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The Diversity of Terrestrial Mammals Surrounding Waterfall at Billy Barquedier National Park

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Cover Page Footnote
Kelsey Johnson is a Pre-Professional Animal Science Major Dr. Jason Apple is a Professor in the Animal Science Department

The diversity of terrestrial mammals surrounding a waterfall at Billy Barquedier National Park

Meet the Student-Author

Kelsey Johnson

Research at a Glance

- Billy Barquedier National Park, located in the Stann Creek District of Belize has very little published research about the biodiversity in the area. Conservation efforts can be improved with more data.
- The purpose of this study was to identify terrestrial mammals using live traps, game cameras, and tracks surrounding a tourist-attraction waterfall in the park to provide a baseline list of species. Eleven different species were identified.
- This data will supplement past and future studies regarding mammal inventories both within the national park and in Belize as a whole. The data collected have been used in reports about the park and to apply for funding for further biodiversity research.

This article was written in memory of Dr. Kimberly Gray Smith: He served as an influential advisor and committee member for me and passed away on April 9, 2018.

I am from Bixby, Oklahoma and a 2019 graduate of the Pre-Professional Animal Science program. I was a member in the Pre-Vet Club, Alpha Delta Pi sorority and held two leadership positions in the Wildlife Society at the University of Arkansas. Instilled with a passion to travel, I studied abroad twice. My first trip involved research with chick dehydration on the New Horizons poultry farm in Mozambique, Africa. That opportunity lead me to an Honors thesis pilot program over the summer in Dangriga, Belize where I conducted research on the terrestrial mammals in Billy Barquedier National Park.

After my travels, I became an International Programs Office mentor for a year to encourage other students to take advantage of the amazing study abroad opportunities Bumpers College provides. I was also a member of Animal Science Representing, Educating, and Promoting Scholars (REPS) for two years. I helped REPS with events for students, faculty, and staff in the Animal Science Department and assisted with community outreach.

After graduation, I plan to attend medical school and continue traveling through medical missions abroad.

I would like to thank my colleague Mersady Redding for helping me collect data in Belize. Additionally, I want to thank my family and friends for their constant encouragement throughout my college career. I am also grateful to Peacework, Jennie Popp, Amy Farmer, Chelsea Hodge, Kimberly Smith, Jacques Hill, Jason Apple, J.D. Willson, Charles Rosenkrans, Lawton Lanier Nalley, Fred Dustan Clark, and Isabel Whitehead for their continued support. In Belize, I want to thank Peter White, Mark Faux, Fidel Brooks, Anthony Hislop, and Tanisha Cacho.

Kelsey with a Northern Climbing Rat, from the Billy Barquedier National Park.

The diversity of terrestrial mammals surrounding a waterfall at Billy Barquedier National Park

Kelsey L. Johnson and Jason Apple†*

Abstract

Billy Barquedier is a National Park located in the Stann Creek district of Belize that contains Neotropical (the zoogeographical region which contains Central and South America) vegetation and wildlife. This study was performed to provide a baseline inventory and appearance frequency patterns of the terrestrial mammals located within Zone 1 of the park near a waterfall and to gain a greater understanding of the biodiversity and activity patterns of terrestrial mammals within the park. The methods included camera traps, small Sherman live traps, large live traps, and tracking methods. A non-random sampling method of placing camera traps and live traps on or near human-made or animal-made trails was used to identify the maximum amount of species possible within the eight-week study period. Bait including the local fruit Mamey Apple (*Pouteria sapota*) was used to attract wildlife to the study area. Based on discussions with park personnel, it was anticipated that approximately eight species would be identified within Zone 1; however, eleven different species were identified over the course of the study. The non- random sampling method introduced bias into the data. Consequently, definite conclusions about relative density and abundance of animals in the area cannot be drawn by this study alone. Statistical analysis of camera placement, length of camera placement, and time of day animal images were captured revealed that animals appeared more frequently in the central region during the first three days of image collection and during nighttime hours (2000 to 0459).

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Introduction

Billy Barquedier National Park is located in the Stann Creek District of Belize. The climate in the Stann Creek district is Neotropical (zoogeographical region which contains Central and South America) and contains dense jungles with thick lush vegetation. This study took place during the onset of the wet season. The Stann Creek District has the densest river and stream systems in Belize and animals tend to congregate by water (Hakre et al., 2004). Figure 1 is a waterfall located within Zone 1. Billy Barquedier is overseen by Steadfast Tourism and Conservation Association (STACA; Dive into the Wilderness, 2017).

