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Roosting site selection by *Artibeus watsoni* (Chiroptera: Phyllostomidae) on *Anthurium ravenii* (Araceae) in Costa Rica

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ABSTRACT. *Artibeus watsoni* (Chiroptera: Phyllostomidae) was found in Costa Rica to alter the shape of 11 species of broad-leafed plants in the families Araceae, Cyclanthaceae, Marantaceae, Musaceae, and Palmae to form diurnal roost sites. The plant most commonly used for tent construction was *Anthurium ravenii* (Araceae). Bats create a tent on *A. ravenii* by severing the basal 2 to 5 lateral nerves at a distance of 5 to 10 mm from the midrib; the entire margin of the leaf then collapses downward to form a pyramid-shaped tent. The number of altered leaves per plant ranges from 1 to 4 with a mean of 2.1. *A. watsoni* appears to be selecting leaves of medium size and low within the plant. The size, shape, and location of leaves selected is consistent with the hypothesis that tent construction provides bats with roost sites that will be available to them for a long period of time and provides protection from both predators and the elements, thus conveying a selective advantage to the bats.

RESUMEN. *Artibeus watsoni* (Chiroptera: Phyllostomidae) fue encontrado en Costa Rica alterando la forma de 11 especies de plantas de hojas anchas en las familias Araceae, Cyclanthaceae, Marantaceae, Musaceae, y Palmae para formar sitios de perchas diurnas. La planta más comúmente usada para construcción fue *Anthurium ravenii* (Araceae). Murciélagos crean una carpa en *A. ravenii* cortando las 2 o 5 nervaduras laterales basales a una distancia de 5 a 10 mm de la nervadura central; entonces todo el margen de la hoja colapsa hacia abajo para formar una carpa en forma de pirámide. El número de hojas alteradas por planta varió de 1 a 4 con un promedio de 2,1. *A. watsoni* parece estar seleccionando hojas de talla mediana y de posición inferior en la planta. El tamaño, forma y posición de las hojas seleccionadas es consistente con la hipótesis de que construcción de carpas provee a los murciélagos con sitios de perchas que serán disponibles para ellos por un largo período de tiempo y provee protección de predadores y elementos, dando así una ventaja selectiva a los murciélagos.

KEY WORDS: *Anthurium ravenii*, Araceae, *Artibeus watsoni*, bats, Costa Rica, Phyllostomidae, plant-animal relationships, tent construction.

INTRODUCTION

Bats were first noted altering the shape of leaves for diurnal roosting structures by Barbour (1932) who found that *Uroderma bilobatum* cut the leaves of palms in Panama. Chapman (1932) reported that *Artibeus watsoni* also roosted

under altered palm leaves which he called 'tents'. Subsequently, several species of phyllostomid bats, all members of the subfamily Stenoderminae, have been found to modify leaves of various species of plants to form tents for diurnal roosting sites (Foster & Timm 1976, Koepcke 1984, Timm 1984, Timm in press, Timm & Mortimer 1976). One Old World bat, *Cynopterus sphinx* (Pteropodidae), has been reported altering palm leaves to create a diurnal roosting structure (Goodwin 1979). Tent construction along with other roosting habits of bats has been reviewed by Kunz (1982) and Timm (in press).

Although there are several reports of bats using cut leaves, few studies have addressed specific leaf choice by bats and its ecological and evolutionary significance. The discovery of an abundant population of *Artibeus watsoni* in Costa Rica that was altering leaves of *Anthurium ravenii* for tents led to the following questions: (1) Does *A. watsoni* select leaves of a specific size class? (2) Does *A watsoni* preferentially select leaves located within a particular region of the plant? (3) How many leaves per plant does *A. watsoni* modify for tents? and (4) What is the selective advantage incurred by the bats in choosing specific leaves and modifying them?

