PRELIMINARY COMPARISON OF FOUR NEOTROPICAL SURVEY TECHIQUES FOR TERRESTRIAL MAMMALS

by

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INTRODUCTION

This thesis presents the results of data collected from January to December 1993 in the Indio-Maíz Biological Reserve, Nicaragua. The thesis is divided into 3 independent manuscripts that each to be submitted for publication. As a result each manuscript is written in the style required by the target journal. The "Use of scent-stations as a survey technique in the Neotropics" and "Seasonal variation among three Neotropical mammal survey techniques" will both be submitted to Biotropica. The "Comparison of survey techniques of large, terrestrial Neotropical mammals" will be submitted to Oecologia.

ACKNOWLEDGMENTS

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My advisor, Dr. Eric Anderson was of invaluable help in providing ideas, guidance, and support in the development of the project as well as in reviewing the manuscripts. My committee members, Dr. Hans Schabel, Dr. Jim Hardin, and Mr. Ron Zimmerman, encouraged and supported me throughout the project. Dr. Schabel first informed me of the possibility of doing research in SI-A-PAZ and shared his experience and knowledge of the area with me. This project would not have been possible without the moral and logistical support I received from Cindy Taft, Environmental Education Coordinator for SI-A-PAZ, and Mauricio Araquistain, National Coordinator of SI-A-PAZ, who took me into their home and under their wings.

I am indebted to Ramon García Solís, my guide and assistant throughout the entire project. His knowledge of the rain forest flora and fauna never ceased to amaze me. I thank the people of New Greytown who welcomed me into their homes and their hearts and supported me and my project in ways to which no price tag could be attached.

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Use of Scent-Stations as a Survey Technique in the Neotropics

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ABSTRACT

A scent-station survey technique was tested in the rainforest of southeastern Nicaragua to survey large terrestrial mammal fauna. The technique was adapted for use in the rainforest environment by adding a simple roof structure, using the naturally soft soil as tracking surface, and locating transects on riverbanks. The technique successfully attracted a wide range of animals from felids to opossums and was equally successful in the dry and rainy seasons.

Key words: mammal survey; Neotropics; Nicaragua; scent-station.

Little survey work on larger mammals has been done in the neotropical rainforests and few survey methods have been developed for that ecosystem (Vaughan 1983). Attempts to describe the mammal community at individual sites involve many technical problems including the inaccessibility of undisturbed sites and the cryptic and nocturnal nature of many rainforest mammals. Furthermore, any one census method reveals only a portion of the total mammalian species present (Malcolm 1990). As a result there are few lists of the mammal faunas of single localities in lowland moist forests (Janson and Emmons 1990),

Despite these obstacles, a variety of survey techniques have been used in neotropical mammal communities including visual censuses from trail transects (Cant 1977, Walker and Cant 1977, Glanz 1982; Emmons 1984, Whitesides et al. 1988), track transects (Fragoso 1991), and mark-recapture techniques (Glanz 1982). Techniques for determining mammalian densities vary greatly between taxonomic groups. What works for large diurnal species, such as the line transect method, becomes impractical for cryptic nocturnal species. Most recent surveys of tropical mammal communities have used

techniques that are less precise in their measurements of density, but applicable to a broader variety of species (Glanz 1990).

The scent-station survey is one technique that has been used successfully in the temperate zone to index medium to large sized carnivores (Linhart and Knowlton 1975, Morrison et al. 1981, Linscombe et al. 1983). To my knowledge a scent-station method developed specifically for use in the tropical rainforest has not appeared in the literature. The scent-station survey is inexpensive, requires limited manpower, and can cover extensive areas. The objectives of this project were to test the feasibility of scent-station surveys in the lowland wet tropical forests and to gather baseline data on large mammal populations in southeastern Nicaragua for future trend analysis.

STUDY SITE

The study site included 5 areas within the 3,787km^2 Indio-Maíz Biological Reserve, part of the SI-A-PAZ (Sistema de Areas Protegidas Para la Paz) system of protected areas in southeastern Nicaragua (Fig 1). Annual rainfall is 4.5- 6.3m (Wernstedt 1966, Castiglione 1990) and falls during 11 to 12 months. The dry season is from January to April, March being the driest. The vegetation at all 5 sites is mature, evergreen, lowland, tropical rainforest. There is one town of approximately 250 people within the Reserve (New Greytown) and human disturbance within the Reserve consists of limited trail cutting, subsistence hunting, selective removal of individual trees, and limited orchard farming in 2 areas. Human influence and activity diminishes as distance from New Greytown increases. The 5 study sites (San Juanillo, Chirripa, Toby, La Tigra, and Caño Blanco) were chosen because of their accessibility by boat and to represent a gradient of human influence, based on their distance from town.

The San Juanillo site was off the San Juan River and was the site closest to New Greytown (Table 1). Heavy fighting occurred here during the Sandinista\Contra war (1980-1990) and during that time hunting and wood extraction pressure were very heavy, but since the end of the war in 1990 pressure has not been as high. There was an old (1890's) railroad line and a small working orchard farm within the study site. The area was approximately 50% Raffia palm swamp, which was flooded in the rainy season. The Toby site was on Caño Negro; there were no farms in the area and very little swamp,

although there were several small streams. The Chirripa site was located on the Indio River near a small farm that was inhabited irregularly. There were several small creeks and swamps throughout the site. The Caño Blanco site was on a tributary to Caño Negro. There were several small creeks, but no swamps in the area. The site farthest from New Greytown was the La Tigra site, an undisturbed (pristine) upland site on the Indio River. It was the only site with no signs of human disturbance. There were several small creeks, but no swamps in the area. La Tigra and Caño Blanco were near the headwater of the Indio and Negro Rivers respectively. In those watershed areas the riverbeds and banks become very rocky, rather than the soft mud found in the lower reaches.

METHODS

The scent-station survey is an adaptation of a method originally described by Linhart and Knowlton (1975) and later refined for use in the U.S. Fish and Wildlife Service survey (Roughton 1980, Roughton and Sweeny 1982). Scent-station transect lines were located along river banks and stations were placed at 0.5km intervals with a total of 10 stations per line and 1 line in each study area. Each scent-station consisted of a 2m diameter circle cleared of all vegetation and the soil surface smoothed clean. All stations were placed on the river banks to promote a more efficient use of time (since there were no trails in the area, travel by river was much faster than by land) and to take advantage of the soft mud tracking surface found there. Once the surface was prepared, a Q-tip with the scent on it was placed in the center of the station. The tracking surface was the natural soil found at the site.

Three scent types (FAS, "Pro's Choice" and "Cat-man-do") were compared to find the most effective attractant. FAS is the government formula fermented egg essence; "Pro's Choice" is a gland lure produced by Russ Carmen; "Cat-man-do" is a gland lure produced by Milligan Brand. During the dry season the same scent was used for all stations within a site and a different scent was used at each site ("Cat-man-do" and "Pro's Choice" were each used in 2 sites). In the rainy season only Pro's Choice and Cat-man-do were used, alternating scents by station within each site for 2 days, and then switching the sequence for the next 2 days.

During the dry season each station was checked for 3 consecutive days and for 4 days in the rainy season. Each station was classed as operative or inoperative. Inoperative stations were those which had been obliterated by rain or where the soil had gotten too hard to leave track impressions. Operative stations were carefully checked to see if they had been visited and, if so, by which species. All tracks were identified with the aid of a local guide and the guide book by Aranda (1981). During the rainy season a roof structure was built for each station to protect the scent and the tracks from the rain (Fig. 2). The roof was built out of small tree trunks and large palm or fern leaves found at the site. The roof was 2m X 2m square and approximately 2m tall. Each roof took about a half hour to construct.

A visitation rate (number of stations with tracks/number of operable stations X 100) was calculated by species for each transect line and a mean visitation rate was calculated by species for the entire reserve area. A Wilcoxon Signed Rank test (Siegel 1956) was run for each species to test for differences in their adjusted index (Linhart and Knowlton 1975) between the wet and dry seasons. Chi square and Bonferroni (Kirk 1968) tests were run on each species separately to detect differences in their visitation rates between sites.

RESULTS

Approximately 79% of the 150 stations set in the dry season (Jan -May) and 93% of the 160 stations set in the rainy season (Jul- Dec) were operable with visitation rates of 46.2% and 40.1% in the dry and wet seasons, respectively (Tables 2 & 3). The percent of operable station nights in the rainy season was significantly ($P \leq 0.05$) greater than in the dry season.

Paca (Agouti paca) visited scent-stations more than any other mammal, and were present at every site throughout the year. Most scent-station surveys do not report rodent visitation rates, but because paca are such an important part of the subsistence hunting culture in the area an index to its abundance could be a valuable tool for wildlife managers. Margay (Felis pardalis) also visited the stations in all of the sites in both the wet and dry seasons. Jaguarundi (Felis yagouaroundi) and puma (Felis concolor) are the only 2 cats known from the area that were never recorded at a scent-station.

