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Authors of this Abstract:
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I. IDENTIFIERS

Common Name: KOSTER'S CURSE                       Global Rank: G?

General Description:
Shrub of the Melastome family (Melastomataceae).

II. STEWARDSHIP SUMMARY

Clidemia, which forms monospecific subcanopy stands in native forests, is one of the most disruptive alien plants in Hawaii. It is very widespread on Oahu where it spread very rapidly, and has recently become established on almost all the other major islands. Its potential range is very great, essentially all wet and mesic habitats below 1,500 m. Clidemia's success as a weed is due to high production of seed, prolific establishment from seed, rapid growth and maturation, broad environmental tolerances, and availability of dispersal vectors. It is a threat to Kamakou Preserve and potentially a threat to lower elevations in Waikamoi Preserve. Biological control is the long-term solution, and two partly successful biocontrol agents have been released. More are probably needed. Control of long-distance establishments is worthwhile, even though the effectiveness of control efforts has been limited. Research is needed on an effective herbicide to augment manual techniques in controlling new invasions and long-distance establishments.

III. NATURAL HISTORY

Range:
Clidemia is native to tropical America, including parts of South and Central America and the Caribbean islands (Wagner et al., 1990, Smith in press). Where it has been observed in its native range in Trinidad, it occurs at low density in early successional plant communities (Nakahara et al. in press). Wester and Wood (1977) describe it as an uncommon constituent of secondary rain forest. It is now a pest in much of the Paleoptrics (Wagner et al. 1990), including Oceania, Southeast Asia, and the Indian subcontinent (Smith in press).

It was originally reported from Oahu in 1941, and was considered a noxious plant by 1957 (Smith in press). By 1988 it had expanded into all suitable habitat, with a range over 100,000 ha. Although its distribution has not been systematically studied, small, multiple infestations were reported from all major islands except Kaua‘i and Ni‘ihau in the 1970's and 1980's. These reports suggest continued expansion of clidemia on neighboring islands.
Habitat:
Clidemia is found in a great variety of mesic to very wet, open to closed habitats from 10-1,200 m elevation (Smith in press), with a potential upper elevation limit of 1,500 m based on limits in its native range (Smith pers. comm). Its failure to spread to Kahoolawe and Niihau may be due to restricted access and the aridity of these islands (Smith in press). One known small population is established at Kamakou Preserve. A fruiting plant was discovered in 1981, and a seed bank has become established; seedlings continue to be found in 1991. Clidemia is not known from Waikamoi. However, it is found along the Ko`olau Ditch banks and associated roads below the preserve (Smith in press).

Ecology:
Clidemia has very broad environmental tolerances (Wester and Wood 1977). It is found in areas ranging from mesic (1,270 mm of rainfall per year) to very wet (7,600 mm/year), as well as in exposed habitats or sites with 100% canopy cover. It grows well under native forest trees as well as under introduced trees.

Clidemia can invade both disturbed and undisturbed areas in Hawaii (Smith in press). Population levels usually remain low in undisturbed sites. It spreads rapidly and achieves high densities after disturbances such as storms, feral pigs (Sus scrofa), landslides and fire, all of which open the subcanopy (Wester and Wood 1977, Smith in press). Disturbance is also the key to its intensification and spread in its native range (Smith in press). It can develop dense monotypic stands, shading out understory plants below its canopy, even bryophyte ground cover (Wester and Wood 1977, Smith in press). However, uluhe in exposed areas appears to be capable of excluding clidemia (Wester and Wood 1977). In moist, shaded habitats clidemia can reach 5 m, entering the subcanopy of Hawaiian forests. In exposed areas, it typically grows less than 1 m tall.

Reproduction:
Vegetative growth and sexual reproduction typically occur throughout the year in rain forest habitats with no dry season, but in drier and seasonal habitats, dry periods reduce flowering and fruiting (Smith in press).

Clidemia reproduces by seed which are spread by alien birds (Hosaka and Thistle 1954, Smith 1985). Humans, mongooses (Herpestes auropunctatus), and feral pigs (Sus Scrofa) are also responsible for localized dissemination (Wester and Wood 1977, Smith in press). Humans are undoubtedly responsible for frequent, inadvertent, long-distance dispersal. Hunters, hikers, marijuana (Cannabis sativa) growers, and vehicles are the main vectors.
The seeds are thought to be viable in the soil for up to four years.

