REVIEW AND STATUS OF BIOLOGICAL CONTROL OF CLIDEMIA IN HAWAI'I

Larry M. Nakahara,
Robert M. Burkhart, and George Y. Funasaki

ABSTRACT

Efforts to control clidemia (*Clidemia hirta*) in Hawai'i with phytophagous insects began in 1952. Several attempts have been made since then to introduce potential biological control agents to reduce the spread of this weed into forest areas, and other control measures have been tried by various groups and agencies. It was not until recently, however, through the enactment of significant legislation and subsequent funding, that explorations and studies were conducted specifically on clidemia insects in Trinidad, West Indies. Fourteen species of insects were evaluated, including *Carposina bullata, Mompha trithalama*, a midge or cecidomyiid, two *Eurytoma* species, *Piesmopoda* sp., and *Compsolechia seductella*, which feed on the flowers and fruits; *Lius poseidon, Antiblemma acclinalis, Druentia* sp., prob. *inscita, Ategumia matutinalis* (formerly *Blepharomastix ebulealis* but originally thought to be *Sylepte matutinalis*), *Penestes* n. sp., and a leaf beetle or chrysomelid, which feed on the leaves; and a long-horned cerambycid beetle, which bores into the stem. Studies indicated that several species were sufficiently host specific to warrant introduction into Hawai'i for the biological control of clidemia.

INTRODUCTION

In Hawai'i, clidemia or Koster's curse (*Clidemia hirta*) (Melastomataceae), a fast-growing, heavy-seeding, tropical American shrub, has colonized forest clearings, trailsides, and burn sites and intruded into the understories of forests that were formerly free of introduced, or alien, weeds (Wester and Wood 1977). The species has spread rapidly throughout the State and represents a serious threat to our native forests. First observed on O'ahu in 1941, it has since spread to Hawai'i (1972), Moloka'i (1973), Maui (1977), and Kaua'i (1982).

Clidemia hirta is generally not considered a pest in its native range. Interspecific competition may be a major factor for its low density in Trinidad, where at least 100 species of melastomes and other aggressive weeds compete for space. Clidemia is commonly found along trails, roadsides, and at the edges of forests there, and unlike Hawai'i, it is rarely found in non-disturbed forest areas with dense canopies. Plants in Trinidad are shorter and have thinner stems than those in Hawai'i, and few seedlings are found under mature plants (Burkhart 1983).

The manner in which clidemia developed into a weed pest in Hawai'i, the problems encountered while trying to control it, the strategies employed, and the reliance on biological control measures as the only possible cost-effective, long-lasting, management solution are similar to many other weed problems we face in Hawai'i. The cooperation and support provided by concerned individuals and agencies in controlling this weed are also indicative of what can be accomplished when people work together to solve a common problem. Early attempts made to reduce clidemia and the current status of additional insects being studied for possible introduction into Hawai'i to aid in its biological control are reviewed in this paper.

BIOLOGICAL CONTROL ATTEMPTS IN HAWAI'I

Clidemia was recognized as a serious potential weed pest following a survey in the forest reserve near Wahiawā, O'ahu in 1952 (Krauss 1954). Because of the problems experienced in Fiji (Simmonds 1933), the major concern was that the weed would spread over wide areas into pastures, cultivated lands, and forest areas in Hawai'i (Krauss 1952). Officials of the Board of Commissioners of Agriculture and Forestry initiated surveys on the neighbor islands (*i.e.*, the main Islands other than O'ahu) (Thistle 1952) and distributed information sheets with sketches of the plant, background information, and a chemical control recommendation (Hosaka and Thistle 1953). A biological control program was begun in 1952 by soliciting comments from the Committee on Beneficial Insect Introductions; this Committee reviewed the merits of introducing the thrips *Liothrips urichi* into Hawai'i. The Hawaii Department of Agriculture (hereafter called the Department) has continued to evaluate biological control of clidemia off and on for the past 34 years.

In April 1953, after testing, review, and approval for introduction by other entomologists employed by the pineapple and sugar industries and the University of Hawaii, *L. urichi* was imported into Hawai'i from Fiji to control clidemia (Fullaway 1954). Although extensive host range tests had been conducted on *L. urichi* before release in Fiji, there was concern that the thrips could be a vector of the spotted wilt virus that affected pineapple (*Ananas comosus*) in Hawai'i (Sakimura 1953). Tests showed that *L. urichi* did not transmit the virus, and the first release of the thrips was made on June 1, 1953, in Wahiawā Forest Reserve. Eight days later, on June 9th, the thrips were found breeding on clidemia plants in the area and were considered to be established.

