Activity of tent-making bats and use of artificial tents in Barra Del Colorado Wildlife Refuge, Costa Rica

Caño Palma Biological Station - COTERC
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CANADIAN ORGANIZATION FOR TROPICAL EDUCATION AND RAINFOREST CONSERVATION

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Preface

You are reading the paper: activity of tent-making bats and use of artificial tents in Barra Del Colorado Wildlife Refuge, Costa Rica. This paper was written as a result of an internship at Caño Palma Biological Station. The project was undertaken between February and June 2016.

I would like to thank Charlotte Foale for the opportunity to do my internship at Caño Palma Biological Station. I would also like to thank Molly McCargar, my research coordinator, for her assistance and great help during my project. I would like to thank Manuel Arias for his guidance in the forest and sharing his knowledge about tent-making bats. I would like to thank my supervisors Hanneke van Leur and Liesbeth Dingenboom for supervising and support. Finally I would like to thank all volunteers and interns who helped me during the surveys.

Contents

Summary

Tent-making bats are bats that modifying the shape of leaves to build their own roosts. There are three such species known to use leaf-tents as their primary roosting structure, including *Artibeus watsoni*, *Uroderma bilobatum* and *Ectophylla alba*. There are eight known tent-styles created by bats. Little is known about how tent making bats respond to forest fragmentation and human activity. Little is known about how these bats respond to forest fragmentation and increased proximity to humans. This study focus on the activity of tent-making bats in El Cerro Tortuguero, where previous research has been done on tent-making bat activity. Since this baseline study, a concrete path has been built, and forest cleared for its construction, in order to facilitate eco-tourism in the area. This gives us the opportunity to directly compare bat activity pre and post fragmentation. Additionally, we investigated whether artificial tents could be used by bats as roosts. In the Cerro we found 3.7 tents and 2.1 occupied tents per 100 meters after construction, compared with 4.6 tents and 1.1 occupied tents per 100 meters before construction. Before construction 72 bats were directly observed and after construction only eight were observed. This could indicate that bats found the area more suitable for foraging instead of resting. Additionally, fewer tent-styles were found after construction of the path than before, and a significantly lower understory density was found. None of the artificial tents were used during this study, however we recommend continued monitoring of the artificial tents to see if bats will use them for either foraging or roosting.

1. Introduction

Different bat species roost in different styles of roosting sites. They use natural roosting sites such as caves, leaves or hollow trees, as well as artificial roosts, such as buildings, water tunnels and bridges (Anthony, et al, 2001). Some tropical bat species from the subfamily *Stenodermatinae* (family *Phyllostomidae*) can use leaves as roosting sites as well (Rodrígeuz-H et al., 2007; Kunz, 1982). There are three such species known to use leaf-tents as their primary roosting structure (*Artibeus watsoni, Uroderma bilobatum* and *Ectophylla alba*), out of 16 species of *Stenodermatinae* found in the Neotropics (Brooke, 1987; Lim, 1998; Rodríguez-H, et al. 2001).

Tent-making bats have been observed since 1924 (Phillips; Barbour, 1932). These bat species practice a type of engineering allowing them to construct ''tents'' from vegetation (figure 1.1). A tent protects bats during the daytime from the rain, the sun and predators. When they roost they hang close together, upside down, in the center of the leaf. One tent can shelter multiple bats (Timm, 1987). Each bat species seems to use a specific pattern of cuts and prefer certain plants (Brooke, 1987).

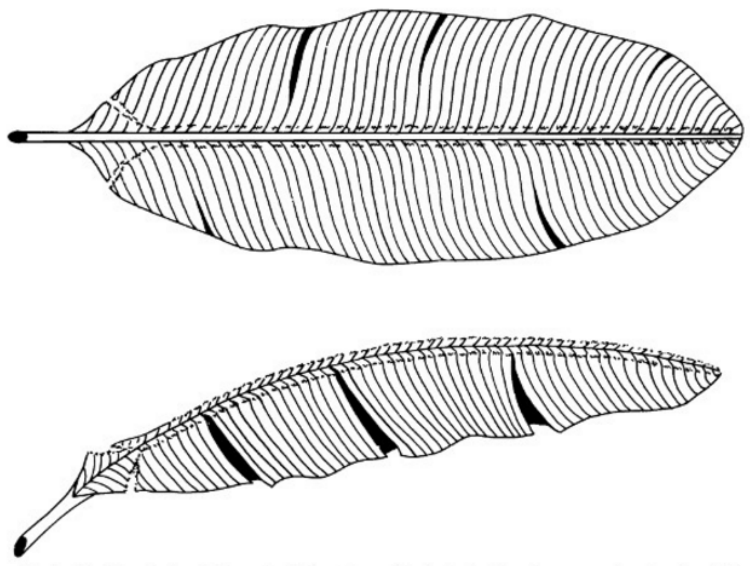

Figure 1.1 An example of a banana leaf that has been turned into a roosting place for tent-making bats.

Different plant species are used for different types of tents (Goodwin, & Greenhall, 1961). Every bat selects specific leaves for their size and a roosting site in the right environment with a food source, and appropriate plant species in the surrounding areas. A specific angle to the ground is important so predators cannot reach them. Height is critical also: if the tent is too high, they can be vulnerable to arboreal predators, and if the tent is too low they may be vulnerable to snakes or other ground-dwelling predators (Timm, 1985). There are eight different tent-types: conical, umbrella, pinnate, apical, bifid, paradox, inverted boat and boat/apical (Attachment 1; Kunz et al.,1994; Zortéa, & Debrito, 2000).