Although the Wilcoxon Signed Rank test showed no significant differences in the relative ranking of visitation rates between the wet and dry seasons for any of the species ($P \leq 0.05$), the chi square tests did expose significant seasonal differences in some species. Jaguar (Panthera onca) and ocelot (Felis pardalis) only visited the scent-stations in the dry season, resulting in a significantly ($P \leq 0.01$) higher visitation rate for those species in the dry season (Tables 2 & 3), as elaborated by Nachman (1993). Of the 10 other mammalian taxa that visited the scent-stations during this survey opossum had the highest visitation rate in the dry season (6.7%) and agouti (Dasyprocta punctata) in the rainy season (16.8%) (Tables 2 & 3).

The chi square and Bonferroni tests exposed significant differences in the visitation rates of some species between certain sites in both the dry (Table 4) and wet (Table 5) seasons. There were significantly more agouti at the San Juanillo site during both seasons (Tables 4 & 5). This may, in part, be attributed to the farm at the site where cacao (Theobroma cacao), coconuts (Cocos nucifera), and sugar cane (Saccharum officinarum) were growing. The La Tigra site was visited by significantly more jaguar than any other site (except Chirripa) (Table 4). La Tigra is the most pristine site and is the farthest from human settlement, 2 factors which may affect jaguar visitation rates.

In the dry season paca visitation rates were significantly higher at San Juanillo and La Tigra (Table 4). In the wet season Chirripa had the highest visitation rate for paca. The significantly higher visitation rate for armadillos (Dasypus novemcinctus) in the San Juanillo site in the rainy season is perplexing since armadillos are not known to frequent forest areas subject to flooding and this site was mostly flooded during the wet season.

Although overall visitation rates were higher with Russ Carmen's "Pro's Choice" scent than the Milligan Brand scent (48.7% vs 34.0%), the difference was not significant at $X = 0.05$. The difference in visitation rates between scents was not significant for any individual species either.

Since these data represent the first year for this index, no conclusions can be drawn regarding population trends. Instead, these data may be useful as a baseline for analysis of scent-station data in future years.

DISCUSSION

The non-random placement of the scent-station lines (i.e. on the river banks) created a bias in the survey as water is a strong attractant for many animals. A further bias was created if the animals are using the river banks as travel corridors since the stations would no longer be independent. Large species, such as jaguar and ocelot can easily travel 0.5km in a single night. Crawshaw and Quigley (1991) showed that jaguar never wandered far from water in a radio telemetry study in Brazil. But since one of the purposes of this study was to gather baseline data for future comparison, the numbers may apply to some extent as scent-station lines in subsequent studies within the Reserve are also located along river banks. An important consideration when evaluating this index method for use throughout the rainforest environments was the time commitment involved. Locating transect lines along river banks reduced the time necessary to locate suitable sites and the time required to review and reset the transects since all travel could be done by boat.

The distance between stations should be adjusted depending on the species being surveyed. Jaguar travel an average of 2.4km each night (Crawshaw and Quigley !991), so spacing should be at least 2.5km between stations, more if it is determined that they are using the river banks as travel corridors. For less mobile species, such as agouti or paca whose entire home range is 2 to 3 hectares (Smythe 1983), a much smaller spacing distance of perhaps 150m should be sufficient.

Since stations were run for 3 consecutive nights, it is possible for the same animal to have visited the station every night, not 3 independent visits. The stations were run 3 consecutive nights to increase the probability of recording a footprint sample size since visitation rates were usually quite low. This could also be accomplished by running more stations on a single night if available personnel permitted, or running stations in different areas on consecutive nights, such as opposite sides of the river. Because of seasonal variations in visitation rates (Nachman 1993) sites or years to be compared should have data covering an entire year or only data from the same season in different sites or years should be compared. In addition if sited are to be compared the habitats must be identical so as not to add additional bias.

Visitation rates at my scent-stations in the tropical rainforest environment were comparable to visitation rates obtained for related species in the temperate zone. Reported visitation rates for bobcat

range from 1.9% to 6.7% (Brady 1979, Morrison et al. 1981, Linscombe et al. 1983). Morrison et al. (1981) recorded visitation rates of 18.8% for rabbits and 4.4% for armadillo in northcentral Louisiana, while Linscombe et al. (1983) reported visitation rates of 11.8% for opossum (Didelphis virginiana), and 7.2% for raccoon (Procyon lotor). Jaguarundi and puma were the only 2 cats known from the area that were not recorded at scent-stations. Puma do not often use river bank habitat (Emmons 1986) and so were less likely to visit the stations.

The roof structure built over each station allowed me to continue to run scent-stations throughout the rainy season. The roof protected the scent and tracks from pounding rains, but was of no help if the forest floor flooded over the station (which occurred once during this study). The percent of operable station nights in the rainy season was greater than the dry season when no roof was used. Although it rains less in the dry season, even the short pounding rains common in the dry season can wipe out tracks. As a result a roof over the stations would probably increase the percent of operable stations, even in the dry season. In the rainy season a station site needs to be on higher ground than the surrounding area to protect it from the flooding. In the dry season stations should be placed in lower lying areas to take advantage of the soft mud there, which is an excellent tracking surface.

Using the bare soil as the tracking surface at the stations was most successful at the beginning of the dry season. At this time the soil was still very soft and held track marks well, making them easy to identify. Toward the end of the dry season any ground that was slightly higher than the surrounding area had harder soil and would often not show tracks of smaller mammals (< 10kg). Since there was no difference is visitation rates between the 2 scents used, either one can be recommended for future studies.

In conclusion, when absolute density numbers are not necessary, the scent-station technique is a viable method that deserves further refinement to establish if a relationship between visitation rates and population density exists. Such a relationship would allow rangers, within a limited budget and with limited training (most rangers will already be able to identify all relevant animal tracks) to able to keep track of the population trends of various species, especially the ones for special appeal to hunting or ecotourism development. The scent-station technique is an inexpensive, simple survey method that can be

recommended for use by park rangers in the Indio-Maíz Biological Reserve, or probably any other rainforest reserve with a navigable river system or a well developed trail system.

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TABLE 1. Characteristics of sites surveyed in the Indio-Maíz Biological Reserve, Nicaragua.

	Sites				
Characteristic	Chirripa	Toby	San Juanillo	La Tigra	Caño Blanco
Distance from town(km)	25	22.3	6.5	38	36
Soil drainage	moderate	moderate	poor	good	good
Stream waters	white water	white water	black water	white water	white water
Undergrowth density	very dense	very dense	very dense	dense	dense
Human hunting	heavy	moderate	heavy	none	moderate
Wood extraction	yes	no	yes	no	no
Elevation (m)	0-10	20-62	10	20-300	20-30

Table 2. Dry season (Jan-May) scent station visitation rates (%) for the Indio-Maíz Biological Reserve, Nicaragua.

Species / Sites (operable stations)	Visitation Rates (%) Chirripa (n=21)	Toby (n=30)	San Juanillo (n=26)	La Tigra (n=12)	Caño Negro (n=30)	Weighted Mean
OPOSSUMS (Didelphidae)	9.5	0	0	8.3	16.7	6.7
ARMADILLO						
Dasypus novemcinctus	4.8	3.3	0	0	0	1.7
LARGE RODENTS						
Dasyprocta punctata	0	0	19.2	0	0	4.2
Agouti paca	9.5	3.3	30.8	41.7	6.7	17.6
RACCOONS						
Procyon lotor	0	0	3.8	0	0	0.8
Nasua narica	9.5	0	3.8	0	0	2.5
Potos flavus	9.5	0	0	0	0	1.7
WEASELS						
Eira barbara	4.8	0	7.7	0	0	2.5
Lutra longicaudiis	0	0	0	0	10.0	2.5
CATS						
Felis wiedii	9.5	6.7	3.8	8.3	3.3	5.9
Felis pardalis	4.8	3.3	0	0	0	3.4
Panthera onca	9.5	0	3.8	33.3	0	5.9
DEER						
Mazama americana	4.8	0	3.8	0	0	1.7

Table 3. Wet season (Jul-Dec) scent station visitation rates (%) forthe Indio-Maíz Biological Reserve, Nicaragua.

