HISTORY AND ECOLOGY IN NORTH AMERICA

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Boreioglycaspis melaleucae
Melaleuca psyllid

Boreioglycaspis melaleucae is a biological control agent approved in the USA for release against melaleuca.

CLASSIFICATION

RANKING	SCIENTIFIC NAME	COMMON NAME
Kingdom	Animalia	Animals
Phylum	Arthropoda	Arthropods
Class	Insecta	Insects
Order	Hemiptera	True bugs
Family	Psyllidae	Jumping plant lice
Genus	*Boreioglycaspis*	
Species	*Boreioglycaspis melaleucae* Moore	Melaleuca psyllid

DESCRIPTION

Eggs are yellow, cylindrical (**Fig. 1a**), and have a spine-like projection on one end. Nymphs more closely resemble adults through each subsequent instar. Early nymphal instars are pale yellow with no markings (**Fig. 1b**). Mature nymphal instars have gray to black markings (**Fig. 1c**) and have filamentous wax loosely covering their bodies (**Fig. 1d**). Adults are up to 3 mm long and pale yellow-orange to white in color with gray to black markings (**Fig. 1e**). Their wings are transparent with yellow veins. Two finger-shaped appendages extend outward and downward from below their eyes.

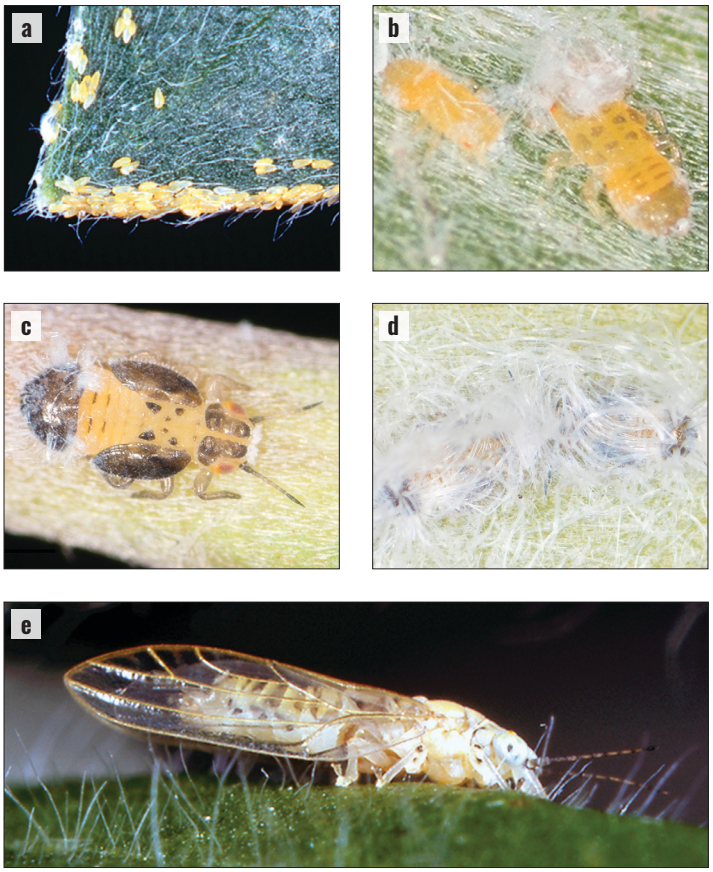

Figure 1. *Boreioglycaspis melaleucae* (a) eggs; (b) early-instar nymphs; (c) later-instar nymph; (d) late-instar nymphs covered in filamentous wax; (e) adult (a,e: Susan Wineriter-Wright, USDA-ARS Invasive Plant Research Lab; b–d: Jesse Rorabaugh, iNaturalist.org CC0)

LIFE CYCLE

This species reproduces year-round, resulting in multiple overlapping generations. Female adults insert the spine-like projections of eggs into melaleuca stems and leaves. They lay eggs singly or in small groups, but up to 275 in their lifetime. Nymphs secrete waxy filaments that cover their bodies as a form of protection. Wax secretions form a dense, woolly mass on stems and leaves (**Fig. 2**). Nymphs and adults feed by piercing and sucking out the cell contents of melaleuca leaf and stem cells. Nymphs develop through five instars, each secreting copious amounts of honeydew. There are up to 13 generations per year, depending on site conditions.

