Tent building by female *Ectophylla alba* (Chiroptera: Phyllostomidae) in Costa Rica

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Introduction

Twenty-one species of bats around the world have been recorded using modified leaves as roosts, usually called 'tents' (Timm, 1987; Kunz and Lumsden, 2003; Rodríguez-Herrera and Tschapka, 2005). Most tent roosting bats are members of the family of New World leaf-nosed bats (Phyllostomidae) except three pteropodids (*Balionycteris maculata*, *Cynopterus brachyotis*, and *C. sphinx*) and one vespertilionid bat (*Scotophilus kuhlii*). Similarities in tent architecture among the Old World pteropodids and the New World phyllostomids support an interpretation of convergence in tent-making and tent-roosting behavior (Kunz *et al*., 1994; Kunz and Lumsden, 2003).

It has been suggested that the mating system associated with tent use is polygamy, based on the defense of a resource — tents (Brooke, 1990; Balasingh *et al*., 1995; Kunz and McCracken, 1996; Storz *et al*., 2000; Kunz and Lumsden, 2003; Chaverri and Kunz, 2006). The main idea is that males modify leaves to create a refuge, so that females would select a male based upon some characteristics of a tent that potentially can be defended against other males (Balasingh *et al*., 1995; Kunz and McCracken, 1996; Kunz and Lumsden, 2003).

To date, the construction of tents has only been observed in the flying fox, *C. sphinx* (Balasingh *et al*., 1995) where males modified palm fronds. However, little information is available for other tent-making or tent-roosting species. Using telemetry, Chaverri and Kunz (2006) observed that a male *Artibeus watsoni* remained motionless at a site for 30 min; the following day they found the bat in a new tent where it had stayed throughout the previous night. Hence, it remains an open question which sex constructs tents and how they are constructed. This information, however, is crucial to better understand the evolution of this complex behavior, in particular with regard to the social organization in tent-making bats.

The Honduran white bat, *Ectophylla alba*, is a small phyllostomid (forearm length 27–31 mm) with distinctively white fur, and yellow ears and noseleaf. Its distribution is restricted to the lowlands of the Caribbean slopes of Honduras, Nicaragua, Costa Rica, and northwestern Panama (Timm, 1982; LaVal and Rodríguez-H., 2002). This species apparently roosts only in tents; it has never been recorded in other types of refuges like hollow tree trunks or caves. Although there are at least 10 species of plants used for tents, most have been located in *Heliconia imbricata* and *H. pogonantha* (Timm and Mortimer, 1976; Brooke, 1990; Kunz *et al*., 1994).

As part of a long-term study on the mating system and social organization of *E. alba* in Costa Rica, we are investigating tent construction, and herein present for the first time information on tent construction by a phyllostomid bat in the field. We observed a female *Ectophylla* modifying *Heliconia* leaves into a tent. This is the first direct

observation of a phyllostomid bat constructing a tent and the first evidence that, contrary to expectation, females contribute to tent construction.

Materials and Methods

The study is being carried out in La Tirimbina Biological Reserve, Sarapiquí, Heredia, Costa Rica (10°24'N; 84°07'W) where we conduct a weekly census of tents in a marked area of seven hectares in secondary forest and two hectares in a cacao plantation abandoned for 20 years. During the day we check for leaves with fresh marks such as cuts along the midrib. We then observe potential activity of bats at the leaves during the night by placing a Sony HandyCam DCR-HC42 camera and an infrared light (Wildlife Engineering, model IRLamp6) at distances up to 4 m from the leaf.

Results

On 7 September 2005, we found a *Heliconia imbricata* leaf with an 11 cm long stretch of perforations parallel to both sides of the midrib (cuts). A subsequent inspection after the first half of the night revealed that the stretch of perforation had been lengthened to about 15 cm. Based on this initial observation we began filming on September 8th at 01:00 h. About three hours later, at 04:20 h, an adult male that we had previously marked with a band on the forearm arrived at the tent (Fig. 1a). This male stayed under the leaf for about two minutes without modifying it; then flew around the tent for about two more minutes. The same day, we began filming at 17:30 h and continued filming until 06:30 h on 9 September. At 18:14 h a female that we clearly identified as such because it was visibly pregnant (Fig. 1b) landed on the half-built tent. The bat stayed for about five minutes, actively modifying the leaf.

The female repeatedly pressed its snout against the leaf from the underside, next to the central leaf vein, apparently biting and puncturing the leaf with its canines (Fig. 2a) and thereby lengthening the cut on both sides of the central vein. While slowly crawling along the entire length of the cut along both sides of the central vein, she used her claws to expand the holes, which finally led to the collapse of the leaf next to the cut. Using her teeth, the female also made various holes in the central section of the leaf away from the midrib where the bats usually land when they arrive at a tent. These modifications may facilitate landing by the bats and may be the main cause for the characteristic punctured areas near the center (Fig. 2b). The female positioned herself along the cuts next to the midrib, clinging on with both feet and one thumb and grasped a section of the leaf away from the

