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POTENTIAL BIODIVERSITY LOSS IN FLORIDA BROMELIAD PHYTOTELMATA DUE TO *METAMASIVUS CALLIZONA* (COLEOPTERA: DRYOPHTHORIDAE), AN INVASIVE SPECIES

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ABSTRACT

An annotated list of the aquatic invertebrates inhabiting water impounded in the leaf axils of Florida's native epiphytic bromeliads is provided. Of the 22 species reported, 9 are yet undescribed. Of the 13 described species, 10 are believed to be native. Five of the native species and perhaps all of the undescribed species are precinctive ("endemic"). These invertebrate animals and their bromeliad host plants are at risk of extinction due to destruction of the host plants by *Metamasius callizona* (Chevrolat) (Coleoptera: Dryophthoridae), an invasive weevil.

Key Words: biodiversity, macro-invertebrates, endangered species, phytotelmata, precinctive species, endemic species, invasive species

RESUMEN

Se provee una lista anotada de los invertebrados acuáticos que viven en agua acumulada en las axilas de las hojas de bromeliáceas (Bromeliaceae) epifíticas nativas de Florida. De las 22 especies reportadas, nueve no han sido descritas. De las 13 especies descritas, 10 son aparentemente nativas. Cinco de las especies nativas y posiblemente todas las especies no descritas son precinctivas ("endémicas"). Estos invertebrados y sus hospederos están bajo riesgo de extinción por *Metamasius callizona* (Chevrolat) (Coleoptera: Dryophthoridae), un gorgojo invasivo.

Translation provided by the authors.

In the early 1970s, D. Fish conducted an extensive study of the aquatic invertebrate fauna of the phytotelmata in the leaf axils of native bromeliads from central Florida south to the Everglades, but not the Florida Keys. Meanwhile, J. H. Frank was conducting an intensive ecological and ethological study of the mosquito genus *Wyeomyia*, whose immature stages inhabit bromeliad leaf axils in southern Florida. The Ph.D. dissertation of Fish (Fish 1976) reported several species for which specialist taxonomists were unable at that time to provide species-level identifications. The two investigators collaborated on chapters of a book. Fish (1983) wrote about phytotelmata in general. Frank (1983) wrote about bromeliad phytotelmata; included was a review of the knowledge of the way of life of southern Florida's *Wyeomyia* mosquitoes; included also was a catalog of aquatic organisms from bromeliad phytotelmata worldwide with bibliography; this catalog included records provided by Fish (1976).

In the late 1980s G. F. O'Meara (Florida Medical Entomology Laboratory) began studies on mosquito larvae in imported, ornamental bromeliads. Frank et al. (2004) reported on the total (not just aquatic) macro-invertebrate fauna of a small

sample of native bromeliads in Sarasota County, collected in 1997 by S. Sreenivasan, an intern at the Marie Selby Botanical Gardens. Then, L. J. Hribar (Florida Keys Mosquito Control District) reported new finds of bromeliad-inhabiting aquatic invertebrates from this limited area (Wagner & Hribar 2005; Grogan & Hribar 2006; Reid & Hribar 2006).

In 1989, an invasive weevil, *Metamasius callizona* (Chevrolat), was detected in Broward County, destroying native Florida bromeliads. Its larvae mine the meristematic tissue and kill the plants (Frank & Thomas 1994). By 2005, its populations had spread to most southern Florida counties, it threatened the survival of 12 of the 16 species (Table 1) of native Florida bromeliads, including all those species that provide phytotelmata, and a biological control campaign had been started to attempt to limit the destruction (Frank & Cave 2005). Several native bromeliads had already been declared to be threatened or endangered, and attrition by the weevil caused 2 more to be placed on the list of endangered species (Florida Administrative Code 1998). Natural bromeliad populations suffer losses due to natural causes such as wind and breakage of tree

TABLE 1. FLORIDA NATIVE BROMELIADS, THEIR ABUNDANCE AND STATUS UNDER FLORIDA LAW, SUSCEPTIBILITY TO ATTACK BY *M. CALLIZONA*, AND WHETHER THEY PROVIDE PHYTOTELMATA.

Bromeliad species	Florida status	Attacked ¹	Phytotelm ²
<i>Catopsis berteroniana</i> Schult. (f.) Mez	rare, endangered	probably ³	yes
<i>Catopsis floribunda</i> L.B. Sm.	rare, endangered	probably ³	Yes
<i>Catopsis nutans</i> (Sw.) Griseb.	very rare, endangered	probably ³	Yes
<i>Guzmania monostachia</i> (L.) Rusby ex Mez	rare, endangered	yes	Yes
<i>Tillandsia balbisiana</i> Schult. and Schult. f.	occasional, threatened	yes	No
<i>Tillandsia fasciculata</i> Sw.	frequent, endangered	yes	Yes
<i>Tillandsia flexuosa</i> Sw.	infrequent, threatened	yes	No
<i>Tillandsia paucifolia</i> Baker	occasional	yes	No
<i>Tillandsia pruinosa</i> Sw.	rare, endangered	probably ³	No
<i>Tillandsia simulata</i> Small	frequent ⁴	yes	slight
<i>Tillandsia utriculata</i> L.	frequent, endangered	yes	Yes
<i>Tillandsia variabilis</i> Schltdl. ⁵	occasional, threatened	yes	Yes
<i>Tillandsia bartramii</i> Elliott	frequent	no	No
<i>Tillandsia recurvata</i> (L.) L.	common	no	No
<i>Tillandsia setacea</i> Sw.	common	no	No
<i>Tillandsia usneoides</i> (L.) L.	common	no	No

