

A New Tent Roost of Thomas' Fruit-eating Bat, *Artibeus watsoni* (Chiroptera: Phyllostomidae), in Panama

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Thomas' fruit-eating bat, *Artibeus watsoni*, is known to alter leaves of a wide variety of tropical plants to construct tent roosts. On Barro Colorado Island and Gigante Peninsula in the canal zone, Panama, *A. watsoni* is found to use the black palm, *Astrocaryum standleyanum*, as its tent plant. Bats cut the first five to ten pinnae from the proximal side of the terminal blade and chew additional four to nine pinnae without severing their central veins. The distance from the frond rachis to the cut decreases distally, leaving an inverted V-shaped cut path. The distal portions of the bifurcated blade are then collapsed and folded to form the 'bifid' tent with an inverted boat-shaped cavity underneath. All tents were in fronds of trunkless juvenile plants.

Tent-making habit of bats has been reported for 18 species, including 15 phyllostomid species of the genera *Artibeus*, *Ectophylla*, *Mesophylla*, *Rhinophylla*, *Uroderma*, and *Vampyressa* from the New World tropics (Kunz, 1982; Brooke, 1987; Timm, 1987; Charles-Dominique, 1993), and two pteropodids of the genus *Cynopterus* (Phillips, 1924; Goodwin, 1979; Sandhu, 1984; Balasingh et al., 1993, 1995; Kunz et al., 1994) and one vesperilionid of *Scotophilus* (Rickart et al., 1989) from the Old World tropics. No bats in temperate regions have ever been observed roosting under modified plant leaves.

Most of these bats alter large single leaves to construct tent roosts of various shapes and sizes. However, at least two species of bats, *Uroderma bilobatum* (Choe, 1994) and *Cynopterus brachyotis* (Kunz et al., 1994), are reported to build conical tents using multiple leaves. Recently, Bhat and Kunz (1995) observed that bell-shaped cavities created under the modified flower/fruit clusters of the kital palm are used as roosting tents by the short-nosed fruit bat, *Cynopterus sphinx*, in southern India.

Artibeus watsoni, Thomas' fruit-eating bat, is found throughout Central America from southern Veracruz to northern South America and by far the most frequently observed species as it has been reported roosting in 19 different species of broadleaved plants in Costa Rica alone (Timm, 1987). Choe and Timm (1985) conducted an ecological research on leaf selection by *A. watsoni* in terms of leaf size and relative position within the plant, *Anthurium ravenii*, in Corcovado, Costa Rica. On Barro Colorado Island, Panama, *A. watsoni* is abundant

and has been reported modifying leaves of two *Geonoma* species (Chapman, 1932; Ingles, 1953). In the following account, I describe the construction of tents by *A. watsoni* in yet another plant, *Astrocaryum standleyanum* Bailey, the black palm, in Panama.

Materials and Methods

This study was conducted at the field station of the Smithsonian Tropical Research Institute on Barro Colorado Island (79°50'15"W, 9°9'41"N) in the Panama Canal and Gigante Peninsula in the nearby mainland, Panama, during February-August 1987. About half of the island is covered by young semideciduous forest less than 100 years old and the other half by much older semideciduous forest that has been relatively little disturbed over the past 200-400 years (Foster and Brokaw, 1982). The forest in Gigante Peninsula is also relatively young and semideciduous. Although the timing of rainy season on Barro Colorado Island and its vicinity varies considerably, it usually starts there late April and lasts until December (Rand and Rand, 1982). Details of the climate, vegetation, and habitats of Barro Colorado Island are available in Croat (1978) and Leigh et al. (1982).

Once bat tents were discovered in *A. standleyanum*, as many individual plants of the same and related species were examined for the presence of tents. Plants that contained tents were surveyed at least once every two or three days, except for the ones in Gigante Peninsula. I visited Gigante Peninsula only twice in May and July 1987. The occupied tents were visited daily to monitor the movement of bats.

For each tent plant I measured the following: (1) number of tents in a plant; (2) height of the plant

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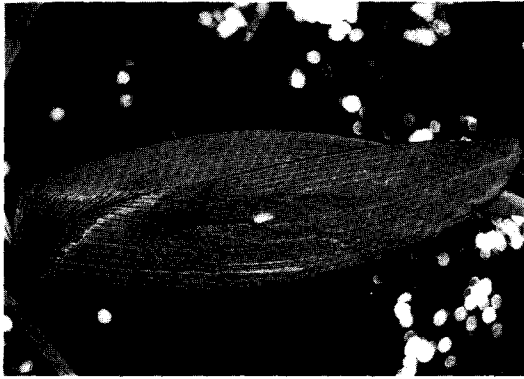


Fig. 1. An *Astrocarylum standleyanum* tent, showing the cut positions.

measured along the length of the highest frond; (3) height of the tent roost measured vertically from the ground; and (4) cut positions in the terminal blade of the plant. I used binoculars to observe bats roosting under the tents and determined their approximate age. I netted one bat to identify the species.