DAMAGE

Both adults and nymphs feed on melaleuca, but nymphal feeding is most damaging. Their saliva is thought to be phytotoxic and cause premature leaf drop. Heavy infestations kill attacked leaves, young plants, and saplings.

FIELD IDENTIFICATION

Two other approved biological control agents are established on melaleuca in the USA, and a third was recently released

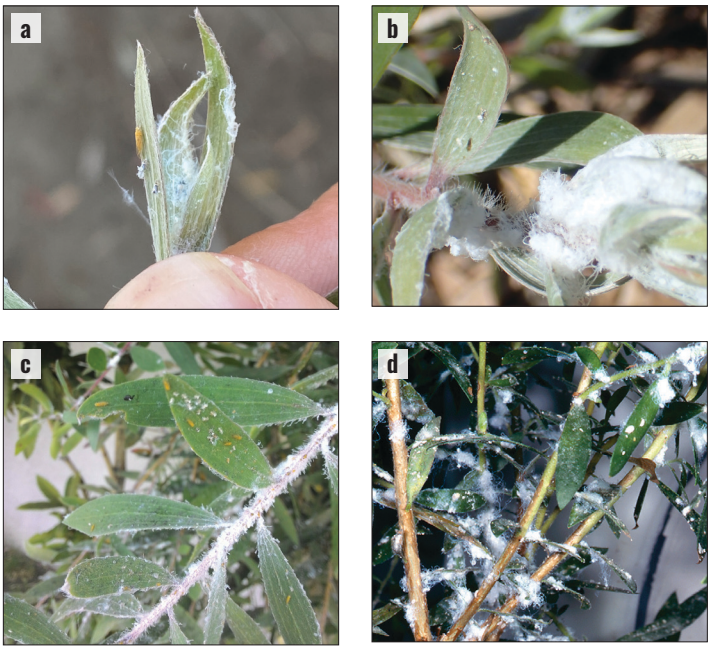

Figure 2. *Boreioglycaspis melaleucae* waxy flocculence produced by nymphs on melaleuca foliage (a: Will Sweet; b: Ron Matsumoto; c: Chris Mallory [a–c , iNaturalist.org CC BY-NC 4.0]; d: Susan Wineriter-Wright, USDA-ARS Invasive Plant Research Lab)

(2022) but is not yet confirmed established. These can be readily differentiated from *B. melaleucae* in all life stages and by their distinctive feeding damage. Where *B. melaleucae* is established, filamentous wax secretions can be observed on attacked melaleuca foliage throughout the year (**Fig. 2**). The melaleuca gall midges, *Lophodiplosis trifida* and *L. indentata*, are similar in size to *B. melaleucae*, and their larvae and pupae are a similar yellowish-orange. However, adult *Lophodiplosis* have long, delicate legs and antennae (**Fig. 4, Fig. 6**). Where *Lophodiplosis* midges are established, their feeding galls should be readily apparent on melaleuca leaves (**Fig. 5a**) and stems (**Fig. 7**). The beetle *Oxyops vitiosa* is much larger (up to 9 mm long) and should not be confused with the other species. Its larvae are often slug-like (**Fig. 9a,b**), and the adults are brown to gray with hardened, knobby elytra and an obvious snout (**Fig. 9c,d**). Larval and adult feeding by *O. vitiosa* also causes distinctive defoliation (**Fig. 10**).

PREFERRED HABITAT

Boreioglycaspis melaleucae is well adapted to most habitats throughout southern Florida. High temperatures (above 86°F or 30°C) reduce psyllid populations during the summer months.

HISTORY AND CURRENT STATUS

Boreioglycaspis melaleucae is native to Australia. Individuals were released on melaleuca in Florida, USA beginning in 2002. This psyllid is now established well throughout Florida (**Fig. 3**), though populations are seasonably variable and densities are greatest in southern Florida. In combination with the other established melaleuca biocontrol agents, *B. melaleucae* causes severe damage to mature melaleuca trees. Cumulative damage is reduced plant height, branching, and biomass of surviving coppices as well as increased fruit abortion and seedling/sapling mortality. Summer temperatures possibly reduce population growth. Predation by generalist species may reduce populations as well, though this is likely insignificant.

