# Activity of tent-making bats in the Barra Del Colorado Wildlife Refuge, Costa Rica

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# Summary

Some species of bats are known to build their own roost environments by modifying the shape of leaves. These modified leaves are called tents. There are 21 species of tent-making bats, 11 of which live in Costa Rica. This research aimed to learn more about this tent-making behaviour, comparing two different habitats, comparing day and night roosts and comparing occupied and unoccupied tents. Two transects were set out, one next to the Caño Palma Biological Station and one close to a village nearby, each tent located within these transects were marked and monitored. We monitored for 15 weeks; the amount of bats and the species utilizing the tents were recorded. Tent type, tent density, tent height, basal area and understory density were measured for each tent. Weather data was also recorded. Per 100 m we found 13.8 tents and 2.1 occupied tents at one transect, where we also found a higher basal area and a lower understory density. The other transect had 4.6 tents and 1.1 occupied tent per 100 m, this transect had less bat activity, but more different types of tents. The only difference in day and night roost that was found, was in the density of tents. This is explainable by the fact that bats probably need a tent close by in case they get disturbed (e.g. predator attack). There was no difference found between occupied and unoccupied tents. This is probably because almost all tents are used at least once by the bat that made them. Most bats also use multiple tents at the same time and can switch between tents weekly. Further research can show if bats have specific requirements on the place where they build their tents.

# 1. Introduction

Bats play an important role in their environment, as they disperse seeds and pollen. Many native plants in Costa Rica depend completely on bats as their only pollinators (Gorchov et al, 1993; Melo et al, 2009). But plants play an important role for the bats too, as more than half of the bat species in the world uses plants for roosting (Kunz and Lumsden, 2003). Roosts are important for the survival as they provide sites for mating, hibernation, rearing young, promotion of social interactions, the digestion of food, and offer protection from extreme weather and predators (Kunz, 1982). Some species of bats are known to build their own roost environments by modifying the shape of leaves (Kunz and Lumsden, 2003). The modifying of leaves for roosting sites by bats was first described by Thomas Barbour (1932), who found the species *Uroderma bilobatum* roosting under leaves of cultivated palms. Chapman (1932) discovered *Artibeus watsoni* roosting under modified leaves and was the first to call these modified leaves 'tents'. Tent-making bats create roosting habitat by weakening the structural veins of the leaves by biting them so the leaf collapses (Barbour, 1932; Kunz et al, 1994).

To date there are 24 species of bats that have been recorded using modified leaves as roosts, 18 Neotropical species and 6 Paleotropical species (Chaverri and Kunz, 2010; Rodríguez-Herrera et al., 2007). At least 11 of these bat species live in Costa Rica, including the Great Fruit-eating Bat (*Artibeus literatus*), Heller's Broad-nosed Bat (*Platyrrhinus helleri*), Honduran White Bat (*Ectophylla* alba), Jamaican Fruit-eating Bat (*Artibeus* jamaicensis), Northern Little Yellow-eared Bat (*Vampyressa thyone*), Macconell's Bat (*Mesophylla macconneli*), Pygmy Fruit-eating Bat (*Artibeus* phaeotis), Striped Yellow-eared Bat (*Vampyressa nymphea*), Common Tent-making Bat (*Uroderma bilobatum*), Thomas Fruit-eating Bat (*Artibeus* watsoni) and the Toltec Fruit-eating Bat (*Artibeus toltecus*) (IUCN, 2014; Rodríguez-Herrera et al., 2007).

There are eight basic architectural styles of tents, including conical, palmate umbrella, pinnate, apical, bifid, boat, paradox, and the last is a mix of a boat and an apical tent shape (See figure 1; Kunz et al 1994; Kunz and Lumsden, 2003). Different styles of tents are created with different types of plants, and certain bat species are capable of creating several types of tents. This suggests that architectural styles of tent are more dependent on the plant morphology rather than on a species specific behaviour (Kunz et al, 1994). However, some species are known to build only one specific style of tent.