Liothrips urichi was effective in preventing the spread of clidemia into open pastures and cultivated lands. It did not, however, prove to be effective in shaded areas (Davis 1969; Reimer 1985) and was thus ineffective under forest conditions (Davis and Chong 1969). Recent studies by Reimer (1985) showed that while *L. urichi* was effective in killing or reducing the growth of juvenile clidemia plants, female thrips laid significantly fewer eggs in shady than in sunny areas. Predation also affected thrips populations. The beneficial anthocorid *Montandoniola moraguesi*, purposely introduced into Hawai'i in 1964 to control the Cuban laurel thrips, *Gynaikothrips ficorum*, was found to feed on *L. urichi*. There was no significant correlation between *M. moraguesi* and *L. urichi* populations, however. Further cage exclusion experiments showed that predation on *L. urichi* by the alien big-headed ant, *Pheidole megacephala*, was significantly greater than that by *M. moraguesi*.

Several species of insects were found attacking the melastome *Dissotis hensii* during explorations in Africa in 1956. These insects showed promise in attacking clidemia and another weed, *Melastoma candidum*, and were shipped to Hawai'i and studied in quarantine. Larvae of one unidentified moth among these species were found to feed on clidemia. The caterpillars also fed on princess flower or lasiandra (*Tibouchina urvilleana*), however, which was considered an attractive ornamental by most people during the 1950s, so the stock was destroyed (Nakao 1975).

The search for additional natural enemies of clidemia was reemphasized when the ineffectiveness of *L. urichi* under forest conditions became more apparent during the late 1960s. Chemical control and mechanical clearing were not considered feasible due to the rugged, mountainous terrain in which the weed occurred (Uehara 1968). During 1968-69, an arctiid moth, *Selca brunella*, and a pyralid moth, *Bocchoris fatualis*, were tested for possible clidemia control on O'ahu. Both species had been released earlier on Hawai'i and Kaua'i for control of *Melastoma candidum*. Neither species was able to survive on clidemia (Au 1968; Nakao 1969).

Another pyralid moth, *Ategumia matutinalis*, was introduced to Hawai'i from Puerto Rico and Trinidad and studied in the Hawaii Department of Agriculture's quarantine facility in 1969. This moth had been collected from *Heterotrichum cymosum* (family Melastomataceae) in Puerto Rico and from a species of *Clidemia* in Trinidad. Host specificity studies were conducted on 31 species of plants from 29 families (Nakao and Suzukawa 1970). Trace feeding occurred on rose, cucumber, hibiscus, and passion fruit (*Rosa* spp., *Cucumis sativus, Hibiscus* spp., *Passiflora edulis*), but the larvae were unable to survive on these plants. *Ategumia matutinalis*, however, completed its life cycle on all melastomes that were tested, including princess flower, which was achieving weed status by the late 1960s. After review of the host range tests by the Advisory Committee, a request for the release from quarantine of *B. ebulealis* was made to the Board of Agriculture in September 1970 (Uehara 1970). Approval was given the following month (Davis 1971), and the first release of the moth was made in December 1970 after mass propagation in the Department's insectary facility. With the help of Sierra Club (Hawai'i Chapter) and Hawaiian Trail and Mountain Club members, thousands of adult moths were liberated on O'ahu to control clidemia and on Hawai'i for control of other melastomes (Davis 1974). No recoveries of the moth, however, were made until October 1974, when light infestations and feeding damage were observed on clidemia along a two-mile stretch on the Kawai Iki Trail on Oʻahu (Nakao and Funasaki 1976). Infestations were subsequently observed on the Hauʻula and Pōamoho trails and in Waiāhole Valley on Oʻahu in the mid 1970s. All infestations were light, and parasites were thought to be reducing the effectiveness of this leaf roller (Fujii 1977).