A small population of this psyllid was found near Los Angeles International Airport in California in 2009 (**Fig. 3**). It remains unknown if this originated from the population established in Florida, or if it arrived accidentally directly from its native Australia. Though still observed as spreading in California on ornamental melaleuca trees, the population there is considered to be small.

NOTES

The melaleuca snout beetle, *O. vitiosa,* cannot establish at permanently flooded melaleuca sites because of its requirement to pupate in soil. *Boreioglycaspis melaleucae* is a good complement at these types of sites because it completes its life cycle entirely in the tree canopy.

NONTARGET EFFECTS

None reported

Figure 3. *Boreioglycaspis melaleucae* reported distribution in North America (Winston et al. 2021)

Lophodiplosis indentata

Melaleuca leaf pea-galling midge

Lophodiplosis indentata is a biological control agent approved in the USA for release against melaleuca.

CLASSIFICATION

RANKING	SCIENTIFIC NAME	COMMON NAME
Kingdom	Animalia	Animals
Phylum	Arthropoda	Arthropods
Class	Insecta	Insects
Order	Diptera	Flies
Family	Cecidomyiidae	Gall midges
Genus	*Lophodiplosis*	
Species	*Lophodiplosis indentata* Gagné	Melaleuca leaf pea-galling midge

DESCRIPTION

Eggs are ovoid and bright yellow, measuring 0.5–1 mm in length. Larvae are cream to yellow-colored and up to 3 mm long. Adults are small (3–5 mm long) with orange to red abdomens and pale wings (**Fig. 4**). They have fine, delicate legs and antennae.

Figure 4. *Lophodiplosis indentata* adult female (Susan Wineriter-Wright, USDA-ARS Invasive Plant Research Lab)

LIFE CYCLE

Lophodiplosis indentata requires 45–48 days to complete its life cycle and reproduces throughout the year, creating multiple, overlapping generations. Females lay 200–300 eggs singly or in small groups on melaleuca leaves. Larvae burrow into leaf tissue, and enzymes in their saliva initiate the formation of pea-like galls around the feeding larvae. Galls are up to 1 cm across (**Fig. 5a**) and have three chambers. Larvae feed within galls through three instars. Pupation occurs within galls. As larvae near pupation, they begin chewing through the gall tissue to create a thin "window" from which the adult will emerge. Adults leave behind an exuvia when they emerge that appears as a white case protruding from the gall (**Fig. 5b**). Adults are sexually mature upon emergence and live 2–3 days.

DAMAGE

Extensive leaf galling causes both physiological and mechanical damage. Galls are resource sinks that divert resources away from normal plant growth. Heavily galled leaves are also frequently excised from plants, and heavily galled branches incur injury from the weight of the galls.

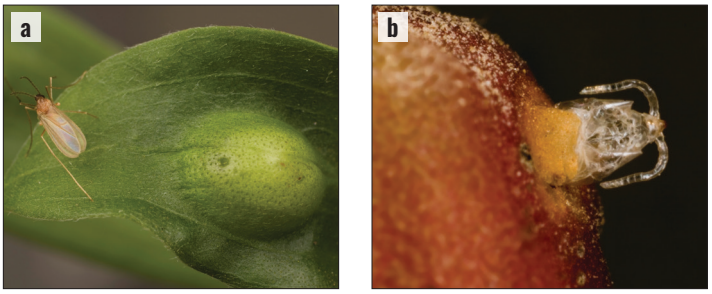

Figure 5. *Lophodiplosis indentata* (a) adult and gall surrounding feeding larva; (b) adult emerging from its leaf gall and leaving behind an exuvia (a,b: Susan Wineriter-Wright, USDA-ARS Invasive Plant Research Lab)

