Abundance and species richness of amphibians and reptiles in a Bolivian moist forest

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January 2009

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Fem 80439 - Thesis Forest Ecology and Forest Management

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Acknowledgements

Hereby I would like to thank IBIF for their welcome and support during my stay in Bolivia. I thank Marielos and Lourens for their direct support and patience with me and Steffen and Mayra for supervising and supporting me in Bolivia and in the field. A special thanks to Steffen and his wife for the time I spend in their home, I have enjoyed living in their beautiful house very much. Thanks for Cristina and Willem for giving me the whitest Christmas ever and for Charissa and Marc for sharing the experience of New Years Eve on a roof in a t-shirt. At last I would like to thank all my friends and family for thinking about me and helping me when needed. I would especially like to thank my parents and Joost for getting me on track again and making sure that I finish this report.

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Preface

As part of my biology study, I was interested in doing research in the field in a tropical country. At the chair group Forest Ecology and Forest Management they were looking for somebody to look at amphibians and reptiles in logged forests in Bolivia. Amphibians and reptiles are being used as indicators to asses the impacts of logging on biodiversity. However information needed to estimate the population size is still lacking, due to the sampling method being used. Therefore, the objective of my research was to try to define the home-range of amphibians and reptiles in two different microhabitats and if possible correlate these findings to the ecology of the animals.

Summary

Amphibians and reptiles are very sensitive to environmental changes in humidity, irradiance and temperature; environmental factors that will change when logging occurs in the forest. Therefore, both groups of species are being used in a monitoring program in Bolivia to assess the effect of logging on abundance and species richness of both amphibians and reptiles. To be able to assess correctly the impact of logging in the populations of these animals, it is necessary to know the home range of these animals. This study is an attempt to measure home ranges for amphibians and reptiles in a moist forest in 2 microhabitats, forest matrix and forest next to a river. Two trapping sites were established in each microhabitat, consisting of a grid with 42 buckets, used as pitfall traps, which were monitored for 48 days. The trapped animals were marked (toe clipped or belly pattern recognition), measured and released again. Weather parameters were obtained from La Chonta sawmill and from a nearby weather station from all trapping days. Vegetation characteristics were also evaluated.

Amphibians have a preference for the river microhabitat over the forest matrix microhabitat. Reptiles were captured more often in one of the forest matrix sites. Overall captures of amphibians was four times higher than for reptiles. Amphibians were captured mostly when air pressure was low and one day after a rain event in the forest. Reptiles were captured more three days after a rain event in the forest. Both amphibians and reptiles have no preference for differences in vegetation as measured in this research. The longest distance moved could be established for individual animals if they were captured more than once. For the lizard *Stenocercus caducus* leg length and longest distance moved were correlated, while for the toad *Rhinella margaritifera* leg circumference was correlated with longest distance. Body size (body length and leg length) are correlated with the longest distance moved for the frog *Ameerega picta*.

The grid system seems adequate to measure home ranges of animals, especially ground dwelling amphibians, reptiles and small mammals. I would recommend trapping periods of at least 30 consecutive days to optimize the chance on favourable trapping weather and a lot of capture data, since a lot of data is needed to do home range statistics.

Introduction

Amphibians and Reptiles

The subphylum Vertebrata consists of fish, amphibians, reptiles, mammals and birds. Mammals and birds are endothermic and fish, amphibians and reptiles are ectothermic (Kardong 1998). Endothermic animals derive the energy needed to raise the body temperature from within the body, for example from metabolic heat production (Pough 2001). On the other hand, ectothermic animals derive the energy needed to raise the body temperature from external energy sources; the sun (Pough 2001).These animals use the sun energy directly (basking) or indirectly via surfaces heated by the sun. The use of the sun as energy source limits the activities of reptiles; they have to diminish or cease activities when there is no direct heat source available, which occurs for example at night, in water, or beneath the closed forest canopy (Pough 2001). Because ectothermic animals use external sources to maintain their body temperature, they have a very low metabolic rate. The low metabolic rate means that they also have low energy requirements; 3% of the daily energy requirement of a mammal of the same size (Pough 2001). They are, therefore, able to live in environments with limited food availability, like deserts (Pough 2001). Low metabolic rates of ectothermic animals make it possible to have very small body sizes; the modal body size of lizards is between 1-10 g and nearly 20% of adult lizards have a body mass below 1g. Snakes however are at the opposite range of body masses, 80% have a body mass larger than 20 g (Pough 2001). Most reptiles have a limited aerobic capacity and they shift to anaerobic pathways to derive ATP during high levels of activity. The activity patterns of reptiles are adjusted to that; they 1) use the sit-and-wait foraging strategy, 2) escape predators by fleeing to a nearby shelter, and 3) their behaviour lacks long periods of sustained high levels of activity (Pough 2001).