Recent studies by Reimer (1985) have shown that parasites are an important mortality factor for *Ategumia matutinalis*; the moth averaged 43% parasitization in sampled sites. The following four species of parasites have been reared from *A. matutinalis* larvae. The chalcid *Brachymeria obscurata* was purposely introduced into Hawaiʻi in 1895 to control two native insects considered to be serious pests at that time, the coconut leaf roller, *Hedylepta blackburni*, and the sugar cane leaf roller, *Hedylepta accepta*. The braconid *Meteorus laphygmae* was purposely introduced in 1942 to control armyworms, then plaguing the Islands. Finally, two species of ichneumonids, *Trathala flavoorbitalis* and *Casinaria infesta*, were reared. Both species are aliens that have established in the Islands since arrival in 1910 and 1921.

Caterpillars of a fruit-feeding lepidopteran were collected from a species of *Clidemia* and shipped to Hawaiʻi during a 1969 exploration in Trinidad. The collection was heavily parasitized, and no adult moths were recovered in quarantine.

A pseudococcid, *Crisicoccus* sp., was found infesting clidemia in 1977, while explorations were being conducted in El Salvador. Specimens were shipped to Hawaiʻi and a colony was established in the Hawaii Department of Agriculture's quarantine facility. In a joint project with the University of Hawaii, host specificity studies of this mealybug were conducted on various economically important crops. The mealybug bred successfully on avocado, coffee, mountain apple, and gardenia (*Persea americana, Coffea arabica, Syzygium malaccense, Gardenia jasminoides*), and the colony was destroyed (Gon 1978; Lai 1978).

As biological control efforts continued on Oʻahu, other control methods were being applied by concerned individuals, government agencies, and other groups on the neighbor islands. Infestations at Wailau on Molokaʻi were periodically rogued (controlled) by Sierra Club members and Hawaii Division of Forestry and Wildlife personnel (Shinbara 1977). In the Puna and Waiākea Forest Reserves on the island of Hawaiʻi, a combination of roguing and herbicide treatments was applied by the Hawaii Division of Forestry and Department of Agriculture staff members (Kami 1977). Efforts to eradicate or control localized infestations through these methods proved unsuccessful, however, due to difficulties with the terrain and the need to remove all clidemia seedlings and the seed bank.

SIGNIFICANT LEGISLATION AND FUNDING

In the past, biological control efforts by the Department were spread over a number of serious agricultural, forest, and urban pest problems. These pests were not only economically important but also affected the health and well-being of the people in the State. During the 25-year period from 1953 to 1978, many biological control organisms were introduced into the Department's quarantine facility for screening, rearing, and host specificity testing. Introductions were made to combat 85 pests, including 14 species of weeds (Lai and Funasaki 1986). Many of these candidate control agents were destroyed in quarantine after studies were conducted. Eventually, 283 species were approved for release, of which 98 actually became established. Funds and effort to control clidemia during this period had to be shared with projects on 84 other pests.

The enactment of significant legislation during the late 1970s enabled State agencies to focus specific funding on clidemia control programs; this resulted in an in-depth exploration program directed at clidemia insects. In 1975, the Legislature adopted Senate Resolution No. 240, which requested the Department to compile data on the weed and to propose control measures and funding requirements. This resulted in a joint Hawaii Department of Agriculture, Department of Land and Natural Resources, and University of Hawaii proposal to 1) conduct a biological and ecological study of clidemia in the tropics; and 2) initiate exploration, screening, and evaluation of biological organisms by an entomologist and a plant pathologist.

Through the efforts of legislators, the Hawaii Chapter of the Sierra Club, and other concerned parties, funds were appropriated in 1977 for the biological control of clidemia. Because of spending restrictions in 1978, the funds allocated could not be used. That same year, however, the Governor designated the Department as lead agency in the biological control effort and directed that current resources be used, with additional funding available if needed (Ariyoshi 1978). An exploration specifically for clidemia insects was planned for the following year.

Exploration plans had to be revised in late 1978 with the discovery of the spiraling whitefly, *Aleurodicus dispersus*, in September of that year. The whitefly spread rapidly on O'ahu, posing a serious threat to many facets of Hawai'i's economy because of its host diversity (over 100 species of plants) (Hawaii Department of Agriculture 1981; Kumashiro *et al.* 1983). Top priority was given to the control of this new pest, and clidemia control was relegated to secondary status. Nevertheless, a three-month exploration, partially funded by the Department of Land and Natural Resources, was conducted in tropical America in 1979, and several species associated with clidemia were collected and shipped to Hawai'i for screening. Continuous propagation of the insects in quarantine was unsuccessful due to problems in growing host plants for the rearing of these insects under laboratory conditions to the flowering and fruiting stages.