FIELD IDENTIFICATION

Three other approved biological control agents are already established on melaleuca in the USA. The closely related *Lophodiplosis trifida* is extremely difficult to differentiate from *L. indentata*; adults of both are tiny, delicate, and orangish-red in coloration (**Fig. 4, Fig. 6**). Both *Lophodiplosis* midges will gall various plant tissues, but *L. indentata* prefers newly emerged melaleuca leaves, whereas *L. trifida* prefers stems (**Fig. 7**) and stem tips. Anecdotally, *L. indentata* is more often found on large, mature trees in Australia. When *L. indentata* becomes established, the leaf pea galls (**Fig. 5a**) should be readily apparent. The remaining two established species can be readily differentiated from the *Lophodiplosis* midges and from each other in all life stages and by their distinctive feeding damage. The melaleuca psyllid, *Boreioglycaspis melaleucae*, is a similar size to *Lophodiplosis* spp., and its nymphs and adults are a similar yellowish-orange to *L. indentata* (**Fig. 1b,c**). However, its adults (**Fig. 1e**) lack the long, delicate legs and antennae of *Lophodiplosis* adults (**Fig. 4, Fig. 6**). Where *B. melaleucae* is established, filamentous wax secretions should be readily visible on attacked melaleuca foliage throughout the year (**Fig. 2**). The beetle *Oxyops vitiosa* is much larger (up to 9 mm long) and should not be confused with the other three species. Its larvae are often slug-like (**Fig. 9a,b**), and the adults are brown to gray with hardened, knobby elytra and an obvious snout (**Fig. 9c,d**). Larval and adult feeding by *O. vitiosa* also causes distinctive defoliation (**Fig. 10**).

PREFERRED HABITAT

This midge does well with high humidity and at sites with prolonged flooding or near water. It also seems to prefer the new growth at the higher points of mature trees although this observation has not been directly measured.

HISTORY AND CURRENT STATUS

Lophodiplosis indentata is native to Australia. Midges were released on melaleuca in Florida, USA beginning in 2022.

It is too early to confirm establishment of this species in the field.

NOTES

The melaleuca snout beetle, *O. vitiosa,* cannot establish at permanently flooded melaleuca sites because of its requirement to pupate in soil. *Lophodiplosis indentata* should be a good complement to this biocontrol agent because it does best at moist and humid sites.

NONTARGET EFFECTS

None reported

Lophodiplosis trifida
Melaleuca gall midge

Lophodiplosis trifida is a biological control agent approved in the USA for release against melaleuca.

CLASSIFICATION

RANKING	SCIENTIFIC NAME	COMMON NAME
Kingdom	Animalia	Animals
Phylum	Arthropoda	Arthropods
Class	Insecta	Insects
Order	Diptera	Flies
Family	Cecidomyiidae	Gall midges
Genus	*Lophodiplosis*	
Species	*Lophodiplosis trifida* Gagné	Melaleuca gall midge

Figure 6. *Lophodiplosis trifida* adult female (Susan Wineriter-Wright, USDA-ARS Invasive Plant Research Lab)

DESCRIPTION

Eggs are elongated and red-orange in color. Larvae are yellow to orange and up to 2 mm long. Pupae are a yellowish-orange, becoming darker orange as they mature. Adults are very small (3 mm long) and have dark red bodies, tan heads, and pale gray wings and legs (**Fig. 6**). They have fine, delicate legs and antennae.

LIFE CYCLE

This species reproduces year-round, resulting in multiple overlapping generations. Females lay up to 160 eggs singly or in small groups on young melaleuca stems, buds, and leaves. Larvae burrow into stem or leaf tissue, and enzymes in their saliva initiate the formation of galls. Though galls develop in stems, buds, and leaves, it is stems that are most heavily galled (**Fig. 7**). Larvae feed within galls through three instars. Galls may have single chambers housing one individual or several chambers, each housing a single larva. Larger galls can be a few inches (several cm) long. Pupation occurs within galls. Adults are sexually mature upon emergence and live for up to five days. There are multiple overlapping generations per year.

Figure 7. *Lophodiplosis trifida* galls on melaleuca foliage (Matthew F. Purcell, USDA-ARS Australian Biological Control Laboratory)

DAMAGE

Galling (**Fig. 7**) halts the growth of young, infested stems on mature melaleuca trees and kills small seedlings and saplings.

