THE BROMELIAD *CATOPSIS BERTERONIANA* TRAPS TERRESTRIAL ARTHROPODS BUT HARBORS *WYEOMYIA* LARVAE (DIPTERA: CULICIDAE)

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ABSTRACT

Small numbers of terrestrial arthropods were trapped in the water-filled leaf axils of the bromeliads *Billbergia pyramidalis*, *Neoregelia spectabilis*, and *Tillandsia utriculata*. In experimental comparison, 12 X as many per plant were trapped in leaf axils of *Catopsis berteroniana*, supporting the hypothesis that this bromeliad is insectivorous. In Everglades National Park (Florida, USA), larvae, pupae, and pupal exuviae of *Wyeomyia vanduzeei* and *Wyeomyia mitchellii* were found in water held in leaf axils of *C. berteroniana*. Thus, despite its insectivorous habit, this plant provides a suitable habitat for the development of *Wyeomyia* mosquitoes.

RESUMEN

Pequeños números de artrópodos tererstres fueron atrapados en las axílas llenas de agua de las bromélias *Billbergia pyramidalis*, *Neoregelia spectabilis* y *Tillandsia utriculata*. En comparaciones experimentales, 12 veces más artrópodos por planta fueron atrapados en las axílas de *Catopsis berteroniana*, lo cual le da creencia a la hipótesis que esta bromélia es insectívora. En el Parque Nacional Everglades (Florida, EUA) se encountraron larvas, pupas, y exúvias pupales de *Wyeomyia vanduzeei* y de *Wyeomyia mitchellii* en el agua acumulada en las axílas de *Catopsis berteroniana*. Así pues, a pesar de su hábito insectívoro, esta planta provee un habitat adecuado para el desarroyo de mosquitos del género *Wyeomyia*.

While studying the aquatic invertebrate communities inhabiting epiphytic bromeliads in southern Florida, Fish (1976) noted accumulations of chitinous remains of terrestrial arthropods in leaf axil pools of *Catopsis berteroniana* (Schult.) Mez. He transported 4 of these plants to Gainesville, Florida, where he observed that they collected 105 terrestrial members of 9 arthropod orders during 8 days. A slippery, white, ultra-violet-reflecting powder, exuded by *C. berteroniana* leaves, was considered to be part of an entrapment mechanism leading terrestrial arthropods to tumble into water contained in the leaf axils and preventing escape. It was concluded that *C. berteroniana* is insectivorous (Fish 1976, Ward and Fish 1979). Here we compare arthropod trapping by *C. berteroniana* with that of other bromeliads.

In southern Florida, the epiphytic bromeliad *Tillandsia utriculata* L. acts as a nursery for immature stages of the mosquitoes *Wyeomyia vanduzeei* Dyar & Knab and *Wyeomyia mitchellii* (Theobald) (Frank and Curtis 1982). However, Fish (1976) found immature stages only of *W.*

vanduzeei in *C. berteroniana* axils. The present study attempted to determine whether *W. mitchellii* immature stages develop within *C. berteroniana* axils.

Methods and Materials

Mature *C. berteroniana* plants were collected in May 1980 from Everglades National Park and brought to Vero Beach. The plants were cleaned of their contents using a sampling apparatus (Frank et al. 1976) and water pressure from a hose. For comparison, native *T. utriculata* and exotic *Billbergia pyramidalis* (Sims) Lindley and *Neoregelia spectabilis* (Moore) L. B. Smith bromeliads of roughly equal size were selected and similarly cleaned of their contents. The *B. pyramidalis* and *N. spectabilis* resembled *C. berteroniana* in their growth form by possessing a water-filled central cup but only a few surrounding, water-filled leaf axils. In contrast, *T. utriculata* lacks the central cup but possesses more water-filled axils (Fig. 1 and Frank and Curtis 1982). Of these, only *C. berteroniana* exudes a white powder.

Fig. 1. Photographs showing growth form of bromeliads: Tu *Tillandsia utriculata,* Cb *Catopsis berteroniana,* Ns *Neoregelia spectabilis,* Bp *Billbergia pyramidalis.* A white powder exuded by the leaves of *C. berteroniana* gives the base of this plant a white appearance.

To compare entrapment of arthropods by *C. berteroniana* and the other 3 bromeliad species, 16 small baskets were made from wire and attached to 1 m aluminum rods. Rods were set in a straight N-S line along a woodland edge, 1 m apart and with the wire basket 80 cm above the ground. The row of 16 rods was considered to have 4 groups numbered N-S: 1-4, 5-8, 9-12, and 13-16. Four bromeliads of each of the 4 species were selected visually by size, randomized by species within each of the 4 groups, set within the wire baskets, and filled with water. After 3 days, as a preliminary test of method, the contents of the leaf axils of each plant individually were washed by wash bottle into enamel pans and then the plants were returned to their positions in the wire basket and filled again with water. Dead arthropods were picked from the enamel pans. This washing procedure was repeated 4 times at weekly intervals during June 1980.