¹Attacked by larvae of *M. callizona*.
²Forming phytotelmata.
³Not yet seen to be attacked in nature in Florida perhaps only because it is rare. They or their close relatives have been seen to be attacked in greenhouses.
⁴The only precinctive species.
⁵Listed as *T. valenzuelana* Richard in Florida Administrative Code (1998).

branches, but *M. callizona* has increased those losses to an unsustainable level. Death of *Tillandsia utriculata* and *T. fasciculata* from natural populations was monitored in the Myakka River State Park (Sarasota County for 49 mo.), Loxahatchee National Wildlife Reserve (Palm Beach County, for 28 mo.), Highlands Hammock State Park (Highlands County for 33 mo.), and St. Sebastian River Preserve State Park (Indian River County for 17 mo.) ending in Jun 2005. The percentage deaths due to *M. callizona* ranged from 71% to 82%, far exceeding the deaths due to other causes (Cooper 2006).

The fate of all specialist aquatic organisms inhabiting phytotelmata in Florida’s native bromeliads may now depend upon the success of this biological control campaign. It is now urgent to catalog the invertebrates that depend upon these plants as habitat. This paper is an attempt to describe what may be lost if the weevil is not controlled. Although vertebrates in Florida may use bromeliads as food, concealment, hunting grounds, or water sources (the free water in the axils), no vertebrates depend upon bromeliads in Florida as habitat for reproduction; it is the invertebrate fauna that will be most affected.

We present an annotated list of the specialist aquatic bromeliad-inhabiting organisms in Florida. Species that seem to be occasional inhabitants are mentioned in passing. We attempt to distinguish the precinctive species (those that have been detected only in Florida, often called “en-

demic”, but see Frank & McCoy 1990) from species with a wider distribution. For those species with a wider distribution, we attempt to distinguish those that have been present for a long time (probably pre-Columbian) from those that may have arrived very recently as contaminants of imported, ornamental bromeliads or other imported materials. We start with the viewpoint that the ancestors of Florida’s native bromeliads arrived as wind-dispersed seed (see e.g., Luther 1993). The bromeliads established, dispersed, and began to diverge. One result of their evolution in Florida was the precinctive species *Tillandsia simulata*. Other results included increasing genetic diversity of Florida’s native bromeliads and the evolution of natural hybrids which may be incipient species. Once the bromeliads had colonized southern Florida, they in turn were subject to colonization by wind-blown invertebrates especially from the Greater Antilles and Mexico’s Yucatan peninsula. Then, the invertebrates began to evolve. It must not be supposed that arrival of the bromeliads or the invertebrates was a single event; instead, there probably is continual natural arrival (immigration) of propagules (Luther 1993), but it has recently been complicated by inadvertent effects of international trade (human activities) in allowing the arrival of additional invertebrate species as contaminants of imported bromeliads.

When a species known only from Brazil has been detected recently in Florida, we suspect that it arrived as a contaminant of imported plants.

When a species known from the Greater Antilles has been known in Florida for decades, we suspect that it arrived in pre-Columbian times.

SPECIALIST MACRO-INVERTEBRATES DETECTED IN BROMELIAD PHYTOTELMATA IN FLORIDA

Turbellaria:

Family, genus and species unidentified, of Fish, 1976

Fish (1976) noted this turbellarian but was unable to obtain an identification. The record was reported by Frank (1983) who had seen the organism occasionally in *Tillandsia utriculata* at Vero Beach.

Annelida: Oligochaeta: Tubificidae, Naidinae

Dero Oken

Dero (Aulophorus) superterrenus Michaelsen, 1912

This aquatic annelid was reported as unidentified by Fish (1976), but was abundant in epiphytic bromeliads in some localities. Specimens collected from *T. utriculata* at Vero Beach sent by Frank to J. K. Hiltunen (Great Lakes Laboratory, Ann Arbor, MI) were identified as reported by Frank & Lounibos (1987). The species was originally described from epiphytic bromeliads in Costa Rica by Michaelsen (1912), an early discovery by Picado (1913). It has a wide distribution in the Neotropics. Lopez et al. (2005) in Brazil found that it is attracted to frogs visiting the bromeliads, and crawls onto their skin and uses frogs for dispersal.