A biological inventory is desirable because they "are fundamental surveys that generate presence or absence of information about a species from a collection of sampling units and often serve as the first step in assessing biodiversity" and when "followed by the development of monitoring programs" are used "as a way to track changes in populations" (Gilbert et al., 2008). Camera trapping is a vital tool when collecting data for a biological inventory because it offers "researchers more reliable evidence of animal presence" (Sunarto et al., 2013).

Live trapping is a helpful method when composing a biological inventory because it yields minimum disturbances to population structure and density and can supplement the camera trap data by specifically identifying small rodent species that would be nearly impossible using camera data (King and Edgar, 1977). Studies have shown "trapping success of researchers and densities of small mammals varied greatly between sites" and trapping success could be low in this study (Kelly and Caro, 2003).

When a study has a short time frame, a non-random sampling method may be more beneficial because it targets " features of the landscape—such as game trails, roads, water points, and salt licks—that increase the probability of photographing one or several target species" (Cusack et al., 2015) More information regarding mammals in Billy Barquedier will be beneficial in drawing patterns of mammalian diversity and understanding their activity patterns in the area. This information can be used to guide conservation efforts within the park and throughout Belize as a whole.

Materials and Methods

Sampling Method

A non-random sampling method was used by placing camera traps and live traps on or near human-made or animal-made trails in order to identify as many species as possible in the eight-week study period.

Fig. 1. Billy Barquedier National Park, photo taken by Kelsey Johnson.

Camera Trap Methods

Moultrie (model MCG-12594 and product name M-880) cameras were set to take the photos with a one-second-trigger speed after detection, three consecutive pictures, with a five-second delay before the next trigger. "Photo series at the same camera for the same species were considered independent if 10 minutes passed with no captures of the respective species" (Kolowski and Forrester, 2017). Cameras were set up along the hiking trails either facing up or down the human-made trail, where trails created by small mammals intersected the larger human-made hiking trails, off the human trail where a game trail was located or on the ground facing small Sherman traps to capture photos of rodent species.

The information recorded for the cameras included: species, number of animals, time and date of record, camera number, longitude and latitude, and image number. The longitude and latitude were recorded using a GPS device (iPhone 6 Compass Application).

The satellite image (Fig. 2) shows the locations of the camera sets throughout this study. Location groups within the study area were joined as follows for the test: East group: camera locations 2, 3, 6 and 7; Central Group: camera locations 14, 15, 16, 19, 20, 21, and 23; and Other Group: camera locations 1, 8, 9, 10, 11, 12, 17, 18, 24, 25, 4, 5, 13, 22, 27, and 26. All Chi-square analysis for the camera trap data was run using PROC FREQ (frequency procedure) of SAS (SAS Institute Inc., Cary, N.C.).

Live Trap Methods

Small Sherman traps (8.9 cm H, 7.6 cm W, 22.9 cm L) and larger live traps (Steel GoPlus 4.5 kg 30.5 cm H, 25.4 cm W, 81.28 cm L) were used in this study. Traps were set between 1800 and 2000 and checked the following day between 1800 and 2000 in order to minimize stress to any animal caught within the trapping period. Traps were unable to be set directly by the waterfall due to the steep rocky terrain. The small traps were set along human-made trails in areas where small rodents were expected to reside. Large traps were set along the human-made trails where there appeared to be small mammal trails intersecting. For each live trap capture, the date, time, longitude, latitude, scientific name and common name were recorded. The longitude and latitude were recorded using a GPS device (iPhone 6 Compass Application).

Bait for Camera Traps and Live Traps

The baits used included peanut butter, oats, bananas, mangos, mango jelly, Mamey apple (*Pouteria sapota*), tuna, and canned cat food.