Amphibians have at least one period in their lifetime in which they live as aquatic animals, breathing through gills (Alford *et al.* 2001). They differ from other tetrapod (four legged) vertebrates by enclosing the embryo in a jelly capsule instead of an amnion (membranous sac that protects the embryos of the other tetrapod vertebrates). The Class Amphibians consists of three living orders, the Anura (frogs and toads), Caudata (salamanders) and Gymnophiona (caecilians) (Hickman *et al.* 1997a).

Reptiles are amniotic tetrapods, which live their whole life on land. This is possible because they protect their eggs with an extra membrane, the amnion. The amnion protects the egg from water loss. Consequently, reptiles can lay eggs on land. The reptiles of today are represented by four living orders; 1) Crocodilia (crocodiles, caimans and alligators), 2) Sphenodontia (Tuataras from New Zealand, 3) Squamata (lizards, snakes and amphisbaenids ("worm-lizards")) and 4) Testudines (turtles) (Hickman *et al.* 1997b).

The main difference between amphibians and reptiles is their skin. Amphibians have a thin, smooth and moist skin, which allows them to breathe through it (deMaynadier & Hunter 1998; Hickman *et al.* 1997a). The amphibian skin is probably also useful in preventing overheating by evaporative cooling (Navas 2003). Reptiles have a rough and dry skin. This difference in skin probably accounts for the differences in thermoregulation strategies of amphibians and reptiles. For example, the lizard *Liolaemus multiformis* thermoregulates by heliothermy, obtaining energy from the sun by radiation, usually basking, while the toad *B. spinulosus* uses several behaviours like microhabitat selection and basking for obtaining their energy (Navas 2003).

Home range and its relation with body size

Home-range is the total area in which an individual of a particular species lives and wanders when active, and where it finds food, mates and shelter (Rose 1982). So far very little is known about the home range of anurans. The only home range I found reported in the literature is of the European tree frog, *Hyla arborea*. This frog has a home range of about 10 m^2 in a circular area of about 3-4 m in diameter (Stumpel & Tester 1993). On the other hand, the home range of terrestrial lizards (reptiles) has been related to their body weight (Turner *et al.* 1969), so that heavier animals have a bigger home range. To be able to measure the home range of a lizard, Rose (Rose 1982) calculated that 18 sightings per animal were needed to describe 80% of the home range of the lizard *S. virgatus* in a specific population.

Microhabitat and environmental factors

A habitat is the place in which an organism lives, which is characterized by its physical features or by the dominant plant types. There are normally a number of different microhabitats within a large habitat, each with its distinct set of environmental conditions. For example, in a stream (habitat) are different microhabitats, due to differences at smaller scales in water flowing rates, ph and temperature.

Based on a literature review it is clear that, up till this moment, little is known about the species specific (micro) habitats and home ranges of reptiles (Rose 1982) and amphibians (Cushman 2006), which have been mostly studied in the USA (deMaynadier & Hunter 1998, 2006; Hickman *et al.* 1997a; Loehle *et al.* 2005) On the other hand, several studies have found a higher amphibian species richness with increasing forest cover (Cushman 2006) or higher abundance with a high stand basal area (Loehle *et al.* 2005).The decrease of salamander counts in the study of Marsh and Beckman (Marsh & Beckman 2004) was however linked to soil moisture, and not canopy cover. Loehle and colleagues (Loehle *et al.* 2005) found the highest reptile richness in an area with a low stand basal area. There was no effect of distance to water on amphibian or reptile richness. The older the stand age of the plot, the steeper the decline of amphibian and reptile richness was (Loehle *et al.* 2005).

Human impacts on Amphibian and Reptile densities

Habitat loss and fragmentation appear to threaten both species with large dispersal abilities and those with relatively small dispersal abilities, although in different ways. Elevated dispersing mortality (road kill, predation, and desiccation (deMaynadier & Hunter 2006)) can be severe enough to lead to local extinction of a wide dispersing species. The species with small dispersal abilities may ultimately be doomed to extinction due to isolation by habitat fragmentation. Even species that are not influenced by these direct habitat losses, rely on population connectivity because of the frequent extinction and turnover rate of amphibian populations (Cushman 2006).

Logging

Harvesting practices often create stand boundaries that contrast greatly in vegetation structure and composition. The cumulative effects of creating extensive amounts of edge habitat over large areas and over long periods of time may have significant negative effects for some forest interior species (deMaynadier & Hunter 1998). Litter depth, canopy cover, understory vegetation density and hiding place abundance are directly affected by harvesting intensity (deMaynadier & Hunter 1998; Fredericksen & Fredericksen 2002). Previous research on amphibians and reptiles in logged areas showed a higher number of anurans in the recent logged gaps than in surrounding forest (Born 1994; Fredericksen & Fredericksen 2002). Especially near the crown of the cut tree the number of anurans was higher than in the surrounding forest. The fallen crown provides anurans with insects and other food items, which are otherwise not found on the forest floor (Born 1994; Fredericksen & Fredericksen 2004). Other research showed that the species composition (not necessary anurans or reptiles) found in logged gaps differed (slightly) from unlogged areas (Ernst *et al.* 2006; Fredericksen & Fredericksen 2004; Fredericksen *et al.* 1999; Scott *et al.* 2006) but this depends on the animal group being considered.