At the end of the 4 week test period, plants were measured by 2 methods. First, the volumetric capacity of each plant was determined by filling with water until the plant overflowed, then decanting the retained water through a large funnel into a measuring cylinder. Second, to determine the target area presented by each plant to insects approaching it in horizontal flight, each plant was photographed against a plain background and at a standard distance from a camera lens while supported by a retort stand. A 20 x 20 cm square of card was photographed similarly. Photographic prints of the 16 plants and the square of card were made to a standard enlargement and the area of each object was measured by planimeter. The card square measured 400 cm^2 and so the target area of each plant was determined by simple ratio.

Visits were made in March 1980 and September 1983 to Everglades National Park where an extensive area (25°15′N, 80°45′W) is covered by about 1 m of water. Scattered dwarf red mangrove trees (*Rhizophora mangle* L.) protrude from the water and there is a thicket of taller red mangrove trees interspersed with buttonwood (*Conocarpus erecta* L.). Small numbers of *T. utriculata* grow epiphytically and principally in the deep shade of the thicket of trees. Typically, *C. berteroniana* grows in sun-exposed habitats at the tops of the dwarf red mangroves (Craighead 1963), but small numbers of these plants were found in September 1983 epiphytic in the partial shade near the tops of the trees in the thicket.

A wide-mouthed syringe was used to evacuate most of the water from leaf axils of a selection of bromeliads at each of these visits. Water from each plant sampled was held separately in labelled plastic containers for microscopic examination of the aquatic insects therein. *Wyeomyia* larvae and pupae were identified on each occasion within 24 h of the time of collection. Instar I *Wyeomyia* larvae are difficult to identify to species, so they were not recorded. Intact pupal exuviae were recorded from *Catopsis* in September, and were characterized as having all parts of the exoskeleton present, but split at the frontal and dorsal ecdysial lines (Harbach and Knight 1980) indicating successful adult emergence.

Results and Discussion

Mean numbers of arthropods per sample collected from *C. berteroniana* plants were patently higher and outside the range of those collected from plants of the other 3 species (Table 1). A 1-way ANOVA with equal replica-

TABLE 1. DEAD TERRESTRIAL ARTHROPODS COLLECTED FROM BROMELIADS OF 4 SPECIES, EACH REPRESENTED BY 4 PLANTS SAMPLED 4 TIMES AT WEEKLY INTERVALS. THE TABLE GIVES MEAN ± SD FOR VOLUMETRIC CAPACITY AND TARGET AREA FOR THE 4 PLANTS OF EACH SPECIES, AS WELL AS TOTAL OF ARTHROPOD SPECIMENS COLLECTED AND SAMPLE MEAN ± SD.

Bromeliad species:	*Billbergia pyramidalis*	*Catopsis berteroniana*	*Neoregelia spectabilis*	*Tillandsia utriculata*
VOLUME (ml)	105 ± 47	172 ± 107	164 ± 34	89 ± 52
AREA (cm^2)	218 ± 62	328 ± 97	320 ± 58	521 ± 269
ARTHROPODS				
Arachnida	0	2	0	1
Orthoptera	0	0	1	2
Isoptera	0	1	0	0
Psocoptera	1	5	0	4
Heteroptera	0	1	0	0
Homoptera	0	13	1	0
Coleoptera	1	40	0	0
Lepidoptera	1	19	0	0
Hymenoptera	10	89	8	6
Diptera	1	24	4	0
TOTAL	14	194	14	13
SAMPLE MEAN	1 ± 1	12 ± 5	1 ± 1	1 ± 1

tion performed on the sample data set the significance level at $P < 0.001$ (1-tailed, $F = 63.03$, d.f. = 3,60) for the difference between *Catopsis* and the other 3 species.

Sample means from plants of the other 3 species showed remarkable interspecific uniformity. This uniformity suggests that differences in volume and target area among the plants used experimentally (Table 1) were of trivial importance in determining the number of arthropods collected. The much larger numbers collected by the *C. berteroniana* plants support the hypothesis of insectivory. No mosquito adults were among the Diptera collected. Aquatic stages of mosquitoes were excluded from the records, for they were not dead and are not terrestrial.

Samples from Everglades National Park showed that *W. mitchellii* occurred in *C. berteroniana* and *T. utriculata* when these plants were in shade or partial shade (Table 2). In fact, 9 of the 15 *C. berteroniana* plants in partial shade contained *W. mitchellii* larvae. Presence of pupal exuviae of both *Wyeomyia* species in *C. berteroniana* axils showed that completion of development was achieved. Further, no dead mosquito adults were observed in water extracted from *C. berteroniana* axils and so adults emerging from the pupal stage evidently were able to escape from the plants despite the ability of the plants to trap terrestrial arthropods.

