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THE EFFECT OF SIZE OF HOST PLANT (*TILLANDSIA UTRICULATA*: BROMELIACEAE) ON DEVELOPMENT OF *METAMASIUS CALLIZONA* (DRYOPHTHORIDAE)

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ABSTRACT. *Metamasius callizona* (Chevrolat) (Coleoptera: Dryophthoridae) female weevils, when challenged with 21 *Tillandsia utriculata* L. plants (Bromeliaceae) of size 11.9 ± 0.3 cm diameter (longest leaf 9.8 ± 0.5 cm) in the laboratory, did not produce offspring, whereas they did so on 21 plants of 16.2 ± 0.3 cm diameter (longest leaf 17.1 ± 0.6 cm) and larger. The minimal size of *T. utriculata* plants needed to sustain a reproducing population of *M. callizona* is thus defined. It is not clear from experimental evidence that *T. utriculata* plants of size 21.4 ± 0.3 cm diameter (longest leaf 29.7 ± 1.5 cm) were better hosts for developing *M. callizona* weevils than were plants of size 16.2 ± 0.3 (longest leaf 17.1 ± 0.6 cm).

RESUMEN. Se utilizaron hembras de *Metamasius callizona* (Chevrolat) (Coleoptera: Dryophthoridae) para analizar el potencial de oviposición y desarrollo de larvas en tres tamaños de bromeliáceas. Se utilizaron 21 plantas de *Tillandsia utriculata* L. (Bromeliaceae) de 11.9 ± 0.3 cm de díametro (hoja de mayor longitud 9.8 ± 0.5 cm) y bajo condiciones de laboratorio. *Metamasius callizona* no produjo ninguna cría en estas plantas. Sín embargo en 21 plantas de la misma especie de 16.2 ± 0.3 cm de díametro (hoja de mayor tamaño 17.1 ± 0.6 cm) las hembras ovipositaron y las larvas emergieron de los huevos. De esta forma se define el tamaño mínimo que necesitan estas plantas para sostener una población del picudo *M. callizona.* Los datos colectados no muestran una evidencia clara de que plantas de mayor tamaño 21.4 ± 0.3 cm de díametro (hoja de mayor tamaño 29.7 ± 1.5 cm) son mejores hospederos que las plantas con 16.2 ± 0.3 cm de díametro (hoja de mayor tamaño 17.1 ± 0.6 cm) para *M. callizona.*

Key words: Weevil, bromeliad, Florida

INTRODUCTION

Metamasius callizona (Chevrolat) is a weevil (Coleoptera: Dryophthoridae [formerly Curculionidae]) pest of bromeliads. Native to southern Mexico and Guatemala, and perhaps to other areas of Central America, it was detected in Florida in 1989 (Frank & Thomas 1994). The range of this weevil has expanded in Florida, until now it occupies at least 17 counties in the state (Frank & Thomas 1996).

Larvae use their powerful mandibles to mine the meristematic tissue of the host plant, which they kill. Salas and Frank (2001) found that *Metamasius callizona,* on what may be an optimal diet under optimal conditions, took eight weeks to develop from egg to adult (egg, five instars, and pupa). These weevils were reared in the laboratory on pineapple (*Ananas comosus* L., a bromeliad) stems at 27°C and high humidity. Under less favorable conditions in the laboratory, Frank and Thomas (1994) found that similar development took longer on medium-sized *Tillandsia utriculata* L. plants at lower humidity. Larvae were collected in the field throughout the year, and development took considerably more than eight weeks at cool winter temperatures. Eggs were found to be laid singly in slits cut by the female in leaf bases (Frank & Thomas 1994).

Frank (1999) listed the species of host bromeliad plants in which weevil larvae had been collected in the field. *Tillandsia utriculata,* when fully grown the largest of Florida's 16 native bromeliad species, is a frequent host. Frank's field collections suggested that larger individual plants were much more likely to be hosts. He speculated that perhaps ovipositing weevils select large plants, perhaps because very small plants do not contain enough meristematic tissue to allow development of weevil larvae. Selection of larger plants also may reduce the risk of one larva encountering another, which could have

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survival value. When two larvae are placed together in a small container, they consider the other an intruder and defend themselves by striking out with their mandibles, and both may die by evisceration (Frank & Thomas 1994). The evidence about plant size, however, was solely the result of field observations. Lacking measurement of plant size, the data may have resulted from biased collecting methods.

Regardless of their requisites for oviposition and larval development, adult weevils have been observed to feed on leaves of even very small bromeliads of various species. In the field, this did not appear to be consequential for the plants, because weevil population densities previously were not observed approaching levels at which feeding by adults threatened survival of the plants.

The objective of this study was to determine the smallest size of *Tillandsia utriculata* bromeliads in which the weevil will oviposit and in which its larvae will develop. This size may be used in modeling effects of the weevil on populations of its host. No special efforts were made to include plants of the largest size in the study, for they are known to be targets for oviposition.

