

METAMASIOUS CALLIZONA IS DESTROYING FLORIDA'S NATIVE BROMELIADS

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ABSTRACT

Bromeliads (Bromeliaceae) are a family of about 2,500 species native to the Neotropics, with 16 native to Florida. For decades, enthusiasts have imported into Florida numerous species from Neotropical countries for their attractive foliage and colorful flowers. The impression of enthusiasts, still fostered by growers' manuals, was that bromeliads have no serious pest insects – only a few easily controllable scale insects and mealybugs (Coccoidea). In 1989, an unidentified weevil was detected on ornamental bromeliads at a nursery in Ft. Lauderdale. The nursery was treated with chemicals to eradicate the population, but too late – surveys showed that this weevil was established on native Florida bromeliads in nearby county parks. It was *Metamasius callizona* (Chevrolat) (Coleoptera: Dryophthoridae, formerly Curculionidae). It had been shipped from infested shadehouses in the state of Veracruz, Mexico. USDA-APHIS records showed interceptions year after year of this and other *Metamasius* weevils on bromeliads imported to Florida. There was little knowledge of it in Mexico except as an occasional pest of cultivated pineapples, which was unpublished information at the time. A chemical eradication attempt was not supportable because (1) the weevil was already in county parks that may not be treated with chemicals, and (2) there were no funds except for eradication of major agricultural pests. Bromeliad enthusiasts called for research but could raise little money. Their immediate needs were met by the discovery that carbaryl (Sevin®) would control bromeliad weevil in plant collections. As the multivoltine weevil population spread from county to county destroying native bromeliad populations and invading state parks, botanists of Florida's Endangered Plant Advisory Council became alarmed and declared two more of Florida's native bromeliad species to be endangered (Florida Administrative Code). Brief searches for potential biological control agents were carried out in Mexico, Panama, and Honduras. In Honduras, an undescribed fly (Diptera: Tachinidae, cf. *Lixophaga* sp.) was found as a parasitoid of the closely related *M. quadrilineatus* Champion, a species that inhabits remnant cloud forests on hilltops. Climatic conditions could not be duplicated in Florida's unsuitable main quarantine facility, and attempts to rear this fly failed. Recently, Florida Park Service personnel saw the devastation to native bromeliad populations and became alarmed. Increased funding led to further exploration in Guatemala, Belize, Mexico

(again) and even Paraguay for candidate biological control agents. None, other than the Honduran tachinid fly (also found in Guatemala), was detected. Research efforts were then concentrated in Honduras where adequate stock of the fly could be obtained and maintained at temperatures cooler than obtainable in Florida's Gainesville quarantine facility. Stock of *M. callizona* and *M. mosieri* Barber (a native Florida non-pest species) has been supplied to Honduras for tests. A new Biological Control Research and Containment Laboratory at Ft. Pierce has just become operational. At time of writing, the weevil's population was outside the northern edge of Everglades National Park.

INTRODUCTION

Bromeliads (Bromeliaceae) are a family of about 2,500 species native to the Neotropics, with 16 native to Florida. For decades, enthusiasts have imported to Florida numerous species from Neotropical countries for their attractive foliage and colorful flowers. From these have been created numerous hybrids. The impression of enthusiasts was that bromeliads have no serious pest insects – only a few controllable scale insects and mealybugs – a false idea that is perpetuated in horticultural advice to growers (e.g., Black and Dehgan 1993; Wall 1988). *Ananas comosus* (L.), pineapple, is the only major agricultural bromeliad crop, but its extent is trivial in Florida.