The inter-mosquito-species comparison of percentage of instar IV larvae in bromeliads in shade (Table 2) suggests that larvae of the 2 mosquito species performed similarly in terms of development and survivorship. Table 2 also provides evidence that pupation success of both mosquito species together did not differ between *C. berteroniana* and *T. utriculata* (test of

TABLE 2. COLLECTION TOTALS OF *Wyeomyia vanduzeei* AND *W. mitchellii* LARVAE, PUPAE, AND PUPAL EXUVIAE FROM LEAF AXILS OF *Catopsis berteroniana* AND *Tillandsia utriculata* EPIPHYTIC ON MANGROVE TREES AND GROWING IN DEEP, PARTIAL, OR NO SHADE IN EVERGLADES NATIONAL PARK. BOTH SPECIES OCCURRED IN *Catopsis*, BUT *W. mitchellii* WAS ABSENT FROM FULLY SUN-EXPOSED SITES WHICH ARE THE NORMAL HABITAT OF *Catopsis*. THE NUMBER OF PLANTS SAMPLED = n. AN ASTERISK (*) INDICATES WHERE NO RECORD WAS TAKEN.

Bromeliad	n	Shade	Date	Mosquito species	Larval Instar I	II	III	IV	%IV	Live pupae	Pupal exuviae
Catopsis	13	none	13-III	*vanduzeei*	*	6	8	94	87	16	*
				mitchellii	*	0	0	0	0	0	*
Catopsis	15	none	20-IX	*vanduzeei*	*	46	62	108	50	8	13
				mitchellii	*	0	0	0	0	0	0
Catopsis	15	part.	19-IX	*vanduzeei*	*	77	182	271	51	13	23
				mitchellii	*	21	24	42	48	0	1
Tillandsia	6	deep	19-IX	*vanduzeei*	*	15	19	25	42	1	*
				mitchellii	*	24	48	47	39	2	*
Tillandsia	1	none	13-III	*vanduzeei*	*	1	4	18	78	2	*
				mitchellii	*	0	0	0	0	0	*

observed vs. expected no. of pupae, $\chi^2 = 0.88$, NS). Absence of *W. mitchellii* from fully sun-exposed *C. berteroniana* and *T. utriculata* (Table 2) possibly reflects macrohabitat preferences or restrictions of the adult mosquitoes.

It remains to be determined just how *C. berteroniana* traps terrestrial arthropods. The concept of aquatic stages of *Wyeomyia* mosquitoes existing in the fluid held by an insectivorous plant is not novel, since the aquatic stages of *W. smithii* (Coquillett) inhabit the water-filled leaves of the pitcher plant *Sarracenia purpurea* L. (Bradshaw 1983, Istock et al. 1983). Aquatic stages of various mosquito genera, notably *Tripteroides* (a sabethine relative of *Wyeomyia*), inhabit pitchers of Old World insectivorous pitcher plants of the genus *Nepenthes* (Beaver 1983).

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THE IDENTITIES OF *TITYUS FLORIDANUS* AND *TITYUS TENUIMANUS* (SCORPIONES, BUTHIDAE)

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ABSTRACT

The taxonomic status of the 2 nominal species of the genus *Tityus* C. L. Koch described from the United States is revised. *Tityus floridanus* Banks, 1904, from Key West, Florida, is a junior synonym of *Tityus dasyurus dasyurus* Pocock, 1897, from Puerto Rico and St. Thomas (U. S. Virgin Islands). *Tityus tenuimanus* Banks, 1910, from Buena Vista Lake, California, is a junior synonym of *Buthus atlantis* Pocock, 1889, from Morocco.

RESUMEN

La posición taxonómica de dos especies nominales del género *Tityus* C. L. Koch, descritas de los Estados Unidos de Norte américa es revisada. *Tityus floridanus* Banks, 1904, de Key West, Florida, es sinonimizada bajo *Tityus dasyurus dasyurus* Pocock, 1897, de Puerto Rico y de St. Thomas (Islas Vírgenes). *Tityus tenuimanus* Banks, 1910, de Buena Vista Lake, California, es sinonimizada bajo *Buthus atlantis* Pocock, 1889, de Marruecos.

The genus *Tityus* C. L. Koch has the widest distribution among the neotropical buthids. It has been found in all of South America except Chile; in Panama and Costa Rica in Central America; in Cuba, Hispaniola, Jamaica, Puerto Rico and St. Thomas in the Greater Antilles; and in St. Vincent, St. Lucia, Grenada and the Grenadines in the Lesser Antilles. Three nominal species, nonetheless, have been described as originating from North America: *Tityus crassimanus* (Thorell 1876) from Mexico, *Tityus*


Tu
Cb
Ns
Bp