In Bolivia Fredericksen and Fredericksen (Fredericksen & Fredericksen 2002, 2004), found an increase in amphibian captures in the dry season in a riparian zone and a trend for more captures of amphibians in the disturbed riparian zone, compared to the undisturbed zone (Fredericksen & Fredericksen 2004). When areas disturbed by logging and fire were compared with undisturbed areas, species richness of amphibians and reptiles was higher in disturbed areas, although the number of individuals captured was the same (Fredericksen & Fredericksen 2002). In a tropical dry forest they found trends for more captures of amphibians and reptiles in undisturbed areas compared to small and large logging gaps (Fredericksen *et al.* 1999).

Currently the Bolivian Forest Research Institute (IBIF due to acronym in Spanish) is working on a biodiversity monitoring program to assess the effect of different logging intensities on biodiversity. Three animal groups (amphibians, reptiles and understory birds) are being used as indicator groups because previous studies have shown that these groups are very sensitive to changes in forest structure and disturbances. Amphibians and reptiles are being monitored using pitfall traps (following a Y design, one trap at each end and one trap in the centre). Animals captured in one trap have not been found in another trap, which suggest that home range of the animals is smaller than the distance between traps. Consequently, there is concern that the design being used is actually underestimating the densities of amphibians and reptiles present in the area. To be able to make a good estimation of the abundance of amphibians and reptiles in a certain area, it is necessary to know the home range sizes of the different species being trapped. There is, however, very little known about the home ranges of the species. My research aims to provide information on home ranges so that better estimates of animal abundances can be made.

Research questions and hypotheses
The research questions of this study are:

1. What is the abundance and species richness of amphibians and reptiles in two different microhabitats; the forest matrix and forest near streams?
2. Is the abundance and species richness defined by abiotic conditions (temperature, humidity, air pressure, precipitation, and vapour pressure deficit) and biotic conditions (vegetation cover)?
3. Is the home range size affected by the body (part) size of the species?

For every research question I have formulated a hypothesis.
1. Abundance and species richness of amphibians is higher in forest near streams because most of the species need water to lay their eggs. Abundance and species richness of reptiles does not differ between the forest matrix and forest near streams because they are not limited by the absence of water.
2. There is a positive correlation between high vegetation cover, high humidity and abundance of amphibians (because they have a thin, moist skin to breathe through and will not be able to survive in dry environments) and a positive correlation with less vegetation cover, high day temperature and the abundance of reptiles (because they can endure direct sunlight).
3. Home range size is positively correlated with animal size; longer hind legs and thicker thigh (muscles). Larger animals have larger home ranges because they are able to cover larger distances in shorter time to look for food; for frogs this can be induced by longer hind legs and thicker thigh muscles which produces higher jump velocities. In reptiles the longer legs and thicker hind legs facilitate a higher run or walking power.

Material and methods

Research site

The research was carried out in cooperation with IBIF. Fieldwork was carried out in the forest concession La Chonta (Appendix 1) of the company Agroindustria Forestal La Chonta Ltda (15°47'S, 62°55'W), situated in the province Guarayos, department of Santa Cruz, Bolivia. La Chonta is one of the study sites of IBIF. Mean annual rainfall is 1580 mm (data La Chonta 1994-2006) and the mean annual temperature is 25.3°C. There is a dry period from May till September (Figure 1), during this period hardly any amphibians and reptiles are found in the traps (Mayra Maldonado, personal communication), and about one third of the trees will drop their leaves. The forest can be classified as a moist semi-evergreen forest. It is a transitional forest between the Amazon rainforest and the Chiquitano dry forest, having species of both sites and an intermediate amount of rainfall/humidity. The canopy is about 20-30 m high. Emergent trees can reach a height of 40 m. The density of individuals with a diameter at breast height > 10 cm is 367 per ha, the stand basal area is 19.2 m^2 per ha (Peña-Claros et al. 2008).

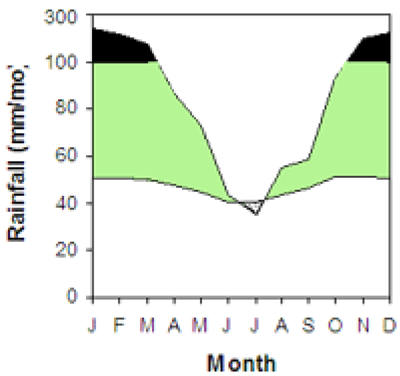

Figure 1 Rainfall in mm/month in La Chonta with a total of 1580 mm per year.