Arthropoda: Crustacea: Ostracoda: Cytheridae

Metacypris Brady & Robertson

Metacypris maracaoensis Tressler, 1941

This ostracod was initially reported from epiphytic bromeliads in Puerto Rico, and was later found in epiphytic bromeliads in Collier County, Florida (Tressler 1956). It was collected by Fish, identified by C. W. Hart (Smithsonian Institution, Washington, D.C.) reported by Fish (1976); it was abundant in leaf axils of *T. fasciculata* in Everglades National Park, and less common in other bromeliads. Lopez et al. (2005) found that *Elpidium*, another ostracod genus, used phoresy on frogs for transport from bromeliad to bromeliad in Brazil, like *Dero* worms.

Arthropoda: Crustacea: Ostracoda

Podocopa, family unknown, sp. indet. of Fish, 1976

Only juvenile forms of this ostracod were collected and sent to C. W. Hart, who therefore could not identify them at the family or species level. They were found in bromeliads of tropical hardwood hammocks, often with *M. maracaoensis*.

Arthropoda: Crustacea: Copepoda: Cyclopidae

Paracyclops Claus

Paracyclops bromeliicola Karaytug & Boxshall, 1998

This copepod, originally described from bromeliads in Brazil by Karaytug & Boxshall (1998), was found in a bromeliad in the Florida Keys by Reid & Hribar (2006) who suggested that it might have arrived in Florida on ornamental bromeliads imported from Brazil. They did not identify the bromeliad in which it was collected. They did not identify the bromeliads from which 2 other cyclopids were collected in the Florida Keys: *Bryocyclops muscicola* Menzel, and *Paracyclops chiltoni* (Thomson). These last 2 species are not believed to be bromeliad specialists.

Arthropoda: Crustacea: Copepoda:
Phyllognathopodidae

Phyllognathopus Mrazek

Although *Phyllognathopus vigueiri* (Maupas) has been found in bromeliad phytotelmata in several countries (Frank 1983); it seems to be a generalist, not a bromeliad specialist. Its finding in unnamed bromeliads in the Florida Keys was predictable given that it had been found in other non-phytotelm habitats elsewhere in Florida (Reid & Hribar 2006).

Arthropoda: Arachnida: Acari: Histiostomatidae
(formerly Anoetidae)

Anoetus Dujardin

Anoetus sp. of Fish, 1976

Initial identification was made by H. L. Cromroy (University of Florida) as reported by Fish (1976). To the best of our knowledge the species has not yet been described. If it really belongs to the genus *Anoetus*, it may feed on bacteria as do other species in the genus.

Arthropoda: Insecta: Diptera: Sciaridae

Corynoptera Winnertz

Corynoptera sp. of Fish, 1976

Specimens collected by Fish were identified by W. A. Steffan (Bishop Museum, Honolulu, HI) as reported by Fish (1976). The aquatic larvae are presumed to feed on fungi growing on decaying leaf litter. To the best of our knowledge the species has not yet been described.

Arthropoda: Insecta: Diptera: Psychodidae

Alepia Enderlein

Alepia symmetrica Wagner & Hribar, 2005

Fish (1976) reported that aquatic larvae of a psychodid were abundant in epiphytic bromeliads

in some localities in southern Florida. The tentative identification supplied by F. C. Thompson (USDA Systematic Entomology Laboratory) was as an unidentified species of *Neurosystasis*. However, specimens apparently of the same species collected in 1997-2001 and supplied to a specialist taxonomist were identified as a species of *Alepiea* (Frank et al. 2004). The name *Alepiea symmetrica* Wagner & Hribar was based on specimens from the Florida Keys. For the present, we assume that this is the same species that occurs in bromeliads elsewhere in Florida, and that it has been present in Florida for a long time as an inhabitant of leaf axils of native epiphytic bromeliads. It has adapted to imported, ornamental bromeliads in urban areas. For lack of evidence, we here treat it as a precinctive species because we have no way of knowing whether it occurs elsewhere. We presume that the larvae feed on submerged leaf litter.

Arthropoda: Insecta: Diptera: Culicidae

Wyeomyia Theobald

Wyeomyia mitchellii (Theobald), 1905

W. vanduzeei Dyar & Knab, 1906

Wyeomyia mitchellii was originally described from Jamaica, and is known also from other islands of the Greater Antilles, eastern Mexico, and Florida. *Wyeomyia vanduzeei* was originally described from Florida, and is known also from Cuba, the Cayman Islands, and Jamaica. Both species are considered native to Florida. Fish (1976) reported both species. Adults and larvae may be identified by the key by Darsie & Morris (2003).

Adults of both species are active during daylight hours (Frank 1983; Frank et al. 1985). Of the two, *W. mitchellii* is more restricted to shaded habitats (Frank & O'Meara 1985). Females of both species use color vision to detect bromeliads in which to oviposit, although their color preferences differ slightly (Frank 1985, 1986). They hover over leaf axils while ovipositing, and eggs of *W. vanduzeei* are made buoyant by a remarkable sculpted wax-like coating (Frank et al. 1981). Their typical nursery plant is *T. utriculata* (Frank & Curtis 1981a), but they also will develop in other native water-impounding *Tillandsia* spp. (Fish 1976) and in the insectivorous bromeliad *Catopsis berteroniana* (Frank & O'Meara 1984). Larvae filter-feed on small particles in a nutrient-poor environment which is enriched by throughfall from tree canopies above. They compete intra- and inter-specifically for food, and have evolved a remarkable ability to survive long periods of starvation (Frank 1983). Larvae will not develop in less time than about 2 weeks—attempts to provide them with a rich diet to hasten their development in the laboratory may prove fatal to them (Frank 1983).