Costa Rica is one of the good places for tent-making bats to live. Several studies have already been conducted on tent-making bats. One of the wildlife refuges where research has been conducted is called Barra del Colorado national wildlife refuge (Agnelli, 2010; Barbour, 1932; Boeren, 2015; Brooke, 1987; Kunz, 1982; Kunz, 1994; Lewis, 2010; Rodríguez, 2001; Rodrígeuz, 2007; Timm, 1985; Timm, 1987; Vervoorn, 2016). This research will focus on habitat changes in an area within Barra Del Colorado national wildlife refuge, called El Cerro Tortuguero. A concrete path has recently been built in El Cerro Tortuguero in order to facilitate tourism, fragmenting the habitat. Forest fragmentation can affect the natural movement corridors of both terrestrial and aerial animals (Green, 2000; Shaughnessy et. al, 2008; Courbis, 2007). Additionally, tourism can have negative consequences for wildlife, through supplemental feeding, habitat alteration and loss, and increasing accidental mortality (Orams, 1996; Green, 200). As such, there is the need to monitor any potential consequences of this newly constructed path.

This project focuses on the activity of tent-making bats in El Cerro Tortuguero. Given that earlier research has been done on this topic in El Cerro Tortuguero, before the construction of the path, we have the unique opportunity to use the earlier study as a baseline to compare the results of this study with. Due to the recent fragmentation and disturbance of the habitat, discussed above, we hypothesize that bat activity and tent density will be reduced relative to the previous study. Additionally, as a way to explore a potential management option, we also investigate whether artificial roosts (in this case, artificially constructed leaf tents) were used by bats, and with what frequency. Given success in other environments with artificial roosts such as bat boxes (Anthony et al., 2001; Agnelli, 2010), we further hypothesize that artificial tents may potentially increase density of bat roosting activity in an area, hopefully leading to a valid management tool for countering habitat fragmentation and loss of tent-making bats.

2. Methodology

The observations were made at Caño Palma Biological Station, Pococí, Limón, Costa Rica, between February and June 2016. Caño Palma is located in the Barra De Colorado National Refuge in North-East Costa Rica, 8 kilometers north of the village Tortuguero (Figure 2.1). The area is a lowland Atlantic tropical rain forest with a rainfall of 5,000 mm per annum, and an average daily temperature of 26 degrees Celsius (Lewis et al; 2010). 10 Out of 17 Neotropical Stenodermatinae bats live in this area (Patterson et al. 2003). Two transects were used, one at the base of El Cerro Tortuguero and one in the forest behind Caño Palma Biological Station.

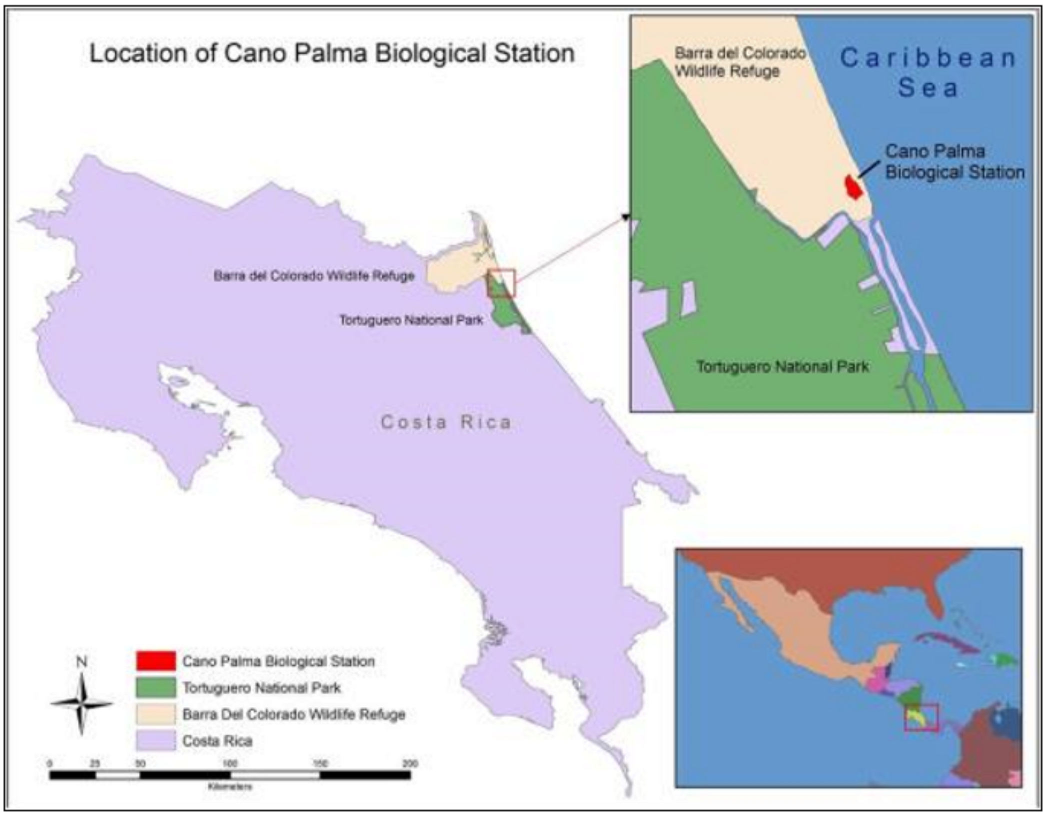

Figure 2.1 Location of Biological Station Caño Palma in Limón, Costa Rica (Vervoorn, 2016).