Experimental design

Four different sites were selected within half an hour walking distance from the field station of IBIF in La Chonta. Two sites are situated next to a river (from now on referred to as 'river-sites') and two sites are located in the middle of the forest (from now on referred to as 'matrix-sites') (Figure 2 and Appendix 2). In each site 42 50 l buckets were dug into the ground in such a way that the top of the bucket was at the same level as the forest floor. The buckets were placed in a rectangular grid system of 7 x 6 rows, with 5 m in between each of the buckets (Figure 3). The day before the first trapping day, the lids of the buckets were removed. The design is based on the idea that to establish a home range, it is best to cover as much of a given area as possible. The 5m space between the buckets is chosen with the experience with the y-trap design with 10 meters between the buckets and the example of the home range of the European tree frog, *Hyla arborea* (Stumpel & Tester 1993) in mind. The final area that is covered was limited by the amount of buckets and time to survey all of them in one day.

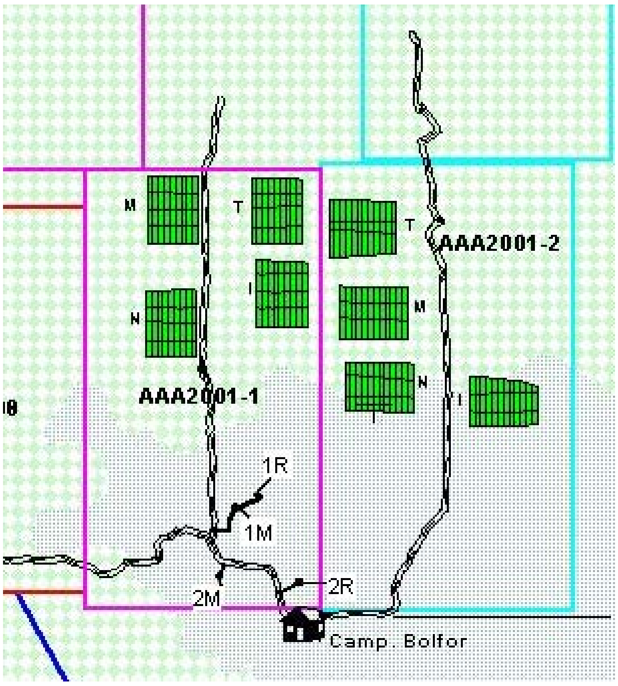

Figure 2. Location of the 4 sites (river-sites 1R and 2R and forest matrix-sites 1M and 2M) in the forest concession of La Chonta.

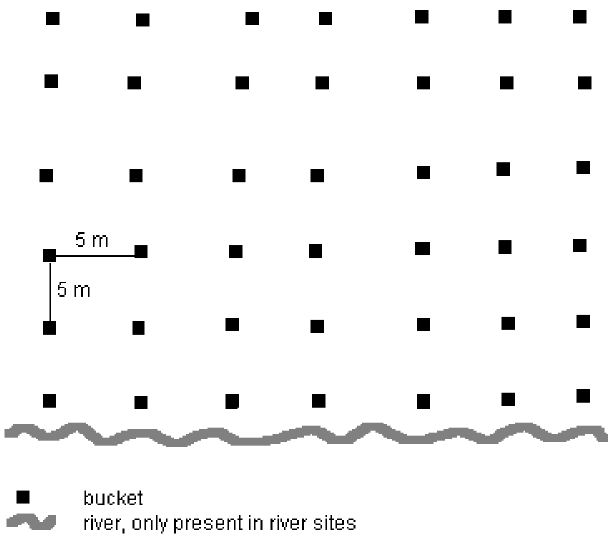

Figure 3. Every site consists of 42 buckets arranged in a grid with 6 rows of 7 buckets. The distance between 2 buckets is 5 m. In river sites the rows are parallel to the river.

One day before trapping the lids of the buckets were removed and a cup of water was emptied in each bucket. Also a dry wooden stick, flattened at two sides, was placed inside. The water prevents trapped animals from dehydration. The sticks will float in case of a lot of rainwater entering the bucket and thus provides a save haven for trapped mice fallen into the trap. The buckets were emptied except for a little bit of water in case of excess rainwater and refilled (one cup of water) when dried out. Fallen leaves and other litter were removed from the buckets. The traps were revised every day, starting at about 8:00 AM for 48 consecutive days (from Oct 28th to Dec 14th 2006). At the end of the field period, the buckets were closed with the lids, thus preventing animals from being trapped without any form of release possibility or chance of escape.

The trapped amphibians and reptiles were measured from snout to vent (cloacae) and for reptiles from snout to the tip of the tail as well. Further data were gathered for the length of one hind leg and the circumference of the thigh for both amphibians and reptiles (Appendix 3 and 4). The length of the animals and legs were measured with a calliper or a ruler, depending on the size of the animal. The circumference of the leg was measured by wrapping a piece of string around the leg and then measuring the string length wrapped around the leg with the calliper. To identify a specific individual, the toes were clipped in a specific order, thus making it possible to number each animal in a unique way. From every encounter of an animal the species, mark, number of the bucket, site and date were noted. After the individual had been measured, it was released at the same spot as it was found. From every site a list was kept with the found species and the number of the animals of that species to prevent double numbering.

