36 Biological Control of Melaleuca— Insect Quarantine Research

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Abstract

The Australian melaleuca or paperbark tree was imported as an ornamental at the beginning of the 20th century. It is now invading natural systems in south Florida at an alarming rate. This invasion threatens the success of plans for the restoration of the south Florida ecosystem. Researchers at the USDA-ARS Biological Control of Weeds Laboratory in Australia have surveyed melaleuca and identified many potential control agents. One of these, the melaleuca snout beetle (*Oxyops vitiosa* Pascoe), was released in southern Florida in 1997 after extensive testing. Three additional species have been imported into quarantine at Gainesville, Florida, for host range tests following initial testing in Australia. A pergid sawfly (*Lophyrotoma zonalis* Rohwer), a type of non-stinging wasp, has caterpillar-like young that can defoliate melaleuca trees. Over 48 plant species were tested in quarantine for oviposition and larval development and 44 species for feeding of medium-sized larvae. A small sap-sucking psyllid (*Borieoglycaspis melaleucae* Moore) kills the foliage of plants in quarantine that are heavily infested with nymphs. Oviposition and nymphal development tests are being conducted. A small colony of a mirid bug (*Eucerocoris* suspectus Distant) has been maintained in quarantine after initial host testing with native and introduced Myrtaceae. Adults and nymphs feed on leaves causing dark blotches and leaf death. Further quarantine testing is awaiting results of additional field studies in Australia.

Introduction

Melaleuca, or the Australian paperbark tree *Melaleuca quinquenervia* (Cav.) S.T. Blake (Myrtaceae), was introduced from Australia into south Florida in the early 1900s to drain wetlands and for use as an ornamental (Bodle et al. 1994). The aerial dissemination of melaleuca seeds over the Everglades in 1936 was one form of intro-

duction. The ability of melaleuca to reproduce unchecked and to grow as much as 1.8 m/yr has allowed it to develop from widely spaced saplings rising out of open landscapes to dense monocultures which displace natural ecosystems at an alarming rate.

One reason melaleuca is a pest in Florida and not in its native habitat, Australia, is that it was introduced here without its natural enemies. Explorations for natural enemies of melaleuca were initiated in Australia in the late 1970s by Dale H. Habeck, University of Florida, and continued in the mid-1980s by Joseph K. Balciunas, also of the University of Florida and later of the U.S Department of Agriculture, Agricultural Research Service (USDA-ARS). Over 450 herbivores were found. By the early 1990s, the first biocontrol candidates had been selected and approved for testing at the Florida Department of Agriculture and Consumer Services quarantine facility in Gainesville, Florida. Thus far, we have conducted quarantine research on four potential biocontrol agents of melaleuca: tip-feeding melaleuca snout beetle, defoliating melaleuca sawfly, sap-sucking melaleuca psyllid, and leaf-blotching melaleuca mirid.

Tip-Feeding Melaleuca Snout Beetle

The first melaleuca biocontrol candidate studied in quarantine was the tip-feeding melaleuca snout beetle or weevil *Oxyops vitiosa* Pascoe (Coleoptera: Curculionidae). Permission to study the beetle in quarantine was based on field and laboratory studies conducted in Australia from 1986 to 1994 (Balciunas et al. 1994; Purcell and Balciunas 1994; Purcell et al. 1997). Host range studies were conducted in quarantine from 1992 to 1996. Test results showed that this insect had a narrow host range and was safe to release in Florida (Wineriter and Buckingham 1997). The first beetles were released in the spring of 1997 (Wood 1997). Both adults and larvae feed on the young growth of melaleuca with larvae consuming ten times that of the adults (Balciunas et al. 1994). Field studies are now being conducted in south Florida by the USDA-ARS to evaluate its effectiveness as a biocontrol agent.

Defoliating Melaleuca Sawfly

The second melaleuca biocontrol candidate studied in quarantine was the defoliating melaleuca sawfly *Lophyrotoma zonalis* Rohwer (Hymenoptera: Pergidae). Permission to study the sawfly in quarantine was based on field and laboratory studies conducted in Australia from 1989 to 1992 (Burrows and Balciunas 1997). Host range studies were conducted in quarantine from 1994 to 1997. The wasp-like adults, about 0.5 in long, are strikingly colored (yellow-orange and black), but do not sting. Adults are short-lived. They feed heavily on honey in the lab but have not been observed feeding in the field. Essentially, adults mate, reproduce, and die. Eggs are inserted in a single row beneath edges of mature melaleuca leaves.