Both of these *Wyeomyia* mosquitoes have adapted to the habitat provided by imported, or-

namental bromeliads that usually are cultivated terrestrially in urban habitats in southern Florida (Frank et al. 1988). They are sometimes present in greenhouses and even outdoors in northern Florida where these plants are grown beyond the northern limit of native, water-impounding bromeliads.

Culex Linnaeus

Culex (Micraedes) biscoynensis Zavortink & O'Meara, 1999

This species was discovered in imported, ornamental bromeliads in Dade County and also was found in *T. utriculata* and *T. fasciculata* (O'Meara & Evans 1997). It was described as a new species (Zavortink & O'Meara 1999) on the grounds that specimens could not be matched to any known mosquito species despite resemblance to a species of the subgenus *Micraedes* known from the Bahamas, Hispaniola, Puerto Rico, and the U.S. Virgin Islands. One interpretation is that it could be a species that evolved in isolation in southern Florida, having the same common ancestor as the abovementioned *Micraedes*. Another could be that it is a species that arrived as a contaminant of imported, ornamental bromeliads, and that its true origin remains to be discovered. For lack of other information, we consider it as a species precinctive to Florida.

Immature stages of mosquito species sometimes occur in bromeliads. *Toxorhynchites rutilus* (Coquillett) is a treehole specialist but its predatory larvae are sometimes found in *Tillandsia utriculata* (Frank et al. 1984) and imported, ornamental bromeliads (Frank et al. 1988). *Aedes aegypti* (L.) and *Culex quinquefasciatus* Say are not bromeliad specialists, but they sometimes colonize imported, ornamental bromeliads, especially those having the impounded water accidentally enriched by lawn grass clippings (Frank et al. 1988). *Aedes bahamensis* Berlin was detected in imported, ornamental bromeliads in southern Florida but it was not abundant in such habitat, and is not a bromeliad specialist (O'Meara et al. 1995). After the Asian species *Aedes albopictus* (Skuse) was detected in Florida, it began to displace *A. aegypti* in water-filled containers where *A. aegypti* larvae could previously be found. In places in northern Florida where imported, ornamental bromeliads are cultivated, *A. albopictus* larvae usurped the phytotelmata provided by those bromeliads to the extent that it was occupied by mosquito larvae at all (O'Meara et al. 1993). In southern Florida, inroad made by *A. albopictus* was much more limited and it represented just a small proportion of the mosquito larvae in ornamental bromeliads—the vast majority being *Wyeomyia* (O'Meara et al. 1993). Lounibos et al. (2003) concluded that competition with bromeliad-specialist *Wyeomyia* was the reason for

the low numbers of *A. albopictus* in imported, ornamental bromeliads in southern Florida.

Arthropoda: Insecta: Diptera: Ceratopogonidae

Forcipomyia Meigen

F. (s. str.) seminole Wirth, 1976

F. (Warmkea) fishi Wirth & Soria, 1979

Forcipomyia (Phytohelea) bromelicola (Lutz) 1914

The first 2 species of midge were reported as unnamed by Fish (1976). Wirth (1976) described *F. seminole* from adult specimens collected at Vero Beach. Wirth & de Soria (1979) described *F. fishi* from specimens collected in *T. utriculata* in Brevard, Indian River, and Monroe counties. There is no indication that either of these species occurs outside Florida. The detection of *F. bromelicola* in the Florida Keys results from contamination of imported bromeliads (Grogan & Hribar 2006). In addition to these species, *Forcipomyia (Phytohelea) oligartha* Saunders was reported from pineapple leaf axils in Highlands County, Florida, by de Meillon & Wirth (1979). This species is known from terrestrial bromeliads (*Ananas* and *Bromelia*) in several countries, but apparently not from epiphytic bromeliads, so it cannot be considered native to Florida where there are no native terrestrial bromeliads.

Arthropoda: Insecta: Diptera: Chironomidae:
Tanypodinae

Monopelopia Fittkau

Monopelopia tillandsia Beck & Beck, 1966

Monopelopia caraguata Mendes, Marcondes & de Pinho, 2003.

Monopelopia tillandsia has not yet been reported outside Florida and is considered a precinctive species. The predatory, orange-colored larvae were recorded from epiphytic *Tillandsia* spp. by Beck & Beck (1966), and by Fish (1976). It was seen in *Tillandsia utriculata* at Vero Beach and reported by Frank (1983). *Monopelopia caraguata*, originally described from Brazil by Mendes et al. (2003), and discovered in the Everglades by R. Jacobsen (Epler 2007), seems to be a new discovery. Because we do not know how long it has been present in Florida, we treat it as a recent arrival.