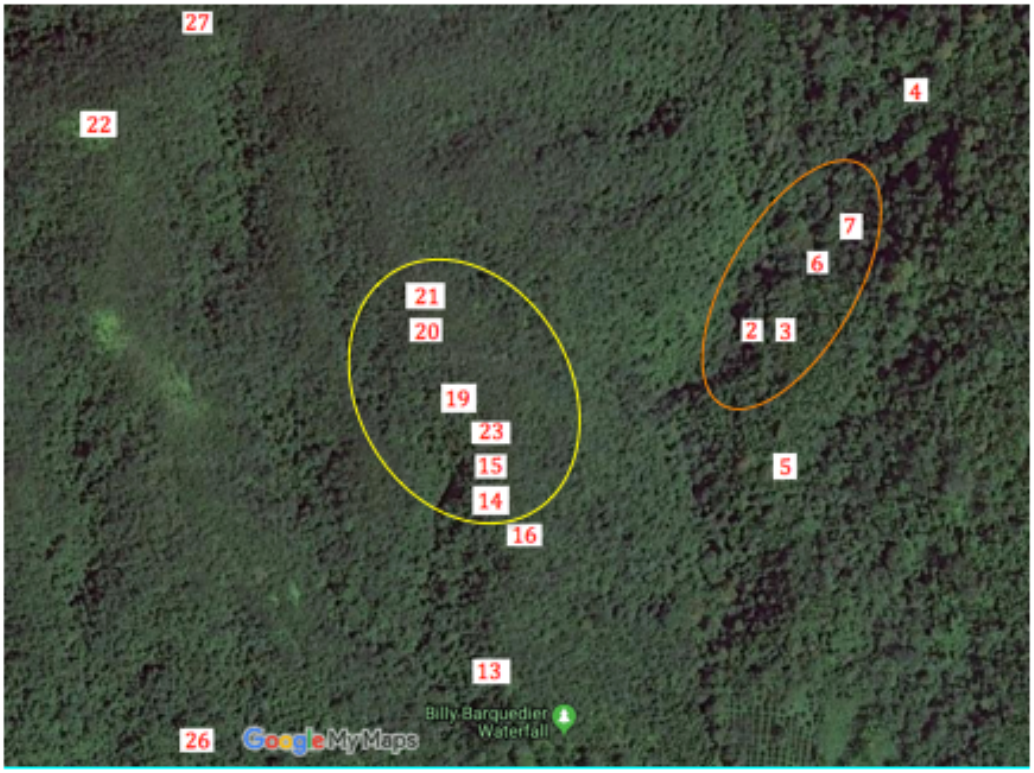

Fig. 2. Central Group camera locations circled in yellow, East Group camera locations circled in orange, and the other group includes camera locations 1, 8, 9, 10, 11, 12, 17, 18, 24, 25, 4, 5,11,13, 22, 27, 26.

Tracking Methods

Knowledge of the park guides was used to aid in locating and identifying tracks made in the naturally muddy areas within Billy Barquedier. The tracks were ultimately identified using *A Field Guide to the Mammals of Central America and Southeast Mexico* (Reid, 2009) and *Neotropical Rainforest Mammals: A Field Guide* (Emmons and Feer, 1999). Once a track was identified, the common name, scientific name, date, time, latitude, and longitude were recorded.

Data Analysis

Camera location (east, central, and other) within Zone 1, length of camera placement in a particular location (ranging from 3 to 11 days of image capture), and time of the day when images were captured [dawn (DN) = 0100 to 0400; morning (AM) = 0400 to 0800; daytime (PM) = 0900 to 1600; dusk (DK) = 1700 to 2000; and nighttime (N) = 2100 to 2400] were analyzed using the chi-square option within the frequency procedure of SAS (SAS Institute, Inc., Cary, N.C.). Although not a primary objective of this study, this information could assist future inventory surveys within the Billy Barquedier National Park.

Results and Discussion

A comprehensive summary of the results from this study is shown in Table 1.

The Northern Climbing Rat and Big-eared Climbing Rat were the only two species caught in the small Sherman live traps within Zone 1, near the end of the study period in mid to late July.

The Northern Climbing Rat (*Tylomys nudicaudus*) was captured twice, but because it was released without being marked, it was possibly the same rat captured twice. The individual appeared to be a juvenile. "No other large rats in the Northern Climbing Rat's range have a long,

Table 1. Comprehensive results.