Since 1980, the Hawaii Department of Agriculture and the Department of Land and Natural Resources have jointly funded explorations to evaluate natural enemies of clidemia in Trinidad. In 1980, a six-month expedition was conducted there to search for control agents of agricultural pests as well as to survey insects attacking *C. hirta*. A joint agreement was signed in 1982, whereby the Department of Agriculture would search for additional biological control agents and do basic studies, while the Department of Land and Natural Resources would provide the necessary funding. All studies would be done in areas where *C. hirta* is native, due to difficulties of propagating the weed, other test plants, and the candidate insects in the Honolulu quarantine facility. Twelve species of insects were identified from June 1982 to June 1983 as showing a potential to control *C. hirta*. Of particular interest were the insects that caused an estimated 95% reduction in seed production. This group of insects could be very useful in Hawai'i, where clidemia occupied only a small percentage of its possible range. Preliminary host range studies indicated that feeding by most of the 12 species was confined to melastomes (Burkhart 1983). The June 1984 to June 1986 exploration emphasized studying the biology and ecology, developing rearing techniques, and completing host range testing of the selected candidate biological control agents.

STRATEGIES AND OBJECTIVES

The objectives of the biological control program are to search for and evaluate insects that may be effective in destroying or placing stress on *C. hirta* plants, especially in shady areas, as well as those insects and pathogens that are effective in destroying its seeds. Potential biological control agents are screened with particular attention to 1) the ability of *C. hirta* to aggressively invade new areas because of its abundant seed production, and 2) its ability to establish itself primarily in shaded areas.

The Department of Land and Natural Resources has actively coordinated a strategy of using both insects and pathogens to control *C. hirta*. Work with pathogens at the University of Hawaii has been fruitful, with the discovery in Panama of a leaf spot fungus that attacks clidemia foliage. The fungus, *Colletotrichum gloeosporioides* f.s. *clidemiae*, was introduced to Fort Detrick, Frederick, Maryland, in September 1985. After preliminary host range testing, permission was obtained for its introduction into Hawai'i, where further host range studies were conducted (Trujillo 1986a; Trujillo *et al.* 1986).

SCREENING PROCEDURES

Studies have been conducted in Trinidad since 1982, where the availability of plants, insects, and the facilities of the Commonwealth Institute of Biological Control provide the necessary combination for the required studies and host range tests. Field data were collected from 40 sites, most of them in the Northern Range, which represents the widest range of ecological conditions for *C. hirta* in that country. The elevations of these sites range from 2 to 3,090 ft (0.5-936 m), mean minimum-maximum temperatures ranged from 95.4 to 110.7 F (21.0-29.5 C) (1984-1985), and mean annual precipitation varied from 45 to 110 in. (1,120-2,920 mm) among sites (Burkhart 1986).

Species determinations are sought for all insects attacking *C. hirta* as well as for natural enemies of the insects, yet the identities of many are unknown. Laboratory studies are conducted to determine basic biological information, such as life history, adult longevity, mating and oviposition requirements, and feeding behavior. These studies enable the development of rearing techniques for further testing, as well as for the development of mass-rearing procedures should the insect be approved for release in Hawai'i. Other biological and ecological field observations relating to habitat preference, seasonal abundance, natural enemies, and natural host plants provide clues to the potential importance of each species as a candidate biocontrol agent. Finally, further testing in the lab determines the host specificity of each insect under laboratory conditions. For some species, a starvation test may be all that is necessary to determine if the plant-feeding stage(s) of the insect can survive on test plants. For others, the tests may be more involved to determine if the candidate insect can complete its life cycle on test plants. Sometimes the degree of preference when candidate insects are given a choice of several host plants is determined.

Host specificity studies for flower- and fruit-feeding insects are conducted by bagging the insects with the susceptible reproductive stage of test plants. Leaf-feeding insects are exposed to mixed bouquets of freshly cut test plant shoots. Plant selection for studies is based on their economic importance in Hawai'i as well as their taxonomic relationship to *C. hirta* (Burkhart 1983, 1986).