Arthropoda: Insecta: Diptera: Chironomidae:
Orthoclaadiinae

Metriocnemus van der Wulp

Metriocnemus sp. A of Epler, 2001

This species was reported from Florida by Beck & Beck (1966) and then by Fish (1976) under the name *Metriocnemus abdominoflavatus* Picado, but Epler (2001) stated that was an incorrect

identification. Larvae may be abundant, do not build cases and are thought to feed on debris.

Genus H of Epler, 2001

A species of this unknown genus was reported only from bromeliads in Highlands County, Florida by Epler (2001).

Arthropoda: Insecta: Diptera: Chironomidae:
Chironominae

Tanytarsus bromelicola Cranston, 2007

Although described from Puerto Rico, from *Guzmania berteroniana* (Schultes f.) Mez bromeliads, this species was also reported from Indian River County, Florida from *Tillandsia* sp. (Cranston 2007). Almost certainly it is the unidentified tanytarsine reported by Fish (1976), who found it to be the most abundant chironomid in bromeliads. Larvae of this species, with red hemolymph, are restricted in Florida to *T. utriculata* where they form transportable cases and feed on microorganisms (Fish 1976).

Epler (2001) reported the finding of a larva of *Dicortendipes leucoscelis* (Townes) in a Florida bromeliad, but this species is widespread in the eastern USA and is not a bromeliad specialist.

Arthropoda: Insecta: Diptera: Syrphidae

Meromacrus Rondani

Meromacrus sp. of Fish, 1976

Fish (1976) reported an unidentified species of this genus from bromeliad phytotelmata in Florida. A few larvae probably of the same genus were noted by Frank in *T. utriculata* at Vero Beach, and he reported Fish's observation (Frank 1983). F. C. Thompson (USDA, Systematic Entomology Laboratory, Washington, DC) is preparing a description of this species using specimens collected by Fish.

Arthropoda: Insecta: Diptera: Perisclididae

Stenomicro Coquillett (formerly in Aulacigastridae)

Stenomicro sp. of Fish, 1976

Fish (1976) reported predatory aquatic fly larvae identified as *Stenomicro* by C. W. Sabrosky (USDA Systematic Entomology Laboratory, Washington, D.C.). Larvae are dorso-ventrally flattened, have forked "tails" and are pale, and were reared to maturity on a diet of *Wyeomyia* larvae. This species has not yet been described.

Arthropoda: Insecta: Diptera: Muscidae

Neodexiopsis Malloch

Neodexiopsis sp. of Fish, 1976

Specimens collected by Fish were identified by H. C. Hockett (Cornell University) and reported by Fish (1976). Larvae are cylindrical, pale, predatory, and were reared to maturity on a diet of

Wyeomyia larvae. This species has not yet been described.

DISCUSSION

That many of the invertebrates discussed here exist in no habitat other than bromeliads is supported by the work of Picado (1913). Picado (1913, pp. 264-274) reviewed data of earlier authors as well as his own to argue that many bromeliad-inhabiting invertebrate species are restricted to bromeliads. Frank & Curtis (1981b) reviewed published collection records for 241 mosquito species whose larvae had been reported from bromeliads in the Americas south of the U.S.A., revealing that many had been found only in bromeliad phytotelmata. Some had been collected also in water-impounding leaf axils of other plants; conversely, some had been found mainly in axils of other plants, rarely in bromeliads. Corbet (1983) reviewed the phytotelma-inhabiting Odonata, distinguishing specialists from generalists and showing that some species develop only in bromeliads. These data support the existence of a specialist bromeliad-inhabiting fauna.

Florida law defines the conservation status of Florida's native biota without regard to extralimital distributions. Seven of the bromeliad species

attacked by *M. callizona* are listed as endangered (two because of attack by *M. callizona*) and three more as threatened under Florida law (Florida Administrative Code 1998). The only precinctive species among the species under attack, *T. simulata*, has no protected status (Table 1). None of the specialist invertebrates inhabiting these bromeliads is protected under Florida law. However, protection under Florida law provides no guarantee of funding to achieve protection—it just makes permits necessary for biologists or anyone else to collect or possess them.

U.S. Federal law, under the Endangered Species Act, operates differently. Purportedly, it pays no attention to species that may be at risk in the U.S. while having a large population outside the U.S. It concentrates on species that are precinctive in some part of the USA. Thus, we might expect that *T. simulata* (and the 5 invertebrates listed as precinctive in Table 2) would be eligible for protection under Federal law. The U.S. Fish and Wildlife Service has not yet accorded them protected status.

Under the Endangered Species Act, funding is available for protection of Florida populations (named as subspecies) of species that have populations elsewhere, even though these extralimital populations may be widespread and thriving.