In 1989, an unfamiliar weevil was detected on ornamental bromeliads at a nursery in Ft. Lauderdale. The nursery was treated with chemicals to eradicate the population, but too late – surveys showed that this weevil was established on native epiphytic Florida bromeliads in nearby county parks. It was found to be *Metamasius callizona* (Chevrolat), native to Mexico and Guatemala, and believed at the time also to occur in other Central American countries (O'Brien and Thomas 1990). It was the realization that the larvae do not merely feed on native bromeliads, but kill them (Frank and Thomas 1991a), that made this pest serious. The probable origin was traced to infested shadehouses in the state of Veracruz, Mexico (Frank and Thomas 1994). USDA-APHIS records showed interception year after year of this and other *Metamasius* weevils on bromeliads imported to Florida. Exporters (in Latin America) and importers (in Florida and other parts of the U.S.A.) had been careless. USDA-APHIS inspection of imported plants at U.S. ports and airports examines fewer than 2% of shipments (Frank and Thomas 1994). This had been a potential disaster waiting for years to manifest itself. If the infested plants had been shipped to a nursery in most states of the U.S.A., the weevils might have harmed only the stock of that nursery. But in southern Florida, susceptible native bromeliads grow in trees in close proximity to nurseries, easing establishment barriers for weevils outside of cultivation.

A chemical eradication attempt in Florida was not supportable because (1) the weevil was already in county parks which may not be treated with chemicals, (2) the situation was unprecedented and could not be evaluated confidently, (3) there were no funds for eradication except of major new pests of major agricultural crops (e.g., citrus), and (4) there are no low density monitoring tools to accurately measure the efficacy of eradication attempts.

There was little knowledge of *M. callizona* in Mexico except as an occasional pest of cultivated pineapples, unpublished until Rebolledo *et al.* (1998). *M. callizona* invades pine-

apple fields in newly-cleared land close to forest edges and has been controlled by use of broad-spectrum chemicals. Bromeliad enthusiasts in Florida called for research for control but could raise little money. Their immediate needs were met by the discovery that carbaryl (Sevin®) would control *M. callizona* in their collections. However, all of Florida's native bromeliads are epiphytic, and chemical control of weevils in bromeliads growing high above ground over large areas of land is an infinitely more difficult proposition technically, environmentally, legally, and financially.

Lack of feasibility of chemical eradication led to initiation of a biological control project. The project is far from complete. This paper reviews its progress to date.

M. CALLIZONA DEVASTATES NATIVE FLORIDA BROMELIAD POPULATIONS

As the *M. callizona* population spread from county to county in native bromeliad populations, botanists of Florida's Endangered Plant Advisory Council became concerned. They declared two more of Florida's native bromeliad species to be endangered. This brought to 10 the number of native species listed as threatened or endangered under the Florida Administrative Code (1998) (Table 1). Florida law is independent of federal U.S. law in this respect, for none of these species is so listed under the federal Endangered Species Act. Suffice it to say that all the native Florida bromeliads but one are known at the **species** level to occur also in the West Indies. So of course is the West Indian manatee, a 'charismatic' species whose Florida populations have been declared to be a distinct subspecies, and it is the Florida **subspecies** which is 'an endangered species' under federal law. One Florida bromeliad species occurs only in Florida (is precinctive) and has now been found to be attacked by *M. callizona*. Twenty years ago this might have resulted in its federal listing as an endangered species, but now the Environmental Protection Agency is under pressure to prevent expansion of the list of endangered species. That species, *Tillandsia simulata*, was only belatedly found to be attacked because its range is in central Florida, north of the counties where weevil-caused damage was at first concentrated.

Monitoring of the spread of *M. callizona* in Florida has been intermittent since 1989 (Frank 2005). The spread of the weevil now seems likely to continue until it has overrun all parts of Florida having those 12 native bromeliad species with individuals capable of growing to a considerable size (Table 1, Fig. 1). Spread is not only by flight of adults but also caused by people carelessly moving infested ornamental bromeliads from place to place. There is one curious anomaly: by 1991 the weevil was found in a county park in southern Miami-Dade County (Frank and Thomas 1991b), but was not found in that park after hurricane Andrew (August 1992), and has not been detected elsewhere in that county despite relatively frequent surveys.

Invasion of Broward County parks in 1989-1991 left drifts of fallen large bromeliads (mostly *T. utriculata*, Fig. 2). Visits to those same parks in 1999 showed very sparse *T. utriculata* populations, with *M. callizona* infesting some of the few remaining larger plants. The slow growth of the plants to flowering size (upward of 10 years), and apparent preference of *M. callizona* for attacking large plants strongly suggested a powerful negative effect on *T. utriculata*

Table 1. Florida bromeliad species, their abundance and status under Florida law, and susceptibility to attack by *M. callizona* larvae.