Results

I discovered a total of 17 tents of *A. watsoni*: 14 on Barro Colorado Island and 3 in Gigante Peninsula. All tents were in fronds of trunkless juvenile *A. standleyanum*. The average height of *A. standleyanum* with tents was 2.6 ± 0.5 m ($\bar{x} \pm$ SD; range=1.7-3.6 m; $N=17$). Tents themselves were situated 2.1 ± 0.4 m ($\bar{x} \pm$ SD; range=1.4-3.3 m; $N=17$) above ground. Twenty-nine mature *A. standleyanum* with the trunk were examined on Barro Colorado Island, but no tents were located. Although the number of fronds in a plant ranged from four to eight ($N=17$), only one frond was cut in nine plants, two in one, and three in two.

Artibeus watsoni constructed roosting tents in the terminal blade of *A. standleyanum* by chewing parts of the unseparated pinnae (Fig. 1). The first five to ten pinnae from the proximal side of the terminal blade were severed completely and additional four to nine pinnae were partially chewed without severing the central vein (Fig. 1). Bats cut the most proximal pinnae farthest from the frond rachis ($\bar{x} \pm$ SD=9.4 \pm 1.1 cm; range=6.5-13.1 cm; $N=34$). The distance from the rachis to the cut decreased distally, leaving an inverted V-shaped cut path that usually ended 2-4 cm before the point of bifurcation (Fig. 1).

Due to the cuts by bats the bifurcated, distal portions of the blade collapsed and folded, creating an inverted boat-shaped chamber (Fig. 2). The two sides of the bifurcated blade overlapped completely for the entire length (Fig. 1). The degree of overlap between the two bifurcated blades in the *A. standleyanum* tent was generally greater than that in the *A. macrocalyx* tent of *V. macconnelli*, where a narrow gap sometimes exists between the two blades (Foster, 1992). Although

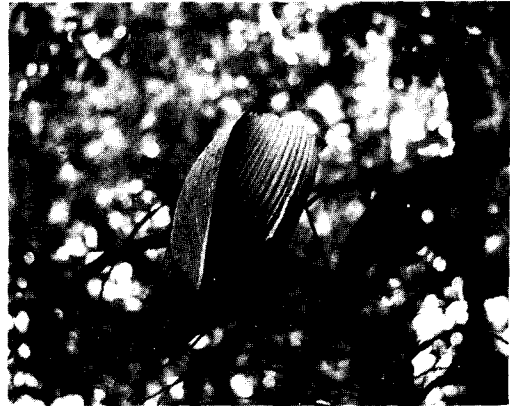


Fig. 2. Lateral view of an *Artibeus watsoni* tent in a frond of *Astrocarylum standleyanum*.

the bifurcated blades of *A. standleyanum* appeared to overlap more in older tents, none of the tents deteriorated to become unusable during my observation period.

Only four of 17 tents were used by bats at least once. A tent in Gigante Peninsula was occupied by two bats, presumably an adult female and her subadult offspring, in May. Two tents on Barro Colorado Island were also occupied by mother-offspring pairs for two consecutive days in April. A single bat of an unknown sex was noted roosting under a tent for a day in August. Bats were hanging near the apex of the tent (Fig. 3).

Artibeus watsoni were found to defecate while roosting under *A. standleyanum* tents, evidenced by the fecal stain on the distal blades in nearly half ($N=8$) of the tent leaves (Fig. 4). I also noted remains of fruit pericarps and/or seeds of unidentified fig species on the ground below some tent plants ($N=7$).

I netted a single female bat from a tent on Barro Colorado Island. It weighed 9.2 g, and its forearm was 36.8 cm long. It had more or less evenly bilobed upper middle incisors and minute, peg-like molars in the lower

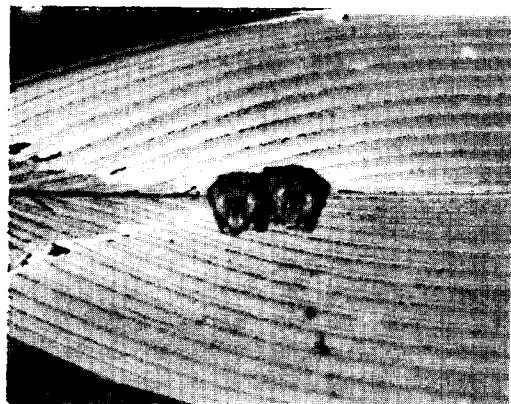


Fig. 3. Adult female *Artibeus watsoni* and her subadult offspring roosting in a *Astrocarylum standleyanum* tent on Barro Colorado Island, Panama.