Common name	Scientific name	Method of capture	Status	Population trend	Date last assessed	Total number of observations	Activity dattern from literature	Time of day[a]	Location[b]	Number of days camera was out[c]
Northern Climbing Rat	*Tylomys nudicaudus*	Sherman Live trap	Least Concern	Stable	8/24/16	2	Nocturnal	N/A	N/A	N/A
Big-eared Climbing Rat	*Ototylomys phyllotis*	Sherman Live trap	Least Concern	Stable	8/24/16	1	Nocturnal	N/A	N/A	N/A
Nine-banded Long-osed Armadillo	*Dasypus novemcinctus*	Camera Trap	Least Concern	Stable	10/2/13	36	Nocturnal/ Diurnal	Night (83.33%)	N/A	N/A
Striped Hog-nosed Skunk	*Conepatus semistriatus*	Camera Trap	Least Concern	Unknown	3/1/15	1	Nocturnal	N/A	N/A	N/A
Tayra	*Eria barbara*	Camera Trap	Least Concern	Declining	3/1/15	11	Diurnal/ Crepuscular	AM (45.45%) and PM (36.6%)	N/A	N/A
Collared Peccary	*Pecari tajacu*	Track Identification	Least Concern	Stable	6/24/11	N/A	Nocturnal/ Diurnal	N/A	N/A	N/A
White-nosed Coati	*Nasua narica*	Camera Trap	Least Concern	Declining	2/18/15	18	Diurnal	DN (38.89%) and AM (38.89%)	Central (100.00%)	N/A
Central American Agouti	*Dasyprocta punctata*	Camera Trap	Least Concern	Stable	6/10/16	13	Diurnal	PM (53.85%)	N/A	N/A
Paca	*Cuniculus paca*	Camera Trap	Least Concern	Stable	3/1/16	15	Nocturnal	Night (53.33%)	East (66.67%)	N/A
Ocelot	*Leopardus pardalis*	Camera Trap	Least Concern	Declining	5/11/14	4	Nocturnal/ Crepuscular	N/A	N/A	N/A
Tapir	*Tapirus bairdii*	Camera Trap[d]	Endangered	Declining	11/1/14	2	Nocturnal/ Diurnal	N/A	Other (100.00%)	N/A
Small Rodent	*N/A*	Camera Trap	N/A	N/A	N/A	28	N/A	Night (89.29%)	Center (75.00%)	Day 1 to 3 (53.57%)

[a] Time of Day: Dawn (0500 to 0659), Morning (0700 to 1159), Afternoon (1200 to 1759), Dusk (1800 to 1959), and Night (2000 to 0459).

[b] Location: Frequency of appearance of species between Center, East, and Other Locations. East group: camera locations 2, 3, 6 and 7; Central Group: camera locations 14, 15, 16, 19, 20, 21, and 23; and Other Group: camera locations 1, 8, 9, 10, 11, 12, 17, 18, 24, 25, 4, 5, 13, 22, 27, 26.

[c] Number of Days: Frequency of Appearance of All Animals Between Days 1 to 3, Days 4 to 6, and Days 7 to 11.

[d] Tapir tracks were also identified once.

Note: The Status, Population Trend and Date Last Accessed column information all came from the official International Union for Conservation of Nature. (IUCN) Red List website. N/A means either the method of capture did not allow this data to be collected or the data collected was not statistically significant (P-value > 0.05).

white tip to the tail" (Reid, 2009). It is typically caught in traps baited with banana or other fruits and the specimen caught in this study was caught with banana and Mamey apple. A camera was set in front of the trap and the specimen appeared to be caught on the camera (Fig. 3) eating Mamey fruit before being captured in a trap that was set on the ground under leaves (Reid, 2009).

The Big-eared Climbing Rat (*Ototylomys phyllotis*) was caught once and the trap was baited with tuna. This specimen was possibly caught on a game camera (Fig. 4) and a trap was placed in the area it was spotted in order to try and capture it and make a positive species identification. The capture was successful with the trap placed in the ground under leaves.

A Nine-banded Long-nosed Armadillo (*Dasypus novemcinctus*) went inside one of the large traps baited with Mamey apple but unfortunately pushed its way out and defecated inside the trap. The escape appeared to be caught on one of the cameras.

Fig. 3. Northern Climbing Rat *(Tylomys nudicaudus)*. This photo was taken in the field .

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Fig. 4. Big-Eared Climbing Rat (*Ototylomys phyllotis*). Possible photo taken on camera trap.