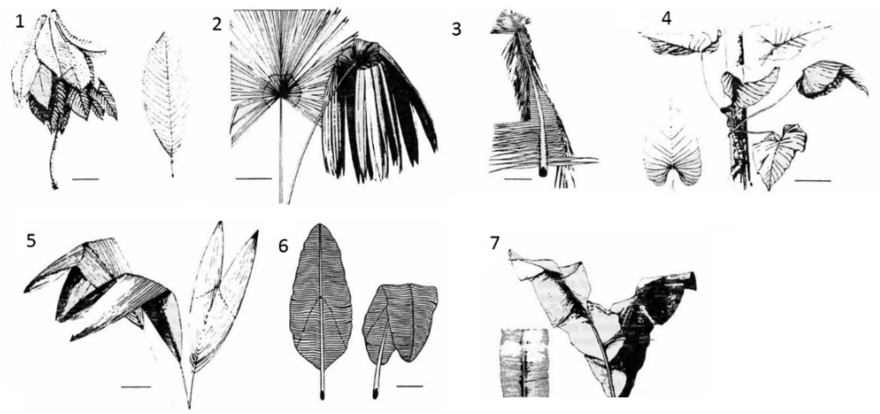


*Figure 1: Different styles of tents made out of leaves by the tent-making bats. 1 conical, 2 palmate, umbrella, 3 pinnate, 4 apical, 5 bifid, 6 paradox and 7 inverted boat (Kunz et al, 1994).*

All tent-making bats in Costa Rica are fruit-eating bats of the family *Phyllostomidae* (leaf-nosed bats) of the subfamily *Stenodermatinae,* and are mostly found in the tropical lowlands (Flemming, 1972; Gardner, 1977). In most species of bats, males defend the tents that they have built as well as the females that use the tent as a roost (Balasingh et al, 1995). Bats roost in tents in groups which are composed either of all males or several females with one male. Groups often remain together when they move to newly cut tents (Brooke, 1990). Some species like the *A. jamaicansus*, *A. literatus*, and *A. toltecus* have been found roosting in a wide variety of locations including caves, hollow trees, and buildings, and thus are not obligate tent-roosting species. Other species, like *E. alba,* are known to roost only in tents, and are thus considered obligate tent-roosting bats (Chaverri and Kunz, 2010; Timm, 1987; Ortega & Casto-Arellano, 2001; Rodríguez-Herrera et al., 2007). Although most people attributed tent-making to the species roosting in tents, only two species of bats (*Cynopterus sphinx* and *Ectophilla alba*) have actually been observed in the act of tent-making. This means that some species of bats may only use tents constructed by other bats and not construct tents themselves (Balasingh et al, 1994).

This research aimed to document the activity of tent making bats in the Barra Del Colorado Wildlife Refuge over a time period of 20 weeks. There has been little research done on the tent-making bats (Rodríguez-Herrera et al., 2007), so this research aims on learning more about the tent-making bats and their behaviour in tent making and tent usage. This research included a comparison on two different habitats, because there was believed to be more variety in tent types in one habitat than the other. Another comparison was made between day and night roosts, to see if there is a difference in tents used to roost during the day and tents used to forage during the night. A third comparison was in the differences in occupied and unoccupied tents, because there are many empty tents found in the area.

# 2. Methodology

*Study site*

Fieldwork was conducted between February and July 2015 at Caño Palma Biological Station, Pococí, Limón, Costa Rica (N 10°35'36.1"; W 83°31'39.4"). The biological station is located in the Barra del Colorado National Wildlife Refuge in north-east Costa Rica, approximately 8 kilometres north of the village of Tortuguero. The area is a lowland Atlantic tropical wet forest and has an average daily temperature of 26 degrees Celsius with rainfall of 5,000 mm per annum annually (Lewis et al; 2010).

