from Panama in 1985, was approved for release in October 1986. Following release in selected forest areas on all islands, it has shown promise as an effective control agent under conditions of moderate to high humidity (Trujillo et al. 1986).

After completion of host-range testing in Trinidad during the mid-1980s, 4 species of moth showing promise for clidemia control were introduced. Specimens of the noctuid *Antiblemma acclinalis* Hübner were received in February 1995. Following propagation, first releases were made on Kauai and Oahu the following May. Additional releases were made on Maui, beginning in April 1996. Larvae of this species feed on leaves of young *C. hirta* plants, primarily in cool, moist habitats with moderate to heavy shade (Nakahara et al. 1992). Thus far, establishment of the moth has been confirmed only on Oahu.

Carposina bullata Meyrick was introduced in September 1995. Simmonds (1933) found this carposinid abundant on clidemia in Trinidad, suggesting its importance in the natural control of the weed. Larvae feed internally in the newly formed flower buds, more rarely in berries. Flowers thus attacked fail to produce seed. Because of difficulties encountered in its propagation, only an extremely small number of *C. bullata* was available for release on Oahu. Field recovery of this agent has yet to be made, leaving its establishment in doubt.

Another microlepidopteran, *Mompha trithalama* Meyrick (Momphidae), was introduced in March 1995, and a small number released on Oahu the following September. Here too, Simmonds (1933) hinted at this species' importance in the natural control of clidemia. Larvae feed internally in berries or occasionally inside flowers, causing a failure of seed set. First recovery of this agent was made in November 1996 within a small group of clidemia plants in a nursery. However, the inadvertent trimming of the plants may have extirpated the local population. The moth has not been recovered from any other release site on Oahu.

Small numbers of the fourth moth, *Druentia* prob. *inscita* (Schaus) (Lascosomidae), received in late 1986, were not successfully colonized.

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

This noxious vine, which is indigenous to parts of tropical Africa, Asia, and Australia, was first found in Hawaii on Oahu in 1968 (Nagata 1988). By 1986, it had been discovered in the Kona district of Hawaii (Linney 1986). A rank grower, the vine produces an abundance of leaves; white, star-shaped flowers; and elongated fruits, quickly covering the ground and enshrouding trees, other vegetation, fences, and utility lines in residential and agricultural areas, and low elevation forests. Roots and stems are succulent, probably enabling the plants to survive prolonged periods of dry weather. Fruits, 7–8 cm long, become a scarlet red when ripe. Birds, especially the red-vented bulbul (*Pycnonotus cafer* [L.]), are avid feeders on the fruits, and have been implicated in the spread of the vine. The fruits also serve as reservoir hosts for pestiferous fruit flies in Hawaii (Uchida et al. 1990). In 1992, specimens of a sesiid moth, *Melittia oedipus* Oberthür, were introduced into quarantine from Kenya. After completion of host-range testing, final approval was granted to release the moth in July 1996. Small numbers of adult and larval *M. oedipus* were released on Oahu, beginning the following month. Larvae of the moth bore through the shoots and down into the large, tuberous root, killing the vine in the process. Pupation occurs within the vine instead of in the soil, a previously unreported behavior for a species of *Melittia* (Eichlin 1995). Two other promising coccinia control agents, curculionid weevils of the genus *Acythopeus* Pascoe, have been maintained in quarantine since their introduction in 1992 and are nearing completion of host-range testing.

Passiflora mollissima (Humboldt, Bonpland & Kunth) Bailey (Violales: Passifloraceae), banana poka

This perennial, woody vine, native to the Andes of South America, was introduced into Hawaii, as an ornamental or for its fruit, early this century (La Rosa 1984). An aggressive, heliophilic weed, *P. mollissima* has invaded the mid- to high-elevation forests on Hawaii and Kauai where it tends rapidly to overgrow native trees. During 1993 and 1994, several

small releases of a South American pyralid, *Pyrausta perelegans* Hampson, obtained through cooperation of the USDA Forest Service, were made on Kauai. Larvae of the moth generally feed within flower buds, causing them to abscise, although they also may attack the fruits and terminal shoots (Pemberton 1989 [1990]). Establishment of *P. perelegans* on Kauai has yet to be confirmed. However, releases made jointly by the Forest Service and the Hawaii Department of Land and Natural Resources, Division of Forestry and Wildlife, have resulted in the moth's establishment on Hawaii and on Maui (where the *P. mollissima* infestation is of limited extent).