2.1 El Cerro Tortuguero

The transect in the Cerro was 700 meters long, with 7 plots of 100 meter on both sides of the concrete path. Each plot is 10 meters from the path into the jungle (figure 2.2). The existing tents inside plots were marked using flagging tape.

For every tent the tent-type, density of other tents in a five meter radius from the tent (even this extended outside the plot), basal area and the understory density was documented. The basal area was measured by counting the trees in a 5 meter square around a tent (with the tent in the middle) to estimate the surface area occupied by trees (Forestry Suppliers Inc., Jackson, Mississippi). The understory density was measured with the visual obstruction technique described by Mitchell and Hughes (1995), using a pole with orange and white fragments. The pole was held under the tent, while the visibility in percentages was measured by eye from a 15 meter distance north from the pole.

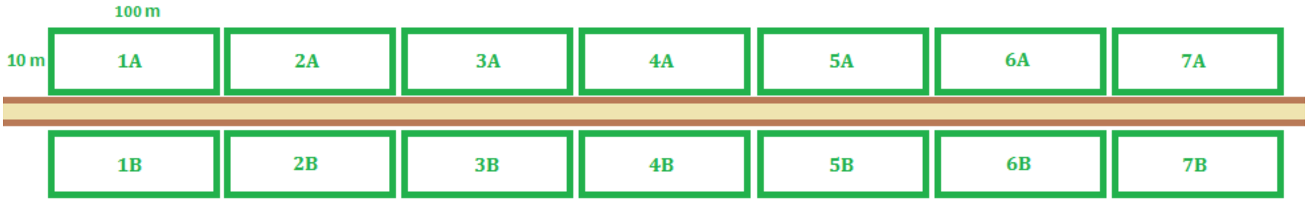

Figure 2.2 A demonstration of the plots in the Cerro. Plots are made on each side of the path. Each plot start direct beside the path and goes 10 meter into the jungle. Each plot is 100 meters long, equal to the path.

The tents were monitored once a week, over 14 weeks. Each tent was checked for the presence of bats, feces or evidence of foraging in or under the tent. If there were bats present, the species, number of adults and/or number of juveniles were noted. If it was not possible to identify the species in the field, a photo was taken for later analysis.

2.2 Caño Palma

The Caño Palma transect included 4 plots, each 15 by 10 meters (excluding a small dirt path that runs through part of them, figure 2.3). Artificial tents were made from suitable leafs and three were placed in each plot in Caño Palma. Designation of possible leafs for artificial tents were dependent on leaf size, presence of insect activity, height, structural integrity of the leaf, and presence of necrosis. (Sagot et al., 2013; Timm, & Choe, 1985). Only bifid tent-types were made, as previous research demonstrated that this was the natural dominant tent-style found in these plots (Vervoorn, 2016). Once a week all the tents (natural and artificial tents) were checked in the plots for the presence of bats, feces or evidence of foraging in or under the tent, just as in the protocols for the plots in El Cerro Tortuguero. If bats were present, the species, number of adults, and number of juveniles were noted. If it was not possible to identify the species in the field, a photo was taken for later analysis.

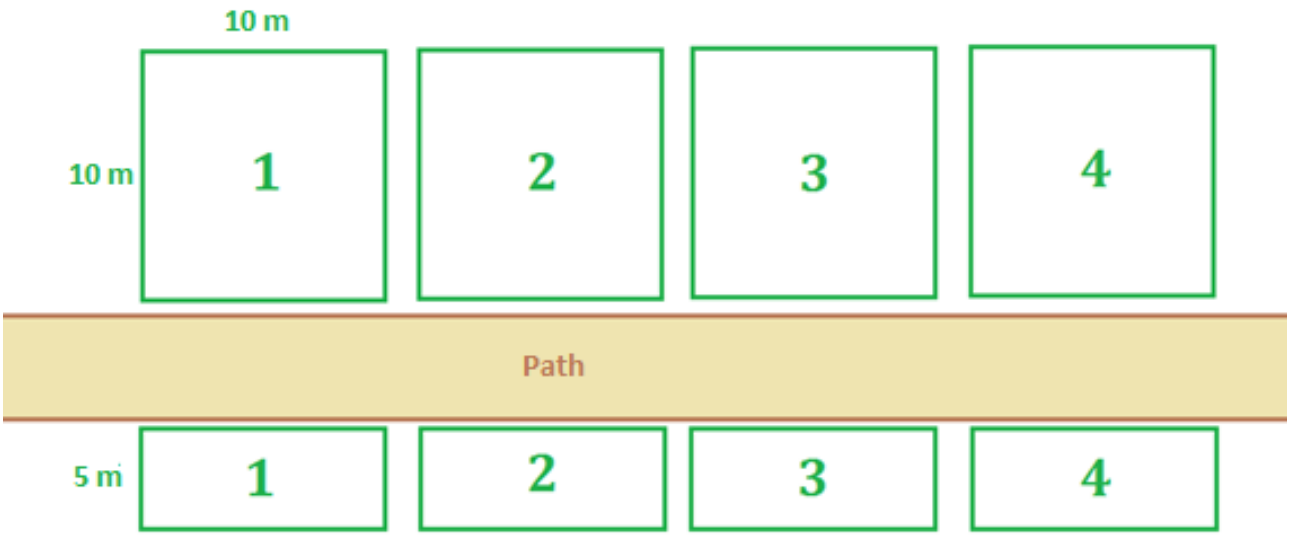

Figure 2.3 A demonstration of the plots in Caño Palma. Each plot is 15 by 10 meters, excluding a small dirt path that runs through part of them.