Its success as a weed may be due in part to prolific seed production, rapid recruitment from the seed bank, fast growth and maturation, and availability of dispersal vectors. A fruit contains over 100 seeds, and mature plants produce over 500 fruits per year. Growth is rapid after germination. Gill (pers. comm.) have observed that seedlings grow into fruiting plants in 10 months. Harada (pers. comm.), from his attempts to control clidemia, found that some plants grew from seedling stage to fruiting in six months.
IV. CONDITION

Threats:
Smith (1985) ranks clidemia as one of the 86 most disruptive alien plant species in Hawaii, principally because of its broad ecological tolerances, very rapid spread in Hawaii, capacity for long-distance dispersal, and tendency to form monospecific subcanopy stands. He characterizes its effects as devastating (Smith in press). Clidemia is established in Kamakou Preserve and nearby Wailau and Pelekunu Valleys, and is intensifying in these areas (Misaki pers. comm.). It is also established in Koolau Gap below the current boundaries of Waikamoi Preserve. Projected distributional limits of clidemia suggest that it will be confined to sites below 1,500 m (Smith pers. comm.), the lower boundary of Waikamoi. However, its upper elevational limit may not have been tested yet in Hawaii, and clidemia may reach higher elevations than expected from its distribution on Oahu and in central America.

Restoration Potential:
Recovery potential of plant communities from which clidemia has been removed has not been examined. Recent mortality to clidemia in drier sites with a biological control pathogen (Colletotrichum gloeosporoides) may test the potential of native forest recovery. Smith (in press) is concerned about the spread of strawberry guava (Psidium cattleianum) or alien grasses into gaps created by loss of clidemia to biocontrol agents. Alien plants often are successful invaders of such open habitats.

V. MANAGEMENT/MONITORING

Management Requirements:
Smith (in press) is skeptical of the efficacy of manual, mechanical, and chemical means of control (Smith in press). Although many clidemia plants can be manually uprooted, efforts to control small populations have almost always failed. In addition, seedling recruitment is prolific, small plants grow rapidly, and seed banks are large and persistent. Finally, similar to other Melastomes, uprooted clidemia may resprout when uprooted in wet areas. However, long-distance establishments can probably be controlled if effective herbicides are identified. These can be used on slash of manually removed plants, for foliar treatments of larger populations, and on dense mats of seedlings.

However, controlling small populations that represent new long distance establishments in otherwise clidemia-free sites makes sense. This is the strategy being employed at Kamakou Preserve. Biocontrol is often only partly successful, and the recovery of native plant communities following removal of clidemia is problematic (Markin in press, Smith in press). Long-distance establishment sites are in disturbed areas such as trails or roads. Such sites lend themselves to early discovery, and are important because they readily serve as the seed source for further dispersal vectored by humans.
Manual control works for all but the largest plants or those in rocky soil. Mechanical aid such as picks are needed for some plants (Harada pers. comm.).

Effective herbicidal control has apparently not been applied in Hawaii, although control methods have been developed in Southeast Asia (Heong et al. 1982).

Use of Colletotrichum in drier sites is warranted. This herbicide is now permitted on an experimental basis (Tanimoto pers. comm.). Probably the best strategy for areas with little or no clidemia is to vigilantly monitor predictable corridors of invasion and eliminate populations, preferably before seed is set, inoculate nearby populations with available biocontrol agents, and support biocontrol efforts in the state. Retreatments are required at less than six month intervals to prevent seed production.

Management Programs:
Volunteer groups have attempted to control infestations in Wailau and Waimanu Valleys with little success (Smith in press). Kamakou Preserve has been successful in preventing the spread of its one known infestation. Other efforts Oahu and elsewhere have generally failed (Smith in press).

Monitoring Requirements:
Populations of currently introduced biocontrol agents, their impacts on clidemia, and plant succession in areas in which clidemia infestations are removed by biological or conventional control methods should be monitored. Monitoring at Kamakou Preserve should focus on determining the full extent of the infestation in the preserve, the success of experimental introduction of Colletotrichum in Pelekunu Valley, and populations in Wailau and Pelekunu. The ingress of clidemia should be monitored in the lower elevations of Waikamoi, especially if the boundaries of the Preserve are extended to lower elevations.