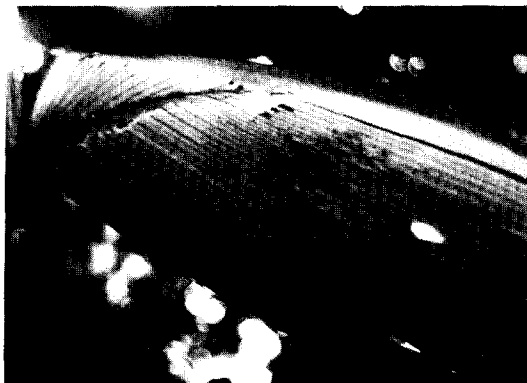


Fig. 4. Ventral view of the bifurcated blade stained with the excretion of bats.

jaw. Based on these characters, I identified the bat as *Artibeus watsoni*.

Discussion

Artibeus watsoni cut the terminal blades of *Astrocaryum standleyanum* fronds in much the same way as they do in other bifurcated palms of *Geonoma* or *Asterogyne* (Chapman, 1932; Timm, 1987). The cutting pattern is also very similar to those of *Vampyressa macconnelli* in *Astrocaryum macrocalyx* in Peru (Foster, 1982) and *Rhinophylla pumilio* in *Astrocaryum sciophilum* in French Guiana (Charles-Dominique, 1992). This type of tent has been categorized as the 'bifid' tent by Kunz et al. (1994). Convergences in tent architecture such as this and other types that occur between different species of bats and in widely separated geographic regions are reviewed by Timm (1987) and Kunz et al. (1994).

Artibeus watsoni showed a strong preference for young *A. standleyanum*. Although a more mature and bigger plant would provide many more fronds that can be used to construct tents, no tents were found in plants with the main trunk. Choe and Timm (1985) reported earlier that *A. watsoni* tend to roost under younger leaves of *Anthurium ravenii*. Foster (1992) also observed a preference for juvenile *Astrocaryum macrocalyx* fronds by *Vampyressa macconnelli*. *Uroderma bilobatum* building tents in *Coccoloba manzanillensis* also select only young plants (Choe, 1994).

Why do tent-making bats prefer to roost under juvenile plants? First, younger leaves are energetically less costly to modify (Choe and Timm, 1985). Second, younger leaves may provide better protection from rain and other elements, and more effective concealment from predators above, because juvenile plants generally produce much larger leaves (Croat, 1978). Third, tents made of younger leaves are likely to last longer. Fourth, the height of young plants may correspond with the preferred height of foraging flight for tent-making bats

(Timm and Lewis, 1991; Choe, 1994).

The primary function of bat tents is thought to be diurnal protection from weather elements and predators (Timm and Mortimer, 1976; Boinski and Timm, 1985; Brooke, 1987; Choe, 1994). Recently, however, Brooke (1990) observed that the Honduran white bat, *Ectophylla alba*, uses tents as the feeding station as well as diurnal roost. Based on the field data from radio-tracking experiments and the collection of food remains from beneath tent plants, Charles-Dominique (1993) also concluded that *R. pumilio* and *Artibeus gnomus* use tents as nocturnal feeding roosts. This study revealed that *A. watsoni* too carry fruits back to their tent roosts and consume them there. These observations suggest that tents function as camping quarters set up near food sources. Although no field data are available to test if bats build tents near fruiting trees, having such camping quarters close to food sources would help bats reduce traveling time and enhance feeding efficiency.

To date, over 80 species of vascular plants have been reported to be altered by bats for the construction of roosting tents (Kunz et al., 1994). What type of ecological or evolutionary relationship do bats maintain with their tent plants? Foster and Timm (1976) hypothesized that the relationship between the tent-making bats and their tent plants might be a form of mutualism. The plants obviously provide bats with roosting sites and in return obtain nitrogen-rich nutrients as bats defecate while roosting, as revealed in this study and others (Brooke, 1990; Charles-Dominique, 1993). Foster and Timm (1976) suggested that one or a few damaged leaves may be a small cost compared to the nutritional benefit especially in tropical forests with the nutrient-poor soil. To date, however, no experimental tests have been conducted for this hypothesis.

From data reported herein in addition to those of previous reports (e.g., Choe and Timm, 1985; Timm, 1987; Kunz et al., 1994), *A. watsoni* is clearly among the most versatile of all tent-making bats in terms of the variety of tent construction style as well as the diversity of tent plants. Timm (1987) identified four distinct styles: the simple cuts of a few side veins on aroids to produce a rounded pyramid (see Choe and Timm 1985 for illustrations), the elongated J-shaped cuts on banana and *Heliconia*, the polygonal cuts on cyclanths (see Timm 1987 for illustrations), and the inverted V-shaped cuts on bifurcated palms. These represent the pyramid, boat, palmate umbrella, and bifid type of tents, respectively, in the classification by Kunz et al. (1994). Such variety of cutting patterns does not represent geographical variations, as Timm (1987) found all four styles at a single locality, Corcovado, Costa Rica. How this rather smaller member of phyllostomid bats can adopt different cutting styles on leaves of different shapes deserves further investigation with respect to behavioral plasticity and animal cognition.

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