2.3 Analysis

Results that were collected in El Cerro Tortuguero in this study were compared to previous studies, carried out before the concrete path was constructed. Occupied and unoccupied tents were compared in basal area, understory density and tent density with an independent t-test. Occupied tents are defined as tents that have had bats or bat activity present at least once. Unoccupied tents were tents with no bat activity or bats during the whole monitoring. Occupied and unoccupied tents were also tested before and after construction of the path. To see if there was a difference between occupied and unoccupied tents in basal area, understory density and tent density in only this study, also an independent t-test was used. Finally, basal area, understory density and tent density were compared between this study and previous study, with an independent t-test. All statistical tests were done with IBM SPSS Statistics(v20).

3. Results

3.1 El Cerro Tortuguero

26 Natural tents were found in El Cerro Tortuguero, with 15 newly made during the 14 weeks of monitoring and six old tents that became unusable. Before construction of the concrete path 32 tents were found, with 17 newly made and 14 old tents that became unusable. A lower amount of total tents, new tents, and tents that became unusable, were found after the construction of the concrete path.

During the monitoring we encountered 15 occupied tents and 11 unoccupied tents. A total of eight bats were seen, including six adults and two juveniles. Tents with bats present contained between one and four adults. In comparison, the previous study found eight occupied tent and 24 unoccupied tents. A total of 76 bats were seen, including 61 adults and 16 juveniles (table 3.1). Tents with bats present contained between one to eight adults. The percentage of tents with signs of bat activity before construction was 0% (table 3.1), and was 57.7% after construction (table 3.1), while the percentage of tents where bats were directly observed was higher before construction (table 3.1).

To make results comparable with previous research, the amount of tents and bats was calculated per 100 meter. Before construction of the path 4.6 tents and 1.1 occupied tents per 100 m^2 were found. In comparison, 3.7 tents and 2.1 occupied tents per 100 m^2 after construction of the path were found.

Table 3.1 Number of tents, number of occupied tents and number of tent seen with bats present before and after construction of the concrete path.

Study	Number of tents	Number of tents with indirect signs of bat activity (%)	Number of tents with bats present (%)
After construction	26	15 (57.7%)	3 (11.5%)
Before construction	32	0 (0%)	8 (25%)

Three different tent-types were found in the Cerro, including apical (57,7%), boat (11,5%) and boat/apical (30,8%). Before construction of the path, five tent-types were found including, apical (46.8%), bifid (3.1%), boat (12.5%), umbrella (15.6%) and boat/apical (21.9%) (table 3.2).

Table 3.2 Summary of the percentages of the five tent-styles found before and after construction of the concrete path.

Tent-style	Before construction of concrete path	After construction of concrete path
Apical	46.8%	57.7%
Boat/apical	15.6%	30.8%
Boat	12.5%	11.5%
Umbrella	15.6%	-
Bifid	3.1%	-

Only one bat species, *Artibeus watsoni*, was directly observed during monitoring after construction (table 3.3). Research conducted before construction directly observed three different species: *A. watsoni* (71.4%), *Ectophylla alba* (23.8%), and unknown bat species (4.8%). Previously, *A. watsoni* was only found in apical tents, while in this study A. watsoni was found in both, boat and boat/apical style tents.

Table 3.3 Summary of bat species found in the Cerro before and after construction of the concrete path.

Species	Before construction of concrete path	After construction of concrete path
Artibeus watsoni	56 (71.4%)	8 (100%)
Ectophylla alba	19 (23.8%)	-
Uroderma bilobatum	-	-
Unknown	4 (4.8%)	
Total of bats found	**79**	**8**

There was no significant difference found in basal area (p=0.781), understory density (p=0.737) and tent density (p=0.462) between occupied and unoccupied tents within this study (attachment 2; table 3.4). With the previous study, no significant difference was found either. There was also no significant difference found between occupied and unoccupied tents in basal area (0.954), understory density (p=0.059) and tent density (0.185) between both studies (attachment 3; table 3.4). However, a significant lower amount of occupied tents was found after construction of the path (F=6.234; df=50.072; p=0.12) (attachment 4).

Table 3.4 Summary with all the p-values for every test. The table shows differences in basal area, understory density and tent-density between occupied and unoccupied tents after construction, before and after construction and only between occupied an unoccupied tents in general. P<0.005 shows a 95% reliability rate and makes it acceptable that there is a significant difference.

	Occupied and unoccupied only after construction	Occupied and unoccupied before and after construction	Only between occupied and unoccupied
Basal area	0,781	0,954	0,534
Understory density	0,737	0,059	0,000
Tent density	0,462	0,185	0,652

There was a significant higher understory density found after construction of the concrete path (F=19.022; df=38.728; p=0.000) (attachment 5; table 3.4). The understory density had an average of 71.09% before and 37.62% after construction of the path. Basal area (p=0.534) and tent density (p=0.652) showed no significant difference before or after construction of the path (attachment 5; table 3.4).

3.2 Caño Palma

13 Natural tents were found in Caño Palma, which one newly made tent during the 14 weeks of monitoring and five old tents that became unusable. 12 artificial tents were made, three in each plot. None of the artificial tents were used.