Bromeliad Species	Florida Status	Attacked by <i>M. callizona</i> Larvae?
<i>Catopsis berteroniana</i> Schult. (f.) Mez	Rare, endangered	probably ¹
<i>Catopsis floribunda</i> L.B. Sm.	Rare, endangered	probably ¹
<i>Catopsis nutans</i> (Sw.) Griseb.	Very rare, endangered	probably ¹
<i>Guzmania monostachia</i> (L.) Rusby ex Mez	Rare, endangered	yes ²
<i>Tillandsia balbisiana</i> Schult. and Schult. f.	Occasional, threatened	yes
<i>Tillandsia fasciculata</i> Sw.	Frequent, endangered ³	yes
<i>Tillandsia flexuosa</i> Sw.	Infrequent, threatened	yes
<i>Tillandsia paucifolia</i> Baker	Occasional	yes
<i>Tillandsia pruinosa</i> Sw.	Rare, endangered	probably ¹
<i>Tillandsia simulata</i> Small	Frequent ⁴	yes
<i>Tillandsia utriculata</i> L.	Frequent, endangered	yes
<i>Tillandsia variabilis</i> Schltdl. ⁵	Occasional, threatened	yes
<i>Tillandsia bartramii</i> Elliott	Frequent	no, too small
<i>Tillandsia recurvata</i> (L.) L.	Common	no, too small
<i>Tillandsia setacea</i> Sw.	Common	no, too small
<i>Tillandsia usneoides</i> (L.) L.	Common	no, too small

¹The three *Catopsis* spp., *G. monostachia*, and *T. pruinosa* have not yet been observed to be attacked in nature, probably because of their rarity.

²Cultivated specimens of *G. monostachia* and *Catopsis* spp. have been attacked.

³*T. fasciculata* is much less susceptible than *T. utriculata* perhaps because of its high fibrosity. Perhaps it was listed as endangered because of its high phenotypic variability. It is still illogical that it should have been listed as endangered, but *T. paucifolia*, which is readily attacked and much less common, is not.

⁴Precinctive; native to and occurring only in central Florida.

⁵Listed as *T. valenzuelana* Richard in Florida Administrative Code (1998).

population sustainability. The research project of graduate student Teresa Cooper (Cooper 2005) is an evaluation of the dynamics of the bromeliad populations attacked by *M. callizona*, especially in the Myakka River State Park.

Most of the larger native bromeliads (Table 1), led by *T. utriculata* and *T. fasciculata*, the species of *Catopsis* and *Guzmania*, down to *T. flexuosa*, *T. simulata* and *T. variabilis*, impound water in their leaf axils, forming phytotelmata. The phytotelmata house an aquatic invertebrate fauna causing no harm to the plants (Frank 1983). An estimated 15 of these invertebrate species, several of which have not yet been described by taxonomists, seem to be specialists, living only in bromeliad phytotelmata (Frank 1983 and unpublished). Destruction of their host plants by *M. callizona* necessarily destroys populations of these invertebrates. A

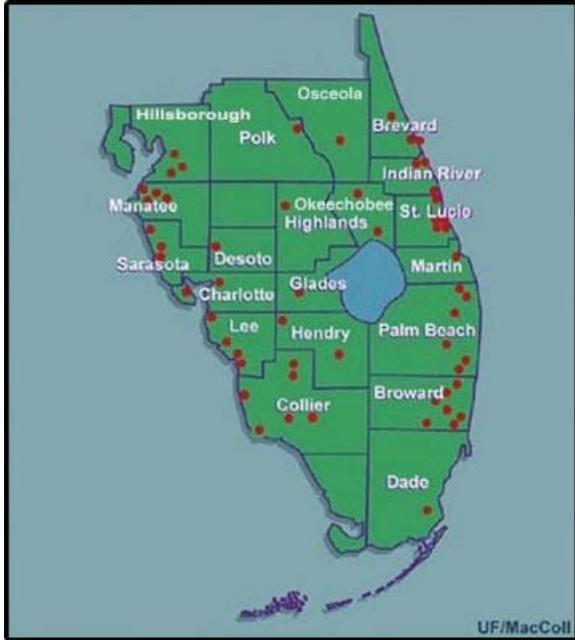


Figure 1. Recorded distribution of *Metamasius callizona* in central and southern Florida and showing county boundaries and their names, as of early 2005.