For each bucket the vegetation cover was assessed in 3 categories: open (1), intermediate (2) and closed (3). Closed vegetation meant that nothing could be seen through the vegetation layer and open meant that the sky or the next vegetation level could be seen without obstruction. This categorisation was made for vegetation between 0-2 m, 2-15 m and >15 m above each bucket, hereafter called vegetation height. For the statistical analysis I also computed the mean of the vegetation coverage above the buckets. Because of the physiology of amphibians weather can have a strong effect on capture success. Consequently, I collected weather data to look if there was a relation between capture success and weather conditions. Except for the precipitation data at the sawmill of La Chonta (25 km from the field station); all meteorological parameters were only available from Ascensión de Guarayos, a town at 60 km from the field station by road (approximately 40 km in a straight line).Using the relative humidity and temperature data, a new parameter, the vapour-pressure deficit, was calculated using the equation:

(100-RH)/100*SVP = VPD

Where RH is the relative humidity, SVP is the saturated vapour pressure and VPD is the vapour pressure deficit in Kpa. The SVP can be looked up in a table (Appendix 5) and depends on air temperature (UBC).

Statistical analyses

The effect of site on total amount of amphibians and reptiles captured was tested using ANOVAs or Kruskall Wallis tests if variances were not equal. LSD test and Mann Whitney U-tests were used as post hoc tests. Each bucket in a site was used as a replicate, so that each site had 42 data points. A similar test was done for individual amphibian and reptile species with at least 10 captures.

The abundance of animals per site was calculated as the amount of animals captured minus recaptures. The effect of site on animal abundance was then tested with ANOVA or Kruskall Wallis, followed by LSD or Mann Whitney as post hoc tests.

To determine the effect of vegetation density on the amount of captured animals (amphibians and reptiles) and on species number I conducted an ANOVA or Kruskall Wallis test, depending on the equality of variance, for each vegetation height separately. With species as fixed factor and vegetation density (0 = open, 1= semi open and 2 = closed) as variable. Additionally I carried out the same analysis at the species level for species of which at least 5 animals were captured.

Different colour buckets (red, blue and green) were used in the sites. Therefore, I conducted an ANOVA or Kruskall Wallis test to see if amphibian and reptile species richness, total amount of animals captured, and individual species with at least 5 captures would show a preference for a specific colour (colour as grouping variable and amphibian and reptile species richness, total amount of animals captured and individual species as fixed factor.)

Because of the different skins of reptiles and amphibians I carried out separate analysis for each group to see if they responded differently to weather conditions. Since weather is a continuing phenomenon, I wanted to see if weather conditions in the past and the mean weather conditions from the past had influence on the capture rate and thus movement of the animals. For this purpose I correlated the capture data of a given day with weather data from previous days; one day before capture (d-1), two days before capture (d-2), three days before capture (d-3), and four days before capture (d-4). I also calculated new parameters by taking the mean of the values of the day of capture and one day before capture (d01); the mean of the values of the day of capture and the previous days before capture (d012); the mean of the values of the day of capture and the previous three days before capture (d0123) and also the mean of the values of the day of capture and the previous four days before capture (d01234).These mean weather values were also correlated to the animal capture rate. The weather factors with the highest correlation with amount of amphibians captured ($p<0.01$) (Table 6) were included in a forward multiple regression analysis. The same procedure was followed for the analysis of reptile reaction to different weather factors (Table 7).

To compare the allometry of the species captured, the natural logarithm of the leg length and the leg circumference at standard body length were plotted. The leg length, leg circumference and body length were also correlated with each other using a Pearson correlation analysis. Species included in the analysis had > 5 captures, and individuals were used as sample units in the correlations.

For the home range analysis I calculated the longest distance between the different capture points for each recaptured animal (hereafter referred as “longest distance moved”), as there were too little data points to use real home range statistical methods like the minimum convex polygon method. For this analysis I only used species with at least 5 animals being captured at least twice. To define if body length had an effect on longest distance moved at the species level, I correlated the average body length, leg length and leg circumference with the longest distance moved, using individuals as sample units. Additionally I plotted the average longest distance moved against the average body length of each species to see if there was a tendency that larger species moved longer distances than smaller species.

SPSS version 15.0 (2006) and Microsoft © Office Excel 2003 (part of Microsoft Office Professional Edition 2003) were used to do the analysis.

Results

Site

During the 48 days of the study, 386 animals from 20 species were captured (Table 1). Twelve amphibian species were captured, accounting for 307 individuals. On the other hand, 8 reptile species were captured, accounting for 79 individuals. Abundance is the amount of animals captured for the first time; the amphibian abundance is 231 animals and reptiles' abundance is 60 animals, making a total of 291 animals. Only 4 species had > 5 individuals captured at least twice. Consequently, I was only able to calculate the 'longest distance moved' for those species (Table 1). During my research five amphibian species were given a new scientific name; the old names are listed below as a reference.

Table 1 Summary of capture data of 48 consecutive trapping days in two habitats in a moist forest in Bolivia, including total number of individuals and species found for amphibians and reptiles. 'Animals captured' shows the total amount of captures. 'Abundance' is the number of animals captured for the first time. Longest distance moved is the mean of the distance between at least two capture events of the same individual. This information is provided only for species with ≥5 individuals being captured at least twice. Former species names are given as a reference.