FIELD IDENTIFICATION

The closely related *Lophodiplosis indentata* was recently (2022) released on melaleuca in Florida and is extremely difficult to differentiate from *L. trifida* in the field. Adults of both are tiny, delicate, and orangish-red in coloration (**Fig. 4, Fig. 6**). Both *Lophodiplosis* midges will gall various plant tissues, but *L. trifida* prefers stems (**Fig. 7**) and stem tips, whereas *L. indentata* prefers newly emerged melaleuca leaves (**Fig. 5a**). Anecdotally, *L. indentata* is more often found on large, mature trees in Australia. Two other approved biological control agents are established on melaleuca in the USA. The melaleuca psyllid, *Boreioglycaspis melaleucae*, is a similar size to *Lophodiplosis* midges, and its nymphs are a similar yellow-orange (**Fig. 1b,c**). However, its adults (**Fig. 1e**) lack the long, delicate legs and antennae of *Lophodiplosis* adults. Where *B. melaleucae* is established, filamentous wax secretions should

be readily visible on attacked melaleuca foliage throughout the year (**Fig. 2**). The beetle *Oxyops vitiosa* is much larger (up to 9 mm long) and should not be confused with the other species. Its larvae are often slug-like (**Fig. 9a,b**), and the adults are brown to gray with hardened, knobby elytra and an obvious snout (**Fig. 9c,d**). Larval and adult feeding by *O. vitiosa* also causes distinctive defoliation (**Fig. 10**).

PREFERRED HABITAT

This midge does best with high humidity and at sites with prolonged flooding or near water. Populations are reduced in dry habitats.

HISTORY AND CURRENT STATUS

Lophodiplosis trifida is native to Australia. Midges were released on melaleuca in Florida, USA beginning in 2008. They quickly established at all release sites except one where the midges were killed by frost (**Fig. 8**). Populations are moderately abundant overall. Populations are high in areas with a long hydroperiod (wetlands) but lower in upland systems where they are restricted to the lower canopy. Galling reduces melaleuca sapling height by 10.1%, leaf biomass by 42%, woody biomass by 42.7%, and root biomass by 30.3%. In conjunction with the other established biocontrol agents, *L. trifida* decreases melaleuca plant growth and survival.

Figure 8. *Lophodiplosis trifida* reported distribution in the USA (Winston et al. 2021)

NOTES

The melaleuca snout beetle, *O. vitiosa,* cannot establish at permanently flooded melaleuca sites because of its requirement to pupate in soil. *Lophodiplosis trifida* is a good complement to this biocontrol agent because it does best at moist and humid sites.

NONTARGET EFFECTS

None reported

Oxyops vitiosa
Melaleuca snout beetle

Oxyops vitiosa is a biological control agent approved in the USA for release against melaleuca.

CLASSIFICATION

RANKING	SCIENTIFIC NAME	COMMON NAME
Kingdom	Animalia	Animals
Phylum	Arthropoda	Arthropods
Class	Insecta	Insects
Order	Coleoptera	Beetles
Family	Curculionidae	Weevils
Genus	*Oxyops*	
Species	*Oxyops vitiosa* Pascoe	Melaleuca snout beetle

DESCRIPTION

Eggs are 1 mm long and yellow but are coated with a dark protective secretion. Early instar larvae are small and yellow while mature larvae are up to 14 mm long, grayish, and slug-like in appearance. Larvae produce long, thin coils of feces and are covered in an orangish protective oily secretion that turns dark with fecal matter (**Fig. 9a,b**). Adults are up to 9 mm long and reddish-brown initially but turn darker gray with age (**Fig. 9c,d**). They have knobby protuberances on their elytra and a stout snout.