Figure 2. A fallen *Tillandsia utriculata* showing *Metamasius callizona* cocoons in mined stem. Photo: J. L. Castner. UGA1390013



Figure 3. An adult *Metamasius callizona*. Length 11-16 mm. Photo: J. L. Castner. UGA1390014

few of these invertebrate species, especially the mosquitoes among them, were found to have adapted their existence in phytotelmata of nonnative ornamental bromeliads cultivated in urban habitats (Frank *et al.* 1988), and some of these ornamental bromeliads seem not to be attacked by *M. callizona*. Nevertheless, dependence upon cultivated bromeliads in urban habitats in southern Florida makes for a tenuous existence. The two most abundant mosquito species in native bromeliads are *Wyeomyia mitchellii* (Theobald) and *W. vanduzeei* Dyar and Knab. Females of both species take blood from humans and are pests. However, they are specialists to the bromeliad habitat and, in bromeliads in Florida, their larvae outcompete and exclude invasive mosquitoes whose females are known to be able to transmit viral diseases to humans (Lounibos *et al.* 2003).

If *M. callizona* (Fig. 3) eradicates 12 native bromeliad species in Florida, it also is likely to eradicate up to 15 invertebrate species. A loss of 27 species from a single cause may be the worst ecological disaster to befall Florida by an invasive terrestrial arthropod.

BEHAVIOR OF SOME *METAMASIVUS* WEEVILS

Thirty-two bromeliad-eating weevil species are known in the Neotropics (Frank 1999). Three of them, and one other *Metamasius* species, are important to this project.

***METAMASIVUS MOSIERI* BARBER**

This weevil was described from Florida and Cuba in 1920, and later was reported from the Dominican Republic. For lack of other evidence, it has been assumed to be native to all three land masses. Little was known about *M. mosieri* (Fig. 4) until it was encountered sometimes in searches for *M. callizona*. Adults and larvae are considerably smaller than those of *M. callizona*. Larvae develop in small *Tillandsia* bromeliads, including *T. balbisiana*, *T. paucifolia*, *T. setacea*, *T. simulata*, *T. utriculata*, *T. variabilis* (Larson *et al.* 2001) and occasionally small nonnative *Tillandsia* in growers' collections (Frank 1999). When *T. utriculata* is attacked, it is only small specimens that are attacked. When *T. balbisiana* is attacked, it is often the flower spike that is mined. Why larger plants are not attacked is unknown. Adults are distinctively colored. Larvae are very difficult to distinguish from small *M. callizona* larvae. The species has been detected only in a few counties in the southwest and the southeast. Why it is not more widely distributed, and why its populations are not abundant are unknown. A few score larvae have been collected in the field and reared, but none has produced adult parasitoids. Larvae are very sensitive to ambient conditions and are harder than those of *M. callizona* to rear. In our biological control attempt against *M. callizona* in Florida, *M. mosieri* will be treated as a nontarget native species.

***METAMASIVUS QUADRILINEATUS* CHAMPION**

This weevil attacks bromeliads in Mexico, Guatemala, El Salvador, and Honduras. At least in Honduras and Guatemala, it is host to the only parasitoid of bromeliad-eating weevils that we have yet discovered (see below). Females are believed to oviposit only in fallen epiphytic bromeliads that have tipped, draining the water impounded in their leaf axils (Alvarez del



Figure 4. An adult *Metamasius mosieri*. Length 6-9 mm.
Photo P. M. Choate. UGA139000515

Hierro and Cave 1999). Thus, the weevil is of little or no threat to bromeliad populations. Indeed at the high altitudes in Honduras where this weevil has been found, native bromeliad populations seem to thrive in the presence of a thriving weevil population and seasonally abundant parasitoids. The bromeliads, the weevil and its parasitoid may exist at high elevations (in remnant cloud forest above 1600 m) by climatic restriction, or they may have existed at lower elevations before clearing of vast tracts of forest for agriculture; we do not know which. In the former case, none of them (including the parasitoid) may be able to exist at Florida's low elevations because of higher summer temperatures.