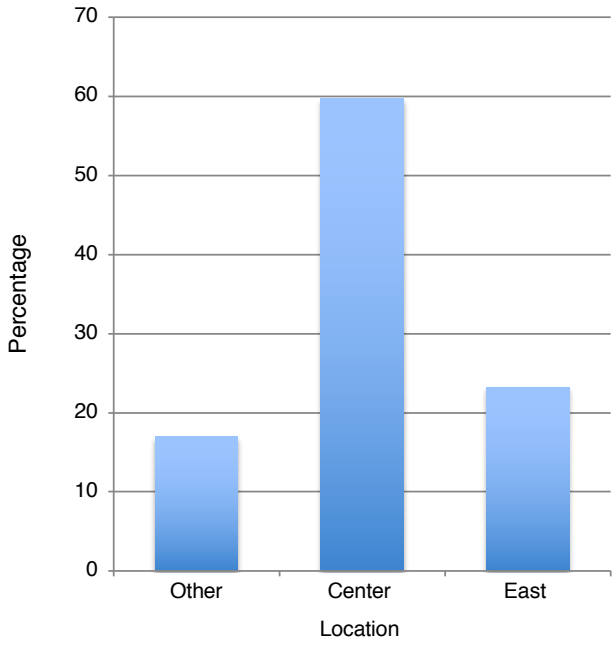

Fig. 5. Frequency of appearance of all animals between Center, East, and Other locations.

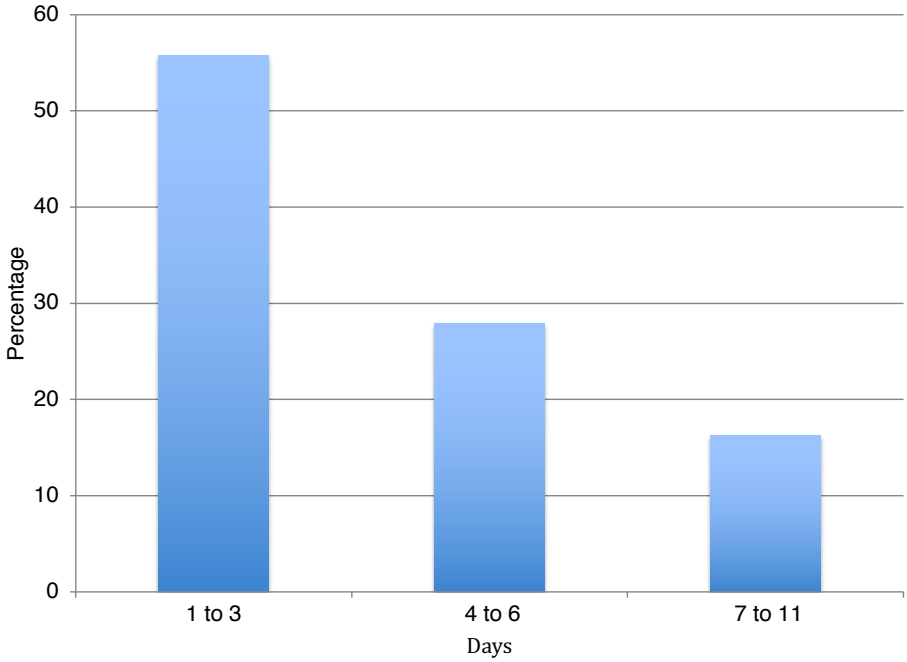

Fig. 6. Frequency of appearance of all animals between Days 1 to 3, Days 4 to 6, and Days 7 to 11.

Overall, live trapping was not widely successful in Zone 1 and no statistical tests could be conducted, but the camera trapping was promising. A total of eight species were captured on camera traps and there were two cases of human traffic captured on camera traps along Tiger Trail as well.

The group with the most frequent animal appearances was the Center Group (along Tiger Trail). A graph of these findings can be found in Fig. 5.

Comparing observation frequencies between the number of days cameras were out (Days 1 to 3, Days 4 to 6, and Days 7 to 11) revealed appearance frequencies from Day 1 to 3 were greater (Fig. 6).

When comparing activity patterns (Fig. 7) during Dawn (0500 to 0659), Morning (0700 to 1159), Afternoon (1200 to 1759), Dusk (1800 to 1959), and Night (2000 to 0459), it appears the Night category had the greatest frequency of animal observations, which leads one to believe many of the animals photographed were nocturnal.