	Former species names	Animals captured	Abundance	Longest distance moved (m)
Total				
# individuals captured		386	291	
# species captured		20		
Amphibians				
# individuals		307	231	
# species		12		
Chaunus schneideri	*Bufo paracnemis*	7	7	
Rhinella margaritifera	*Bufo margaritifer / Bufo typhonius*	63	50	11.8
Ceratophrys cornuta		2	2	
Ameerega picta	*Epipidobates pictus*	37	27	10.6
Chiasmocleis albopunctata		45	20	
Hamptophryne boliviana		3	3	
Leptodactylus spp	*Adenomera spp*	90	78	12.2
Leptodactylus leptodactyloides		6	5	
Leptodactylus lineatus	*Lithodytes lineatus*	9	8	
Leptodactylus mystaceus		32	28	
Physalaemus albonotatus		1	1	
Physalaemus biligonigerus		3	2	
unidentified frogs		9		
Reptiles				
# individuals		79	60	
# species		8		
Amphisbaena fuliginosa		1	1	
Bachia dorbignyi		3	3	
Prionodactylus eigenmani		14	14	
Mabuya cf. frenata		3	3	
Ameiva ameiva		6	6	
Kentropyx pelviceps		1	1	
Tupinambis		1	1	
Stenocercus caducus		50	31	16.4

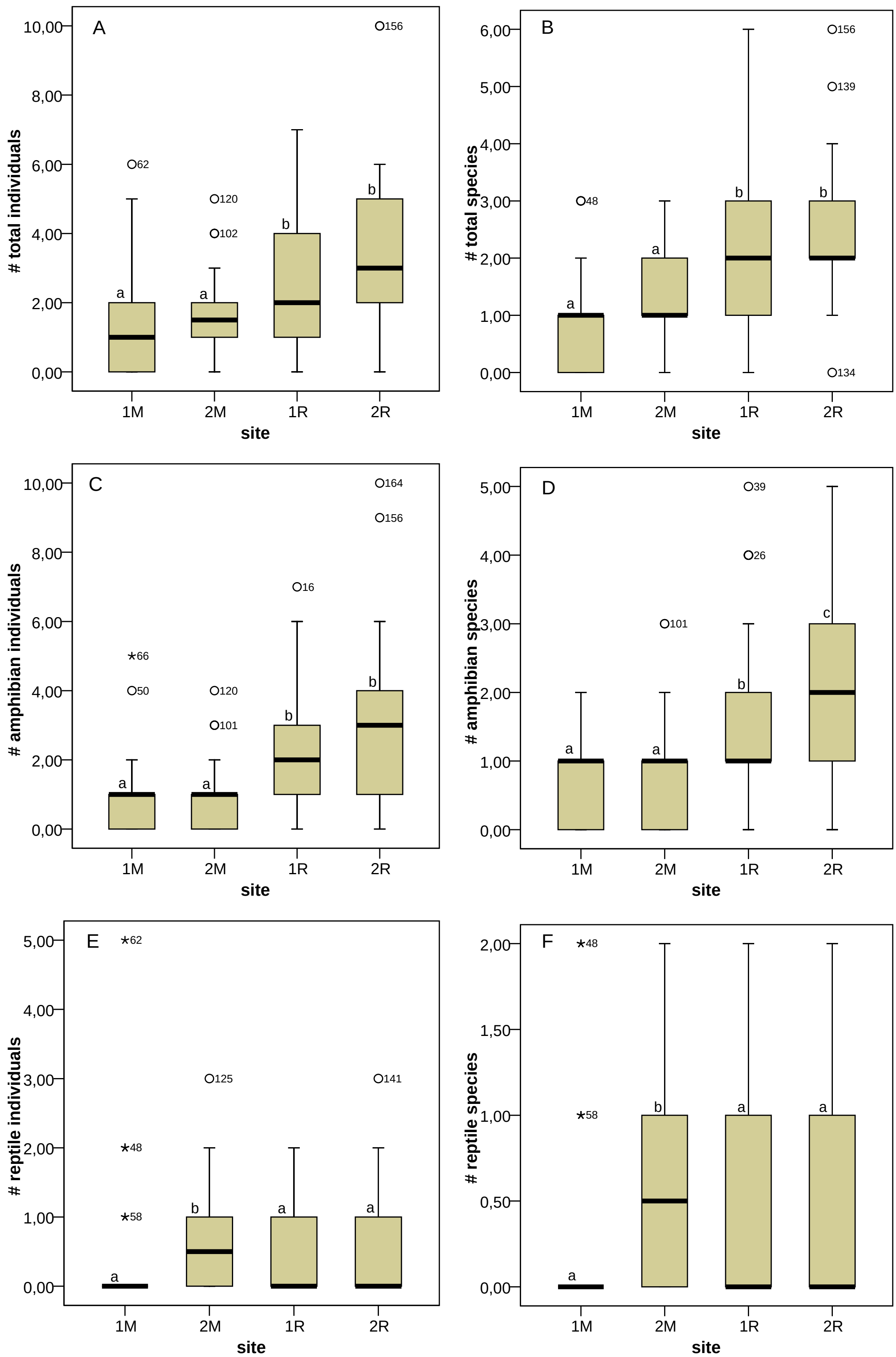

Figure 4. Site preferences shown for: A) total number of captured animals; B) total captured species; C) number of amphibian individuals captured; D) amphibian species captured; E) total of captured reptile individuals, and F) reptile species captured.