POTENTIAL BIOCONTROL CANDIDATES

Fourteen species of insects have been evaluated in Trinidad (Table 1). These insects can be grouped according to the type of damage they inflict on the plant (Burkhart 1983, 1986).

Flower and Fruit Feeders

Carposina bullata. Larvae feed internally in the newly formed flower buds. The life cycle is approximately one month. The host range is limited to plants in the family Melastomataceae, particularly in the genera *Miconia* and *Clidemia*. Studies are completed.

Mompha trithalama. The larvae feed internally on both flowers and berries. When flowers are attacked, no seeds are formed. Host range is limited to the Melastomataceae family. Studies are near completion.

Unidentified midge. The larvae feed on the anthers of flowers, causing some to abort. More studies are needed.

Eurytoma **sp. (black)**. The larvae feed individually on young flowers, resulting in no seed production. More studies are needed.

Eurytoma **sp. (red)**. Larvae feed in developing berries, causing the formation of galls, which reduces seed production. More studies are needed.

Table 1. Species of insects being evaluated for biocontrol of *Clidemia hirta* by Hawaii Department of Agriculture.

Species (Order: Family)	Site of Damage	Type of Damage	Comments
Carposina bullata Meyr. (Lepidoptera: Carposinidae)	Flower / Fruit	Within fruit/Flower	Non gall-forming
Mompha trithalama Meyr. (Lepidoptera: Momphidae)	Flower / Fruit	Within fruit/Flower	Non gall-forming
Unidentified midge (Diptera: Cecidomyiidae)	Flower / Fruit	Within fruit/Flower	Non gall-forming
Eurytoma sp. (black) (Hymenoptera: Eurytomidae)	Flower / Fruit	Within fruit/Flower	Non gall-forming
Eurytoma sp. (red) (Hymenoptera: Eurytomidae)	Flower / Fruit	Within fruit	Gall-forming
Piesmopoda sp. (Lepidoptera: Pyralidae)	Flower heads	Flower feeder	
Compsolechia seductella Walk. (Lepidoptera: Gelechiidae)	Flower heads	Flower/Leaf feeder	
Lius poseidon Napp (Coleoptera: Buprestidae)	Leaves	Leaf feeder	
Antiblemma acclinalis Hubner (Lepidoptera: Noctuidae)	Leaves	Leaf feeder	
Druentia sp. prob. *inscita* (Schaus) (Lepidoptera: Lascosomidae)	Leaves	Leaf feeder	
Ategumia matutinalis (Guenee) (Lepidoptera: Pyralidae)	Leaves	Leaf feeder	
Penestes sp. (Coleoptera: Curculionidae)	Leaves	Leaf feeder	
Unidentified leaf beetle (Coleoptera: Chrysomelidae)	Leaves	Leaf feeder	
Unidentified long-horned beetle (Coleoptera: Cerambycidae)	Stem	Stem borer	

Piesmopoda **sp.** The larvae are voracious feeders, consuming one or more flower clusters, resulting in the destruction of many seeds. In starvation tests, larvae fed on flowers of other plant families. Under field conditions, feeding was confined to plants in the genera *Clidemia* and *Miconia*. More studies are needed.

Compsolechia seductella. The larvae cut the growing leaves and flower clusters and feed on the dead plant mass. In the lab, some feeding occurred on plants outside of the family Melastomataceae. Under field conditions, only plants in the genera *Miconia* and *Clidemia* are recorded hosts. More studies are needed.

Leaf Feeders

Lius poseidon. Both the adult and larval stages of this leaf-mining buprestid feed on *C. hirta* leaves. The shiny black adult feeds externally on the leaves, producing a ragged feeding strip. The egg is laid singly on the upper surface of a leaf. After the egg hatches, the young larva tunnels into the leaf, producing a blotch mine. Pupation occurs in the mine, which forms a "blister" on the leaf, and the adult emerges 40 days after the egg is laid. *Lius poseidon* favors plants in light shade but never in heavy shade and rarely in open fields. In field studies, *L. poseidon* adults fed on 13 species of plants in four genera, while the larvae were recorded from seven species in three genera, all in the family Melastomataceae. Most of the damage was observed on three species of *Clidemia*, including *C. hirta*. In starvation tests, *L. poseidon* did not feed on another 35 species of plants in 27 families. Studies are completed.