The most prevalent species caught on camera in Zone 1 was the Nine-banded Long-nosed Armadillo (*Dasypus novemcinctus*), which was observed 36 times. The animals were not marked but showed up many times on the cameras in various locations throughout Zone 1.

The Striped Hog-nosed Skunk (*Conepatus semistriatus*) that was caught on camera at night in this study appeared to have lost almost all of its hair on its tail, which was an interesting observation that could indicate the need for further investigation on the health of the species in the area.

The Tayra (*Eria barbara*) "may be seen singly or in pairs, occasionally groups of 3 to 4", which is consistent with the observations in this study (Reid, 2009). One of the photos taken was of a group of three individuals eating Mamey Apple (Fig. 8).

Collared Peccary (*Pecari tajacu*) tracks were identified once and the characteristic "musty-cheese odor" was observed in the area as well (Reid, 2009).

The White-nosed Coati (*Nasua narica*) diet consists of "invertebrates found in the leaf litter and under rotting logs" and they use their "strong claws to dig, and root with the long sensitive nose", which may be why it was attracted to cat food and tuna bait (Reid, 2009). It has been stated "males are solitary except during breeding season" and the photos in this study (Fig. 9) appeared to show one male individual traveling alone (Reid, 2009).

The Central American Agouti (*Dasyprocta punctata*) plays a vital role in the ecosystem because "when food is abundant, it carries seeds away and buries them for future use, depositing each seed in a different place. Since not all seeds are recovered this rodent is an important seed disperser for a number of tree species" (Reid, 2009). This species was observed thirteen times within Zone 1, leading one to believe that these rodents are fulfilling this important seed-dispersing role in Billy Barquedier.

There appeared to be some evidence of large cat (Jaguar or Puma) movement at the top of Tiger Trail near

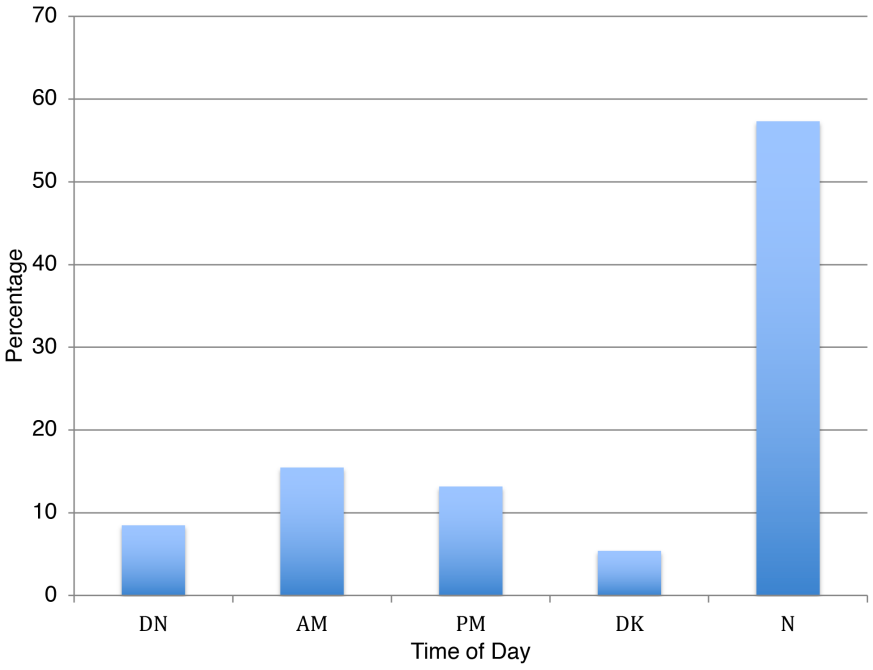

Fig. 7. Frequency of appearance of all animals between Dawn (DN), Morning (AM), Afternoon (PM), Dusk (DK), and Night (N).

Fig. 8. Tayra (*Eira Barbara*) Group of three caught on camera trap.

Fig. 9. White-nosed Coati (*Nasua narica*). Camera trap photo.

camera locations 22 and 27, due to some feces and tracks observed. There was not enough evidence for a firm positive identification, but more research in this area with camera traps could lead to a positive identification.