Tillandsia utriculata plants can be measured for size in various ways. Botanists traditionally use leaf area in measuring plant size, but the technique is laborious and involves killing the plants. Alternatively, dry weight measurements can be used, but they also require killing the plants. For *T. utriculata,* however, Frank and Curtis (1981) used length of longest leaf, a simple measurement that can be performed with a living plant. They found it to be related to age (in a given habitat) and to volumetric capacity of the water-impounding leaf axils (albeit a curvilinear relationship). Several measures of size can be correlated, although the correlations may not be linear.

Materials and Methods

Tillandsia utriculata specimens were collected from trimmed limbs of southern red cedar, *Juniperus silicicola* (Small) L.H. Bailey, at the Gulf Coast Research and Education Center, Bradenton, Florida, in February–March 2001. They were size-classed (small, medium, large) by average diameter (10.0–14.9, 15.0–19.9, and 20.0–24.9 cm). The large category had the minimal sized caudex for inflorescence formation and thus, by other tokens, may be considered small (H. Luther pers. comm.). To remove debris, specimens were cleaned by water pressure from a hose with a sweeper nozzle. The length of longest leaf of each plant was measured, and these data were related to those used by earlier researchers. The weight of each plant also was measured following 48 hours of oven-drying at 54°C. This measurement proved problematic, since some plants had been virtually destroyed by weevils.

Plants were assigned individually to one of three container types: (a) 2.8-L container with the top covered by fine-meshed screening (replicates 1 and 2), (b) 1.7-L Ziploc® container (small and medium plants in replicates 3–7), and (c) 17-L Rubbermaid® container (large plants in replicates 3–7). After weevils escaped from container (a) by chewing through the screen, the authors introduced container types (b) and (c).

Adult females of *Metamasius callizona,* newly-emerged from pupae, were assembled during a 3-week period. All were exposed to males from the time they emerged from the pupal stage. None was given the opportunity to oviposit before this experiment. Thus, most or all should have mated and been replete with eggs. Use of females from this group, beginning on 14 March 2001, was random with respect to the replicates. Three such females were placed into each container. Weevils were removed from the containers after 48 hours. Plants were removed from containers, labeled, and allowed to grow at L:D 14:10, 21–27°C, and 60–65% RH for 43 days. To maintain humidity, they were misted with water on a nearly daily schedule. Weevils removed from containers were recycled into the general pool. This routine should not have invalidated the experiment design, because weevils often lay a few eggs per day (vs. all at once) during many days (Salas & Frank 2001).

The design was a randomized complete block, with three plants per class size and seven replications. The design was complicated, however, and arguably invalidated by the various containers used.

A control set of plants was set aside, without exposure to weevils, as a check to detect whether any of these plants had been infected with weevils before collection. They were held under the same conditions as the experimental plants (once the latter had been removed from containers) and were given a final examination at the same time. Their dry-weight was measured as for the experimental plants.

Analysis of variance (ANOVA) was performed with groupings by replication and size (SAS 1999–2000). Data for the number of larvae where weevils had escaped were considered missing. A Student-Newman-Keals *t*-test compared characteristics of experimental vs. control plants.

An evaluation of oviposition separate from larval development would have been of interest, but oviposition is cryptic. Such an evaluation

TABLE 1. Biological characteristics of *Tillandsia utriculata* exposed to *Metamasius callizona* from replicated trial. Average diameter of *T. utriculata*: 10.0–14.9 cm = small, 15.0–19.9 cm = medium, and 20.0–24.9 cm = large. Values are mean ± SE with superscript letters ($^{x, y, z}$) indicating significant difference across rows using Student-Newman-Keuls test ($P < 0.05$).

	Average plant diameter		
Biological characteristics	Small (n = 21)	Medium (n = 21)	Large (n = 21)
Average diameter (cm)	11.9 ± 0.3^{x}	16.2 ± 0.3^{y}	21.4 ± 0.3^{z}
Plant height (cm)	6.5 ± 0.3^{x}	8.4 ± 0.3^{y}	12.5 ± 0.4^{z}
Dead leaves/plant (no.)	60 ± 3^{y}	55 ± 3^{y}	41 ± 3^{z}
Live leaves/plant (no.)	20±3^{z}	26±3^{z}	26 ± 2^{z}
Leaves/plant (total no.)	80 ± 3^{y}	82 ± 3^{y}	67 ± 4^{z}
Length of longest leaf (cm)	9.8 ± 0.5^{x}	17.1 ± 0.6^{y}	29.7 ± 1.5^{z}
Dry weight of plant (g)	0.9 ± 0.1^{x}	3.3 ± 0.3^{y}	10.8 ± 1.3^{z}
Larvae/plant (no.)	0.0 ± 0.0^{y} (n = 17)	0.3 ± 0.1^{z} (n = 19)	0.5 ± 0.1^{z} (n = 21)

would have doubled the number of plants used and destroyed.