Antiblemma acclinalis. Larvae feed on leaves of young *C. hirta* plants, primarily in cool, moist locations with moderate to heavy shade. The life cycle is about 36 days. Problems with mass rearing this species limited the number of tests. In host range tests, *A. acclinalis* did not feed on 18 non-melastomataceous species from 15 families. In the field, host range was limited to four species of melastomes, with 95% occurring on *C. hirta* and *C. debilis*. Studies are completed.

Druentia **sp., prob.** *inscita*. Larvae cut and fold the leaves of *C. hirta* to form a feeding shelter. The life cycle is approximately two to six months long, due to the ability of the species to aestivate in the pupal stage during the dry season. *Druentia* is found over a wide range of elevations but was common in the upper-elevation sites. It occurred in various habitats, except under conditions of full sun. Field studies show that feeding by this species is restricted to only 13 species of melastomes in four genera, despite the presence of 39 species of melastomes in four genera in the surveyed area. Clidemia, the second-most preferred host plant, was used half as often as *Miconia acinodendrum*, the most preferred. No larval feeding damage was observed on non-melastomes in the field or on 15 species of non-melastomes from 15 families tested in the lab. Studies are near completion.

Ategumia matutinalis. This pyralid leaf roller feeds on only a few species of Melastomataceae. It is adapted to a wide range of ecological conditions but prefers moist, shaded conditions. Studies are continuing.

Penestes **sp.** Adults were most common at higher elevations and in cool, damp locations in deep shade, where they caused as much as 50% leaf damage. In the field, adults feed only on melastomes, species in the genera *Clidemia* and *Miconia* being preferred. After an intensive search, larvae were found breeding in the succulent petioles of a few species of *Miconia*, particularly *M. mirabilis*. No larvae were found breeding in clidemia petioles. Adults fed on eight species of non-melastomes, with heavy feeding on *Begonia*. Although this species was rejected from further studies for *C. hirta* control, its possible role in controlling *Miconia* species would require further work.

Unidentified leaf beetle. Adults caused considerable foliar damage to *C. hirta* leaves. Larvae were not found on *C. hirta*, and adults fed on all non-melastomes tested with extensive feeding on eggplant, cucumber, and bell or sweet pepper (*Solanum melongena, Cucumis sativus, Capsicum annuum*). The candidate was rejected from further studies.

Stem Borers

Unidentified long-horned beetle. Larvae of this unidentified cerambycid beetle were occasionally found in stems of *C. hirta*, with plants showing signs of stunting and dieback. No adults have been recovered. More studies are needed.

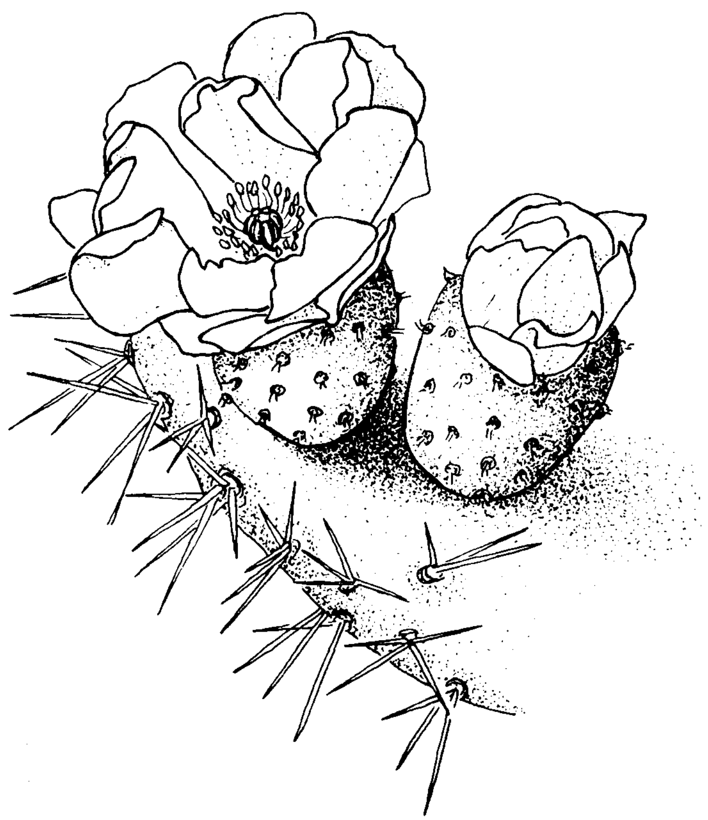
Many of the above lepidopterous species and the buprestid beetle are heavily parasitized in Trinidad by hymenopterous species not found in Hawai'i. While some of Hawai'i's locally established parasites may adapt to these insects were they to be released in the Islands, without their natural enemies, *C. hirta* insects would become established in Hawai'i, probably resulting in higher infestation levels than currently seen in Trinidad.