An isolate of the fungal pathogen *Septoria passiflorae* Syd., introduced from Colombia in 1993, was released on Kauai in March 1996, followed by releases on Hawaii and Maui in April and July, respectively. This agent produces a leaf spot disease in *P. mollissima* and *P. foetida* L. (Trujillo et al. 1994). Infected leaves develop chlorotic spots that enlarge into necrotic lesions; leaves ultimately become entirely chlorotic and abscise. With establishment on the 3 islands now confirmed, *S. passiflorae* is expected to aid significantly in reducing the growth and spread of banana poka.

Ulex europaeus L. (Fabales: Fabaceae), gorse

A native of Europe, this spiny shrub forms extensive, impenetrable thickets up to 2 m high between 200 and 2100 m in elevation on Hawaii and Maui (Smith 1985). Although sporadic attempts at biological control of the weed have been made, beginning in the 1920s (Markin & Yoshioka 1989 [1990]), it is only recently that more coordinated control programs have been implemented. Since 1987, PPC has been involved with other state, federal, and private organizations in a long-term cooperative program to control the weed on roughly 16,000 hectares of pasture, forest, and residential land. Extensive screening of gorse natural enemies by USDA and New Zealand's Department of Scientific and Industrial Research (DSIR) during the 1980s resulted in the identification of promising candidates for control of gorse in Hawaii.

In a series of releases, beginning in late 1988, English and Portuguese strains of an oecophorid moth, *Agonopterix ulicetella* (Stainton), the larvae of which are defoliators, were successfully established on gorse infestations on the 2 islands. Insectary propagation of this agent ceased in September 1995.

A gall-forming apionid weevil from Portugal, *Apion scutellare* Kirby, which previously had been introduced in 1961, but failed to become established, was released from quarantine in 1989. A small number of the beetles was liberated on Hawaii in July of that year; additional releases of a French strain were made on Hawaii in June 1991. (A related, seed-attacking species from England, *A. ulicis* [Forster], last released in the early 1950s ([Weber] 1954), is established on Hawaii and Maui.) Again, there is no indication that this second introduction of *A. scutellare* has resulted in successful establishment.

English and Portuguese strains of the thrips *Sericothrips staphylinus* Haliday were introduced in 1987 and 1989, respectively. Releases of this thrips on Hawaii were begun in 1991 and on Maui in 1992. Establishment was confirmed on Hawaii in July 1992. A French strain of *S. staphylinus*, released in small numbers on Hawaii in 1994, apparently has failed to become established.

A tetranychid mite, *Tetranychus lintearius* Dufour, originally from Spain, was obtained in June 1995 from stocks maintained in California. First releases were made on Hawaii the following month and on Maui in August 1995. A foliage feeder, *T. lintearius* forms large colonies, which produce copious quantities of silk webbing. Heavily infested gorse plants suffer severe bronzing and branch dieback; on occasion, the entire plant may die (Hill 1983). Establishment of the mite has been confirmed on both islands.

Shipments of a pyralid moth, *Pempelia genistella* (Duponchel), originally collected in

Portugal, were received from Montana in June and July 1996 and liberated immediately on Hawaii. Larvae feed on the mature spines (Zwölfer 1963? Markin et al. 1996). Combined feeding of several larvae may cause girdling and die back of stems. Despite the release of large numbers of *P. genistella*, its establishment is as yet unconfirmed.

Insect Pest Control

Bemisia argentifolii Bellows & Perring (Homoptera: Aleyrodidae), silverleaf whitefly

First discovered on Oahu in 1982, *B. argentifolii* was considered to be of little economic importance until 1989, when a physiological disorder of tomato, which caused irregular ripening, was seen to be associated with populations of the whitefly on Hawaii (Johnson et al. 1991). The species, formerly considered a biotype (poinsettia or B strain) of the sweetpotato whitefly, *B. tabaci* (Gennadius) (Cohen et al. 1992, Perring et al. 1993, Bellows et al. 1994), also causes "squash silverleaf," another physiological disorder that produces silvering of foliage in susceptible squash species (Yokomi et al. 1990).

The well-known aphelinid parasitoid *Encarsia formosa* Gahan was first introduced into Hawaii in 1942, and re-introduced in 1978, for biological control of the greenhouse whitefly *Trialeurodes vaporariorum* (Westwood). A third introduction of *E. formosa*, primarily for control of *B. argentifolii*, was made in September 1992 from material collected from *B. tabaci* in Kenya. The purpose behind introduction of the Kenya strain was to improve the species' existing gene pool in Hawaii and increase control of the pest over that provided by the strains previously introduced. Release of the parasitoid from quarantine was approved in April 1993.