METAMASIVS HEMIPTERUS (L.)

This weevil was detected in Florida in 1984 as an invasive species from the Neotropics (O'Brien and Thomas 1990). It attacks banana, some ornamental palm trees and, rarely, ripe pineapple fruits. Its larvae have not been found to attack native Florida bromeliads. It is to be treated as a nontarget species in our project. Attack on it by any biological control agent that we establish against *M. callizona* could only be beneficial, but this would indicate a wider host range and might require testing of the susceptibility of other weevil genera.

METAMASIVS CALLIZONA

The objective of our project is a substantial reduction in population densities of this weevil. Adult weevils nibble on leaves of a wide range of bromeliads. Females oviposit in a narrower taxonomic range of bromeliads. Eggs are laid in slits that are cut in leaf bases and egg-laying is restricted to bromeliads of a size that will allow development of at least one larva mining in the meristematic tissue. The minimal size of *T. utriculata* plants in which *M. callizona* will oviposit is larger than 11.9 cm diam. (length of longest leaf 9.8 cm) (Sidoti and Frank 2002). The egg takes 7-10 d at 26°C to incubate (Salas and Frank 2001). Hatchling larvae tunnel into the meristematic tissue and begin to mine. When larvae were reared on pineapple stems at

26°C, five instars were detected before larvae pupated, the pupal stage lasted 9-15 days, and the total developmental time from egg to adult was about 8 wk (Salas and Frank 2001). Prepupae construct cocoons of plant fiber. Longevity of adults, preovipositional period of females, and total fecundity are under investigation. All life stages may be found throughout the year in natural areas of Florida. Generations are not discrete and the mean generational time of eggs to adults is speculated to be 13-17 wk (Salas and Frank 2001).

COMPONENTS OF A PROJECT AGAINST *M. CALLIZONA*

The initial components included (a) a literature search, (b) monitoring spread of *M. callizona* in Florida, (c) recording native host plants attacked, (d) collecting living specimens from nature in Florida to determine whether any contained parasitoids, (e) studying the life cycle of *M. callizona*, (f) collecting and studying the nontarget species *M. mosieri*, (g) testing and recording effects of *M. callizona* on ornamental (non-native) species, (h) answering grower questions about control methods, including feasibility of chemical control, and (i) preparing and delivering information to people concerned with the native bromeliads in various parts of Florida, including construction of websites (<http://BromeliadBiota.ifas.ufl.edu/wvbrom.htm> and <http://SaveBromeliads.ifas.ufl.edu>).

All of this led to the need to obtain funds to hire personnel and for foreign exploration to study *M. callizona* in its native habitats, and to detect potential biological control agents. The first funding agency strongly suggested it might contemplate funding the project if a seed-collecting project were begun. The idea was widespread collection of viable seed of the species at risk, their germination and growing out to replace the seedlings in nature once the weevil population had begun to decline. In desperation for funds, we undertook this. We were greatly helped by two professional growers who handled the seeds and their germination once these were supplied, but we needed state permits for these growers to grow the seed. Volunteers helped to collect the seed, but we needed state and county permits for them to do so as well. Further, a computerized database had to be constructed to document and catalogue the seed collections.