Of all of the baits used to attract animals, the Mamey apple appeared to be particularly successful. This "ovoid medium-large" fruit comes from the tropical tree species *Pouteria sapota* and has a "vibrant salmon-colored flesh" with a "large center pit" (Slow Food USA).

Due to the short sample period, the need to use a non-random sampling method, and the inconsistent number of days each camera was set in each location for this study, the results are subject to bias. Therefore, this species list and data is a baseline for a terrestrial mammalian inventory for Billy Barquedier National Park. Further studies must be conducted in the park to create an inventory that encompasses all of the species so further conclusions about the density and abundance within the park can be made.

In order to avoid bias in future studies and more successful species identifications, researchers "must balance the desire to maximize overall detection probability and spatial coverage given a limited number of cameras and days available for their study" (O'Connor et al., 2017). Using a randomized sampling method and camera arrays can help create this balance. Other studies suggest "the change from a single camera to even a two-camera array will likely increase detectability during the season but would reduce the number of sites being sampled by half" (O'Connor et al., 2017). With so few cameras in this study, camera arrays seem like they would be difficult to use to achieve quality data. However, the same study suggests "the increase in both survey and season detection probability over short season lengths could allow researchers to retrieve and relocate cameras, thus achieving greater spatial coverage of a landscape without sacrificing data quality" (O'Connor et al., 2017). Camera trap studies are beneficial because they show "tremendous utility in collecting wildlife data in a manner that is minimally invasive and requires reduced human labor" (O'Connor et al., 2017).

To improve studies similar to this one in the future, some alterations should be made. These alterations include: setting more camera traps in the western region of the study area, using a Garmin GPS to obtain more reliable coordinates, using camera arrays to increase the chance of successful identifications, keeping better track of what bait was used for each camera trap, and setting traps with the intention to capture specific elusive species. Fortunately, predictions that were made prior to the study were confirmed.

Agoutis (*Dasyprocta punctata*) were caught on camera within Zone 1. These rodents are a vital player in the ecosystem. They are "a caviomorph rodent" and in one study they were observed burying "13% of the seeds of Pouteria" which is the Mamey Apple used as bait several times in this study (Brewer and Rejmánek, 1999). This means the Agouti is vital in seed dispersal for an ecosystem. This study states that small rodents are typically overlooked when considering important seed predators and dispersers in Neotropical forests even though their "great abundance and ubiquity" allows them to play a vital role in "the mechanisms that determine patterns of tree recruitment in tropical forests", and the "results of this study support predictions by some researchers that small rodents are dominant terrestrial granivores in Neotropical forests" (Brewer and Rejmánek, 1999). Also, since the Mamey apple (*Pouteria sapota*) was successful bait in this study, future researchers in Belize should consider this local fruit when trying to attract wildlife.

In all, the data collected in this study could supplement mammal inventory in the journal article "Inventorying mammals at multiple sites in Maya mountains" (Caro et al., 2001).

Conclusions

The initial hypothesis in this study was with the time frame given (approximately eight weeks) at least eight species would be identified using camera traps, live traps, visual identification, and track identification. The results revealed a total of eleven different species identified within Zone 1 of the Billy Barquedier National park, which exceeded the expectation of eight, or fewer, species. Also, chi-square analysis of image collection parameters indicated that animals appeared more frequently in the central region of the study site, during the first three days the cameras were set out, and during the nighttime hours (2000 to 0459). Eleven species for an eight-week study period is considered a success based on previous studies performed in the neotropics. A longer study period, more randomized camera placements, consistent durations cameras are set out before being switched (between three to seven days after a camera is set it should be re-baited or relocated to maximize species detection), and more randomized live trap placements may yield results that capture the more elusive species (for example the Jaguar, Puma, and more small rodent species) present in Billy Barquedier National park. The location of Zone 1 might have also played a role in seeing less elusive species due to human traffic (humans were spotted twice on camera traps). The pictures and data collected in this study were given to the overseers of Billy Barquedier National Park (STACA) and have been used in reports about the park and to apply for funding for further biodiversity research in the park. Overall, the data produced by this study can supplement other terrestrial mammal species inventory

studies that have been done in the past and other biodiversity research that will be performed in the future.

Acknowledgements

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