Because of the species' proven effectiveness in the control of whiteflies infesting greenhouses in many areas of the world (e.g., Hussey 1985, Lipa 1985), most releases of the Kenya strain of *E. formosa* on Hawaii were made in greenhouses, with few liberated in open field areas. However, despite the release of significant numbers during 1993 and 1994, surveys have found no evidence of greenhouse establishment.

In addition to *E. formosa*, 3 other potential *B. argentifolii* control agents, introduced from Africa and South America, currently are being reared in quarantine. Two species received from Egypt, *Encarsia lutea* (Masi) and *E. mineoi* Viggiani, have undergone host specificity testing and appear safe for release. The other, *E. hispida* De Santis, was collected in Brazil. The fortuitous introduction of another aphelinid, *Encarsia nigricephala* Dozier, also may prove to be an effective contributor to *B. argentifolii* control.

Brontispa chalybeipennis (Zacher) (Coleoptera: Chrysomelidae), blue coconut leaf beetle

Shortly after its detection on Oahu in October 1985, a biological control program was initiated for control of this foliage-feeding beetle. Both larvae and adults feed on and between the young terminal leaflets of coconut palms (*Cocos nucifera* L.), causing browning and fraying of the foliage (Lange 1950). Heavy infestations can result in reduction of yield and, occasionally, death of the tree. In 1986, an eulophid wasp, *Tetrastichus brontispae* (Ferriere), received from cooperators in Guam, was released against *B. chalybeipennis* (Funasaki et al. 1988a). First recovery was made in March 1987. By 1988, visible damage to coconuts in the areas of infestation in Honolulu had been reduced. Additional stocks of *T. brontispae* were received from Java in early 1991. First release of the Java strain was made in July 1991, and propagation of the Guam strain ceased the following month. Releases on Oahu continued through September 1992 (the beetle has not been found on any of the neighbor islands). The project was terminated in January 1993.

Elasmopalpus lignosellus (Zeller) (Lepidoptera: Pyralidae), lesser cornstalk borer

This moth was first discovered in Hawaii in July 1986, attacking sugarcane on Kauai (unpublished HSPA data). Soon thereafter, it was found on all of the main islands except Lanai. Damage is caused by larvae boring into, and feeding within, the stem of the host plant at or just below the soil surface. Feeding can kill newly emerged seedlings and severely weaken older plants. Preferred hosts include various grasses and legumes (Chalfant et al. 1982).

A search for natural enemies of the pest was conducted jointly by the Hawaiian Sugar Planters' Association (HSPA) and HDOA. A braconid wasp, *Orgilus elasmopalpi* Muesebeck, was introduced from Texas and Florida in October 1986. Following completion of host range testing, first release was made in mid-1987 in heavily infested sugarcane fields on Maui, followed by a release on Oahu later that year. The last releases were made in mid-1990, after which the project was discontinued. Since then, the parasitoid has been recovered only in low numbers.

Shipments of an eulophid parasitoid, *Horismenus elineatus* Schauff, were received from Texas (derived from stock originally collected in Bolivia), beginning in 1989. After insectary evaluations, releases were made on Maui, Oahu, Kauai, and Hawaii in 1990. The wasp is now considered established on the first 3 islands. Primary responsibility for production and liberation of this control agent was turned over to HSPA in 1990.

Frankliniella occidentalis (Pergande) (Thysanoptera: Thripidae), western flower thrips

Ongoing efforts to control this thrips, a pest in Hawaii since the 1950s, centered on the mass rearing of the anthocorid *Orius tristicolor* (White) from stocks received from California. Difficulties encountered in the laboratory propagation of the bug, which originally had been introduced in the early 1960s (Davis & Krauss 1963) and was established on Oahu and Hawaii, severely limited the size of field releases. After a small release in 1987, the augmentation program was terminated.

Herpetogramma licarsisalis (Walker) (Lepidoptera: Crambidae), grass webworm

This pest of turfgrasses has been present in Hawaii since the 1960s (LaPlante 1968). Damage is caused by larvae feeding on grass blades and crowns, accompanied by copious deposition of silken webbing (Tashiro 1976). Extensive browning and dieback can occur in lawns and pastures. Soon after its discovery in Hawaii, *H. licarsisalis* was found to be susceptible to attack by established parasitoids (Davis 1969). Observations since the mid-1980s indicate that populations of the webworm are under at least partial control by these agents, including the egg parasitoids *Trichogramma chilonis* Ishii, *T. ostriniae* Pang & Chen, and *T. papillionis* Nagarkatti (Hymenoptera: Trichogrammatidae), and the larval parasitoids *Eucelatoria armigera* (Coquillett) (Diptera: Tachinidae) and *Diadegma pattoni* (Ashmead) (Hymenoptera: Braconidae), which were introduced in earlier years either accidentally or purposely for control of other lepidopterous pests.