TABLE 2. AQUATIC BROMELIAD-INHABITING SPECIALISTS; (A: ADVENTIVE, RECENT ARRIVAL, PERHAPS AS A CONTAMINANT, C: PROBABLY A PRE-COLUMBIAN ARRIVAL, SO CONSIDERED NATIVE, P: PRECINCTIVE TO FLORIDA; U: UNIDENTIFIED/UNDESCRIBED).

Identity	Occurs outside Florida too		Precinctive ("endemic")	Undescribed species
	Recent arrival	Pre-Columbian		
Indet. turbellarian				U
<i>Dero superterrenus</i>		C		
<i>Metacypris maracaoensis</i>		C		
Indet. podocopan				U
<i>Paracyclops bromeliacola</i>	A			
<i>Anoetus</i> sp.				U
<i>Corynoptera</i> sp.				U
<i>Alepia symmetrica</i>			P	
<i>Wyeomyia mitchellii</i>		C		
<i>Wyeomyia vanduzeei</i>		C		
<i>Culex biscoyensis</i>			P	
<i>Forcipomyia seminole</i>			P	
<i>Forcipomyia fishi</i>			P	
<i>Forcipomyia bromelicola</i>	A			
<i>Monopelopia tillandsia</i>			P	
<i>Monopelopia caraguata</i>	A			
<i>Metriocnemus</i> sp. A				U
Genus H sp.				U
<i>Tanytarsus bromelicola</i>		C		
<i>Meromacrus</i> sp.				U
<i>Stenomicroa</i> sp.				U
<i>Neodexiopsis</i> sp.				U

At least the 10 species marked C or P are considered native; most likely the 9 species marked U are also native.

Thus, Florida populations of *Felis concolor* L. (cougar), *Trichechus manatus* L. (West Indian manatee), and *Heraclides aristodemus* Esper (dusky swallowtail) have been given the names of *Felis concolor coryi* (Bangs) (Florida panther), *Trichechus manatus latirostris* (Harlan) (Florida manatee), and *Heraclides aristodemus ponceanus* (Schaus) (Schaus swallowtail). These subspecies have been declared under the law to have protection, and are even called "endangered species." None of the bromeliads listed in Table 1 or invertebrates listed in Table 2 has had Florida subspecies named; we might argue that this is so because the taxonomists involved have been so stretched to provide species-level identification that they have not had time to provide a finer-meshed classification.

Losses being inflicted by *Metamasius callizona* on Florida bromeliad populations also affect their aquatic invertebrate fauna. Twenty one native species, consisting of 12 bromeliads and at least 9 (perhaps 19) invertebrates are at risk of extinction in Florida and in the U.S.A. At least 6 of them (1 bromeliad and 5 invertebrates) seem to be precinctive species.

The most important task with the aquatic invertebrates is to get adult specimens into the hands of expert taxonomists who will identify or describe them. This task has not changed since the 1970s. It requires collecting living specimens of the juvenile aquatic organisms and rearing them to the adult stage. The task is now more difficult than it was in the 1970s because of loss of bromeliad populations and because the community of expert taxonomists is reduced by retirements and deaths.

Readers are requested not to send specimens to the authors for identification. Instead, please use the cited works to make your own identifications, and/or contact expert taxonomists. Conceivably, by making your chosen taxonomist aware of this publication (showing the historical background) you may hasten the identification process. If Florida authorities list them as endangered and require permits for their collection, this will only make more difficult the task of description and study. The best way to protect the bromeliad-associated invertebrates is to control *M. callizona*.

This paper documents, as far as is now possible, the identity of the aquatic invertebrates in native Florida bromeliads in order to highlight the threat caused by *M. callizona*. It does not include the geographic distributional information or much of the host-plant information or abundance data provided by Fish (1976). Frank & Thomas (2001) include an extensive bibliography of aquatic organisms in bromeliad phytotelmata worldwide.