*Monitoring*

We set out a transect to keep track of the tents in the area, surveying those that we found and documenting new tent creation. In the forest around Caño Palma Biological Station (CPBS) there is an existing path (approximately 1500 m long) which was used for the transect. The whole transect was 1000 m long, divided into 10 plots. Plots were 100 m long with a 10 m buffer zone on either side (thus each plot was 100 m X 20 m). Each plot was separated from the next by 50 m. We marked the beginning, centre (at 50 m) and the end of the plot with flagging tape and marked the tents located within the plots with flagging tape (of another colour) and gave them a number. Only tents in good shape (useable as shelter) were marked and monitored. New tents that appeared during the monitoring were also marked and numbered as encountered. We removed the flagging tape if a tents was irreparably damaged and was no longer functional as a shelter for the bats (e.g destroyed by wind or a fallen tree). We set out another transect near the village of San Fransisco (approximately 2 km from the station) on the path in the forest at the base of a hill (an old volcano called 'Cerro'). This transect had a length of 700 m and was also divided in plots of 100 m long, but had no distance in between the plots.

We monitored the tents in the plots ones or twice a week for 15 weeks. During this monitoring each tent was checked for the presence of bats. The number of adults and juveniles and the species utilising the tent was recorded if bats were found in a tent. The presence of faeces and evidence of foraging (seeds of fruits) in or under a tent was also documented. We used a binoculars for very high tents and a torch for very dark tents. A 3 m measuring tape was used to measure the height of the tents and a 50 m measuring tape was used to set out the plots. We took a picture if the species was not identifiable to determine the species later. Species were determined with 'A field key to the bats of Costa Rica' (Timm and LaVal, 1998) and 'neotropical tens-roosting bats' (Rodríguez-Herrera et al., 2007).

*Abiotic variables*

We documented tent type, density of other tents in a 5m distance, and tent height of each tent that was found in the plots. We also measured environmental factors for each tent, including understory density, basal area, and weather for every plot. The understory density was measured with the visual obstruction technique described by Mitchell and Hughes (1995). This is a technique were the visibility is measured from a pole (with white and orange segments) from a distance of 15 m. The basal area was measured with a Cruz-all (Forestry Suppliers Inc., Jackson, Mississippi); the number of trees is counted that fit between a certain space to estimate the surface area occupied by trees (i.e. wood) at breast height. Weather data, including temperature (°C), wind (Km/h) and humidity (%), was measured with a Kestrel (KerstelMeters, Birmingham, Michigan).

*Analysis*

Differences in environmental factors (basal area, understory density and weather) between the transects at CPBS and Cerro were tested with an independent t-test. We also compared number of day and night roosts with each other using the independent t-test. Tents that were seen with bats inside were seen as day roosting tents and tent with fresh foraging signs (without bats) were seen as night roosting tents. All abiotic variables were compared between the day and night roosting tents that were found. As last occupied an unoccupied tents were compared with each other. Occupied tents were seen as tents that have been seen at least once with bats inside or signs of (recent) bat activity (faeces or foraging). Unoccupied tent were tents that had no activity of bats during the whole monitoring. Occupied and unoccupied tents were compared in basal area, understory density, tent height and tent density with the independent t-test. Differences in weather (temperature, wind and humidity) was tested between CPBS and Cerro with an One-way ANOVA. All statistical tests were done with IBM SPSS Statistics (v20).

# 3. Results

In total we found, marked, and monitored 170 tents. During the 15 weeks of monitoring we found 17 newly made tents and 14 old tents became unusable. During the monitoring we encountered occupied tents 40 times at CPBS, seeing a total of 145 bats; consisting of 117 adults and 28 juveniles. At the Cerro we encountered occupied tents 16 times, seeing a total of 76 bats; consisting of 61 adults and 16 juveniles. Occupied tents contained between one to eight bats (excluding juveniles). In total 13 of the tents had a wasp nest inside. The transect CPBS had more tents in total and had more occupied tents than the transect at the Cerro, but the percentage of occupied tents at Cerro was higher than at CPBS (table 1). We only encountered indirect bat activity (feces and/or foraging evidence) in the transect of CPBS; no feces or traces of foraging was found at the transect Cerro. To make the results more comparable between the two transects, the amount of tents and bats is calculated per 100 m. The transect CPBS had 13.8 tents in total and 2.1 occupied tents per 100 m and the transect Cerro had 4.6 tents in total and 1.1 occupied tents per 100 m.