Explorations in Australia and Papua New Guinea from February through April 1988 resulted in the introduction of several additional parasitoids. Of these, an ichneumonid, *Leptobatopsis* sp., was successfully colonized in the laboratory and underwent host range testing. Unfortunately, persistent problems in maintaining laboratory host populations resulted in loss of the colony. Sporadic outbreaks of *H. licarsisalis* continue to damage pastureland, particularly in windward areas on Maui.

Heteropsylla cubana (Crawford) (Homoptera: Psyllidae), leucaena psyllid

This psyllid was first collected from monkeypod (*Samanea saman* [Jacq.] Merr.) and koa haole (*Leucaena leucocephala* [Lam.] de Wit) on Oahu in April 1984, subsequently spread-

ing to the other major islands (PPC staff 1984). Explorations for natural enemies of the psyllid in Trinidad and Tobago during 1985 resulted in the introduction of 2 parasitoids, an encyrtid, *Psyllaephagus yaseeni* Noyes, and an eulophid, *Tamarixia leucaenae* Boucek, and 1 predator, the coccinellid *Cycloneda conjugata* Mulsant. Efforts to propagate *T. leucaenae* in quarantine were unsuccessful, and the colony was lost. The *C. conjugata* colony was destroyed after host range tests showed that it would attack some of the endemic Hawaiian psyllids. After tests showed it to be highly host specific, *P. yaseeni* was approved for release from quarantine in April 1987. Following releases on Oahu, Hawaii, and Kauai, first recoveries were made during early 1988. Propagation then ceased at the Honolulu insectary and was shifted to the Hilo facility on Hawaii.

Not long after its appearance in the state, *H. cubana* was found to be attacked by a previously introduced coccinellid, *Curinus coeruleus* Mulsant. Together, *C. coeruleus* and *P. yaseeni* have provided apparently good control of psyllid populations despite the wasp's vulnerability to hyperparasitoids.

***Liriomyza* spp**. (Diptera: Agromyzidae), leafminers

From the mid-1970s to the early 1980s, a number of species of parasitic Hymenoptera were introduced for control of *Liriomyza* leafminers. Final releases of *Chrysocharis oscinidis* Ashmead (= *C. parksi* Crawford) and *Chrysonotomyia punctiventris* (Crawford) (both Eulophidae obtained from California), *Ganaspidium utilis* Beardsley (a eucoilid from Texas), *Opius dissitus* Muesebeck (a braconid from Florida), and *Halticoptera circulus* (Walker) (a pteromalid from Trinidad) were made on Oahu, Maui, Molokai, and Kauai, and their establishment confirmed, by early 1986 (Funasaki et al. 1988a). Additional releases of *G. utilis* were made on Kauai in 1989 and early 1990. Liberation of *Chrysocharis caribea* Boucek (earlier misidentified as *C. ?giraulti* Yoshimoto) (a eulophid from Trinidad) continued on Oahu during 1987 and on Kauai from 1987 into 1989. However, despite the ease with which *C. caribea* is reared in the laboratory, the wasp apparently has not become established in the field.

Nezara viridula (L.) (Hemiptera: Pentatomidae), southern green stink bug

The southern green stink bug continued to be a pest in macadamia nut orchards in Hawaii through direct feeding damage to nuts (Oi 1991). Augmentative releases of the egg parasitoid *Trissolcus basalis* (Wollaston) (Hymenoptera: Scelionidae), first introduced from Australia and Trinidad in the early 1960s (Davis & Krauss 1963), were made on Hawaii and Maui in 1987 and 1988, and again on Hawaii in 1993, after which the project was discontinued.

Pentalonia nigronervosa Coquerel (Homoptera: Aphididae), banana aphid

A coccinellid, *Scymnus* sp., was introduced in March 1990 from Malaysia and Thailand for control of *P. nigronervosa*, vector of the virus causing banana bunchy top disease. Propagation of the beetle came to a halt the following year after the quarantine colony died out.