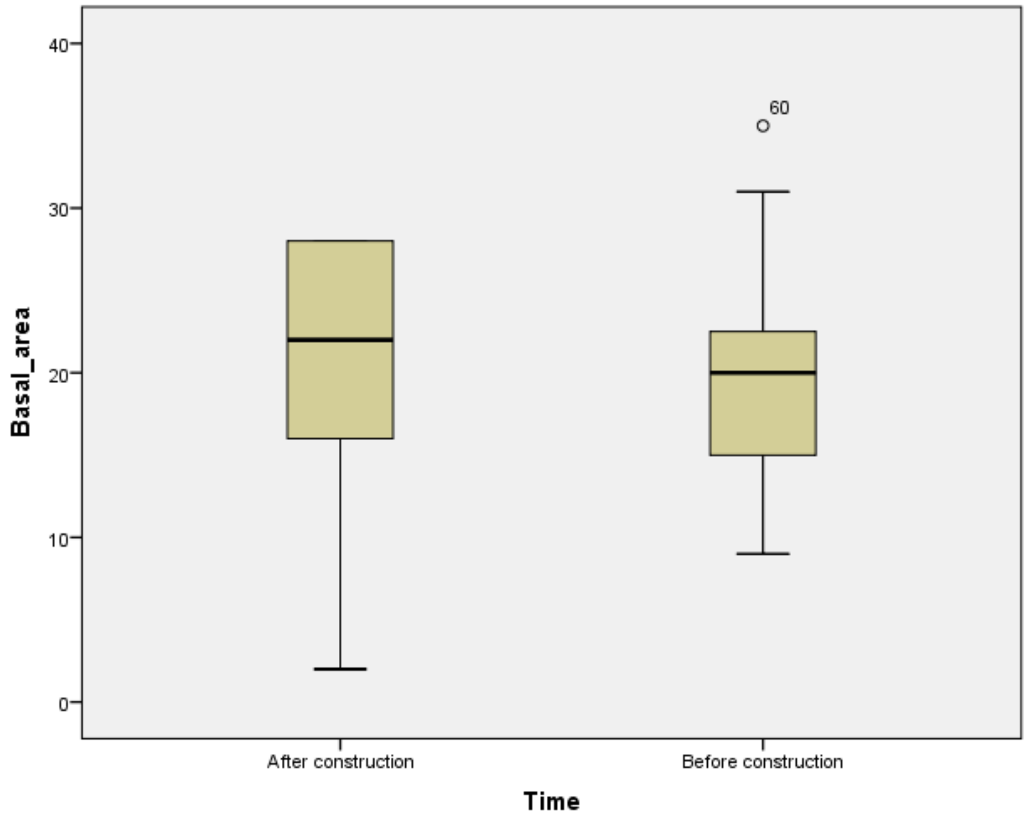

Figure 3.1 Difference in basal area before and after construction of the concrete path. After construction a higher average basal area was found. The outlier is represented by a dot.

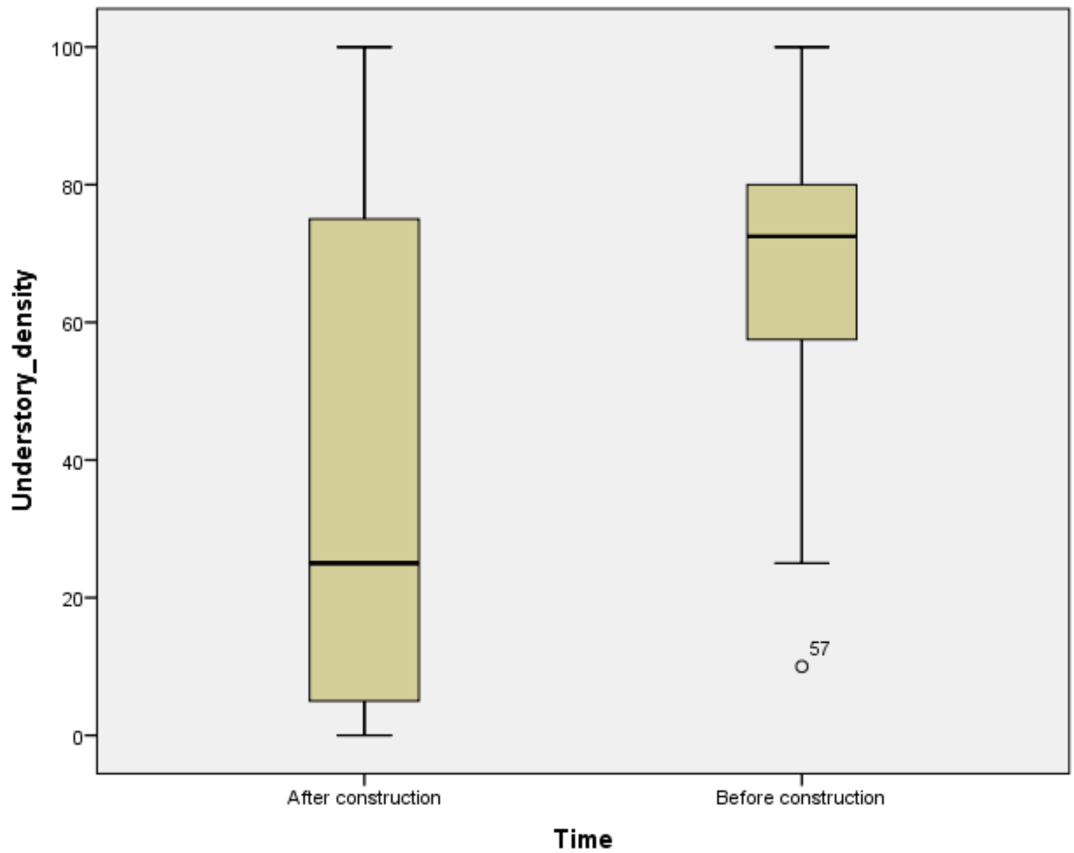

Figure 3.2 Difference in understory density before and after construction of the concrete path. The average of understory density was higher before construction than after construction. The outlier is represented by a dot.