*Table 1: Number of tents, number of tents that have been found occupied at least once, number of tents that have been found with activity of bats (feces or foraging) and the total number of tents used by bats (tents with direct or indirect bat activity) in both transects.*

| Transect | Length of transect (m) | Number of tents | Number of occupied tents (%) | Number of tents with bat activity (%) | Number of used tents (%) |
|---|---|---|---|---|---|
| CPBS | 1000 | 138 | 21 (15.2%) | 34 (24.6%) | 45 (32.6%) |
| Cerro | 700 | 32 | 8 (25%) | 0 | 8 (25%) |

In total 6 different types of tents were found, including the apical, bifid, boat, conical, umbrella and the apical/boat. Only the apical (5.1%), bifid (74.6%) and conical (20.3%) tent types were found at CPBS. At Cerro the apical (46.8%), bifid (3.1%), boat (12.5%), Umbrella (15.6%) and apical/boat (21.9%) were found.

Three different bat species were found during the monitoring, including *Artibeus watsoni*, *Ectophylla alba* and *Uroderma bilobatum*. The species *A. watsoni* (64.3%) and *U. bilobatum* (35.7%) were found in the transect CPBS. The species *A. watsoni* (71.4%), *E. alba* (23.8%), and an unknown species (4.8%) were found in the transect Cerro. The unidentified individuals flew away before the species could be determined. The species *A. watsoni* was only found in a bifid tents in the transect CPBS and only found in apical tents in the transect Cerro. The species *U. bilobatum* was only found in conical tents and the species *E. alba* was only found in boat tents. Unkown species were found in a boat, umbrella and apical/boat tent type.

There was a significant higher basal area found at CPBS compared with Cerro (F=7.217; df=168; p=0.008). The basal area at CPBS had an average of 25.16 $m^2$/ha and the basal area at Cerro had an average of 19.62 $m^2$/ha. There was also a significant lower understory density found at CPBS compared with Cerro (F= 6.438; df= 168; p=0.012). The understory density at CPBS was 59.1% and the understory density at Cerro was 68.0%. The weather data showed no significant difference in temperature or humidity, but showed a significant difference in wind ($F=10.387$; $df=133$ ;$P=0.002$). Wind speed at CPBS had an average of 0,22 km/h and Cerro had an average of 0,71 km/h.

There was no significant difference in basal area, understory density, or tent height between day and night roosting tents, but there was a significant higher density of tents found by the day roosting tents compared with the night roosting tents ($f=6.093$; $df= 44$; $P=0.018$). Day roosting tents had an average of 1.71 tent density and night roosting tents had an average of 1.00 tent density in a 5 m distance.

Between occupied and unoccupied tents there was no significant difference found in basal area and understory density. There was also no significant difference found between the height and density of occupied and unoccupied tents.

# 4. Discussion

The amount of tents and the amount of occupied tents per 100 m at CPBS was higher than at Cerro. The transect CPBS had also a high amount of tents with signs of (recent) bat activity, while there was no sign of bat activity found at Cerro, which could mean that the bats prefer the habitat at CPBS more than at Cerro. The difference in understory density and basal area could play a role in this difference. CPBS had a higher basal area, which means there are probably more and bigger trees which could lead to more fruit (i.e. food) and more canopy cover. Canopy cover would protect the tents and the bats from extreme weather conditions. More canopy cover also means less light that can penetrate to the forest floor, which in turn results in less understory plant growth. This could explain the significantly lower understory density at CPBS. Also a difference in wind could play a role in the amount of tents. At the transect of Cerro there was significant more wind than at CPBS. Wind can damage the tents and the lifetime of a tent is likely shorter under windier conditions. In a plot at Cerro which had the highest average wind speed there was not a single tent found in the whole time of monitoring.