Plutella xylostella (L.) (Lepidoptera: Plutellidae), diamondback moth

Mass propagation and release of 3 purposely introduced parasitic Hymenoptera—the ichneumonids *Diadegma semiclausum* (Hellén) and *Diadromus collaris* Gravenhorst (both from Pakistan), and the braconid *Cotesia plutellae* (Kurdjumov) (from Taiwan) (Lai & Funasaki 1986, Funasaki et al. 1988a)—continued in an effort to establish and augment populations in crop areas infested with diamondback moth. After final release of a small number of individuals on Maui early in 1987, *D. semiclausum* apparently has failed to become established. Releases of *D. collaris* were made on Oahu from late 1987 until termi-

nation of parasitoid rearing at the end of 1988. Since then, this species has been recovered only once, in June 1989, leaving its establishment in doubt. By contrast, *C. plutellae* quickly became established after its reintroduction from Taiwan in 1983. During 1987, releases of this species were made on Oahu and on Molokai (where no previous releases had been made), after which large-scale propagation was ended. Final augmentative releases were made on Maui in 1992.

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

First found infesting kikuyu grass (*Pennisetum clandestinum* Chiov.) in the North Kona district of Hawaii in November 1988 (Beardsley et al. 1992), this aphid feeds on numerous other species of Poaceae (Gibbs 1991). Damage to sugarcane in Hawaii has been minimal, affecting mostly young plantings. Instead, the aphid has become a very serious pest of pastures, in which populations often reach outbreak proportions. Feeding causes pasture grasses to become stunted and lose feed value or suffer premature dieback. Dead patches of grass are rapidly invaded by weeds, resulting in a decrease of cattle forage. *Sipha flava* has spread to all the major Hawaiian islands, with the greatest damage occurring in kikuyu pastures on Hawaii and Maui.

Locally established generalist predators (coccinellids, syrphids, and chrysopids) were observed feeding on *S. flava*, but did not provide adequate control. Chemical control was determined not to be economically feasible except for short-term control of small, initial infestations of the aphid. An aphidiid wasp, *Lysiphlebus ambiguus* (Haliday), was collected in Spain and France during June 1990. After completion of host specificity tests, the parasitoid was approved for release in August 1991. First release of *L. ambiguus* was made in North Kona, followed in short order by releases on Maui, Oahu, and Kauai. Insectary propagation ceased after June 1995. Despite the release of large numbers of *L. ambiguus* throughout the state, very few parasitized aphids have been found in the field, and the wasp's establishment is still in doubt.

Acknowledgements

This paper is dedicated to Robert M. Burkhart, exploratory entomologist extraordinaire (now retired), whose diligent work over twenty years resulted in many cases of successful biological control in Hawaii. We gratefully acknowledge the assistance provided by domestic and foreign biological control agencies and collaborators. Especial thanks are due G. Markin, USDA Forest Service, without whose aid a number of weed control agents could not have been introduced. Natural enemies for many of the biological control projects discussed in this paper were collected by HDOA exploratory entomologists R. Burkhart and M.E. Chun. We thank G. Nakahashi for her help in compiling release records, and the following colleagues for their critical reviews of an earlier draft of the paper: M.E. Chun, P. Conant, R. Heu, E. Killgore, B. Kumashiro, K. Murai, and K. Teramoto.

Literature Cited

Beardsley, J.W., R.A. Heu, A.K. Ota, D.M. Tsuda, and E. Yoshioka. 1992. *Sipha flava* (Forbes) (Homoptera: Aphididae). Notes and exhibitions. Proceedings of the Hawaiian Entomological Society 31: 2–3.

Bellows, T.S., Jr., T.M. Perring, R.J. Gill, and D.H. Headrick. 1994. Description of a species of *Bemisia* (Homoptera: Aleyrodidae). Annals of the Entomological Society of America 87(2): 195–206.

Chalfant, R.B., L.W. Morgan, M.H. Bass, and H. Womack. 1982. The biology of the lesser cornstalk borer, pp. 2–20. *In* H.H.Tippins (ed.). A review of information on the lesser cornstalk borer *Elasmopalpus lignosellus* (Zeller). University of Georgia College of Agriculture Experiment Sta-

tions Special Publication Number 17.

Clausen, C.P. 1951. The time factor in biological control. Journal of Economic Entomology 44(1): 1–9.

Cohen, S., J.E. Duffus, and H.Y. Liu. 1992. A new *Bemisia tabaci* biotype in the southwestern United States and its role in silverleaf of squash and transmission of lettuce infectious yellows virus. Phytopathology 82(1): 86–90.

Davis, C.J. 1969. Notes on the grass webworm, *Herpetogramma licarsisalis* (Walker) (Lepidoptera: Pyraustidae), a new pest of turfgrass in Hawaii and its enemies. Proceedings of the Hawaiian Entomological Society 20(2): 311–316.

Davis, C.J. and N.L.H. Krauss. 1963. Recent introductions for biological control in Hawaii—VIII. Proceedings of the Hawaiian Entomological Society 18(2): 245–249.