Species / Sites (operable stations)	Visitation Rates (%) Chirripa (n=40)	Toby (n=36)	San Juanillo (n=34)	La Tigra (n=39)	Weighted Mean
OPOSSUMS (Didelphidae)	5.1	0	0	2.6	2.0
ARMADILLO					
Dasypus novemcinctus	0	0	11.6	2.6	3.4
LARGE RODENTS					
Agouti paca	30.8	8.3	41.7	12.8	25.5
Dasyprocta punctata	7.7	5.6	44.1	7.7	16.8
RACCOONS					
Nasua narica	0	0	0	5.1	1.3
Potos flavus	0	0	0	0	0
Procyon lotor	2.6	0	0	0	0.7
WEASELS					
Eira barbara	0	0	11.8	0	2.7
Lutra longicaudiis	2.6	0	0	0	0.7
CATS					
Felis wiedii	5.1	2.8	14.7	10.3	8.7
Felis pardalis	0	0	0	0	0
Panthera onca	0	0	0	0	0
DEER					
Mazama americana	0	0	0	2.6	0.7

Table 4. Comparison of visitation rates between sites by 4 species in the dry season (Jan.-May) in sourhestern Nicaragua, during 1992.

	Visitation Rates (%)			
Site	Dasyprocta punctata	Potos flavus	Panthera onca	Agouti paca
Chirripa	0^	9.5*	9.5	9.5^
Toby	0^	0^	0^	3.3^
San Juanillo	19.2*	0^	3.8^	30.8*
La Tigra	0^	0^	33.3*	41.7*
Caño Blanco	0^	0^	0^	6.7^

* indicates a significant difference from ^ at $p \leq 0.05$

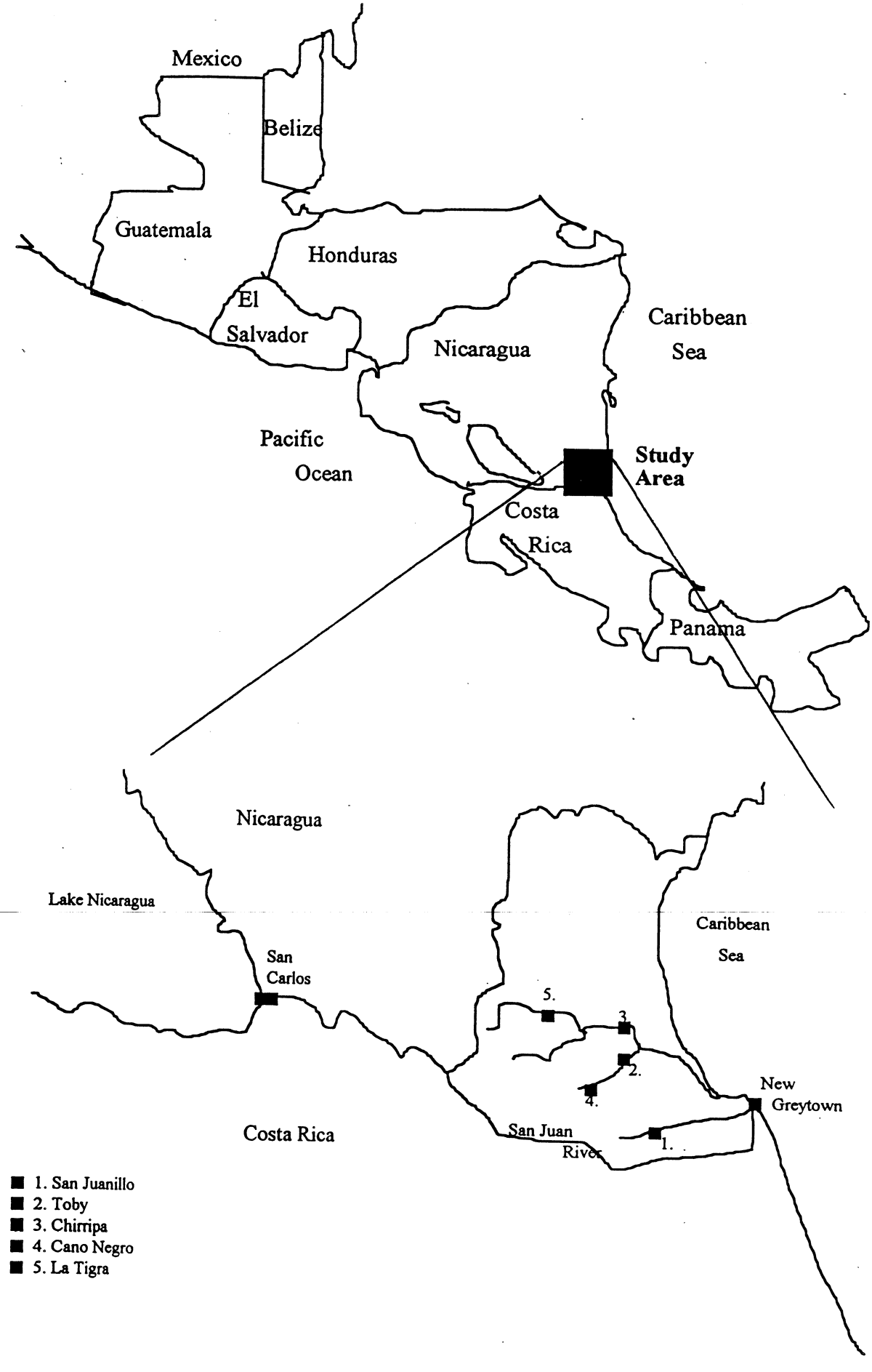
Table 5. Comparison of visitation rates between sites by 3 species in the rainy season (Jul-Dec) in southeastern Nicaragua during 1992.

	Visitation Rates (%)		
Site	Agouti paca	Dasyprocta punctata	Daypus novemcinctus
Chirripa	30.8*	7.7^	0^
Toby	8.3^	5.6^	0^
San Juanillo	41.7*	44.1*	11.8*
La Tigra	12.8^	7.7^	2.6

* indicates a significant difference from ^ at $p \leq 0.05$

Figure 1. Location of SI-A-PAZ in southeastern Nicaragua and the location of study sites in the Indio-Maíz Biological Reserve, Nicaragua.

Figure 2. Protective roof structure over a scent-station in the Indio-Maíz Biological Reserve in the rainy season (Jul-Dec) 1992. The supports and roof slats are thin trees and the roofing is fern or palm leaves which are then held in place by another layer of thin trees.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New Greytown
Costa Rica
San Juan River
1.
1. San Juanillo
2. Toby
3. Chirripa
4. Cano Negro
5. La Tigra

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Comparison of neotropical survey techniques of large, terrestrial mammals

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Comparison of neotropical survey techniques of large, terrestrial mammals

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Abstract. I surveyed the large, terrestrial mammal community in a 3,787km^2 lowland tropical rain forest of southeastern Nicaragua using 4 techniques, and assessed the logistical efficiency and viability of those techniques. The survey methods used were: scent-stations, small mammal trapping, line transects and track transects. Surveys were conducted in both the dry and wet seasons of 1992. Animals visited the scent stations in comparable numbers to published reports of visitation rates of similar species in the temperate zone. Tracks were abundant and easy to identify on the track transect, but results were confounded because the track surface was not cleared of all tracks before each survey. The line transect method yielded very low sighting rates due to the lack of existing trails in the area surveyed. I recommend the use and further development of both the scent-station and track transect methods as simple, inexpensive ways to monitor population trends among a large variety of neotropical mammals.

Keywords: survey, neotropical, line transect, scent-station, track transect, Nicaragua

Introduction

Little survey work on larger mammals has been done in the neotropical rain forests and few survey methods have been developed (Vaughan 1983). Few neotropical sites have been sampled, even for individual mammal taxa and even fewer sites have been studied in detail. Attempts to describe the mammal community at one site involve many technical problems including the inaccessibility of undisturbed sites and the cryptic and nocturnal nature of many rain forest mammals. Furthermore, any one census method reveals only a portion of the number of species present (Malcolm 1990). As a result

there are few lists of the mammal faunas of single localities in lowland moist forests (Janson and Emmons 1990),

Despite these obstacles a variety of survey techniques have been used in neotropical mammal communities including visual censuses from trail transects (Cant 1977; Walker and Cant 1977; Glanz 1982; Emmons 1984; and Whitesides et al. 1988), track transects (Fragoso 1991), and mark-recapture trapping (Glanz 1982). Techniques for determining mammalian densities vary greatly among taxonomic groups. What works for large diurnal species becomes impractical for cryptic nocturnal species. Most recent surveys of tropical mammal communities have used techniques that are less precise in their measurements of density, but applicable to a broader variety of species (Glanz 1990).

The purpose of this study was to survey the large, terrestrial mammal community in the Indio-Maíz Biological Reserve using 4 survey techniques and to asses the logistical efficiency and viability of those techniques.