There is a significant difference between the sites (Kruskall Wallis χ^2= 36.643; df =3; p<0.001; Table 2) in amount of individuals caught per site (Figure 4A and 4B), with forest matrix sites having less animals than river sites. The same applies to the amount of species found in the forest matrix and river sites. Amphibian individuals showed a preference for the river sites (Figure 4 C; Table 2); amphibians species were also more abundant in the river sites, river site 2 being richer in species than river site 1 (Figure 4 D; Table 2). Reptile individuals and species prefer the second forest matrix site most, compared to the other sites (Figure 4 E and F; Table 2). Three amphibian species were checked for a site preference; *Rhinella margaritifera* and *Leptodactylus spp* do not have a site preference, but *Chiasmocleis albopunctata* prefers to go to the second river site. Two reptile species were checked for site preference (*Stenocercus caducus* and *Prionodactylus eigenmani*) but neither of them shows a site preference (Table 2).

Table 2. Site preferences of amphibian and reptile individuals and amphibian and reptile species richness, and site preferences for individual species with > 10 individuals captured.

site preference	Kruskall Wallis		
	X^2	df	p
# Amphibian individuals	53.5	3	< 0.001
# Amphibian species	49.2	3	< 0.001
Chiasmocleis albopunctata	4.7	1	0.030
Leptodactylus spp	2.7	3	0.433
Rhinella margaritifera	2.7	3	0.442
# Reptile individuals	10.3	3	0.016
# Reptile species	9.4	3	0.024
Prionodactylus eigenmani	3.3	3	0.348
Stenocercus caducus	6.3	3	0.100

The bucket colour did not have an influence on trapping success of amphibians or reptiles (Table 3), in terms of total number of individuals, species or number of individuals per species. The amphibian species (n>10) *Rhinella margaritifera*, *Chiasmocleis albopunctata* and *Leptodactylus spp* did not show a colour preference. *Prionodactylus eignmani* and *Stenocercus caducus* the reptile species (n>10) did not show a colour preference either.

Table 3. Test results for bucket colour preference for total amount of captured animals, amphibian and reptile individuals, species number of amphibians and reptiles, and number of individuals of species having > 10 animals captured. Different tests were used, depending on the equality of variance of the data.

	ANOVA			Kruskall Wallis		
	F	df	p	X^2	df	p
Total # animals captured	0.1	2	0.912			
Total # species captured	0.1	2	0.947			
# Amphibian individuals	0.1	2	0.882			
# Amphibian species				1.0	2	0.622
Chiasmocleis albopunctata				2.5	2	0.292
Leptodactylus spp	0.2	2	0.807			
Rhinella margaritifera	0.2	2	0.855			
# Reptile individuals	2.4	2	0.098			
# Reptile species				5.4	2	0.067
Prionodactylus eigenmani	0.5	2	0.622			
Stenocercus caducus	0.7	2	0.498			

Amphibian species and individuals are indifferent to vegetation density at any of the evaluated heights (0-2m, 2-15m, >15m), as are reptilian species and individuals (Table 4).

When tested for different amphibian species (n>10) *Chiasmocleis albopunctata*, *Leptodactylus spp* and *Rhinella margaritifera* did not show preference for vegetation density at any of the evaluated heights (Table 4). For reptilian species with n >10 (*Stenocercus caducus* and *Prionodactylus eigenmani)* also no preference was found.

Table 4. The influence of vegetation density at different vegetation height on capture success of amphibians and reptiles. Different tests were used, depending on the normality of the data.

	vegetation	ANOVA			Kruskall Wallis		
	height	F	df	p	X^2	df	p
# Amphibian individuals	0 - 2	0.6	2	0.565			
	2 - 15	1.1	2	0.334			
	> 15	0.5	3	0.703			
	total				0.9	2	0.956
# Amphibian species	0 - 2	0.6	2	0.541			
	2 - 15	1.8	2	0.174			
	> 15				1.6	2	0.44
	total				2.9	2	0.233
Chiasmocleis albopunctata	0 - 2				1.8	2	0.414
	2 - 15	1.4	2	0.276			
	> 15				1.6	2	0.44
	total	0.2	4	0.926			
Leptodactylus spp	0 - 2	0.1	2	0.877			
	2 - 15				2.3	2	0.315
	> 15	0.1	2	0.884			
	total				3.3	1	0.068
Rhinella margaritifera	0 - 2	1.7	2	0.2			
	2 - 15				3.2	2	0.203
	> 15	1.7	2	0.199			
	total	0.7	5	0.633			
# Reptile individuals	0 - 2				2.0	2	0.374
	2 - 15	1.1	2	0.341			
	> 15	0.9	3	0.444			
	total	0.3	4	0.899			
# Reptile species	0 - 2				1.9	2	0.384
	2 - 15	1.0	2	0.374			
	> 15	1.0	3	0.397			
	total	0.7	5	0.614			
Prionodactylus eigenmani	0 - 2	0.3	2	0.721			
	2 - 15				1.1	2	0.577
	> 15				2.4	2	0.298
	total	0.9	1	0.371			
Stenocercus caducus	0 - 2	0.3	2	0.735			
	2 - 15	0.8	2	0.458			
	> 15				2.2	2	0.336
	total	0.9	2	0.401			