Eichlin, T.D. 1995. New data and a redescription for *Melittia oedipus*, an African vine borer (Lepidoptera: Sesiidae). Tropical Lepidoptera 6(1): 47–51.

Funasaki, G.Y., L.M. Nakahara, and B.R. Kumashiro. 1988a. Introductions for biological control in Hawaii: 1985 and 1986. Proceedings of the Hawaiian Entomological Society 28: 101–104.

Funasaki, G.Y., P.-Y. Lai, L.M. Nakahara, J.W. Beardsley, and A.K. Ota. 1988b. A review of biological control introductions in Hawaii: 1890 to 1985. Proceedings of the Hawaiian Entomological Society 28: 105–160.

Gibbs, I.H. 1991? The yellow sugar cane aphid—a periodic pest of sugar cane and sorghum during dry weather in Barbados. Proceedings of the 9th Annual BSTA Conference 1991: 101–111.

Hill, R.L. 1983. Prospects for the biological control of gorse. Proceedings of the 36th N.Z. Weed and Pest Control Conference: 56–58.

Hussey, N.W. 1985. History of biological control in protected culture: western Europe, pp. 11–22. In N.W. Hussey and N. Scopes (eds.). Biological pest control: the glasshouse experience. Ithaca, NY: Cornell University Press. 240 pp.

Johnson, M.W., D.E. Ullman, B.E. Tabashnik, H. Costa, and A. Omer. 1991. Sweetpotato whitefly information from Hawaii. Unpublished typescript. Department of Entomology, University of Hawaii, Honolulu. 4 pp.

Krauss, N.L.H. 1954. *Clidemia hirta*. Notes and exhibitions. Proceedings of the Hawaiian Entomological Society 15(2): 264.

La Rosa, A.M. 1984. The biology and ecology of *Passiflora mollissima* in Hawaii. Cooperative National Park Resources Study Unit, University of Hawaii, Manoa Technical Report 50. 168 pp.

Lai, P.Y. and G.Y. Funasaki. 1986. Introductions for biological control in Hawaii: 1983 and 1984. Proceedings of the Hawaiian Entomological Society 26: 89–91.

Lai, P.-Y. and G.Y. Funasaki. 1990. The use of natural enemies to control agricultural pests in Hawaii, USA, pp. 51–59. *In* J. Bay-Petersen (ed.). The use of natural enemies to control agricultural pests (FFTC Book Ser. 40). Taipei: Food and Fertilizer Technology Center/ASPAC. 254 pp.

Lange, W.H., Jr. 1950. The biology of the Mariana coconut beetle, *Brontispa mariana* Spaeth, on Saipan, and the introduction of parasites from Malaya and Java for its control. Proceedings of the Hawaiian Entomological Society 14(1): 143–162.

LaPlante, A.A. 1968. Pyralidae sp. Notes and exhibitions. Proceedings of the Hawaiian Entomological Society 20(1): 16.

Linney, G. 1986. *Coccinia grandis* (L.) Voigt: a new cucurbitaceous weed in Hawaii. Newsletter of the Hawaiian Botanical Society 25(1): 3–5.

Lipa, J.J. 1985. History of biological control in protected culture: eastern Europe, pp. 23–29. *In* N.W. Hussey and N. Scopes (eds.). Biological pest control: the glasshouse experience. Ithaca, NY: Cornell University Press. 240 pp.

Markin, G.P. and E.R. Yoshioka. 1989 (1990). Present status of biological control of the weed gorse (*Ulex europaeus* L.) in Hawaii, pp. 357–362. *In* E.S. Delfosse (ed.). Proceedings of the VII International Symposium on Biological Control of Weeds. Rome: Istituto Sperimentale per la Patologia Vegetale Ministero dell'Agricoltura e della Foreste. 701 pp.

Markin, G.P., E.R. Yoshioka, and P. Conant. 1996. Biological control of gorse in Hawaii, pp. 371–375. In V.C. Moran and J.H. Hoffmann (eds.) Proceedings of the IX International Symposium on Biological Control of Weeds. Rondebosch, South Africa: University of Cape Town. 563 pp.

Nagata, K.M. 1988. Notes on some introduced flora in Hawai'i. Bishop Museum Occasional Papers 28: 79–84.

Nakahara, L.M., R.M. Burkhart, and G.Y. Funasaki. 1992. Review and status of biological control

of clidemia in Hawai'i, pp.452–465. In C.P. Stone, C.W. Smith, and J.T. Tunison (eds.). Alien plant invasions in native ecosystems of Hawai'i: management and research. Honolulu: University of Hawaii Cooperative National Park Resources Studies Unit. 887 pp.