Study site

The 4 survey techniques were compared at 5 areas within the 3,787km^2 Indio-Maíz Biological Reserve, part of the SI-A-PAZ (Sistema de Areas Protegidas Para la Paz) system of protected areas in southeastern Nicaragua (Fig 1). Annual rainfall is 4.5- 6.3m (Wernstedt 1966, Castiglione 1990) and falls over 11 to 12 months. The dry season is from January to April; March is the driest month. The vegetation at all 5 sites is mature, evergreen, lowland, tropical rain forest. There is one town of approximately 250 people within the Reserve (New Greytown) and human disturbance within the Reserve consists of trail cutting, subsistence hunting, selective removal of individual trees, and small orchard farms in 2 areas. Human influence and activity diminishes as distance from New Greytown increases. The 5 areas (San Juanillo, Chirripa, Toby, La Tigra, and Caño Blanco) were chosen because of their accessibility by boat and to represent areas of varying distances from town, which represents a gradient of human influence, throughout the Reserve.

The San Juanillo site was off the San Juan River and was the site closest to New Greytown (Table 1). Heavy fighting occurred here during the Sandinista\Contra war and during that time hunting

and wood extraction pressure were very heavy, but since the end of the war in 1990 pressure has not been as high. There is an old (1890's) railroad line and a small working orchard farm within the study site. The area is approximately 50% palm swamp, which is flooded in the rainy season. The Toby site is on Caño Negro; there are no farms in the area and very little swamp area, although there are several small streams. The Chirripa site is located on the Indio River near a small farm that is inhabited irregularly. There are several small creeks and swamps throughout the site. The Caño Blanco site is on a tributary to Caño Negro. There are several small creeks, but no swamps in the area. The site farthest from New Greytown is the La Tigra site, an undisturbed (pristine) upland site on the Indio River; it is the only site with no signs of human disturbance. There are several small creeks, but no swamps in the area. La Tigra and Caño Blanco are near the headwater of the Indio and Negro Rivers respectively. In those watershed areas the riverbeds and banks become very rocky, rather than the soft mud that is found in the lower reaches.

Methods

All the techniques used in this study are designed for large (> 2kg), terrestrial mammals. Both the scent-station and track transect techniques yield indices while the line transect technique is designed to yield a density estimate.

The scent-station technique is designed to attract animals to a scent placed in a cleared area where they will leave a track impression for later be identification. The scent-station method used in this study is an adaptation of the method originally described by Linhart and Knowlton (1975) and later refined for use in the U.S. Fish and Wildlife Service survey (Roughton 1980, Roughton and Sweeny 1982). Scent-station lines were located along river banks and stations were placed at 0.5km intervals with a total of 10 stations in each study area (4.5km). Each scent-station consisted of a 2m circle cleared of all vegetation and the soil surface smoothed clean. Once the surface was prepared, a Q-tip with the commercial gland scent on it was placed in the center of the station. During the rainy season a roof was built for each station to protect the scent and the tracks from the rain (Nachman 1993). A visitation rate

(number of stations with tracks/number of operable stations X 100) was calculated by species for the entire reserve area in both the wet and dry seasons.

Track transect surveys were conducted during the dry season by walking along muddy river banks and recording all tracks that crossed the transect. Unidentifiable and possible repeat tracks of the same individual were omitted. A track was considered to be from a different individual of the same species if it was a different size or was an older or more recent track. Track transects were conducted at Chirripa, Toby, San Juanillo and La Tigra and were between 8.5 and 12.9 km at each site. The possibility of counting the same individual multiple times was considered too high with this method and so several adjustments were made for the second half of the study, during the rainy season.

During the rainy season track transect surveys were conducted by traveling the rivers by boat, stopping approximately every 500m to search an area of 20m along the river bank and 5m in for tracks. This time only the presence or absence of a species track was recorded at each stop. Transect length at each site was 10km long with 20 stops, for a total length of 30km and 60 stops. Each site was surveyed after an approximately 48 hour period of light to no rain. Rains were somewhat heavier in the 24-hour period before Toby was surveyed, however it was not considered heavy enough to have erased all tracks.

A track sightings rate was calculated (number of stops with tracks/number of stops X 100) by species for each site and by species for the entire reserve area. Chi square and Bonferroni (Kirk 1968) tests were run on each species individually to detect differences in the track sighting rate between sites. These calculation were carried out only on the wet season data as the dry season data does not lend itself to statistical analysis.

Line transect surveys were made by walking slowly (1 km/hr) down a trail and recording the species, and position relative to the transect of every mammal encountered. In addition, the number of members in a troop was recorded for group- living species (i.e., primates). Censuses were conducted in the early morning hours. Segments of the transect line were conducted at Chirripa, Toby, and San Juanillo for a total transect length of 10.4km. I was aiming for 4km of transect at each of the 5 sites, for a total transect length of 20km, but because there is no established trail system in the Reserve, all trails for

conducting transects were cut by the researcher. The physical effort involved resulted in a shorter transect length than planned. The starting point and direction were chosen randomly.

Results

Scent-stations

At a visitation rate of 20.0%, paca (Agouti paca) visited scent-stations more than any other mammal (Tables 2). Margay (Felis pardalis) visited the stations often throughout the year indicating that scent-stations may be a viable technique for monitoring margay population trends. Jaguar (Panthera onca) and ocelot (Felis pardalis) only visited the scent-stations in the dry season, resulting in a significantly higher visitation rate for those species in the dry season. (Nachman 1993). Jaguarundi (Felis yagouaroundi) and puma (Felis concolor) are the only 2 cats known from the area that were never recorded at a scent-station.

Ten other mammal species visited the scent-stations during this survey (Table 2). 0f these, agouti (Dasyprocta punctata) had the highest visitation rate (11.2%).

Track transects

Several species whose tracks were never observed at a scent-station were noted on the track transects (Tables 4 and 5), including white-lipped peccary (Tayassu pecari), white-collared peccary (Tayassu tajacu), and Baird's tapir (Tapirus bairdii). All are herbivores and so would not necessarily have been attracted to the glandular scents at the stations. Between sites, chi square and Bonferroni tests showed that there were significantly ($P \leq .05$) more paca (Agouti paca) and brocket deer (Mazama americana) at Chirripa in the rainy season. There were no differences between sites among all the other species. Because the methods used in the wet season differed so much from that used in the dry season, the 2 data sets could not be statistically compared.

Logistical efficiency was assessed based on the time required per technique per area. The time required was also divided into the time involved in set-up versus the overall time requirements of the technique (Table 6).

Line transects

Of the 10.4km of transects walked, a total of 9 sightings were made (Table 3). Only primates and agouti were sighted during this survey. The number of sightings was insufficient for accurate density analysis.

Discussion

Scent-station

Visitation rates at our scent-stations in the tropical rain forest environment were comparable to visitation rates obtained for related species in the temperate zone (Nachman 1993). When absolute density is not necessary the scent-station technique is a useful method of establishing population trends. The scent-station technique is inexpensive; the only equipment needed are the scents, Q-tips, and a machete to clear the site. It is, also, relatively efficient; one person can establish a line of 10 stations in one day and then establish another line the next day after reviewing and resetting the first line, depending on the distance between the 2 lines. It is a simple survey method that can be used by local park personnel with minimal training as most local people are already skilled in identifying animal tracks; in this way park personnel could keep track of the population trends of the species that might be important to hunting or ecotourism.

One disadvantage of this technique is that it did not attract either white-lipped or white-collared peccary, two very important species for local subsistence hunters and certainly of interest to ecotourists. Tapir were not attracted to the stations either and although they are no longer hunted locally they would be of interest to ecotourists. All 3 of these species were assessed using the track transect technique.

Track transects

Tracks have been used for a variety of purposes in neotropical mammal studies, Rabinowitz and Nottingham (1986) used them to document the movements of jaguars and cougar in Belize; Emmons (1987) used them to monitor for the presence of felids in Peru, but they have not been used to establish population trends for a wide variety of species, as was done here.

Animal activity is influenced by a variety of factors including weather, hunger, predator activity and social interactions (Broom 1981). All of these factors will affect the number of tracks found on a

transect as well as at a scent-station and can produce large variances (Thompson et al. 1989). Harris (1986) suggests that the only way to reduce the variance inherent in transect data is to run many replications over a short time, although Thompson et al. (1989) found that even with many replications there was still a high amount of variance in their data. A number of biases and assumptions are associated with the track transect technique used in this study: (1) transects were not randomly located; (2) the same individual could be counted more than once; (3) a track at one stop and tracks at 10 stops could both represent only one individual; (4) the time between heavy rains or river floodings is not the same for all areas being compared.

Since the purpose of this technique was to develop an index to compare population trends across years, non-random placement of transects is valid as long as transects are placed in the same location in succeeding years' surveys. I considered locating transects on river banks necessary for 2 basic reasons: (1) to take advantage of the soft mud there which is an excellent tracking surface and (2) in the rainy season survey, to be able to cover 20 stops at 500m intervals in 1 day, it was necessary to travel by boat.