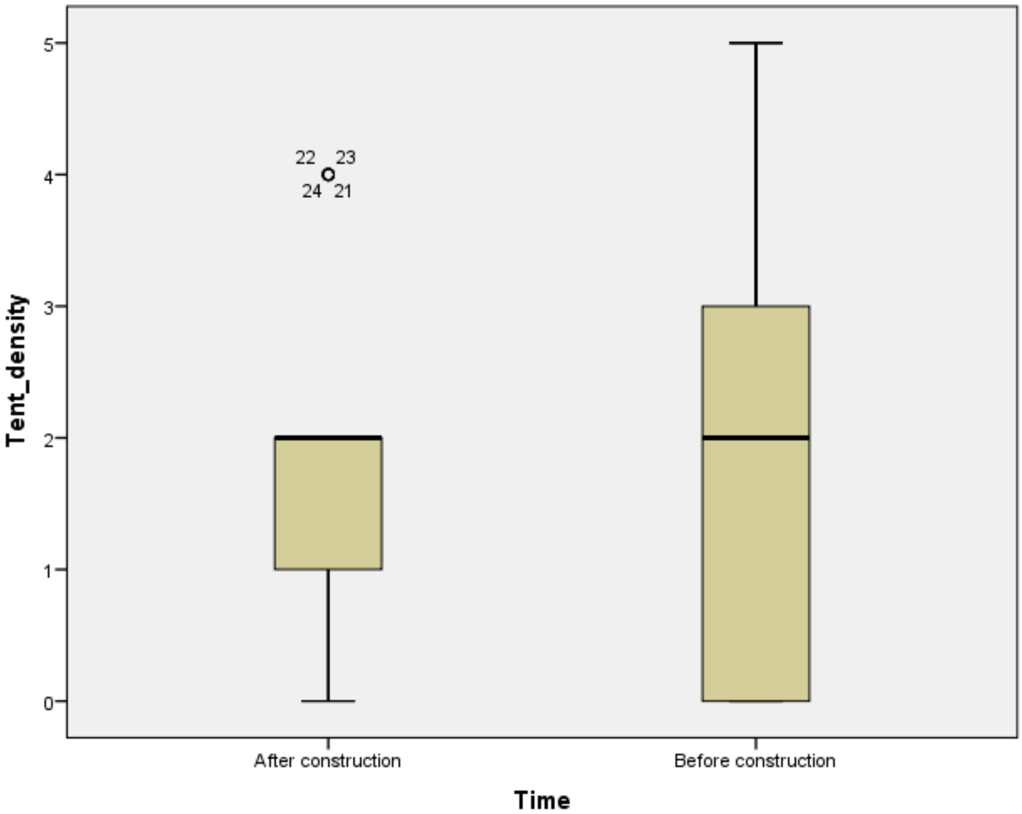

Figure 3.3 Difference in tent density before and after construction of the concrete path. The average tent-density is the same before and after construction. The outliers are represented by dots.

4. Discussion

4.1 El Cerro Tortuguero

The amount of tents before construction of the path was higher than after construction, however, the amount of occupied tents was higher after construction. Before construction, no indirect signs of bat activity were found in any tents, while there was a high amount of indirect signs of bat activity found after construction. The amount of bats seen during the monitoring was lower after construction than before the path was there. An explanation could be that bats find the area suitable for foraging, but not for resting and sleeping. *U. bilobatum* and *A. watsoni* are known to use different tents and can move between tents weekly or even daily (Sagot et al., 2013), so it is not unheard of to find a lot of tents with fresh bat signs, while not seeing any actual bat in these tents.

The difference in understory density could play a role in this potential preference. As vegetation could have been destroyed during the making of the path, leading to a lower understory density. With a lower understory density, wind can penetrate the forest more easily, potentially damaging and breaking tents more easily during storms. Also, the lifetime of a tent can be shorter (Boeren, 2015). This can explain why the amount of tents is lower after construction of the path.

A. watsoni was found in boat and boat/apical style tents after construction, but only in apical tents before construction. This differs from their normal behavior, as *A. watsoni* is most commonly found using bifid tents in Costa Rica (Rodríguez-Herrera et al., 2007). This discrepancy may be due to the lack of understory palms in the Cerro (Boeren, 2015). Although the Cerro did host a small number of bifid tents before construction (table 3.2), there were none found after construction.