METHODS

Observations reported herein were made near the Sirenia field station, Parque Nacional de Corcovado, Costa Rica, from 13 to 18 August 1984. Parque Nacional de Corcovado is located on the Osa Peninsula of south-western Costa Rica at 8° 29′ N, 83° 35′ W; the elevation near Sirenia ranges from sea level to 400 m. Corcovado lies within the Tropical Wet Forest Life Zone, with lowland evergreen forest being the dominant forest type. Mean annual rainfall is ±3800 mm, with the wettest months being August through November. Vegetation and

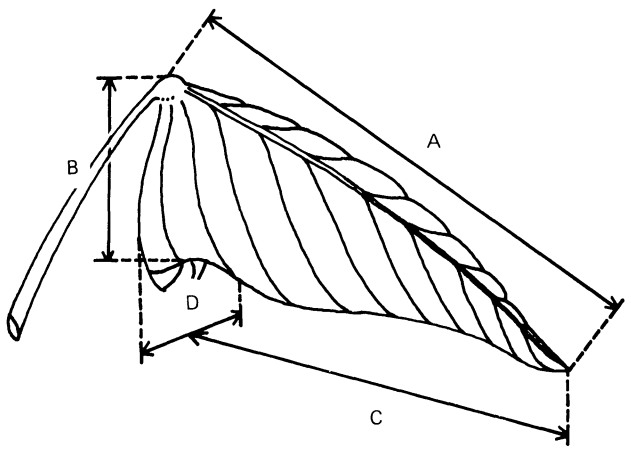

Figure 1. Sketch of a typical tent constructed by *Artibeus watsoni* on a leaf of *Anthurium ravenii* showing the measurements taken: A – length of leaf; B – width of leaf; C – length of tent aperture; D – width of tent aperture. See text for further explanation of measurements.

Table 1. Data (mean ± SD) collected from 21 tents constructed by *Artibeus watsoni* and 152 uncut leaves of *Anthurium ravenii* (measurements in cm)

	Tent leaves	Uncut leaves
Length of leaf (A)	43.14 ± 2.55	41.97 ± 9.13
Width of leaf (B)	19.14 ± 2.04	18.65 ± 4.84
Length of tent aperture (C)	40.29 ± 4.25	–
Width of tent aperture (D)	28.26 ± 6.34	–

habitat types at Corcovado have been described by Hartshorn (1983) and Herwitz (1981).

Approximatley 15 km of trails were searched for tents of *Artibeus watsoni.* As more tents were found on *Anthurium ravenii* Croat & Baker (Araceae) than on any other species of plant, this study was restricted to that one species. Trails were searched for all *A. ravenii* visible; when a plant was located, it was thoroughly searched for cut leaves. When cut leaves were located, the tent was first searched carefully for roosting bats. Subsequently, all leaves of the plants were then numbered from the lowest (oldest) to the highest (youngest) leaf to determine regional preference within a plant. Leaf length was measured along the midrib (A) and leaf width from the base of leaf to margin (B) for all modified and unmodified leaves within reach (Figure 1). For all cut leaves, the length (C) and width (D) of tent aperture was measured (Figure 1, Table 1). Presence of and distance from other *Anthurium* leaves directly above and below the tent also was recorded.

RESULTS

Artibeus watsoni is the most common species of tent-making bat at Sirenia as determined by both numbers of bats observed in tents and netting along trails at night. It is especially abundant in the second growth forest near the park headquarters and in the coastal strand vegetational community. Leaves were found modified by *A. watsoni* to form tents on the following species of plants: *Anthurium ravenii* (Araceae); *Asplundia* sp. and *Carludovica palmata* (Cylanthaceae); *Calathea insignis* (Marantaceae); *Heliconia imbricata, H. latispatha, Heliconia* sp., and *Musa* × *paradisiaca* (Musaceae); *Asterogyne martiana, Cocos nucifera,* and *Geonoma* sp. (Palmae) (also see Timm in press).

Artibeus watsoni creates a tent on *Anthurium ravenii* by severing the basal 2 to 5 lateral nerves at a distance of 5 to 10 mm from the midrib. The entire margin of the leaf then collapses downward to form a pyramid-shaped tent (Figure 2). The midrib is not severed. The resulting tent has an approximately triangular shaped aperture. The bats hang from the midrib or the lateral nerves near the apex (Figure 3).

A total of 64 individuals of *Anthurium ravenii* were located and searched for

Figure 2. Typical tent of *Artibeus watsoni* made from a leaf of *Anthurium ravenii* at Parque Nacional de Corcovado, Costa Rica. Photograph by Jae C. Choe.