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REFERENCES CITED

- BECK, W. M., AND E. C. BECK. 1966. Chironomidae (Diptera) of Florida: 1. Pentaneurini (Tanypodinae). Bull. Florida State Mus. 10: 305-379.
- COOPER, T. M. 2006. Ecological and Demographic Trends and Patterns of *Metamasius callizona* (Chevrolat), an Invasive Bromeliad-eating Weevil, and Florida's Native Bromeliads. M.S. Thesis, Univ. Florida. xi + 69 pp.
- CORBET, P. S. 1983. Odonata in phytotelmata, pp. 29-54 In J. H. Frank and L. P. Lounibos [eds.], Phytotelmata: Terrestrial Plants as Hosts for Aquatic Insect Communities. Plexus; Marlton, NJ.
- CRANSTON, P. S. 2007. A new species for a bromeliad phytotelm-dwelling *Tanytarsus* (Diptera: Chironomidae). Ann. Entomol. Soc. America 100: 617-622.
- DARSIE, R. F., AND C. D. MORRIS. 2003. Keys to the Adult Females and Fourth Instar Larvae of the Mosquitoes of Florida (Diptera, Culicidae). Tech. Bull. Florida Mosquito Contr. Assoc. Florida Med. Entomol. Lab., Inst. Food Agric. Sci., Univ. Florida. Vero Beach, Florida.
- EPLER, J. H. 2001. Identification Manual for the Larval Chironomidae (Diptera) of North and South Carolina. A Guide to the Taxonomy of the Midges of the Southeastern United States, including Florida. Spec. Publ. SJ 2001-SP 13. North Carolina Dept. Envir. Nat. Resources, Raleigh, NC and St. Johns Water Management District, FL. 528 pp. <http://www.esb.enr.state.nc.us/BAUwww/Chironomid.htm>
- EPLER, J. H. 2007. Update: <http://home.earthlink.net/~johnnepler/Newtaxa.html>
- FISH, D. 1976. Structure and Composition of the Aquatic Invertebrate Community Inhabiting Epiphytic Bromeliads in South Florida and the Discovery of an Insectivorous Bromeliad. Ph.D. Dissertation, University of Florida.
- FISH, D. 1983. Phytotelmata: Flora and fauna, pp. 1-27 In J. H. Frank and L. P. Lounibos [eds.], Phytotelmata: Terrestrial Plants as Hosts for Aquatic Insect Communities. Plexus; Marlton, NJ.
- FLORIDA ADMINISTRATIVE CODE. 1998. Chapter 5B-40. Preservation of native flora of Florida. Florida Dept. of State, Tallahassee/Darby Printing Co., Atlanta, GA (The current version is online at <https://www.fl-rules.org/gateway/ChapterHome.asp?Chapter=5B-40>).
- FRANK, J. H. 1983. Bromeliad phytotelmata and their biota, especially mosquitoes, pp. 101-128 In J. H. Frank and L. P. Lounibos [eds.], Phytotelmata: Terrestrial Plants as Hosts for Aquatic Insect Communities. Plexus; Marlton, NJ.