Of the other two common tent-making species in the area, *U. bilobatum* was not present in earlier or current studies, and neither was their preferred tent-type (conical; Boeren, 2015; Rodrígeuz-Herrera et al., 2007; Brooke, 1987; Timm, 1982; Timm and Mortimer, 1976). The other commonly observed species in the area, *E. alba*, was observed before construction but not afterwards, although their obligate tent-type (boat; Brooke, 1987) was still present after construction, if in slightly decreased numbers (table 3.2). Additionally, umbrella tent styles were not found after construction, whereas they were previously found to comprise 15.6% of all tent styles found on the Cerro (table 3.2). As both, *A. watsoni* and *U. bilobatum* construct this style of tents, this could mean that *A. watsoni* and *U. bilobatum* are lower in density or less active in this area (Barbour, 1932; Timm, 1987). The unknown bat species were not identified because they flew away before the specie could be identified.

No differences in basal area, understory density and tent density were found between the occupied and unoccupied tents before or after construction of the path, indicating that bats do not have a specific preference for these variables in creating tents. Additionally, bats do not seem to have a preference for new or old tents, as both groups were occupied. However, given that we have observed a higher amount of foraging activity than actual roosting sites construction, fragmentation could still be affecting bat behavior in the area. As fragmentation is known to have a negative impact on the natural movement corridors of aerial animals (Green, 2000; Shaughnessy et. al, 2008; Courbis, 2007), it is conceivable that it may play a role in the lower amount of occupied tents observed.

For further research it would be interesting to continue long-term monitoring in the same area to see the impact of the concrete path over a longer time period and increased use. Impacts of habitat changes can appear both at early and later stages, necessitating further monitoring to determine the true impact of ecotourism infrastructure on bat populations in the area. It is particularly important to know the true impact on this bat population so that future managers can make better informed decisions about habitat use for ecotourism, both locally and around the world.

4.2 Caño Palma

None of the artificial tents were used. Although there could be many reasons for this, one reason could be that bats did not find the artificial tents yet, because they did not make the tents themselves and the tents were not places beside their fly route. Another reason could be that the tents were placed on the wrong spots in the forest and that the bats do not like the area around the tents. Additionally, only the bifid tent-style was made for artificial tents, because bifid was the most common tent in the area (74.6%; Boeren, 2015). *A. watsoni* is mostly found in bifid tents, as mentioned before, while *E. alba* is known to use only boat tent-styles and *U. bilobatum* is known to use seven out of the eight known tent-types (Rodrígeuz-Herrera et al., 2007).

During a mammal survey around the station (outside the plots of this study) an artificial tent was incidentally spotted with indirect signs of bats present (i.e.: fruit seeds and feces). As such, we are confident that it is still worth pursuing artificial tents as a management option, despite the fact that the ones constructed within the plots used for this study were not used.

Monitoring of artificial tents should continue to see if bats will use them for both foraging and roosting. If it turns out that bats use them, artificial tents can be placed in fragmented habitats to restore lost roosts.

4.3 Conclusions

The construction of the concrete path has a negative impact of the bat activity in El Cerro Tortuguero, the amount of bats and tent decrease. The prove that an artificial tent is used by bats (outside of the plots) could be a solution to increase the bat density again. Further research is necessary to specialize in the use of artificial tents by tent-making bats.

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Attachments

Attachment 1 Different tent-types

Here you can find the different tent-types used by bats.

1.Conical

Bats make several cuts on the petiole at the base of the leaf. The leaves will fall down in a 45^0 to 70^0 angle to the ground. Species that use this type of tent are *Platytthinus helleri* and *Uroderma bilobatum*.

2. Umbrella

The umbrella type tent is formed by cutting the veins and interconnected tissue of palmate leaves. The leaves can have a circular, semicircular, ovoid, heart or spatula shape while leaving the central petiole intact. Species that use this type of tent are *Artibeus jamaicensis, A. watsoni, Uroderma bilobatum* and *Vampyressa nymphaea*.

3. Pinnate

Bats cut several leaflets from a compound leaf or frond, which result in a ventilated tent. Constructing this type of tent requires a lot of time and energy. Species that use this type of tent are *Artibeus jamaicensis, Uroderma bilobatum* and *U. magnirostrum*.

4. Apical

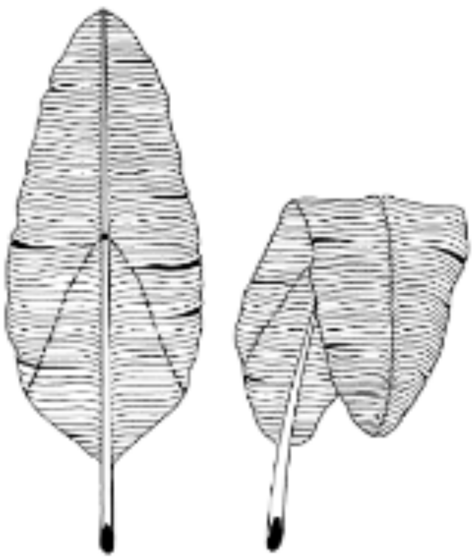
The leaf tip is generally modified in such a way that it hangs straight to the ground. The simplest tent from all the tent-types belong to this style, it can be made with one single cut in the vein. Species that use this type of tent are *Artibeus anderseni, A. cinereus, A. glaucus, A. gnomus, A. jamaicensis, A. phaeootis, A. toltecus, A. watsoni, Mesophylla macconnelli, Rhinophylla pumilio, Uroderma bilobatum* and *Vampyressa thyone*.

5. Bifid

Bats make this tent-type by making ''J'' or ''V'' shaped cuts on both sides of a simple or compound leaves with two tips. The apical tips will fall together en cross each other. Species that use this type of tent *are Artibeus cinereus, A. watsoni, Mesophylla macconnelli, Rhinophylla pumilio* and *Uroderma bilobatum*.