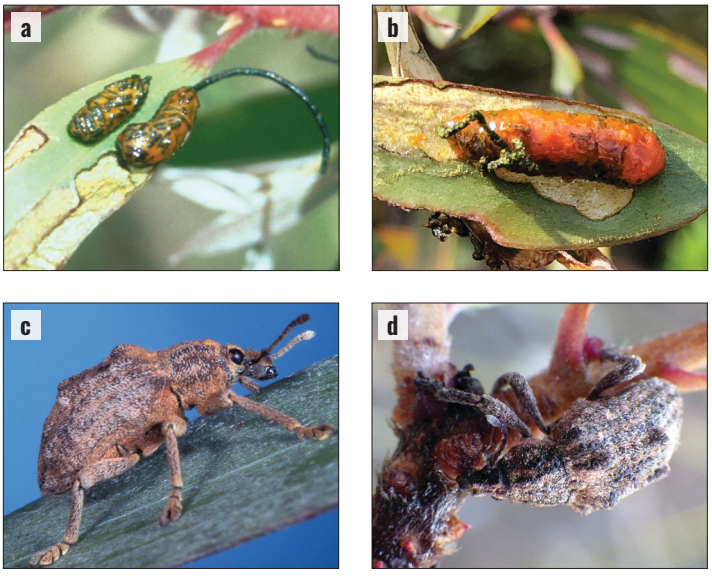

Figure 9. *Oxyops vitiosa* (a) larvae, fecal coil, and feeding damage; (b) larva, beginning of fecal coil, and feeding damage; (c) adult; (d) adult and feeding damage (a: Willey Durden, USDA-ARS, Bugwood.org CC BY-3.0 US; b: Noah, iNaturalist.org CC BY-NC 4.0; c: Gary Buckingham, USDA-ARS, Bugwood.org CC BY-3.0 US; d: Joe MDO, iNaturalist.org CC BY-NC 4.0)

LIFE CYCLE

This species reproduces year-round, resulting in multiple overlapping generations. Females lay 500–1,000 eggs singly on young melaleuca leaves and expanding buds and twigs. Larvae are specialized feeders, feeding on the seasonal flush of young melaleuca leaves through four instars. They consume all layers of leaf tissue except the cuticle, leaving "window" feeding scars (**Fig. 9a,b**). At maturity, larvae drop from the host plant to burrow into the soil for pupation. Adults feed on melaleuca leaves, buds, and stems, leaving holes and gouges in young tissue (**Fig. 10a**) and defoliating young leaves (**Fig. 10b,c**). Adult feeding damage to tough, older leaves is often more superficial, resulting in narrow scars along the leaf surface (**Fig. 10d**). Adults are long-lived (over one year), and there are 2–3 generations produced per year in Florida's climate.

DAMAGE

Heavy larval and adult feeding causes defoliation (**Fig. 9a,b, Fig. 10**) and tip dieback, which in turn stimulate new growth that acts as a nutrient sink and reduces reproductive output. New growth is subsequently attacked by continual generations of the beetle, increasing the impact further.

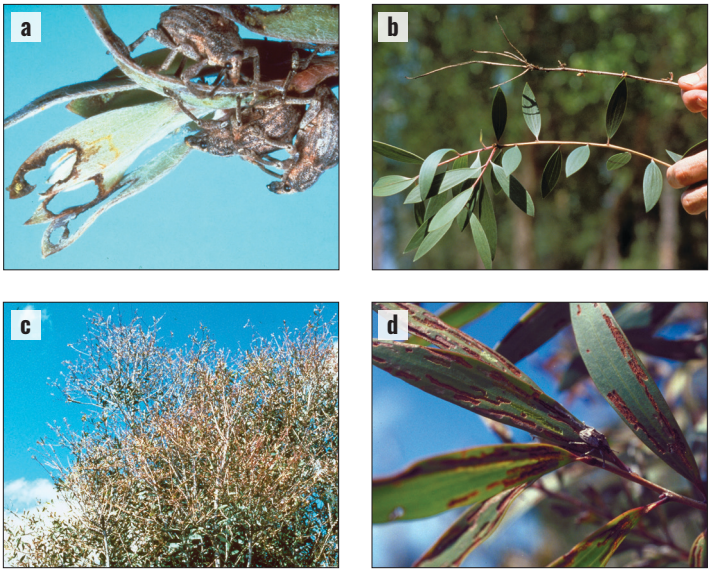

Figure 10. *Oxyops vitiosa* (a) adults and feeding damage to young foliage; (b) defoliation of upper branch compared to undamaged lower branch; (c) severe defoliation of twigs in the upper tree crown; (d) adult and superficial feeding damage to older foliage (a: Gary Buckingham, USDA-ARS; b: Peggy Greb, USDA-ARS; c: Ted D. Center, USDA-ARS Invasive Plant Research Lab; d: Willey Durden, USDA-ARS [a–d: Bugwood.org CC BY-3.0 US])