At the transect CPBS we only found *A. watsoni* in bifid tents. *A. watsoni* is commonly found under bifid tents in understory palms in Costa Rica (Rodríguez-Herrera et al., 2007). At Cerro we only found *A. watsoni* in apical tents which is probably because of the lack of understory palms. *U. bilobatum* was only found in conical tents. Along the Caribbean slope of eastern Costa Rica only *U. bilobatum* have been found (and documented) occupying conical tents, in groups from 2 to 8 (Rodríguez-Herrera et al., 2007). *E. alba* was only found in boat shaped tents, this species is known to only roost in boat shaped tents (Brooke, 1987; Timm, 1982; Timm and Mortimer, 1976).

There was no difference found between day and night roosts in tent height, basal area, or understory density. Therefore, it is likely that tents are probably not built specifically for day or night roosting. However, day roosts had a significant higher density of tents in a 5 m distance than night roost. A reason for this could be for the bats to have a close tent nearby to flee to when disturbed while roosting (e.g. to escape a predator attack). During the monitoring bats were observed flying from one tent directly to another tent close by when spooked. For example, on 7 April we spotted a single bat from the species *A. watsoni* in a tent at CPBS. The bat flew directly to a neighboring tent when spooked, then flew to yet another close tent, and when spooked again it flew back to the second tent. All tents were located within 10 m of each other. This behaviour suggest that bats have multiple tents at the same time (in case they get disturbed). Also the species *U. bilobatum* and *A. watsoni* are known to build and utilize multiple tents for short periods of time (Sagot et al, 2013).

No differences had been found between the occupied and unoccupied tents. It seems that bats have no specific preference in choosing tents. During the whole monitoring bats have been found in newly made tents, but also in tents that were at least a few months old. It seems that the bats will use any tent as long a tent is functional as a good shelter. The lack of difference between occupied an unoccupied tents could be explained by the fact that every tent was probably used at least once by the bat that made it. As previously mentioned, the species *U. bilobatum* and *A. watsoni* are known to use multiple tents for short periods of time. Some groups switch between tents on weekly or even daily bases. Thus, it is not uncommon to find empty tents that were occupied the day before (Sagot et al, 2013). This could mean that during the monitoring, recently occupied tents might have been missed.

Even when the females have young they have been seen switching between tents in short periods of time. Females have even been seen switching between males while rearing young. For example in a tent in the transect Cerro there was a group of bats spotted with 2 adults and 1 juvenile during each survey. After three weeks the group of bats expanded to 4 adults with 3 juveniles for the next two weeks. After the tent was empty during one survey and contained 4 adults with 3 juveniles again the next survey. It is know that a group consist of one male with multiple females or only males (Brooke, 1990). During the surveys juveniles were always observed holding on the chest of what is thought to be the mother. When bats with juveniles were spooked, the adult bat flew away with the juvenile still holding on to the chest.

Wasps have been seen using tents to build their nest in. During the whole monitoring period, 7.6% of the tents had an active wasp nest inside. It would seem that bats don't use the tents occupied with wasp nests. However, in one of the tents of the transect CPBS there was a wasp nest inside for two months. After two months the wasp nest was found (still active) on the ground next to the tent, and in the tent were 6 bats of the species *U. bilobatum*. This suggests that the bats can get rid of a wasp nest and that the tent is still useable. This behaviour was also seen and described by Chaverri and Kunz (2006).

For further research it would be interesting to compare a place with multiple tents and a place with almost no tents in the same habitat. This would give a view on the behaviour of tent making bats for choosing specific places to build a roost. It also would be interesting to do further research on tents in different plant species, to see if the bats would choose a specific area and use the plant species at this place or if the bats rather choose to make a tent in a specific plant species in any area.

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# References


Balasingh, J., Koilraj, J., Kunz, T.H. (1995). Tent construction by the short-nosed fruit bat Cynopterus sphinx (Chiroptera:Pteropodidae) in southern India. Ethology 100, 210–229

Barbour, T. (1932). A peculiar roosting habit of bats. Q. Rev. Biol. 7, 307–312.

Brooke, A. P. (1987). Tent construction and social organization in Vampyressa nymphaea (Chiroptera: Phyllostomidae) in Costa Rica. J. Trop. Ecol. 3(2): 171-175.Chapman, F.M., 1932. A home-making bat. Nat. Hist. 32, 555–556.