Oi, D.H. 1991. Investing in biological control: initiation of a parasite mass rearing program for macadamia nut orchards in Hawaii, pp. 128–130. *In* M.W. Johnson, D.E. Ullman, and A. Vargo (eds.). 1989 ADAP crop protection conference proceedings. University of Hawaii College of Tropical Agriculture and Human Resources Research Extension Series 134. 180 pp.

Pemberton, R.W. 1989 (1990). Insects attacking *Passiflora mollissima* and other *Passiflora* species; field survey in the Andes. Proceedings of the Hawaiian Entomological Society 29: 71–84.

Perring, T.M., A.D. Cooper, R.J. Rodriguez, C.A. Farrar, and T.S. Bellows, Jr. 1993. Identification of a whitefly species by genomic and behavioral studies. Science 259: 74–77.

PPC staff. 1984. New state records. Psyllids, *Heteropsylla* sp. poss. *incisa* (Sulc) and *Heteropsylla* sp. no. 2. Hawaii Pest Report 4(2): 2–8.

Simmonds, H.W. 1933. The biological control of the weed *Clidemia hirta*, D. Don., in Fiji. Bulletin of Entomological Research 24(3): 345–348.

Smith, C.W. 1985. Impact of alien plants on Hawai'i's native biota, pp. 180–250. *In* C.P. Stone and J.M. Scott (eds.). Hawai'i's terrestrial ecosystems: preservation and management. Honolulu: Cooperative National Park Resources Studies Unit, University of Hawaii. 584 pp.

Tashiro, H. 1976. Biology of the grass webworm, *Herpetogramma licarsisalis* (Lepidoptera: Pyraustidae) in Hawaii. Annals of the Entomological Society of America 69(5): 797–803.

Trujillo, E.E., F.M. Latterell, and A.E. Rossi. 1986. *Colletotrichum gloeosporioides*, a possible biological control agent for *Clidemia hirta* in Hawaiian forests. Plant Disease 70(10): 974–976.

Trujillo, E.E., D.J. Norman, and E.M. Killgore. 1994. Septoria leaf spot, a potential biological control for banana poka vine in forests of Hawaii. Plant Disease 78(9): 883–885.

Uchida, G.K., R.I. Vargas, J.W. Beardsley, and N.J. Liquido. 1990. Host suitability of wild cucurbits for melon fly, *Dacus cucurbitae* Coquillett, in Hawaii, with notes on their distribution and taxonomic status. Proceedings of the Hawaiian Entomological Society 30: 37–52.

[**Weber, P.W.**] 1954. *Apion ulicis* L. Notes and exhibitions. Proceedings of the Hawaiian Entomological Society 15(2): 290.

Wester, L.L. and H.B. Wood. 1977. Koster's curse (*Clidemia hirta*), a weed pest in Hawaiian forests. Environmental Conservation 4(1): 35–41.

Yokomi, R.K., K.A. Hoelmer, and L.S. Osborne. 1990. Relationships between the sweetpotato whitefly and the squash silverleaf disorder. Phytopathology 80(10): 895–900.

Zwölfer, H. 1963? *Ulex europaeus* project. European investigations for New Zealand. Report No. 2. Report. Commonwealth Institute of Biological Control, Delémont, Switzerland. 30 leaves.

Table 1. Introduction and liberation of biological control agents in Hawaii, 1987–1996.

Target Pest	Control agent introduced	Sender (affiliation)	Country of origin	Date of first release[1]	Total releases
Bemisia argentifolii Bellows & Perring (silverleaf whitefly)	*Encarsia formosa* Gahan	R. Burkhart (HDOA)	Kenya	Ha: June 1993 Oa: March 1994	Ha: 34,295 Oa: 1,600 Total: 35,895
Brontispa chalybeipennis (Zacher) (blue coconut leaf beetle)	*Tetrastichus brontispae* (Ferriere)				Oa: 707,269
Clidemia hirta (L.) D. Don (Koster's curse)	*Antiblemma acclinalis* Hübner	R. Burkhart (HDOA)	Tobago	Ka: May 1995 Ma: April 1996 Oa: May 1995	Ka: 1,066 Ma: 160 Oa: 4,799 Total: 6,025
	Carposina bullata Meyrick	R. Burkhart (HDOA)	Trinidad, Tobago	Oa: October 1995	Oa: 3
	Lius poseidon Napp	S. Ali	Trinidad	Ha: October 1990 Ka: December 1988 Ma: August 1990 Oa: October 1988	Ha: 585 Ka: 13 Ma: 1,244 Oa: 125 Total: 1,967
	Mompha trithalama Meyrick	R. Burkhart (HDOA)	Trinidad, Tobago	Oa: September 1995	Oa: 11
Coccinia grandis (L.) Voigt (ivy gourd)	*Melittia oedipus* Oberthür	R. Burkhart (HDOA)	Kenya	Oa: August 1996	Oa: 12,286

Table 1. Introduction and liberation of biological control agents in Hawaii, 1987–1996 (continued).