FIELD IDENTIFICATION

Two other approved biological control agents are established on melaleuca in the USA, and a third was recently released (2022) but is not yet confirmed established. All three are very small (≤5 mm long) and can be readily differentiated from *O. vitiosa* by their distinctive feeding damage. Where the psyllid *Boreioglycaspis melaleucae* is established, filamentous wax secretions can be observed on attacked melaleuca foliage throughout the year (**Fig. 2**). Where the melaleuca gall midges, *Lophodiplosis trifida* and *L. indentata*, are established, their feeding galls should be readily apparent on melaleuca leaves (**Fig. 5a**) and stems (**Fig. 7**). *Oxyops vitiosa* larvae are slug-like (**Fig. 9a,b**) and up to 14 mm long while their adults are brownish, up to 9 mm long, and have hardened, knobby elytra (**Fig. 9c,d**). Larval and adult feeding by *O. vitiosa* also causes distinctive defoliation (**Fig. 10**).

PREFERRED HABITAT

Oxyops vitiosa is adapted to sites with dry winter conditions and abundant young melaleuca foliage. Because this beetle pupates in the soil, persistent populations are rare in permanently flooded habitats.

HISTORY AND CURRENT STATUS

Oxyops vitiosa is native to Australia and was released on melaleuca in Florida, USA beginning in 1997. The beetle established well throughout the state (**Fig. 11**), but densities are highest in southern Florida. In combination with the other established melaleuca biocontrol agents, *B. melaleucae* causes severe damage to mature melaleuca trees. Damage occurs as reduced plant height, branching, and biomass of surviving coppices. The beetle also decreases seed production and seed biomass, increases seedling mortality and premature leaf fall, and disrupts plant-nutrient-feedback cycles which reduces the invasiveness of melaleuca. Repeated beetle attack enables other plant species to colonize the sites.

Figure 11. *Oxyops vitiosa* reported distribution in the USA (Winston et al. 2021)

NONTARGET EFFECTS

None reported

NON-ESTABLISHED SPECIES

Fergusonina turneri
(Diptera: Fergusoninidae)
&
Fergusobia quinquenerviae
(Secernentea: Tylenchida)

DESCRIPTION AND LIFE CYCLE

Fergusonina gall flies and *Fergusobia* nematodes have a mutualistic relationship in that female flies oviposit both their own eggs as well as juvenile nematodes into melaleuca leaf and flower buds. Infection with the nematodes stimulates the formation of a gall (**Fig. 12a**), and fly larvae feed on gall tissue through all three instars. Female nematodes then invade third-instar female fly larvae, laying eggs in and feeding on their hosts but not killing them. Third instars create "windows" in galls through which adults later emerge (following pupation within galls). All female flies contain nematodes. Juvenile nematodes migrate to the fly's oviducts in order to be oviposited in new melaleuca tissue along with fly eggs, thus repeating the cycle. Galls act as metabolic sinks, halting melaleuca stem elongation and preventing flower formation. Mature galls are green to reddish-yellow, ½ in (1.3 cm) in diameter, and often appear as grape-like clusters of multiple fly chambers. Adult flies are 3–5 mm long and pale yellow with lateral stripes on the abdomen (**Fig. 12b**). They have iridescent green eyes and transparent wings. Larvae are white and up to 2½ mm long. Adult nematodes are worm-like, unsegmented, and tiny (less than 1 mm long).