- FRANK, J. H. 1985. Use of an artificial bromeliad to show the importance of color value in restricting colonization of bromeliads by *Aedes aegypti* and *Culex quinquefasciatus*. J. American Mosquito Contr. Assoc. 1: 28-32.
- FRANK, J. H. 1986. Bromeliads as ovipositional sites for *Wyeomyia* mosquitoes: form and color influence behavior. Florida Entomol. 69: 728-742.
- FRANK, J. H., AND R. D. CAVE. 2005. *Metamasius callizona* is destroying Florida's native bromeliads, pp. 91-101 In M. S. Hoddle [ed.], Second International Symposium on Biological Control of Arthropods, Davos, Switzerland, September 12-16, 2005. USDA Forest Service Publication FHTET-2005-08. Vol. 1.
- FRANK, J. H., AND G. A. CURTIS. 1981a. Bionomics of the bromeliad-inhabiting mosquito *Wyeomyia vanduzeei* and its nursery plant *Tillandsia utriculata*. Florida Entomol. 64: 491-506.
- FRANK, J. H., AND G. A. CURTIS. 1981b. On the bionomics of bromeliad-inhabiting mosquitoes. VI. A review of the bromeliad-inhabiting species. J. Florida Anti-Mosquito Assoc. 52: 4-23.
- FRANK, J. H., AND L. P. LOUNIBOS. 1987. Phytotelmata: swamps or islands? Florida Entomol. 70: 14-20.
- FRANK, J. H., AND E. D. MCCOY. 1990. Endemics and epidemics of shibboleths and other things causing chaos. Florida Entomol. 73: 1-9.
- FRANK, J. H., AND G. F. O'MEARA. 1984. The bromeliad *Catopsis berteroniana* traps terrestrial arthropods but harbors *Wyeomyia* larvae. Florida Entomol. 67: 418-424.
- FRANK, J. H., AND G. F. O'MEARA. 1985. Influence of micro- and macrohabitat on distribution of some bromeliad-inhabiting mosquitoes. Entomol. Exp. Appl. 37: 169-174.
- FRANK, J. H., AND M. C. THOMAS. 1994. *Metamasius callizona* (Chevrolat) (Coleoptera: Curculionidae), an immigrant pest, destroys bromeliads in Florida. Canadian Entomol. 126: 673-682.
- FRANK, J. H., AND M. C. THOMAS. 2001. Bromeliad Biota. Published on WWW at <http://Bromeliad-Biota.ifas.ufl.edu> [with many additions since 2001, examined May 2007]
- FRANK, J. H., G. A. CURTIS, G. W. ERDOS, AND E. A. ELLIS. 1981. On the bionomics of bromeliad-inhabiting mosquitoes. VIII. The flotational structure of *Wyeomyia vanduzeei* eggs (Diptera: Culicidae). J. Med. Entomol. 18: 337-340.
- FRANK, J. H., G. A. CURTIS, AND G. F. O'MEARA. 1984. On the bionomics of bromeliad-inhabiting mosquitoes X. *Toxorhynchites r. rutilus* as a predator of *Wyeomyia vanduzeei* (Diptera: Culicidae). J. Med. Entomol. 21: 149-158.
- FRANK, J. H., H. C. LYNN, AND J. M. GOFF. 1985. Diurnal oviposition by *Wyeomyia mitchellii* and *W. vanduzeei* (Diptera: Culicidae). Florida Entomol. 68: 493-496.
- FRANK, J. H., J. P. STEWART, AND D. A. WATSON. 1988. Mosquito larvae in axils of the imported bromeliad *Billbergia pyramidalis* in southern Florida. Florida Entomol. 71: 33-43.
- FRANK, J. H., S. SREENIVASAN, P. J. BENSHOFF, M. A. DEYRUP, G. B. EDWARDS, S. E. HALBERT, A. B. HAMON, M. D. LOWMAN, E. L. MOCKFORD, R. H. SCHEFFRAHN, G. J. STECK, M. C. THOMAS, T. J. WALKER, AND W. C. WELBOURN. 2004. Invertebrate animals extracted from native *Tillandsia* bromeliads in Sarasota County, Florida. Florida Entomol. 87: 176-185.
- GROGAN, W. L., AND L. J. HRIBAR. 2006. The bromeliad-inhabiting biting midge, *Forcipomyia (Phytohelea) bromelicola* (Lutz), new to the fauna of the United States (Diptera: Ceratopogonidae). Entomol. News 117: 319-322.
- KARAYTUG, S., AND G. A. BOXSHALL. 1998. Partial revision of *Paracyclops* Claus, 1893 (Copepoda, Cyclopoida, Cyclopoidae) with description of four new species. Bull. Nat. Hist. Mus. London (Zool.) 64: 111-205.
- LOPEZ, L., B. ELIZOLA, I. DEISS, AND R. RIOS. 2005. Phoretic behaviour of bromeliad annelids (*Dero*) and ostracods (*Elpidium*) using frogs and lizards as dispersal vectors. Hydrobiologia 549: 15-22.
- LOUNIBOS, L. P., G. F. O'MEARA, N. NISHIMURA, AND R. L. ESCHER. 2003. Interactions with native mosquito larvae regulate the production of *Aedes albopictus* from bromeliads in Florida. Ecol. Entomol. 28: 551-558.
- LUTHER, H. E. 1993. A new record for *Tillandsia* (Bromeliaceae) in Florida. Rhodora 95: 342-347.
- MENDES, H. F., C. B. MARCONDES, AND L. C. DE PINHO. 2003. A new phytotelmic species of *Monopelopia* Fittkau, 1962 (Insecta: Diptera: Chironomidae: Tanytopodinae) from south Brazil. Zootaxa 262: 1-10.
- DE MEILLON, B., AND W. W. WIRTH. 1979. A taxonomic review of the subgenus *Phytohelea* of *Forcipomyia* (Diptera: Ceratopogonidae). Proc. Entomol. Soc. Washington 81: 178-206.
- MICHAELSEN, W. 1912. Ueber einige zentralamerikanische Oligochäten. Archiv Naturges. 78(A): 112-129.
- O'MEARA, G. F., AND L. F. EVANS. 1997. Discovery of a bromeliad-inhabiting *Culex* (*Micraeodes*) sp. in south Florida. J. American Mosquito Contr. Assoc. 13: 208-210.
- O'MEARA, G. F., A. D. GETTMAN, L. F. EVANS, AND G. A. CURTIS. 1993. The spread of *Aedes albopictus* in Florida. American Entomol. 39: 163-172.
- O'MEARA, G. F., L. F. EVANS, A. D. GETTMAN, AND A. W. PATTESON. 1995. Exotic tank bromeliads harboring immature *Aedes albopictus* and *Aedes bahamensis* (Diptera: Culicidae) in Florida. J. Vector Ecol. 20: 216-224.
- PICADO, C. 1913. Les broméliacées épiphytes considérées comme milieu biologique. Bull. Sci. France Belgique 47: 215-360.
- REID, J. W., AND L. J. HRIBAR. 2006. Records of some Copepoda (Crustacea) from the Florida Keys. Proc. Acad. Nat. Sci. Philadelphia 155: 1-7.
- TRESSLER, W. L. 1956. Ostracoda from bromeliads in Jamaica and Florida. J. Washington Acad. Sci. 46: 333-336.
- WAGNER, R., AND L. HRIBAR. 2005. Moth flies (Diptera: Psychodidae) from the Florida Keys with the description of a new *Alepiea* species. Studia Dipterologica 11: 505-511.
- WIRTH, W. W. 1976. *Forcipomyia pictoni* Macfie and descriptions of two new related species from Florida (Diptera: Ceratopogonidae). Florida Entomol. 59: 77-84.
- WIRTH, W. W., AND S. J. DE SORIA. 1979. Studies on the genus *Forcipomyia* VI. The neotropical species of the subgenus *Warmkea* (Diptera: Ceratopogonidae). Revista Theobroma 9: 137-161.
- ZAVORTINK, T. J. AND G. F. O'MEARA. 1999. *Culex (Micraeodes) biscaynensis* n. sp. from Florida (Diptera: Culicidae). J. American Mosquito Contr. Assoc. 15: 263-270.