The leaf cuticle serves as the egg case. In quarantine, larvae hatch more or less synchronously in about 30 days. Young larvae feed in herds devouring the entire surfaces of leaves; older larvae disperse and feed solitarily or in small groups and eat entire leaves. In quarantine, larvae matured in about five weeks and pupated in the bark of melaleuca trees where they remained for 1-3 months before emerging as adults.

Host range tests of the sawfly determined the plants on which females laid eggs, and on which newly hatched larvae and medium sized larvae developed to prepupae. Females produced on test plants were placed on the same species to test for oviposition. Tests were conducted in our quarantine greenhouse, most often with insects caged on potted plants but sometimes with medium larvae caged with plant bouquets. Plants tested included native and introduced Myrtaceae, and other plants of concern, e.g., wax myrtle (*Myrica cerifera* L.), sugarcane (*Saccharum officinarum* L.), *Citrus*. A summary of test results is listed in Table 1.

Females laid eggs readily on most species of myrtaceous plants. On some plants, leaves were too thin or small for insertion of the eggs. Those eggs laid on test plants hatched, but in most instances, larvae died within a few days or at most in a week or two. Because they were only a few millimeters long at death, the feeding was usually minor. Often it was scattered over the leaves, unlike feeding on melaleuca which usually had an entire surface or both surfaces of the leaf blades consumed. Feeding on bottlebrushes was less than on melaleuca, but it was noticeable and many larvae developed to medium-size and a few to adults. We did not produce enough females to obtain eggs in the next generation. Females were unable to oviposit in the small leaves of *Melaleuca decora* (Salisb.) Britten, but larvae completed development when *M. quinquenervia* leaves with newly hatched larvae were attached to *M. decora*. On those species where sawfly larvae could complete development, *Callistemon* spp. and *M. decora*, pupation sites were not available because the trunk was too hard, and styrofoam blocks had to be provided for pupation. Whether larvae would find suitable pupation sites in larger trunks of these species in the field is not known.

In feeding tests, larvae were reared on melaleuca until medium-sized and then placed on most of the myrtaceous species. The larvae fed on various species for a few days, and on most, they shriveled and died. The exceptions were on *Callistemon* spp., *M. decora*, and wax myrtle. A few larvae on these species pupated and some became adults. Additional tests, including plant species which occur in melaleuca habitats, were performed with medium-sized larvae and bouquets in multichoice tests with and without melaleuca. There was some initial feeding in those tests, but not enough to warrant further testing. These tests indicate that if large larvae defoliate melaleuca in the field, they might feed upon various plants as they crawl in search of new melaleuca, but they would eventually die if they do not find it. Even though they could feed, they probably would not because they would quickly crawl away from non-melaleuca plants. In our tests, if larvae crawled away from test plants, they soon encountered the same plants again because of the small

Table 1. Quarantine host range of the melaleuca defoliating sawfly *Lophyrotoma zonalis*.

Status in Florida	Genus (number of species tested)	Plants on which			
		Eggs laid	Larvae completed development		Adults produced[3]
			Newly hatched	Medium sized	
Native Myrtaceae	*Calyptranthes* (2)	+	-	-	-
	Eugenia (4)	+	-	-	-
	Myrcianthes (1)	+	-	-	-
	Psidium (1)	+	-	-	-
Introduced Myrtaceae	*Accera* (1)	+	-	-	-
	Callistemon (4)	+	+	+	+
	Eucalyptus (4)	+	-	-	-
	Eugenia (6)	+	-	-	-
	Leptospermum (1)	-	-	-	-
	Melaleuca (1)[1]	-	+	+	+
	Melaleuca control[2]	+	+	+	+
	Myrciaria (2)	-	-	-	-
	Pimenta (2)	-	-	-	-
	Pseudanamomis (1)	-	-	-	-
	Psidium (3)	+	-	-	-
	Syzygium (4)	+	-	-	-
Other plants of concern	Sugarcane	-	-	-	-
	Wax myrtle	-	-	+	-
	Citrus (3)	-	-	-	-
	Other (14+)	-	-	-	-

[1] Data refer to *Melaleuca decora;* [2] *Melaleuca quinquenervia*; [3] Adults produced from newly hatched larvae; medium-sized larvae also produced adults on wax myrtle.

cage size. When the tests were stopped, many larvae were off the test plants but were on the companion melaleuca control plants in the control cages.