Target Pest	Control agent introduced	Sender (affiliation)	Country of origin	Date of first release[1]	Total releases
Elasmopalpus lignosellus (Zeller) (lesser cornstalk borer)	*Horismenus elineatus* Schauff	J. Smith (Texas A&M Univ.)	Bolivia	Ha: August 1990 Ka: August 1990 Ma: June 1990 Oa: July 1990	Ha: 5,590 Ka: 1,700 Ma: 26,542 Oa: 2,730 Total: 36,562
	Orgilus elasmopalpi Muesebeck	A. Ota (HSPA)	USA (Florida, Texas)	Ma: June 1987 Oa: November 1987	Ma: 28,957 Oa: 935 Total: 29,892
Frankliniella occidentalis (Pergande) (western flower thrips)	*Orius tristicolor* (White)	M. Johnson (Univ. of Hawaii)	USA (California)	Oa: June 1987	Oa: 40
Heteropsylla cubana (Crawford) (leucaena psyllid)	*Psyllaephagus yaseeni* Noyes	R. Burkhart (HDOA)	Trinidad, Tobago	Ha: June 1987 Ka: June 1987 La: June 1988 Ma: August 1987 Oa: June 1987	Ha: 70,090 Ka: 1,050 La: 400 Ma: 1,655 Oa: 5,955 Total: 81,800
Liriomyza spp. (leafminers)	*Chrysocharis caribea* Boucek				Ka: 218,665 Oa: 11,610
	Ganaspidium utilis Beardsley				Ka: 58,850
					Total: 230,275

Table 1. Introduction and liberation of biological control agents in Hawaii, 1987–1996 (continued).

Target Pest	Control agent introduced	Sender (affiliation)	Country of origin	Date of first release[1]	Total releases
Nezara viridula (L.) (southern green stink bug)	*Trissolcus basalis* (Wollaston)				Ha: 61,069 Ma: 12,105 Total: 72,974
Passiflora mollissima (HBK) Bailey (banana poka)	*Pyrausta perelegans* Hampson	G. Markin (USDA FS)	Colombia, Venezuela	Ka: August 1993	Ka: 253
Plutella xylostella (L.) (diamondback moth)	*Cotesia plutellae* (Kurdjumov)				Ma: 750 Mo: 5,165 Oa: 1,260 Total: 7,175
	Diadegma semiclausum (Hellén)				Ma: 51
	Diadromus collaris Gravenhorst				Oa: 7,759
Sipha flava Forbes (yellow sugarcane aphid)	*Lysiphlebus ambiguus* (Haliday)	R. Burkhart (HDOA)	France, Spain	Ha: September 1991 Ka: December 1991 Ma: October 1991 Oa: November 1991	Ha: 250,296 Ka: 16,482 Ma: 27,985 Oa: 54,012 Total: 348,775

Table 1. Introduction and liberation of biological control agents in Hawaii, 1987–1996 (continued).

Target Pest	Control agent introduced	Sender (affiliation)	Country of origin	Date of first release[1]	Total releases
Ulex europaeus L. (gorse)	*Agonopterix ulicetella* (Stainton)	G. Markin (USDA FS)	Portugal	Ha: November 1988 Ma: February 1989	Ha: 46,573 Ma: 11,000
		R. Hill (NZDSIR)	England		Total: 57,573
	Apion scutellare Kirby	R. Burkhart (HDOA)	France, Portugal	Ha: July 1989	Ha: 74
Pempelia genistella	G. Markin, (Duponchel)	Portugal K. Mann (USDA FS)	Ha: June 1996	Ha: 3,135	
	Sericothrips staphylinus Haliday	R. Burkhart (HDOA)	England	Ha: May 1991 Ma: April 1992	Ha: 26,750 Ma: 5,800
		G. Markin (USDA FS)	Portugal		Total: 32,550
	Tetranychus lintearius Dufour	C. Turner (USDA ARS)	Spain	Ha: July 1995 Ma: August 1995	Ha: 4,500 Ma: 6,100 Total: 10,600

[1]Island abbreviations: Ha = Hawaii, Ka = Kauai, La = Lanai, Ma = Maui, Mo = Molokai, Oa = Oahu.