RESULTS

The untreated (control) plants numbered 37 (14 small, 18 medium, 5 large), none of which produced weevil larvae. Thus it is improbable that any of the 63 experimental plants collected were already infested from the field. The untreated (control) plants had more live leaves than the experimental plants ($t = 7.69$, $P < 0.0001$ for small plants; $t = 3.89$, $P < 0.0004$ for medium plants; and $t = 3.01$, $P < 0.0061$ for large plants).

The behavior of the caged adult weevils differed significantly according to plant size (Chi-Square, df = 4, value = 72.715, $P < 0.0001$). When containers were examined after 48 hours of exposure of weevils to plants, most weevils caged with small plants were found on the container walls (the ratio was 9 escaped: 30 on walls: 24 on plants). For medium plants, the ratio was 3:5:55, and for large plants, 0:0:63. Escapes from type-a containers with small plants in replicates 1 and 2 were the reason for selecting type-b and type-c containers for replicates 3–7.

At final examination, 45 days after exposure of the plants to weevils, no weevil larvae were found in the small plants. Only one plant, of medium size, contained two weevil larvae at examination; the rest had a maximum of one. Between 0.3 ± 0.1 and 0.5 ± 0.1, larvae per plant were found in medium and large plants respectively, with plant characteristics differing by size (TABLE 1). The ANOVA showed a significant difference between number of weevil larvae (0) in small plants compared to medium and large plants, but not between medium (0.3) and large (0.5) plants (TABLE 2).

Weevil larvae recovered from the plants were mainly in instars 2 and 3, as judged by head capsule width (Salas & Frank 2001). Larvae collected from the medium-sized plants averaged instar 2.5 ± 0.6, whereas those from large plants averaged instar 3.4 ± 0.3, with a significant difference in size ($t = 10.10$, $P < 0.0001$). Only one weevil cocoon (with a teneral adult) was found, and this was in a large plant. Most larvae were dead at the time of collection.

TABLE 2. ANOVA results for biological characteristics of *Tillandsia utriculata* exposed to *Metamasius callizona*.

Biological characteristics	Sum of squares	*F* value	*P* value
Average diameter (cm)	976.35	64.21	<0.0001
Plant height (cm)	415.23	23.86	<0.0001
Dead leaves/plant (no.)	4982.67	3.08	0.0062
Live leaves/plant (no.)	1325.02	1.45	0.1957
Leaves/plant (total no.)	3072.32	1.38	0.2244
Length of longest leaf (cm)	4427.61	28.25	<0.0001
Dry weight of plant (g)	1207.60	13.23	<0.0001
Larvae/plant (no.)	4.74	3.09	0.0068

Conclusion and Discussion

Metamasius callizona females, when challenged with 21 *Tillandsia utriculata* plants of size 11.9 ± 0.3 cm diameter (longest leaf 9.8 ± 0.5 cm) in the laboratory, did not produce offspring. They did reproduce, however, on 21 plants of 16.2 ± 0.3 cm diameter (longest leaf 17.1 ± 0.6 cm) and larger. The minimal size of *T. utriculata* plants needed to sustain a population of *M. callizona* is thus defined.

Tillandsia utriculata plants of size 21.4 ± 0.3 cm diameter (longest leaf 29.7 ± 1.5 cm) did not prove to be better hosts for developing *Metamasius callizona* weevils than were plants of size 16.2 ± 0.3 (longest leaf 17.1 ± 0.6 cm). The ANOVA performed indicated that the observed increase in numbers of larvae collected was not significant. The difference in size of larvae collected, however, was significant, showing faster development in the larger plants. A similar experiment with one container type will validate these contrasts. Field observations have shown that up to 25 weevil larvae may develop in very large *T. utriculata* plants (Frank & Thomas 1994). That a single experimental plant, when examined, contained two weevil larvae, with the rest having only one larva, suggests that oviposition by female weevils was restricted, a restriction that may be related to plants of less than optimal size.

Development of weevil larvae in medium and large bromeliads was slower than under the conditions used by Salas and Frank (2001). Only one weevil cocoon (with a teneral adult) was found and that in a large plant. Little evidence was found that larvae complete their development in plants of these sizes, and such a supposition is supported by the finding that most weevil larvae were dead of unknown causes. We suggest that weevils ovipositing in still larger plants in nature are more successful in producing progeny that develop to adult size and, in turn, reproduce.

The larger number of dead bromeliad leaves observed in the experimental plants, as compared to the control plants, has no simple explanation. It is improbable that they were the result of stress from being confined in containers for 48 hours. They may be the result of observed heavy feeding by adult weevils, especially on the limited resource provided by small plants, or of feeding by weevil larvae in some plants.

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