After the dry season survey I determined that when counting every track sighted, the possibility of counting the same individual more than once was unacceptably high. It was often impossible to determine if 2 sets of tracks were made by the same individual unless I could determine the age of either the track or the individual. This difficulty precipitated the changes in the technique that were implemented for the second survey in the rainy season (i.e., counting only the presence or absence of a species at each stop).

If an animal is using the riverbank as a travel corridor its tracks might show-up at all 20 stops or only at 1 stop, depending on where the animal arrived at the bank and began to walk along it. Thus, tracks at 10 stops at one site could represent the same number of individuals as tracks at only 1 stop at another site. The more often the transect is repeated the less this assumption will affect the data.

One of the problems with using an unprepared tracking surface is that the time that surface has been available for animals to leave their tracks is unknown. If one site is surveyed the day after a rain or a flood that erased all tracks, all other sites to be compared with this first one must also be surveyed the day after a heavy rain or the results will be biased, showing more tracks at the site with a longer time between

heavy rains. To minimize this problem I attempted to survey sites after 48 hours with little to no rain, although it was often difficult to determine if a rainfall was heavy enough to erase all tracks. In a track survey of boreal mammals in Canada (Thompson et al. 1989), snowfall, rather than rain, was the element that wiped the tracking surface clean between surveys. Instead of walking transects a determined number of hours after a snowfall they simply divided the number of tracks recorded by the number of 12 hour periods since the last snowfall. Thus, track transects in the rain forest can be standardized either by walking a predetermined number of hours after a heavy rain, or dividing the number of tracks by a set interval of time (e.g., the number of 12 hour periods since the last heavy rain).

Some advantages of this technique include: 1) it is very inexpensive, 2) limited training of personnel is required, 3) it is not very time consuming (no site preparation needed) 4) includes all mammals heavy enough to leave a track mark. Some limitations of the technique include: 1) it may not include arboreal mammals, 2) it does not include puma if transects are located on river banks since this species seems partial to more inland habitat, 3) it is limited to surveying the edges of navigable rivers, 4) changes in the number of tracks recorded may be due to changes in habitat use brought about by seasonal changes rather than actual changes in population levels. DeYoung et al. (1988), in their study of white-tailed deer in southern Texas, suggested that track counts may not reflect an increase in the population if the habitat is good because animals tend to move less under optimal habitat conditions. Likewise, if the population has increased through births, adults with young may be more sedentary and be less likely to leave tracks. Not enough detail is known about the movement and reproductive patterns of many neotropical rain forest mammals to determine if these factors would also significantly affect track counts.

Although both the scent-station and track count techniques, as used in the wet season, are both feasible survey methods for the rain forest environment, the track count technique required only 1/3 the time per stop as required per scent station. The differences become even larger when considering that the scent-stations were run for 3 consecutive nights and the track count was run only once in each site. This does not necessarily lead to the conclusion that track counts is the better method, because, of course the reliability of the data collected would enter into that decision. The track count method, though, appears

to be the more efficient in terms of man-hours required. The line transect method required too many hours of preparation (trail cutting) to be an efficient method, even if sighting rates had been higher.

Line transect

Although my sighting rates were comparable to those obtained in other studies of similar habitats (e.g., Emmons 1984) there were not enough data for a reliable estimation of density. Since there was no existing trail system from which to conduct the line transect survey, a trail had to be cut and clearly marked in each site before a survey could be run. This required 2 weeks of work for 2 people. In addition, since transects were randomly located and assigned a random direction, trails tended to cross streams several times making them very difficult to walk and observe wildlife from at the same time. The need to cut trails caused 2 problems: 1) most mammals were scared off by the activity and by the time the transect was run the only animals remaining in the area were primates and rodents; and 2) trails were necessarily short contributing further to the low number of sightings. For this technique to be effective both logistically and in supplying sufficient data, a preexisting trail system is a prerequisite.

Management Implications

If protected areas are going to be managed for ecotourism or sustainable subsistence hunting, then data on the health and location of the large mammal populations will be needed to 1) advertise the local attractions to potential ecotourists and research scientists; 2) determine if ecotourism is affecting the populations and redirect tourism away from areas where the populations are stressed and; 3) develop a realistic management plan for sustainable hunting for the local people who depend on wild game.

In areas that lack trails and have an adequate network of navigable streams, scent-station and track transect techniques appear to be the best suited for surveying and monitoring population trends of large neotropical mammals. Both techniques are inexpensive, do not require much personnel or training, and appear to provide usable data for relative density or trend analysis. The track transect technique includes several species important to both the local people and ecotourists that are not assessed by the scent-station method. A method of standardizing the time the tracking surface is available before conducting a survey is necessary to improve the reliability of the track transect method. Such a

standardization may include repeating the survey several times over a short period of time, thus increasing the man-hours required to conduct the technique, and reducing the time difference between the two techniques. Line transects have been used extensively in other tropical areas to record either relative or absolute density (Peres 1989), but these are usually areas with an existing trail system or small areas.

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Table 1. Characteristics of surveyed sites in the Indio-Maíz Biological Reserve, Nicaragua.

Characteristic	Chirripa	Toby	San Juanillo	La Tigra	Caño Blanco
distance from village(km)	25	22.3	6.5	38	36
soil drainage	moderate	moderate	poor	good	good
stream waters	white water	white water	black water	white water	white water
undergrowth density	very dense	very dense	very dense	dense	dense
human hunting	heavy	moderate	heavy	none	moderate
wood extraction	yes	no	yes	no	no
elevation (m)	0-10	20-62	10	20-300	20-30

Table 2. Scent-station visitation rates (%) for the Indio-Maíz Biological Reserve, Nicaragua from Jan-Dec 1992.

Species Operable stations	Visitation Rates (%) Dry Season (Jan-Apr) n=119	 Wet Season (May- Dec) n=149	 Mean n=268
OPOSSUMS (Didelphidae)	6.7	2.0	4.1
ARMADILLO			
Dasypus novemcinctus	1.7	3.3	2.6
LARGE RODENTS			
Dasyprocta punctata	4.2	16.8	11.2
Agouti paca	17.6	25.5	22.0
RACCOONS			
Procyon lotor	0.8	0.7	0.7
Nasua narica	2.5	1.3	1.9
Potos flavus	1.7	0	0.7
WEASELS			
Eira barbara	2.5	2.7	2.6
Lutra longicaudiis	2.5	0.7	1.5
CATS			
Felis wiedii	5.9	8.7	7.5
Felis pardalis	3.4	0	1.5
Panthera onca	5.9	0	2.6
DEER			
Mazama americana	1.7	0.7	1.5

Table 3. Number of primate troops and individual agouti observed per 10km of transect walked in the Indio-Maíz Biological Reserve, Nicaragua.

Species	# observed per 10km (N)
Alouatta palliata	1.9 (2)
Cebus capuchinus	0.96 (1)
Ateles geoffroyi	1.9 (2)
Dasyprocta punctata	3.8 (4)
Total (N)	8.56 (9)

Table 4. Total number of tracks and tracks per kilometer of large mammals in 4 areas of the Indio-Maíz Biological Reserve, Nicaragua in the dry season (Jan.- May) 1992.

# km walked	Chirripa (n=8.5)		Toby (n=9.0)		San Juanillo (n=12.9)		La Tigra (n=5.3)	
Species	N	/km	N	/km	N	/km	N	/km
Felis wiedii	3	0.35	8	0.89	9	0.70	5	0.94
Felis pardalis	8	0.94	5	0.56	3	0.23	3	0.57
Felis yagouaroundi	0	0	1	0.11	0	0	0	0
Panthera onca	10	1.20	8	0.89	16	1.2	7	1.30
Nasua narica	2	0.23	1	0.11	1	0.08	1	0.19
Potos flavus	2	0.23	0	0	0	0	0	0
Dasypus novemcinctus	6	0.71	30	3.30	19	1.50	7	1.3
Agouti paca	29	3.40	71	7.82	53	4.10	56	10.6
Dasyprocta punctata	4	0.47	56	6.20	28	2.20	8	1.50
Eira barbara	4	0.47	5	0.56	1	0.08	0	0
Lutra longicaudis	0	0	3	0.33	0	0	3	0.57
Mazama americana	20	2.30	50	5.60	44	3.40	14	2.60
Tapirus bairdii	14	1.60	7	0.78	58	4.50	24	4.50
Tayassu pecari (herds)	4	0.47	1	0.11	11	0.85	2	0.38
Tayassu tajacu	7	0.82	4	0.44	10	0.78	0	0