Biological control monitoring consists of counts of biocontrol agents in life stages or subjective ranking of infestation extent and effects on target plants. Monitoring succession requires standard methods to determine cover and density.

Monitoring Programs:
Monitoring is now being conducted to assess the effectiveness of introduced biological control agents, particularly to assess the density, extent, and presence of all life stages. This is described below under research programs.

VI. RESEARCH

Management Research Programs:
No studies on ecology and life-history are known to be in progress. Wester and Wood (1977) and Smith (in press) have summarized observations about phenology, distribution, and ecology of clidemia.
Considerable research to identify potential biological control agents has been conducted, several releases have been made (Nakahara et al. in press), and monitoring of releases is now in progress. The thrips Liothrips urichi was released in 1953. This agent has been judged to be effective in open areas such as pastures and cultivated lands, but has had little effect in shaded sites. The search for biocontrol agents for forested sites lead to the mostly unsuccessful release of three moths during the 1970's. Intensified exploration in the natural range began in 1982. Fourteen insects were identified as potential biological control agents to attack leaves, flowers, and stems. One of these, Lius peisodon, a beetle, has been recently released and is being monitored on Hawaii Island and Oahu (Campbell pers. comm.). Lius has had little overall impact to date, but appears to attack plants in the shade, in contrast to Liothrips.

A fungus Colletotrichum gloeosporiodes was introduced in 1986 (TenBruggencate 1986). This is being evaluated in a number of locations in the state (Tanimoto, pers. comm.). It appears to be successfully controlling clidemia in drier sites, in both shaded and open habitats, but has had little effect in wetter areas. However, Tanimoto (pers. comm.) has not given up on Collectotrichum in wet areas, because the pathogen is very slow acting. Colletotrichum was originally perceived as a microherbicide which needed to be sprayed on target plants because of poor dispersal capacity. It apparently spreads adequately from plant to plant (Tanimoto pers. comm.). A release of the fungus has been made in Pelekunu Valley, and Preserve staff are contributing to its monitoring (Misaki, pers. comm.).

Local herbicide testing suggest little sensitivity to herbicides, although other studies indicate the potential for herbicidal control. Local investigations showed little sensitivity to 2,4-D, dicamba, glyphosate, and triclopyr (Motooka 1987) using the Uyeda drizzle application method (high concentration application to limited area of foliage). Motooka (pers. comm.) characterized it as a relatively herbicide-resistant plant. However, researchers in rubber plantations in Southeast Asia found that 2,4-D amine and triclopyr at 0.7 kg/ha were very effective in control of clidemia (Heong et al. 1982). Differences may be due to application techniques. These studies are a starting point for local research in finding an effective herbicide to supplement manual and biological control methods.

Research Needs (General):
More detailed life history and demographic information may aid in statewide control efforts. Most current information about growth rates, seed viability, and dispersal is largely anecdotal. No such research is needed in the preserves, but is suitable for University researchers to be carried out in a diversity of sites in the state.

Management Research Needs:
If necessary, further studies should be conducted to assess the suitability and effectiveness of additional insect biocontrol candidates. These potential agents have been identified for testing and could augment the pathogen, Colletotrichum gloeosporiodes (Nakahara et al. in press, Smith pers. comm.). These studies have been placed on hold until the results of releases of Colletotrichum gloeosporiodes have been evaluated (Markin pers. comm.,
Smith pers. comm.). Smith (pers. comm.) feels that additional agents may be needed for wet areas, where the pathogen has not been especially effective to date.

Although biological control is the long-term solution to clidemia management, there is a limited role for herbicides. Biocontrol is usually only partially effective and may not prevent the dispersal and range expansion of the species, even though it may reduce the density of infestations when effective. Control of newly established, disjunct populations, which result from long-distance dispersal, is needed to prevent new major infestations and range expansions. Herbicides may be needed to control these outliers, especially if they are too large for manual control. Herbicides are also helpful in wet areas in controlling clidemia slash or uprooted plants which tend to resprout. Finally, herbicides are needed in the control of large populations (several acres) if the native biotic resources at risk are very important. A selective foliar herbicide would be needed for clidemia plants and slash in a chemical control program.

VII. ADDITIONAL TOPICS

VIII. INFORMATION SOURCES

Bibliography:


IX. DOCUMENT PREPARATION & MAINTENANCE

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