FUTURE CONSIDERATIONS

A request for approval to release *Colletotrichum gloeosporioides* f.s. *clidemiae* for *C. hirta* control is currently being reviewed by the Board of Agriculture's Advisory Subcommittee on Microorganisms (Trujillo 1986a). The pathogen was found to infect only *C. hirta* in inoculation tests on more than 40 other plant species representing 28 families (Trujillo 1986b). In addition, requests for approval to introduce and release *Lius poseidon*, *Antiblemma acclinalis*, and *Carposina bullata* will be made in the near future, following a review of requirements for further testing on native plants found in Hawai'i. Other requests on *Mompha trithalama* and *Druentia* sp. prob. *inscita* would also follow. Requests for the release from quarantine of these candidate biological control insects must first be reviewed by the State Advisory Subcommittee on Entomology and the State Advisory Committee on Plants and Animals; their recommendations are forwarded to the Board of

Agriculture. Field releases may be made if approval is granted by the Board of Agriculture.

Based on the studies conducted so far with the plant pathogen and phytophagous insects, the outlook for the eventual management of clidemia in Hawai'i's forests appears promising. However, it cannot be predicted to what extent these organisms may suppress the continuing spread of *C. hirta* in the forests or reduce its current area of establishment. If *C. hirta* is successfully controlled, it will be because of the cooperation, concern, and efforts of many individuals, groups, and agencies.



Literature Cited

Ariyoshi, G.R. 1978. Memorandum - *Clidemia hirta* - biocontrol program. Executive Chamber. Files, Hawaii Dep. Agric., Honolulu. Typescript.

Au, S.H. 1968. Memorandum - *Selca brunella* Hampson test on *Clidemia hirta*. Files, Hawaii Dep. Agric., Honolulu. Typescript.

Burkhart, R.M. 1983. Progress report on exploratory studies on *Clidemia hirta* in Trinidad, West Indies, June 1982 - June 1983. Files, Hawaii Dep. Agric., Honolulu. Unpub. rep.

Burkhart, R.M. 1986. Progress report on exploratory studies on *Clidemia hirta* in Trinidad, West Indies, June 1984 - June 1985. Files, Hawaii Dep. Agric., Honolulu. Unpub. rep.

Davis, C.J. 1969. Notes and exhibitions. *Proc. Hawn. Entomol. Soc.* 20(3):277.

Davis, C.J. 1971. Recent introductions for biological control in Hawaii -- XVI. *Proc. Hawn. Entomol. Soc.* 21(1):59-62.

Davis, C.J. 1974. Recent introductions for biological control -- XVIII. *Proc. Hawn. Entomol. Soc.* 21(3):355-358.

Davis, C.J., and M. Chong. 1969. Recent introductions for biological control in Hawaii XIV. *Proc. Hawn. Entomol. Soc.* 22(2):317-322.

Fujii, J.K. 1977. Notes and exhibitions. *Proc. Hawn. Entomol. Soc.* 22(3):394-395.

Fullaway, D.T. 1954. Notes and exhibitions. *Proc. Hawn. Entomol. Soc.* 15(2):280.

Gon, S. 1978. Feeding tests on plants of economic importance with *Crisicoccus* sp. (Homoptera: Pseudococcidae) to determine its host specificity. Hawaii Dep. Agric., Univ. Hawaii Joint Project, Honolulu. Unpub. rep.

Hawaii Department of Agriculture. 1981. *Hawaii Pest Report* I(5). Plant Pest Control Branch, Hawaii Dep. Agric. Honolulu.

Hosaka, E.Y., and A. Thistle. 1953. *Clidemia hirta* (L.) D. Don (Melastomataceae), a new and potentially serious weed pest of agricultural lands in Hawaii. Bd. Commissioners Agric. and For. Honolulu. Mimeo.