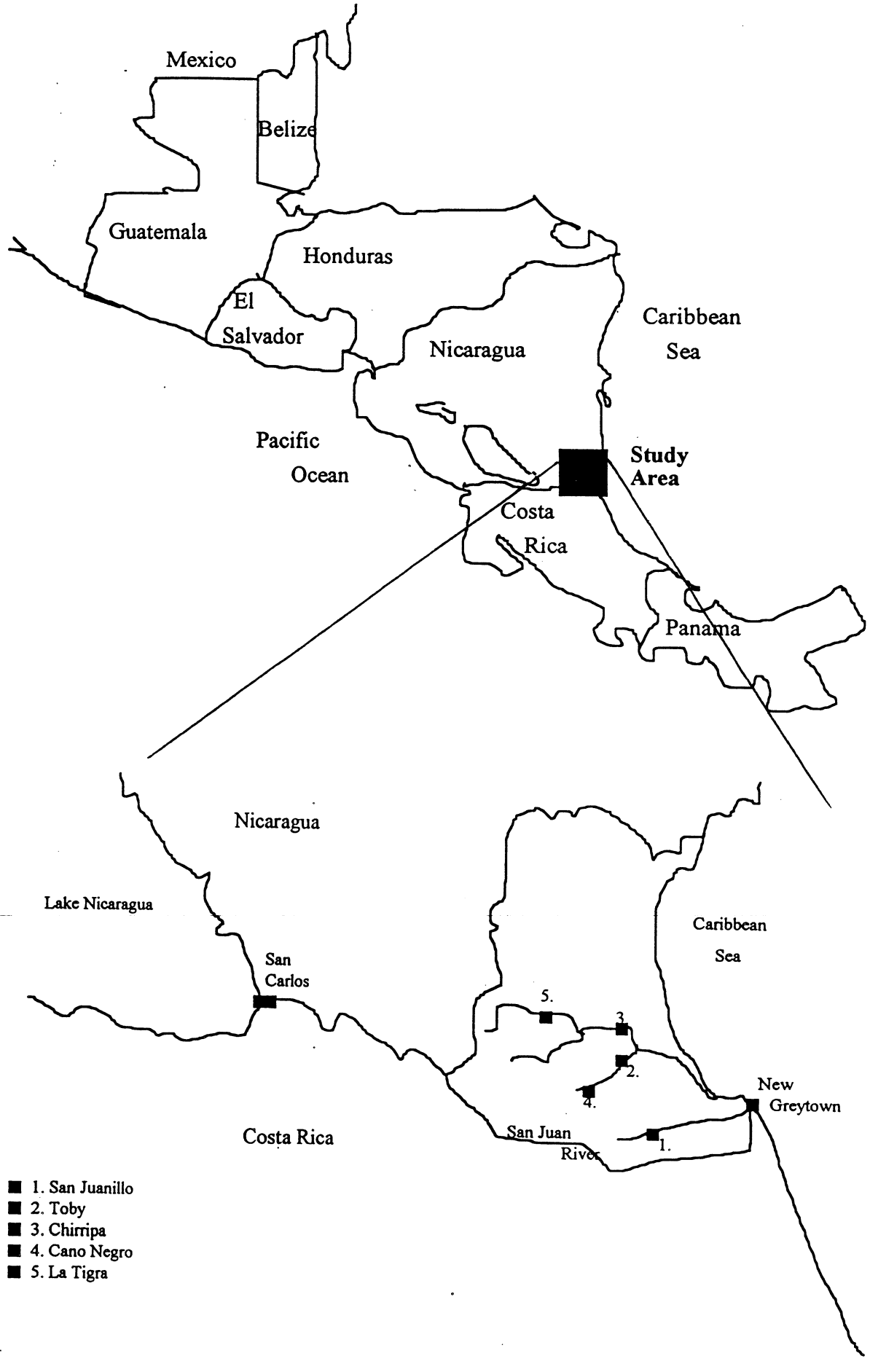
Table 5. Number of tracks recorded at each site in the Indio-Maíz Biological Reserve, Nicaragua in the wet season (Jul- Dec), 1992 and the corresponding rate (%).

# of plots per area	Chirripa (n=20)		Toby (n=20)		San Juanillo (n=20)	
Species	N	%	N	%	N	%
Felis wiedii	1	5	1	5	2	10
Felis pardalis	0	0	1	5	0	0
Panthera onca	3	15	2	10	2	10
Nasua narica	2	10	4	20	0	0
Dasypus novemcinctus	1	5	3	15	1	5
Agouti paca	18	90	11	55	10	50
Dasyprocta punctata	4	20	3	15	4	20
Eira barbara	0	0	0	0	2	10
Lutra longicaudis	0	0	1	5	0	0
Mazama americana	14	70	4	20	8	40
Tapirus bairdii	7	35	5	25	5	25
Tayassu pecari (herds)	6	30	2	10	1	5
Tayassu tajacu	2	10	0	0	3	15

Table 6. Comparison of the effort required for 3 survey techniques used in the Indio-Maíz Biological Reserve, Nicaragua.

Technique	time/station or stop (person hrs)	set-up time/site (person hrs)	total time/site (person hrs)
Scent-stations			
without a roof	0.33	5	11
with a roof	0.58	10	16
Track count			
dry season		0	17-25.8
wet season	0.17	0	4
Line transect		120	124

Figure 1. Location of SI-A-PAZ in southeastern Nicaragua and location of study sites in the Indio-Maíz Biological Reserve, part of the SI-A-PAZ area.


Mexico
Belize
Guatemala
Honduras
El Salvador
Nicaragua
Caribbean Sea
Pacific Ocean
Study Area
Costa Rica
Panama
Nicaragua
Lake Nicaragua
San Carlos
Caribbean Sea
5.
3.
2.
4.
New Greytown
Costa Rica
San Juan River
1.
1. San Juanillo
2. Toby
3. Chirripa
4. Cano Negro
5. La Tigra

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Seasonal Variation Among Three Neotropical Mammal Survey Techniques

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ABSTRACT

While surveying the non-flying mammals of the Indio-Maiz Biological Reserve seasonal variations were noted among populations. Mammals were surveyed using scent-stations, track transects and small mammal traps. The results are not statistically significant, but do indicate a trend toward seasonality among some species.

Key words: mammal survey; Neotropics; Nicaragua; rain forest; seasonal variation .

Neotropical mammal survey techniques show seasonal variation in the data collected. This seasonal variation could be caused by a variety of factors including changes in abundance, activity, distribution, and behavior of the mammal populations. Seasonal variation in abundance is the rule rather than the exception in tropical animals even in areas where seasonal changes in the weather are minimal (Wolda 1983). Thus, it seems advisable to have data covering an entire year when comparing different tropical sites and/or years. Correlated with seasonal changes in the weather, especially temperature, temperate zone animals undergo dramatic changes in abundance and activity. Wolda (1983) states that this is also true for the tropics, with rainfall rather than temperature being the major seasonal element in the weather.

Seasonal changes in tropical animal populations are poorly documented, especially for large mammals. Wolda (1983) used the example of neotropical insects to demonstrate the general trend toward

seasonality in abundance and distribution among tropical animals. In her study of neotropical rodents in the premontane humid forests of Venezuela, O'Connell (1989) found a decline in trapping success rates during the rainy season. During a radio telemetry study in the Pantanal of south-western Brazil, Crawshaw and Quigley (1991) found that jaguar used a significantly smaller home range during the rainy season than in the dry season. They hypothesized that this reduction in home range size was due to the concentration of prey in unflooded areas in the wet season.

This paper reports on the seasonal changes associated with 3 terrestrial mammal survey techniques in the rain forest of southeastern Nicaragua in 1992. The causes of those seasonal changes are beyond the scope of this paper.

STUDY SITE

The study site included 5 areas within the 3,787km^2 Indio-Maiz Biological Reserve, part of the SI-A-PAZ (Sistema de Areas Protegidas Para la Paz) system of protected areas in southeastern Nicaragua (Fig 1). Annual rainfall was 4.5- 6.3m (Wernstedt 1966, Castiglione 1990) and falls over 11 to 12 months (Fig. 2). The dry season was from January to April; March was the driest month. The vegetation at all 5 sites was mature, evergreen, lowland, tropical rain forest. There was one town of approximately 250 people within the Reserve (New Greytown) and human disturbance within the Reserve consists of trail cutting, subsistence hunting, selective removal of individual trees, and small orchard farms in 2 areas. Human influence and activity diminishes as distance from New Greytown increases. The 5 areas (San Juanillo, Chirripa, Toby, La Tigra, and Caño Blanco) were chosen because of their accessibility by boat and to represent areas of varying distances from town, which represents a gradient of human influence, throughout the Reserve.