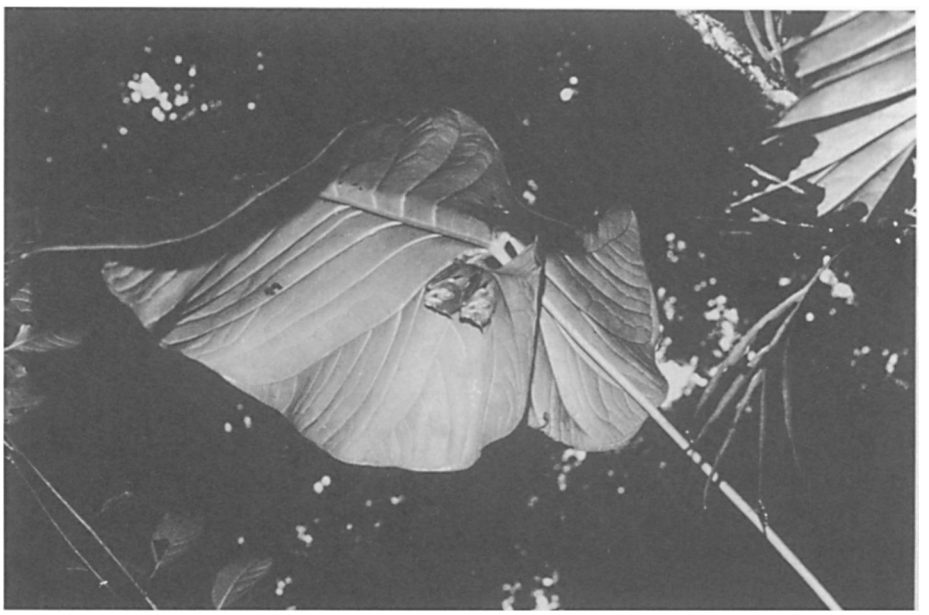

Figure 3. An adult and immature *Artibeus watsoni* roosting in an *Anthurium ravenii* tent. Details of the cut veins can be seen along the midrib of the leaf. Photograph courtesy of Fernando A. Cervantes-R.

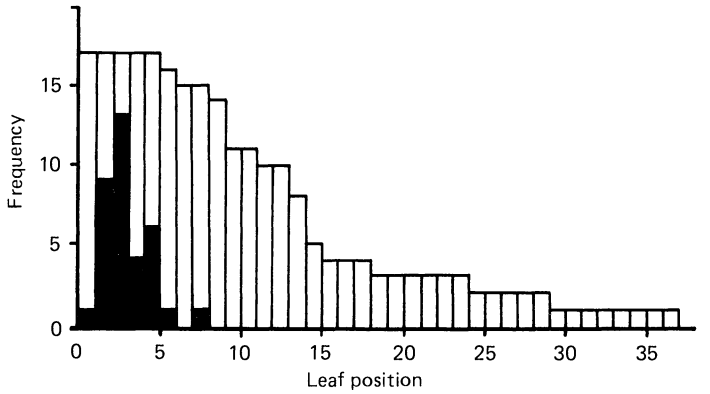

Figure 4. Leaf position within plant from the lowest (oldest) to highest (youngest) leaf for 35 leaves of *Anthurium ravenii* that were altered by *Artibeus watsoni* to form roosting tents (black bars) compared with all leaves (N = 248) from 17 plants (open bars).

tents. Seventeen separate individuals of *A. ravenii* were found to have one or more leaves altered to form tents. A total of 248 leaves were scored on these 17 *Anthurium*, including leaves that had and had not been altered by the bats. Thirty-five (14.1%) of the 248 leaves were cut by *Artibeus watsoni* to form tents. Although the number of leaves per plant ranged from 5 to 37 (mean± SD = 14.6 ± 8.4) (Figure 4), the number of altered leaves per plant ranged only from one to four (mean ± SD = 2.1 ± 0.9) (Figure 5). Measurements were taken on 21 altered leaves and 152 unaltered leaves (Table 1); all other leaves were beyond reach. There was no significant difference ($P > 0.05$; t-test) between length (A) or width (B) of modified and unmodified leaves; however, standard deviations from the mean were over two (leaf width) to three (leaf length) times greater in unmodified leaves. In all tents examined, the first and second basal nerves were severed near the base. In only two (9.5%) of 21 tents, the third lateral nerves also were severed. Length (C) and width (D) of the tent aparture were 40.29 ± 4.25 cm and 28.86 ± 6.34 cm, respectively.