Kami, R. 1977. Memorandum - *Clidemia hirta*. Hawaii Dep. Agric., Honolulu. Typescript.

Krauss, N. 1952. Memorandum on the biological control of the weed *Clidemia hirta* in Fiji. Bd. Commissioners Agric. and For. Honolulu. Typescript.

Krauss, N. 1954. Notes and exhibitions. *Proc. Hawn. Entomol. Soc.* 15:264.

Kumashiro, B.R., P.Y. Lai, G.Y. Funasaki, and K.K. Teramoto. 1983. Efficacy of *Nephaspis amnicola* and *Encarsia ? haitiensis* in controlling *Aleurodicus dispersus* in Hawaii. *Proc. Hawn. Entomol. Soc.* 24(2 & 3):261-269.

Lai, P.-Y. 1978. Memorandum - Destroy and disposition of *Crisicoccus* sp. from quarantine insectary. Files, Hawaii Dep. Agric., Honolulu. Typescript.

Lai, P.-Y., and G.Y. Funasaki. 1986. List of beneficial organisms purposely introduced for biological control in Hawaii: 1890 to 1985. Revised. Hawaii Dep. Agric., Honolulu. Unpub. rep.

Nakao, H.K. 1969. Memorandum - Feeding test with *Bocchoris* sp. on *Clidemia hirta*. Files, Hawaii Dep. Agric., Honolulu. Typescript.

Nakao, H.K. 1975. Memorandum - Bio-control efforts against *Clidemia hirta* in Hawaii. Files, Hawaii Dep. Agric., Honolulu. Typescript.

Nakao, H.K. and G.Y. Funasaki. 1976. Introductions for biological control in Hawaii, 1974. *Proc. Hawn. Entomol. Soc.* 22(2):329-331.

Nakao, H.K., and R. Suzukawa. 1970. Host specificity tests with *Blepharomastix ebulealis* (Guenee) (family Pyralidae) from *Clidemia hirta*. Files, Hawaii Dep. Agric., Honolulu. Unpub. rep.

Pelly, J. 1975. Clidemia information. Memo to State Forester, May 20. Files, Hawaii State Dep. Land Nat. Resour., Honolulu.

Reimer, N.J. 1985. An evaluation of the status and effectiveness of *Liothrips urichi* Karny (Thysanoptera: Phlaeothripidae) and *Blepharomastix ebulealis* (Guenee) (Lepidoptera: Pyralidae) on *Clidemia hirta* (L.) D. Don in O'ahu forests. Ph.D. diss., Univ. Hawaii, Honolulu.

Sakimura, K. 1953. Memorandum - Innoculated test plants with spotted wilt virus for feeding test with *Liothrips urichi*. Pineapple Research Inst. Hawaii, Honolulu. Typescript.

Shinbara, B.H. 1977. Memorandum - Status of *Clidemia* infestations on Molokai and Hawaii. Files, Hawaii Dep. Agric., Honolulu. Typescript.

Simmonds, H.W. 1933. The biological control of the weed *Clidemia hirta* (L.) D. Don in Fiji. *Bull. Entomol. Res.* 24:345-348.

Thistle, A. 1952. Memorandum - *Clidemia hirta*. Bd. Commissioners Agric. and For., Honolulu. Typescript.

Trujillo, E.E. 1986a. Memo - Request approval to release *Colletotrichum gloeosporioides* f.s. *clidemiae* from quarantine for use as a biological control agent of *Clidemia hirta* (Koster's curse) in Hawaii forest. Univ. Hawaii, Honolulu. Typescript.

Trujillo, E.E. 1986b. Host specificity test with *Colletotrichum gloeosporioides* f.s. *clidemia* Cda. (family Melanconiaceae, Fungi Imperfecti). A biological control candidate for *Clidemia hirta* (L.) D. Don. Univ. Hawaii, Honolulu. Unpub. rep.

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* 70:974-976.

Uehara, S. 1968. Memorandum - Meeting on *Clidemia hirta*. Hawaii Dep. Agric. Honolulu. Typescript.

Uehara, S. 1970. Memorandum - Release of the *Heterotrichum* leaf roller, *Blepharomastix ebulealis* (Guenee) from the quarantine laboratory. Hawaii Dep. Agric., Honolulu. Mimeo.

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