An additional concern about the release of *Lophyrotoma* in Florida was the potential toxicity of the larvae to vertebrates. Burrows and Balciunas (1997) discussed the presence of a vertebrate toxin, lophyrotomin, in larvae of the Australian *Lophyrotoma interruptus* Klug which feeds on eucalyptus and suggested that *L. zonalis* be investigated for the toxin. Consequently, dried larvae were fed to mice by a cooperator at the USDA-ARS Toxic Plants Laboratory in Logan, Utah, with no effect on the mice (G. Wheeler, pers. comm.). Additionally, at the USDA Animal and Plant Health Inspection Service Laboratory in Gainesville, larvae with ligated heads and ground up freeze-dried larvae, adults, and melaleuca leaves were fed to red-winged blackbirds with no noticeable ill effects (M. Avery, pers. comm.). There are no reports of *L. zonalis* or any other *Lophyrotoma*, except the one species mentioned, having a toxin.

With the host range tests now complete for the sawfly, the application process for permission to release is now under way. If the permit is approved, the sawfly is likely to be released from quarantine in the summer of 1999.

Sap-Sucking Melaleuca Psyllid

The third melaleuca biocontrol candidate studied in quarantine has been the sap-sucking melaleuca psyllid *Boreioglycaspis melaleucae* Moore (Homoptera: Psyllidae). Permission to study the psyllid in quarantine was based on field and laboratory studies conducted in Australia from 1992 to 1994 (Purcell et al. 1997). Host range studies were initiated in quarantine in 1997 and continue to the present. Studies are more than half complete.

The psyllid adult, about one-eighth inch long, looks like a cream-colored miniature cicada. Unlike sawfly adults, they feed on melaleuca and produce copious quantities of honeydew. Adult feeding damage, however, is non-apparent. Adults mate within 24 h of emergence and live on average about 15-20 days. A female lays about 80 yellow teardrop-shaped eggs during her lifetime on the young growth of melaleuca, including leaf surfaces, edges, petioles, and melaleuca stems (Purcell et al. 1997). Eggs hatch in quarantine in about 14-17 days. The nymphal stage lasts about 3-4 weeks and accounts for the majority of the seven week cycle in quarantine.

Newly hatched nymphs may wander for a few hours but usually settle down and start feeding. Once nymphs start feeding, they produce abundant quantities of honeydew and white waxy flocculent threads throughout all nymphal stages. The waxy threads form a cover over them. If very many nymphs are feeding on a branch of melaleuca, then the branch appears to be shrouded in cotton. The nymphal stage is the most devastating to melaleuca. Yellowing of leaves is an early sign of feeding damage; affected leaves drop with slight pressure. With a heavy infestation, entire plants, leaves, and branches turn brown, leaves and young

stems curl, and plants appear dead; some leaves drop and others persist for months. For example, in December 1997, a melaleuca branch ca. 2 ft in length and infested with psyllids was caged with a 6 ft tall melaleuca sapling. By mid-February, about 1.0-1.5 generations later, the entire sapling looked dead and there was no more plant material to sustain psyllids. The plant was regularly watered thereafter. By late May 1998, or over three months later, three new shoots about 10 in long were observed growing near the base of the sapling. While we hoped to see no regrowth, the lag time for regrowth indicates the level of plant stress caused by psyllids, a benefit for control of melaleuca. Regrowth is a good indication that these psyllids (our quarantine stock) are not vectoring any diseases and provides us with the opportunity to test for host-plant resistance to multiple infestations.