The San Juanillo site was off the San Juan River and was the site closest to New Greytown (Fig. 1). Heavy fighting occurred here during the Sandinista\Contra war and during that time hunting and wood extraction pressure were very heavy, but since the end of the war in 1990 pressure has not been as high (Table 1). There was an old (1890's) railroad line and a small working orchard farm within the study site. The area was approximately 50% palm swamp, which was flooded in the rainy season. The

Toby site was on Caño Negro; there were no farms in the area and very little swamp area, although there were several small streams. The Chirripa site was located on the Indio River near a small farm that was inhabited irregularly. There were several small creeks and swamps throughout the site. The Caño Blanco site was on a tributary to Caño Negro. There were several small creeks, but no swamps in the area. The site farthest from New Greytown was the La Tigra site, an undisturbed (pristine) upland site on the Indio River; it was the only site with no signs of human disturbance. There were several small creeks, but no swamps in the area. La Tigra and Caño Blanco were near the headwater of the Indio and Negro Rivers respectively. In those watershed areas the riverbeds and banks become very rocky, rather than the soft mud that was found in the lower reaches.

METHODS

Scent-station transect lines were located along river banks, and stations were placed at 0.5km intervals in a line of 10 stations in each study area. A commercial scent was placed in the center of each station. Small mammals were trapped at Chirripa, Toby, San Juanillo and La Tigra in Museum Special, rat, and large Sherman (7.6 X9.5 X 30.5cm) traps. Traps were placed at 10m intervals in a line of 30 trap stations, 1 of each type of trap per station. Track transect surveys were conducted during the dry season by walking along the river banks and recording all tracks that crossed the transect. Transects were between 8.5km and 12.9km long. During the rainy season track transect surveys were conducted by traveling the rivers by boat, stopping every 500m to search an area of 20m along the river bank for tracks, recording only the presence or absence of a species' tracks at each stop. Track transects were conducted at Chirripa, Toby, San Juanillo and La Tigra (La Tigra was not surveyed in the rainy season). See Nachman (!993) for a more detailed description of all of these techniques.

Wilcoxon signed rank tests (Siegel 1956) were run on the scent-station data to compare the relative rankings of visitation rates between the dry and rainy seasons. A chi square test was run on each species individually to test for absolute changes in species visitation rates. Data from the track transect from both seasons were compared using a Wilcoxon signed rank test to test for differences in the relative rankings of species' track abundance.

RESULTS

Wilcoxon Signed Rank tests on the scent-station visitation rates showed no significant difference in the rank order of species between the 2 seasons . The chi square tests revealed that jaguar (Panthera onca), ocelot (Felis pardalis), and opossum had a significantly ($P \leq 0.01$) lower visitation rate in the rainy season, while paca (Agouti paca) and agouti (Dasyprocta punctata) had significantly ($P \leq 0.01$) higher visitation rates in the rainy season (Table 2). While 7 jaguar and 4 ocelot visited stations in the dry season, neither were recorded at stations in the wet season (Table 2).

Track transects

The Wilcoxon signed rank test revealed a significant difference in the rank order of species track abundance between the 2 seasons (Table 3). Coati (Nasua narica) and white-lipped peccary (Tayassu pecari) increased in relative abundance from the dry to the rainy season, while margay (Felis wiedii), ocelot, and armadillo (Dasypus novemcinctus) decreased. Although ocelot declined both in visitation rates at the scent-stations and in rank order of abundance on the track transect, in general a significant change in visitation rate at the scent stations did not show a similar change in rank order of abundance on the track transect (Table 4).

I trapped small mammals for a total of 1,859 trap nights, but was only successful in trapping 7 specimens (3 Robinson's opossums, Marmosa Robinsonii, and 4 arborial rodents) all at the La Tigra site (Table 5).

DISCUSSION

The significant changes in visitation rates among jaguar, ocelot, paca, agouti, and opossum could be due to factors which were artifacts of the scent-station technique. Animals may be more or less attracted to the scent at different times of the year, perhaps depending on reproductive cycles or changes in the abundance of their food sources. The scent may not carry as far in the rainy season, resulting in fewer felid visits.

The changes in visitation rates also has a variety of possible ecological explanations. The increase in paca, agouti and opossum visitations may be because stations were placed on the few areas of

dry ground available in an otherwise flooded environment, and so the animals were naturally more concentrated in those areas as the flood waters rose, or may be due to an actual increase in the population levels. The decrease in jaguar and ocelot visitation rates may be due to: 1) emigration to unflooded ground where prey may be concentrated, 2) a decline in population level, 3) reproductive cycle, or other, changes that cause those felids to be less mobile during the wet season (O'Connell 1989).

The fact that there was no relationship between significant changes in visitation rates and the relative abundance of tracks on the track transect (except for ocelot which declined in both cases), indicates that the changes in visitation rates, may in fact be due to factors of the technique and not represent actual changes in the population.

The seasonal changes in the relative rank of species' track abundance may be due to changes in population level, movement patterns, or a seasonal migration of some species. In their study of jaguar in Brazil Crawshaw and Quigley (1991) attributed the reduction in home range size they found in the rainy season to the concentration of prey in unflooded areas. In my study the relative abundance of white-lipped peccary, a major prey source for the jaguar, actually increased in the rainy season indicating that jaguar would not reduce their home range, and in fact the relative abundance of jaguar remained unchanged. White-lipped peccary tracks may have become more abundant because they spend most of their time in swampy areas and the rainy season brings with it an increase in the amount of swamp area in the forest.

Although a trapping program was only attempted during the rainy season, the fact that animals were only captured at the La Tigra site, the highest and most well drained site, suggests that small non-arboreal mammals either abandon the riverside habitats in low-lying areas and concentrate in more upland areas, or suffer increased mortality in those low-lying areas. A trapping program conducted in the wet and dry seasons in both riverine and upland habitats would be necessary to confirm this hypothesis.

Although these data were not definitive in demonstrating seasonal differences among neotropical mammal communities, the variation recorded indicates that for population surveys to truly represent the density or trends in these populations, data covering an entire year is required. More research is needed to explore the question of seasonal variation in tropical communities.

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TABLE 1. Characteristics of sites surveyed in the Indio-Maíz Biological Reserve, Nicaragua.

Characteristic	Chirripa	Toby	San Juanillo	La Tigra	Caño Blanco
distance from village(km)	25	22.3	6.5	38	36
soil drainage	moderate	moderate	poor	good	good
stream waters	white water	white water	black water	white water	white water
undergrowth density	very dense	very dense	very dense	dense	dense
human hunting	heavy	moderate	heavy	none	moderate
wood extraction	yes	no	yes	no	no
elevation (m)	0-10	20-62	10	20-300	20-30

TABLE 2. Changes in the scent-station visitation rates (%) within the Indio-Maíz Biological Reserve, Nicaragua for between dry (Jan-May) and rainy (Jul-Dec) seasons, 1992.

Species operable stations	Visitation Rate (%) Dry Season (n=119)	Rainy Season (n=149)	Difference
CATS			
Felis wiedii	5.9	8.7	+2.8
Felis pardalis	3.4	0.0	-3.4*
Panthera onca	5.9	0.0	-5.9*
RACCOONS			
Nasua narica	2.5	1.3	-1.2
Potos flavus	1.7	0.0	-1.7
Procyon lotor	0.8	0.7	-0.1
ARMADILLO			
Dasypus novemcinctus	1.7	3.3	+1.6
LARGE RODENTS			
Agouti paca	17.6	25.5	+7.9*
Dasyprocta punctata	4.2	16.8	+12.6*
OPOSSUMS (Didelphidae)	6.7	2.0	-4.7*
WEASELS			
Eira barbara	2.5	2.7	+0.2
Lutra longicaudiis	2.5	0.7	-1.8
DEER			
Mazama americana	1.7	0.7	-1.0

* indicates a significant difference at $P \leq 0.01$

TABLE 3. Track transect data from the dry (Jan-May) and wet seasons (Jul-Dec.) of 1992 in the Indio-Maíz Biological Reserve, Nicaragua.

	Dry season			Wet season		
Species	rank order	N	tracks/km	rank order	N	index[a]
Agouti paca	1	209	5.85	1	39	650
Mazama americana	2	128	3.58	2	26	433
Tapirus bairdii	3	103	2.88	3	17	283
Dasyprocta punctata	4	96	2.69	4	11	183
Dasypus novemcinctus	5	62	1.74	8.5	5	83
Panthera onca	6	41	1.15	6	7	116
Felis wiedii	7	25	0.70	10	4	67
Tayassu tajacu	8	21	0.59	8.5	5	83
Felis pardalis	9	19	0.51	12	1	17
Tayassu pecari (herds)	10	18	0.50	5	9	150
Eira barbara	11	4	0.47	11	2	33
Nasua narica	12	5	0.14	7	6	100
Lutra longicaudis	13	6	0.08	13	1	16
Potos flavus	14	2	0.06	14.5	0	0
Felis yagouaroundi	15	1	0.03	14.5	0	0

[a] (# tracks per stop) X 1,000

TABLE 4. Comparison of the changes in rank order of abundance (from track transect data) and visitation rates (from scent-station data) between the dry and wet seasons of 1992 in the Indio-Maíz Biological Reserve, Nicaragua.