Brooke, A. P. (1990). Tent selection, roosting ecology and social organization of the tent-making bat, Ectophylla alba, in Costa Rica. Journal of Zoology, 221: 11–19.

Chapman, F.M. (1932). A home-making bat. Natur. Hist. 32: 555– 556.

Chaverri, G. and Kunz, T.H. (2006). Roosting Ecology of the Tent-Roosting Bat *Artibeus watsoni* (Chiroptera: Phyllostomidae) in Southwestern Costa Rica. Biotropica 38(1): 77–84 2006.

Chaverri, G. and Kunz, T.H. (2010). Ecological determinants of social systems: Perspectives on the functional role of roosting ecology in the social behaviour of tent-roosting bats. In Regina Macedo, editor: Advances in The Study of Behavior, Vol. 42, Burlington: Academic Press, 2010, pp. 275-318.

Flemming, T.H., Hooper, E.T. and Wilson, D.E. (1972). Three central American bat communities: structure, reproductive cycles and movement paterns. Ecology, 53:555-569.

Gardner, A.L. (1977). Feeding habits. Pp. 293-350, in biology of bats of the New World family Phyllostomatidae. Part 2. Spec. Publ. Mus., Texas Tech Univ., 13:1-365.

Gorchov , D.L., Cornejo, F., Ascorra, C. and Jaramillo, M. (1993). The role of seed dispersal in the natural regeneration of rain forest after strip-cutting in the Peruvian Amazon. Vegetatio 107/108: 339-349.

IUCN Red List of Threatened Species (n.d.). Found on 19 December 2014, on http://www.iucnredlist.org/

Kunz, T.H., (1982). Roosting ecology of bats. In: Kunz, T.H. (Ed.), Ecology of Bats. Plenum Press, New York, pp. 1–50.

Kunz, T.H., Lumsden, L.F., (2003). Ecology of cavity and foliage roosting bats. In: Kunz, T.H., Fenton, M.B. (Eds.), Bat Ecology. University of Chicago Press, Chicago, pp. 3–87.

Kunz, T.H., Fujita, M.S., Brooke, A.P. and McCracken, G.F. (1994). Convergence in tent architecture and tent-making behaviour among neotropical and paleotropical bats. J. Mamm. Evol. 2, 57-78.

Lewis, T., Grant, P., Quesada, M.G., Ryall, C. and LaDuke, T.C. (2010). A botanical survey of Caño Palma Biological Station (Estación Biológica Caño Palma), Tortuguero, Costa Rica. Brenesia 73-74: 73-84.

Melo, F.P.L., Rodriguez-Herrera, B., Chazdon, R. L., Medellin, R. A. and Ceballos, G. G. (2009), Small Tent-Roosting Bats Promote Dispersal of Large-Seeded Plants in a Neotropical Forest. Biotropica, 41: 737–743.

Mitchell, W.A. and Hughes, H.G. (1995). Visual obstruction. Section 6.2.6, U.S. Army corps of engineers wildlife resources management manual. Technical report EL-95-23.

Rodríguez-Herrera, B., Medellín, R.A. and Timm, R.M. (2007). *Neotropical tent-roosting bats*. Santo Domingo: INBio.

Sagot, M., Rodriguez-Herrera, B. and Stevens, R.D. (2013). Macro and Microhabitat Associations of the Peter's Tent-Roosting Bat (Uroderma bilobatum): Human-Induced Selection and Colonization? Biotropica, 45: 511–519.

Timm, R.M., (1982). Ectophylla alba. Mamm. Species 166, 1–4.

Timm, R. M. (1987). Tent construction by bats of the genera Artibeus and Uroderma. Fieldiana Zoology 39: 187-212.

Timm, R.M. and Mortimer, J., (1976). Selection of roost sites by Honduran white bats, Ectophylla alba (Chiroptera:Phyllostomidae). Ecology 57, 385–389.

Ortega, J. and Castro-Arellano, I. (2001). Artibeus jamaicensis. Mamm. Species 662, 1–9.