Throughout our quarantine studies with melaleuca and test plants, we have never observed systemic damage caused by psyllid feeding. We are holding some melaleuca plants from tests for a year to determine whether there is a slow acting systemic effect. Some of the possible effects of psyllid damage on melaleuca in the field may be similar to the documented damage caused by the mimosa psyllid *Heteropsylla spinulosa* on *Mimosa invisa* Martius, an introduced weed in Australia: "Flowering and seed production can be appreciably reduced and premature deaths of seedlings and some mature plants have been observed in the field" (Kuniata 1994).

Host-range tests of the psyllid have been designed to determine on which plants females survive at least three days and lay eggs and nymphs complete development and become adults. As with the sawflies, host range tests were conducted in the quarantine greenhouse where insects were caged on test plants with cloth sleeves. Like the sawflies, plants tested included native and introduced Myrtaceae, as well as any other plants of concern.

The percentage of females surviving three days on test plants was lower than on melaleuca (Table 2). We have also observed that the melaleuca psyllid does not produce nearly as many honeydew droplets when placed on test plants as on melaleuca, an indication of physical limitation (mouth parts cannot reach phloem) or physiological/chemical incompatibility. Any adult feeding is a concern, however, as adult psyllids are known to vector diseases. Of particular interest in this case is whether the melaleuca psyllid might vector diseases which cause citrus dieback. Further testing will be conducted in cooperation with the Division of Plant Industry, Florida Department of Agriculture and Consumer Services, and other scientists to determine whether the melaleuca psyllid carries and vectors citrus dieback.

The melaleuca psyllid laid eggs on many of the test plants (Table 3) as was true in Australia (Purcell et al. 1997). When leaf material with eggs was held in rearing dishes with high humidity, eggs did hatch but nymphs did not survive long except on melaleuca. When eggs were tethered in vials to plants or left on plants, nymphs

Table 2. Quarantine host range of the sap-sucking psyllid *Borieoglycaspis melaleucae*. Preliminary data on the survivorship of females on test plants relative to melaleuca. The score is based on the number of females surviving on test plants divided by the number surviving on melaleuca. The highest percentage surviving on any plant of the species, not the mean, is shown.

Status in Florida	Genus (number of species tested)	Survivorship of females for 3 days on test plants (% test plant of melaleuca control)		
		0-25%	26-50%	50-75%
Native Myrtaceae	*Calyptranthes* (2)	+		
	Eugenia (4)	+		
	Myrcianthes (1)	+		
	Psidium (1)	+		
Introduced Myrtaceae	*Callistemon* (4)		+	
	Eucalyptus (4)			+
	Eugenia (6)		+	
	Leptospermum (1)		+	
	Melaleuca decora	+		
	Myrciaria (2)	+		
	Pimenta (2)	+		
	Pseudanamomis (1)	+		
	Psidium (3)	+		
	Syzygium (4)	+		
Other plants of concern	Sugarcane		+	
	Wax myrtle	+		
	Citrus (3)	+		

hatched but did not survive or cause any damage except on *Callistemon* spp. To date, there has been some nymphal development on three species of *Callistemon*, but only on *C. rigidus* have any adults been produced; fewer numbers were produced, however, than on the melaleuca control. Development time on *Callistemon* spp. is generally longer than on melaleuca. Except for *C. rigidus* R. Br., no damage to test plants by adults or nymphs has been observed. Damage to *C. rigidus* was similar to that seen in melaleuca, with yellowing and browning of leaves and leaf drop, but only on the portion of the plant exposed to the psyllids.

Table 3. Quarantine host range of the sap-sucking psyllid *Boreioglycaspis melaleucae*. Preliminary data on the plants on which females lay eggs and nymphs develop and become adults. Blanks in a column indicate data have not been taken yet.

Status in Florida	Genus (number of species tested)	Plants on which		
		Eggs laid	Nymphs complete development	Adults produced
Native Myrtaceae	*Calyptranthes* (2)	+	-	-
	Eugenia (4)	-	-	-
	Myrcianthes (1)	+	-	-
	Psidium (1)	-	-	-
Introduced Myrtaceae	*Callistemon* (4)	+	+	+
	Eucalyptus (4)	+	-	-
	Eugenia (6)	+	-	-
	Leptospermum (1)	+	-	-
	Melaleuca decora	+	-	-
	Melaleuca quinquenervia	+	+	+
	Myrciaria (2)	+	-	-
	Pimenta (2)	+	-	-
	Pseudanamomis (1)	+		
	Psidium (3)	+		
	Syzygium (4)	+	-	-
Other plants of concern	Sugarcane	-		
	Wax myrtle	+	-	-
	Citrus (3)	+	-	-

The data show that the psyllid has a very narrow host range on which it can complete its life cycle. This is true for psyllids in general (Hodkinson 1974). Testing needs to be completed and whether the psyllid vectors any plant diseases needs to be determined.