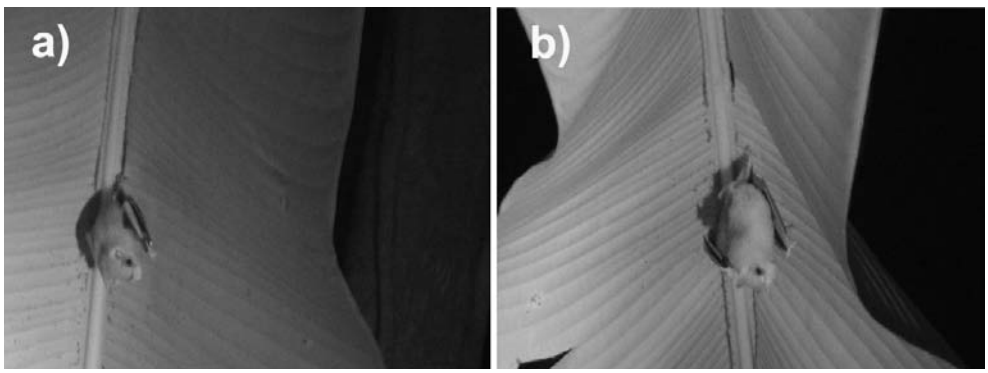

Fig. 1. a) Marked male visiting a partially constructed tent (8 September, 04:20 hr). b) Pregnant female in the same tent (8 September, 18:15 hrs)

midrib. She then pulled it repeatedly up and down and inward so that this part of the leaf finally bent slightly downward (Fig. 2c–d).

After 4 min and 24 s, the female left the roost for about 40 s and returned for about 20 s before she left again. No other bat visited the tent during the rest of the night. At this point, both sides of the leaf blade next to the midrib showed cuts along a length of about 30 cm; the middle section that remained uncut measured about 12 cm. At least 40 punctures had been made on both sides of the midrib in the main area of the leaf.

On September 12th, we found this tent occupied by a marked male and an unmarked pregnant female. A few days later, two pregnant females and two males (one marked) roosted in this tent. The pregnant females gave birth, each to a single young, between 18 and 22 September. This group (adults and juveniles) roosted in that tent until 13 October.

Discussion

Our observations do not support the hypothesis that male phyllostomid bats construct tents to attract females and thus gain access for mating (Kunz and McCracken, 1996; Kunz and Lumsden, 2003; Chaverri and Kunz, 2006). Although a male arrived at the tent during the nights it was modified, we observed no contribution of the male bat towards tent construction. Although we cannot exclude male participation in tent construction, our results clearly show that female bats are not passive, but actively contribute to modification of leaves into tents. Our observations further suggest that the process of tent construction is expensive, in particular regarding the time it takes to modify the large *Heliconia* leaves. Some tents took at least one week to build, whereas in the same area some of the tents that we monitored had been constructed rapidly during two nights. This suggests that tent

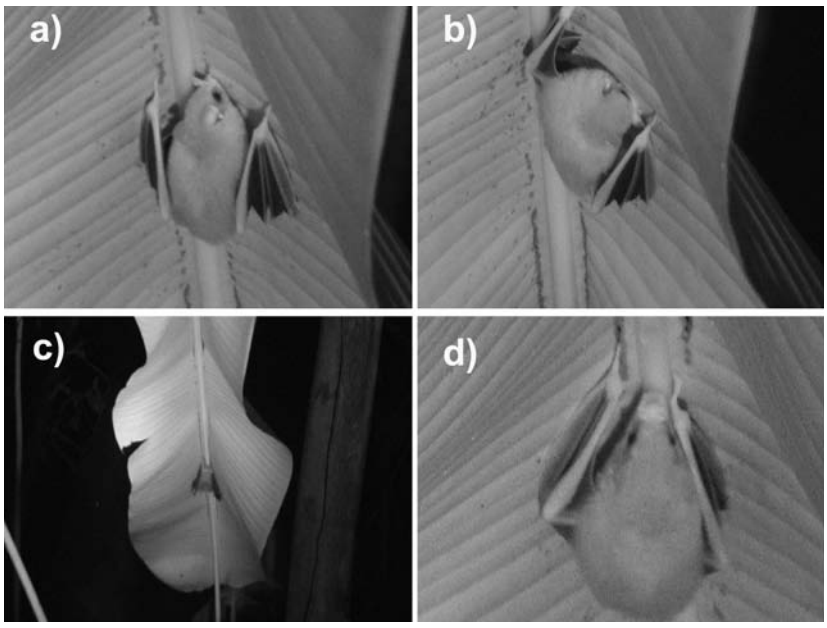

Fig. 2. a) An adult female *E. alba* using its teeth to perforate a *Heliconia* leaf along the midrib. b) Same female perforating the leaf away from the midrib. c) Female pulling down both sides of the leaf with its thumbs bending her forearms. Both sides of the leaf collapsed with the movements of the female to form the tent. d) Female using its feet and thumbs to enlarge holes created with its teeth

construction probably involves more than one individual, perhaps of both sexes.

To conclude, although details of the mating system of *Ectophylla* and of most other phyllostomid tent-roosting species are still unclear, this information on *E. alba* suggests that, at least for this species, tent construction should not be seen as the main characteristic for which the females select a mate. Possibly, there are other features (e.g., vocalization repertoire, direct defense of females, etc.), which are more instrumental for the operation of sexual selection in this species.

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