Species	rank order change	change in visitation rate (%)
Agouti paca	0	+7.9*
Mazama americana	0	-1.0
Tapirus bairdii[a]	0	NR
Dasyprocta punctata	0	+12.9*
Dasypus novemcinctus	-3.5	+1.6
Panthera onca	0	-5.9*
Felis wiedii	-3	+2.8
Tayassu tajacu[a]	-0.5	NR
Felis pardalis	-3	-3.4*
Tayassu pecari (herds)[a]	+5	NR
Eira barbara	0	+0.2
Nasua narica	+5	-1.2
Lutra longicaudis	0	-1.8
Potos flavus	-0.5	-1.7
Felis yagouaroundi[a]	+0.5	NR
Didelphidae[b]	NR	-4.7*

* indicates significance at $P \leq 0.01$

[a] these species were never recorded at a scent-station

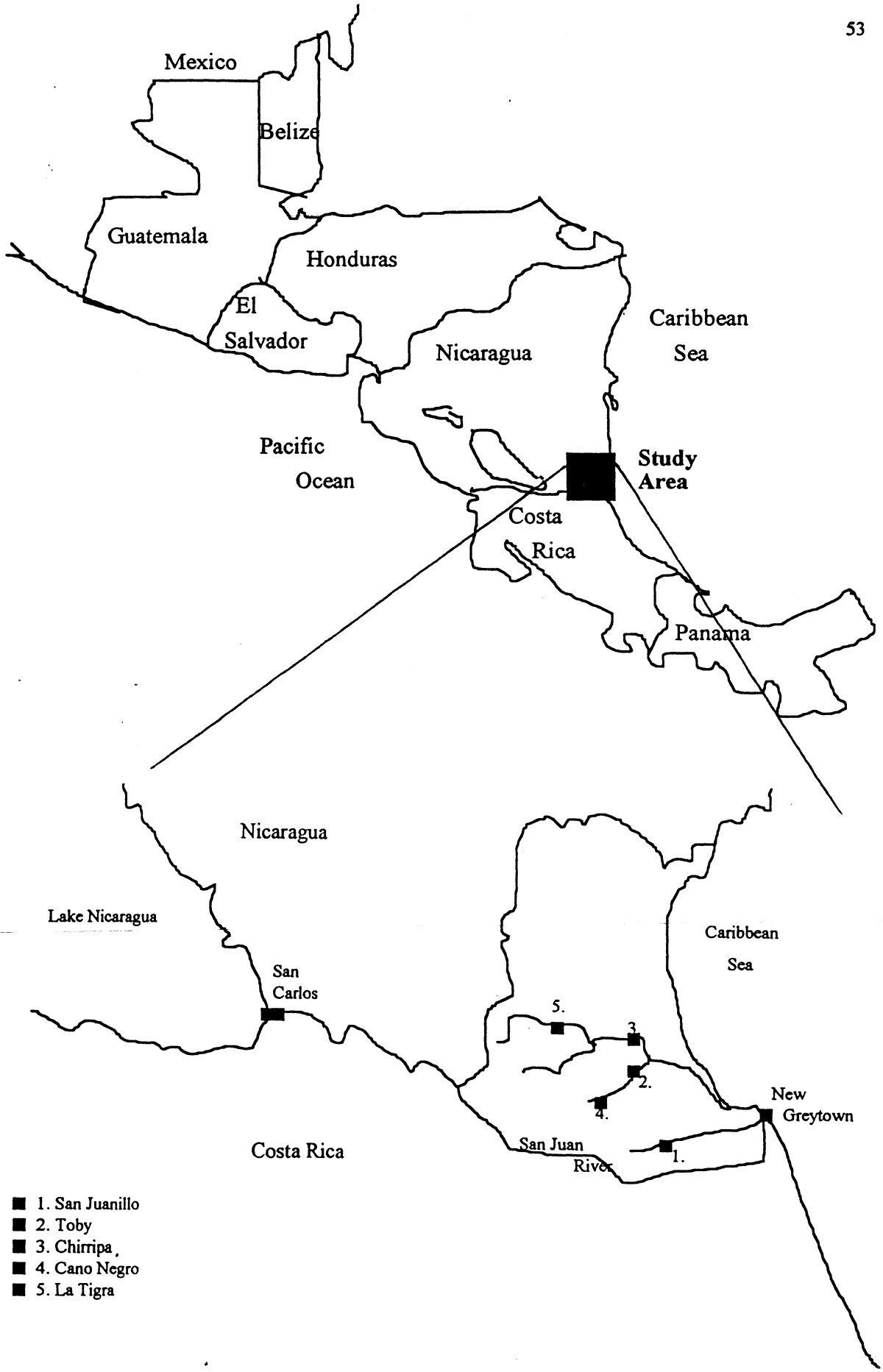
[b] Didelphidae were never recorded on track transects

TABLE 5. Results of small mammal trapping program during the rainy season (Jul-Dec.), 1992 in the Indio-Maíz Biological Reserve, Nicaragua.

Site	Trap nights	N trapped
Chirripa	586	0
Toby	367	0
San Juanillo	416	0
La Tigra	490	7
Total	1,859	7

FIGURE 1. Location of SI-A-PAZ in southeastern Nicaragua, and the location of study sites in the Indio-Maiz Biological Reserve.

FIGURE 2. Monthly precipitation as percent (%) of the annual total in southeastern Nicaragua. Data were collected from 1944-1958 by the Nicaraguan Ministry of War and Aviation (Wernstedt 1966). Data are from Bluefields, the nearest weather station, approximately km from my study sites.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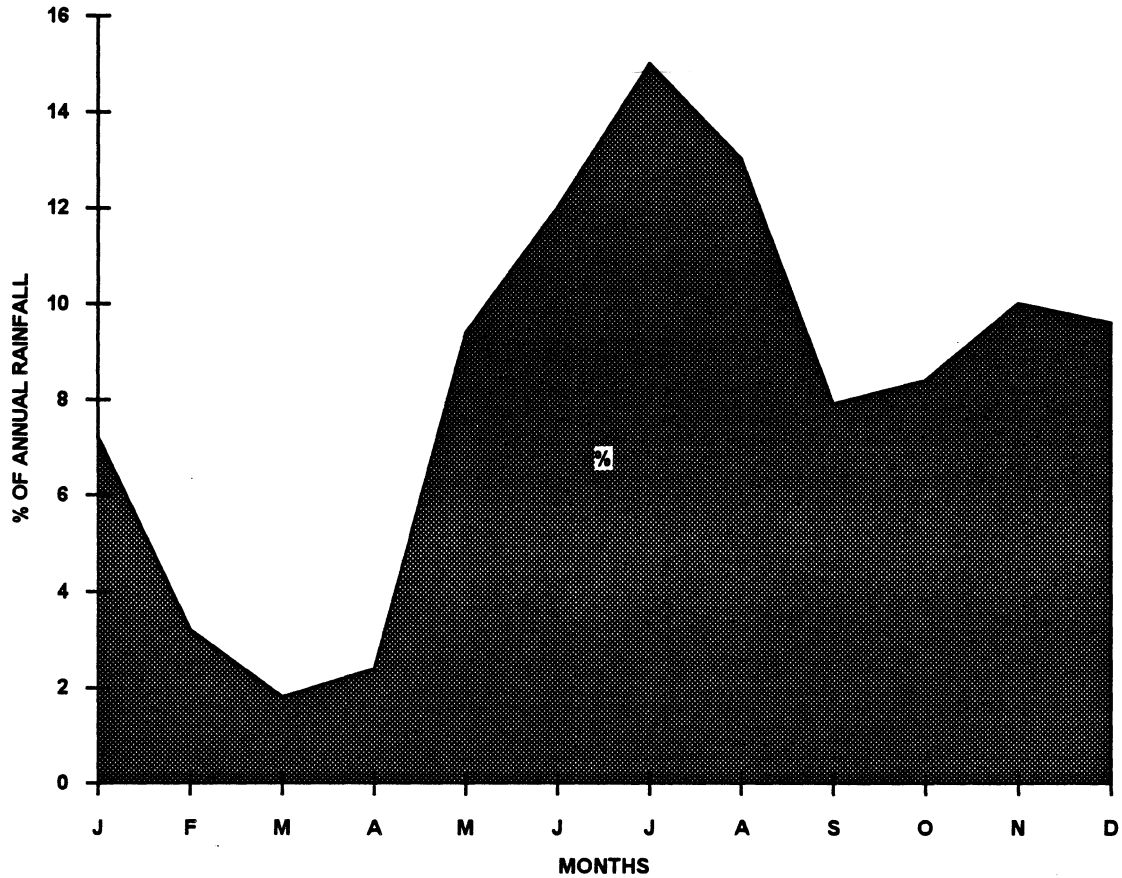
1. San Juanillo
2. Toby
3. Chirripa
4. Cano Negro
5. La Tigra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