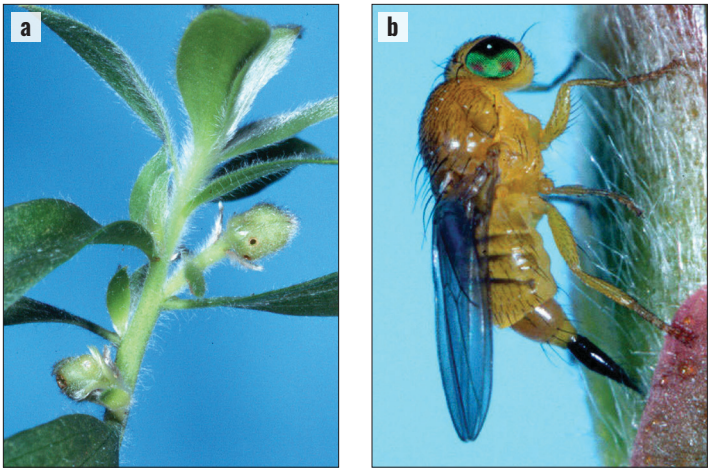

Figure 12. (a) *Fergusonina* and *Fergusobia* galls in melaleuca; (b) *Fergusonina* adult female (a,b: Susan A. Wright, USDA-ARS Invasive Plant Research Laboratory, Bugwood.org CC BY-3.0 US)

HISTORY AND CURRENT STATUS

Because *Fergusobia quinquenerviae* is a mutualistic nematode of *Fergusonina turneri*, both were released together. Individuals sourced from Australia were released in Florida, USA from 2005 to 2007. This pair failed to establish, despite multiple introductions and efforts to improve synchronization with the susceptible stage of melaleuca (buds). They temporarily colonized release sites but disappeared completely after three generations.

UNAPPROVED BIOCONTROL AGENTS

One accidentally introduced species is established on melaleuca in North America that is not approved for use. **It is illegal to intentionally move this species to new areas in the USA.** Care should be taken when transferring approved agents to ensure that this unapproved species is not also included in transferred material.

Austropuccinia psidii (= *Puccinia psidii*)
(Pucciniomycetes: Pucciniales)

DESCRIPTION AND LIFE CYCLE

Although *Austropuccinia psidii* produces teliospores, basidiospores, and (presumably) pycniopspores and aeciospores, its urediniospores are the dominant spore form that repeatedly infects susceptible myrtaceous hosts in Florida and other parts of the world. Urediniospores are yellowish, round, covered in short spines, and tiny (27 µm). Urediniospores occur in powdery mass pustules on both sides of the infected leaves. Leaves become discolored shortly after infection. Even lightly infected leaves turn reddish and then gray-brown at the site of infection (**Fig. 13**); severely infected leaves are heavily distorted and ultimately defoliated. Infected twigs develop lesions and localized swellings. Urediniospores are easily blown to uninfected plants to repeat the entire cycle within two weeks.

HISTORY AND CURRENT STATUS

This rust was first described in Brazil on guava plants in 1884 and was later recorded on numerous host species throughout Central and South America and the Caribbean. In Florida, it was first reported on allspice plants in 1979 and was first discovered attacking melaleuca in 1997. It has since been found attacking both of these species throughout southern Florida. Where infections are high, damage is significant. In combination with two approved biocontrol agents, *Boreioglycaspis melaleucae* and *Oxyops vitiosa*, *A. psidii* causes reductions in plant height, branching, biomass, and stand densities of mature melaleuca. It increases seedling and

mature plant mortality and ultimately helped tame melaleuca and increase plant species diversity. Though it was studied upon arrival for its potential in biological control, this fungus was rejected. **As an adventive species, it is not considered part of the melaleuca biological control program and is not approved for redistribution in the USA.**

Figure 13. *Austropuccinia psidii* infecting leaves of melaleuca. Yellow islands on leaves represent pustules with thousands of urediniospores capable of infecting new succulent leaves and ready to be dispersed by the wind or insects. Red spots represent the old pustules after the spores are dispersed. (Scott Nelson, PestNet.org CC BY-4.0)

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NAISMA is a network of professionals challenged by invasive species: land managers, water resource managers, state, regional, and federal agency directors and staff, researchers, and nonprofit organizations. NAISMA's members are a diverse group of individuals and organizations who are involved in implementing invasive species management programs at all scales. Our mission is to support, promote, and empower invasive species prevention and management in North America. Our vision is to have North America's lands and waters protected from invasive species. NAISMA's programs aim to provide the support, training, and standards needed by the professional invasive species management community.

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