6. Paradox

The paradox type-tent is formed just like the bifid tent-type, with ''J'' and ''V'' shaped cuts on a one tipped leaf. The top of the leaf will simply fall down. Species that use this type of tent are *Artibeus cinereus, Mesophylla macconnelli, Rhinophylla pumilio* and *Uroderma bilobatum*.



7. Inverted Boat

With this tent-type bats will make cuts parallel to the central vine. Both of the sides of the leaf will fall down along the midrib. Species that use this type of tent are *Artibeus anderseni, A. cinereus, A. phaeotis, A. watsoni, Ectophylla alba, Rhinophylla pumilio* and *Uroderma bilobatum*.

8.

8. Boat/Apical

This tent-type is a mixture of two tent-types. Cuts are made almost parallel to the midrib of the leaf. There is also made a deep cut in the apical tip's midrib, so the tip collapses downwards. Species that use this type of tent are *Artibeus jamaicensis, A. watsoni, Vampyressa pusilla* and *V. thyone.*

Attachment 2 Output after construction

Here you can find the output of the independent sample t-test conducted to determine differences in basal area, understory density and tent density between occupied and unoccupied tents within this study.

Group Statistics

	Occupied_unoccupied	N	Mean	Std. Deviation	Std. Error Mean
Basal_area	Occupied	15	20,53	6,739	1,740
	Unoccupied	11	21,27	6,467	1,950
Understory_density	Occupied	15	39,73	39,185	10,118
	Unoccupied	11	34,73	33,853	10,207
Tent_density	Occupied	15	1,60	1,242	,321
	Unoccupied	11	2,00	1,483	,447

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Basal_area	Equal variances assumed	,028	,869	-,281	24	,781	-,739	2,631	-6,169	4,690
	Equal variances not assumed			-,283	22,208	,780	-,739	2,613	-6,156	4,677
Understory_density	Equal variances assumed	1,535	,227	,340	24	,737	5,006	14,710	-25,354	35,366
	Equal variances not assumed			,348	23,263	,731	5,006	14,372	-24,706	34,718
Tent_density	Equal variances assumed	,156	,696	-,748	24	,462	-,400	,535	-1,504	,704
	Equal variances not assumed			-,727	19,287	,476	-,400	,550	-1,551	,751

Attachment 3 Output environmental factors occupied and unoccupied tents

Here you can find the output of the independent sample t-test conducted to determined differences in basal area, understory density and tent density between occupied and unoccupied.

Group Statistics

	Occupied_unoccupied	N	Mean	Std. Deviation	Std. Error Mean
Tent_density	Occupied	23	1,52	1,442	,301
	Unoccupied	35	2,11	1,762	,298
Basal_area	Occupied	23	20,30	6,320	1,318
	Unoccupied	35	20,20	6,859	1,159
Understory_density	Occupied	23	45,91	36,240	7,557
	Unoccupied	35	62,77	30,070	5,083

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Tent_density	Equal variances assumed	1,042	,312	-1,343	56	,185	-,593	,441	-1,476	,291
	Equal variances not assumed			-1,400	53,207	,167	-,593	,423	-1,441	,256
Basal_area	Equal variances assumed	,810	,372	,058	56	,954	,104	1,786	-3,473	3,682
	Equal variances not assumed			,059	49,893	,953	,104	1,755	-3,421	3,630
Understory_density	Equal variances assumed	3,586	,063	-1,925	56	,059	-16,858	8,759	-34,406	,689
	Equal variances not assumed			-1,851	40,981	,071	-16,858	9,107	-35,250	1,534

Attachment 4 Output occupied and unoccupied tents before and after construction of the path

Here you can find the independent sample t-test output conducted to determined differences in occupied and unoccupied tents before and after construction of the concrete path.

Group Statistics

	Tijd	N	Mean	Std. Deviation	Std. Error Mean
Occupied_unoccupied	Cerro_new	26	1,42	,504	,099
	Cerro_old	32	1,75	,440	,078

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Occupied_unoccupied	Equal variances assumed	6,234	,015	-2,637	56	,011	-,327	,124	-,575	-,079
	Equal variances not assumed			-2,600	50,072	,012	-,327	,126	-,579	-,074

Attachment 5 Output environmental factors before and after construction

Here you can find the output of the independent sample t-test conducted to determine differences in basal area, understory density and tent density before and after construction of the concrete path.

Group Statistics

	Time	N	Mean	Std. Deviation	Std. Error Mean
Tent_density	Cerro_new	26	1,77	1,336	,262
	Cerro_old	32	1,97	1,892	,334
Basal_area	Cerro_new	26	20,85	6,503	1,275
	Cerro_old	32	19,75	6,730	1,190
Understory_density	Cerro_new	26	37,62	36,396	7,138
	Cerro_old	32	71,09	21,543	3,808

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Tent_density	Equal variances assumed	3,791	,057	-,453	56	,652	-,200	,440	-1,081	,682
	Equal variances not assumed			-,470	55,025	,640	-,200	,425	-1,051	,652
Basal_area	Equal variances assumed	,001	,973	,626	56	,534	1,096	1,750	-2,410	4,603
	Equal variances not assumed			,628	54,286	,532	1,096	1,744	-2,400	4,593
Understory_density	Equal variances assumed	19,022	,000	-4,354	56	,000	-33,478	7,690	-48,883	-18,074
	Equal variances not assumed			-4,138	38,728	,000	-33,478	8,090	-49,846	-17,111