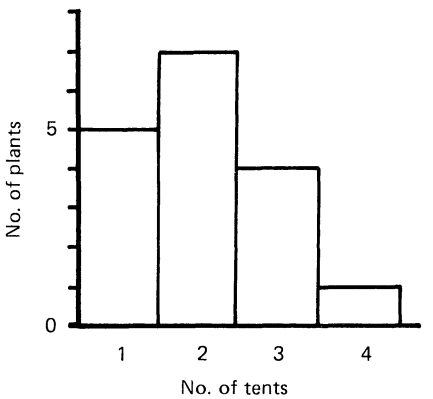

Figure 5. Number of leaves per individual *Anthurium ravenii* that were altered by *Artibeus watsoni* to form roosting tents (N = 17; X = 2.1; SD = 0.9).

Artibeus watsoni preferentially selected lower leaves of a plant for tents, ranging from the first to eighth leaf (Figure 4). No tents were found below 1.5 m or above 5.0 m from the ground, although *A. ravenii* often reached heights of 30 m. The most frequently used leaf was the third (13 plants; 37.1%) followed by the second (9 plants; 25.7%), and the fifth (6 plants; 17.1%). Thirty-one tents (88.6%) were observed to have one or more *Anthurium* leaves directly above them, whereas only four tents (11.4%) had any other *Anthurium* leaves directly below them. The three tents that had no *Anthurium* leaves directly above them had leaves of other species of neighbouring plants within 5 m above them.

In 1984 three individividuals of *Artibeus watsoni* were observed roosting in tents: two bats in one tent (Figure 3) and one bat in another. In 1982 Timm observed 13 *A. watsoni* tents on *Anthurium* at this locality. A single adult female was found roosting in one *Anthurium* tent. No other species of bats have been observed roosting under *Anthurium* tents.

DISCUSSION

Anthurium ravenii is one of the common understory plants at Sirenia. It is a broad-leafed aroid with an elongate heart-shaped leaf, and may grow either as a free standing terrestrial shrub or as an epiphyte. It is also the most common plant used by *Artibeus watsoni* for tent construction.

Artibeus watsoni showed a strong preference for leaf position, using only the lower leaves for tents even though many more, apparently suitable, higher leaves were available (Figure 4). There was no obvious relationship between leaf size and vertical position of leaves. No tents were observed higher than 5 m above the ground, although several *A. ravenii* grew as epiphytes well above 5 m. Although there was no significant size difference in either leaf length or width between modified and unmodified leaves, the smaller standard deviations of tent leaves suggest that *Artibeus watsoni* preferentially selects leaves of medium size. The bats appear to be avoiding the small or young leaves, and the large older leaves. Young leaves may be too weak to support the weight of the bats or perhaps hang at an unacceptable angle. In old leaves, the basal lateral nerves may have hardened such that the bats are unable to sever them. By selecting mature but not old leaves, the bats create a roost site that will be available to them for a longer period of time. All leaves selected by *Artibeus watsoni* for tents were situated directly below other *Anthurium* leaves or leaves of other neighbouring understory plants. This supports the suggestion that tents function to protect roosting bats from predators, rain, and sun (Barbour 1932, Foster & Timm 1976, Timm & Mortimer 1976).

For Honduran white bats, *Ectophylla alba*, Timm & Mortimer (1976) documented that five species of *Heliconia* were selected for tent construction. Altered leaves were chosen for tents on the basis of leaf size and angle to the ground rather than by species of *Heliconia.* In contrast, *A. watsoni* at Sirenia

seems to preferentially select for plant species, location within the plant, and height above the ground.

Boinski & Timm (1985) documented that predation by squirrel monkeys (*Saimiri oerstedi*) and the attending double-toothed kites (*Harpagus bidentatus*) was a major source of mortality in *A. watsoni* at Sirenia. The monkeys recognize the tents created by the bats and actively seek them out, looking for both bats and insects. Thus, selection for specific leaf sites that either best conceal the bats or prevent effective attack by squirrel monkeys and other predators conveys a definite selective advantage for *Artibeus watsoni.*

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