Leaf-Blotching Melaleuca Mirid

The fourth melaleuca biocontrol candidate studied in quarantine has been the leaf-blotching melaleuca mirid *Eucerocoris suspectus* Distant (Hemiptera: Miridae). Both

the adult and nymph cause feeding damage to melaleuca. Their feeding causes dark blotches on leaves and eventually leaf death. They are prolific and easy to colonize in the laboratory. Host range studies were initiated in quarantine in 1997, but during the initial feeding tests, they made distinctive blotches, similar to those on melaleuca, when tasting many test plants. Further hosts range tests are to be conducted in the field in Australia. A small colony is being maintained in quarantine.

Conclusion

The first releases of the snout beetle were made in the spring of 1997. Host-range tests of the sawfly are complete and the application for permission to release is now under way. Host-range tests of the psyllid were initiated in quarantine in 1997 and continue to the present. The data look promising. Host-range tests of the mirid were started in 1997 but have been put on hold until further testing is conducted in Australia. It is hoped that in the near future there will be not only snout beetle adults and larvae feeding on the young succulent leaves of melaleuca, but also sawfly larvae feeding on mature leaves. Later introductions of the psyllid and possibly mirid will place melaleuca under further stress. Use of these natural enemies should reduce flowering and seed set, lower the reproductive rate of melaleuca, reduce plant vigor, and along with other control measures, help halt the spread of melaleuca in southern Florida.

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Literature Cited

Balciunas, J.K., D.W. Burrows, and M.F. Purcell. 1994. Field and laboratory host ranges of the Australian weevil, *Oxyops vitiosa* (Coleoptera: Curculionidae), a potential biological control agent for the paperbark tree, *Melaleuca quinquenervia. Biological Control* 4:351-360.

Bodle, M.J., A.P. Ferriter, and D.D. Thayer. 1994. The biology, distribution, and ecological consequences of *Melaleuca quinquenervia* in the Everglades. In S.M. Davis and J.C. Ogden (eds.), *Everglades: The Ecosystem and Its Restoration.* Delray Beach, Fla.: St. Lucie Press.

Burrows, D.W., and J.K. Balciunas. 1997. Biology, distribution and host-range of the sawfly, *Lophyrotoma zonalis* (Hymenoptera: Pergidae), a potential biological control agent for the paperbark tree, *Melaleuca quinquenervia*. *Entomophaga* 42:299-313.

Hodkinson, I.K. 1974. The biology of the Psylloidea (Homoptera): A review. *Bulletin of Entomological Research* 64:325-339.

Kuniata, L.S. 1994. Importation and establishment of *Heteropsylla spinulosa* (Homoptera: Psyllidae) for the biological control *of Mimosa invisa* in Papua New Guinea. *International Journal of Pest Management* 40:64-65.

Purcell, M.F., and J.K. Balciunas. 1994. Life-history and distribution of the Australian weevil *Oxyops vitiosa* (Coleoptera: Curculionidae), a potential biological control agent for *Melaleuca quinquenervia* (Myrtaceae). *Annals of the Entomological Society of America* 87:867-873.

Purcell, M.F., J.K. Balciunas, and P. Jones. 1997. Biology and host-range of *Boreioglycaspis melaleucae* (Hemiptera: Psyllidae), potential biological control agent for *Melaleuca quinquenervia* (Myrtaceae). *Environmental Entomology* 26:366-372.

Wineriter S.A., and G.R. Buckingham. 1997. Love at first bite—introducing the Australian melaleuca weevil. *Aquatics* 19:10-12.

Wood, M. 1997. Aussie weevil opens attack on rampant melaleuca. *Agricultural Research* 45:4-7.