THE SEARCH FOR A BIOLOGICAL CONTROL SOLUTION

Lack of feasibility of chemical eradication of *M. callizona* stimulated interest in biological control. Nothing was known about parasitoids of any of the bromeliad-attacking *Metamasius* spp. Brief searches for potential biological control agents were carried out in Mexico and Panama. In Veracruz and Oaxaca, Mexico (1992), *M. callizona* was found abundantly only in the infested shadehouses of the grower whose carelessness caused its invasion of Florida. Over 100 larvae brought to a containment facility in Florida produced healthy adults, with no evidence of parasitoids. In Chiriquí, Panama (1994) *M. callizona* was not found, but a close relative, *M. cincinnatus* Champion with the same behavior was found abundantly only at one locality in nature. Again, over 100 larvae brought to Florida produced only healthy adults. In Honduras, an undescribed fly (Diptera: Tachinidae, cf. *Lixophaga*, Fig. 5) was found as a

parasitoid of the closely related *M. quadrilineatus* Champion, a species that inhabits remnant cloud forests on hilltops. The fly and its host became the subject of a Honduran student project, and were reared successfully at 20°C (Alvarez del Hierro and Cave 1999). Climatic conditions for rearing could not be duplicated in Florida's unsuitable main quarantine facility. A few fly larvae were transferred successfully to *M. callizona* larvae in 1998-1999 and developed, but attempts to establish a colony failed.

More recently, Florida Park Service personnel saw the devastation to native bromeliad populations and became alarmed. Increased funding led to further exploration in Guatemala, Belize and Mexico without discovery of additional parasitoids (Cave *et al.* 2004). Even Paraguay in 2004, and Peru in 2005 were explored for candidate biological control agents of any bromeliad-attacking *Metamasius* sp. None, other than the Honduran tachinid fly (also found in Guatemala in *M. quadrilineatus*), was detected. Research efforts were concentrated in Honduras where adequate stock of the fly could be obtained and maintained at temperatures cooler than obtainable in Florida's Gainesville quarantine facility. Larvae of *M. callizona* and *M. mosieri*, grown in Florida, have been supplied month after month to Honduras for tests. Studies there have confirmed that the tachinid cf. *Lixophaga* will attack *M. callizona*, and does so at least as readily as it will attack *M. quadrilineatus* under experimental comparison. *Metamasius mosieri* has been demonstrated to be an appropriate host for the tachinid cf. *Lixophaga*, but *M. callizona* appears to be a preferred host. Many other questions are being investigated by postdoctoral researcher Alonso Suazo. A new Biological Control Research and Containment Laboratory became operational in February 2005 in Ft. Pierce, Florida, and it is to that facility that a stock population of the tachinid will be shipped as soon as possible. The weevil's population is now at the edge of Everglades National Park (Fig. 6), and the control situation is critical.



Figure 5. An adult male tachinid cf. *Lixophaga*. Photo: B. C. Larson. UGA1390016



Figure 6. A scene from the Everglades showing the color form (yellow bracts) of *Tillandsia fasciculata* that exists there and, above and to the left, *Tillandsia paucifolia*. Both species are under attack by *Metamasius callizona*. Photo: J. H. Frank. UGA1390017

CONCLUSION

This is an unusual biological control project in that it attempts to control an invasive species that endangers native flora. As such, it has little easily-documented economic effect. Adequate funding for the necessary components of the project has been especially difficult to obtain and there is no certainty of its continuation. Progress has been made, but we do not yet know whether the only detected potential biological control agent will survive in Florida's climate, what effect it will have on non-target species, nor whether a release permit will be issued. We do not know whether it will be able to reduce populations of *M. callizona*. We do not know to what extent *M. callizona* will eradicate bromeliad species from Florida if left uncontrolled. It would take little phytophagy to completely eradicate the rarest species. The current measured rate of disappearance of *T. utriculata*, still widespread but becoming rarer, if it were continued, suggests that total eradication would be possible for that bromeliad. Most of the other bromeliads now under attack or likely to be attacked in nature may meet the same fate. Expect publications by Teresa Cooper on the dynamics of weevil-attacked bromeliads in Florida, and by Alonso Suazo on rearing conditions and some host-range testing of the tachinid cf. *Lixophaga* in Honduras. Also, we expect to publish a taxonomic description of the tachinid fly by Monty Wood (Ottawa, Canada). Wish us luck in Florida in successful importation of the fly, laboratory colonization, nontarget testing, release permitting, establishment in the field, and control of *M. callizona*.

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