Weather

For the precipitation I have data from the sawmill of La Chonta and from Ascensión de Guarayos (40 km in straight line apart from each other). I calculated the correlation between the precipitations of these two areas to test if in the future data from one area would be sufficient. There is a high correlation (r=0.82) between the daily precipitation in Ascensión de Guarayos and the precipitation at the saw mill of La Chonta.

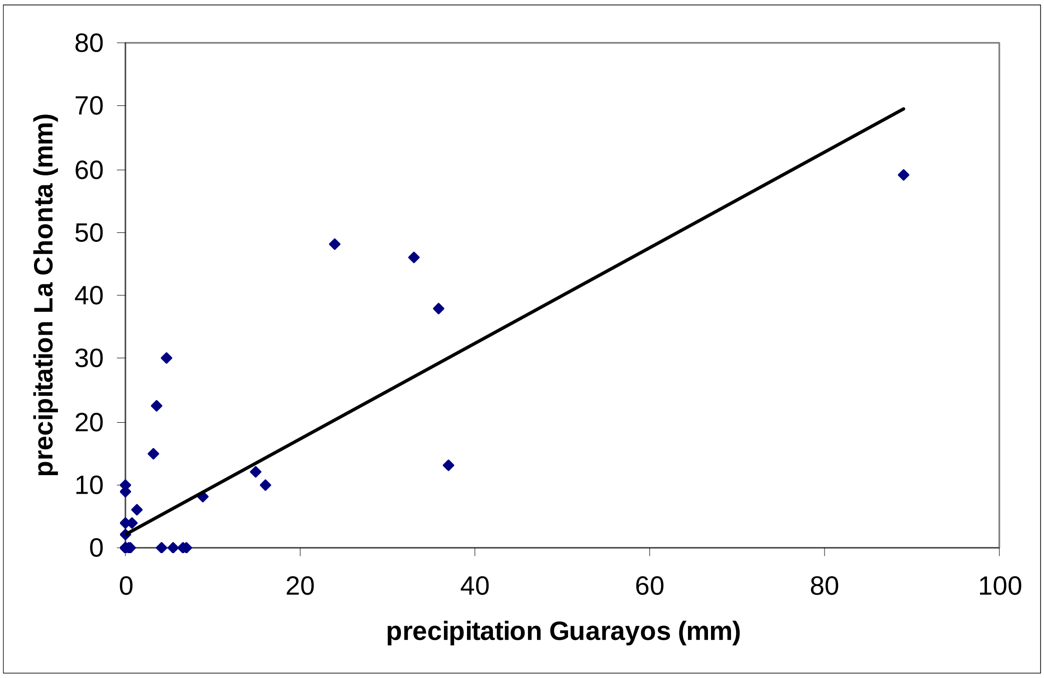

Figure 5. Correlation of precipitation in Ascensión de Guarayos and precipitation at the saw mill of La Chonta (r=0.82).

The total amount of animals captured found in the traps was mostly correlated with the weather parameters one day before capture (d-1) (Table 5). This result is probably due to the fact that the buckets were checked and captured animals released the morning after they fell into the buckets, which means that I actually measured the movement of the animals of the day before. Most animals were found in the traps one day after a rainfall event. The major part of the captured animals consists of amphibians (Figure 6 and 7, Table 1). On December 7th (day 37) a higher than average amount of rain fell and its effect was clearly observed on December 9th (day 39) when 19 amphibians and 1 reptile were captured.

The amount of amphibians found in the traps was negatively correlated to the vapour-pressure deficit (VPD), mean day temperature, maximum day temperature and air pressure (Table 6; Figure 8 A, B, C), and was mostly correlated to one (VPD) to 4 days before capture (air pressure). Minimum day temperature does not seem to be correlated to the amount of caught amphibians. This result is not surprising given that maximum and mean day temperature are highly correlated and mean and minimum day temperature are not (Appendix 6). Humidity and rainfall at the sawmill of La Chonta have the highest correlation with the amount of captured amphibians one day before capture; rainfall in Ascensión de Guarayos shows no significant correlation with number of captured amphibians.

Table 5. Correlation of number of caught animals with weather conditions on the day of capture (d0), one day before capture (d-1), 2 days before capture (d-2), and 3 (d-3) and 4 (d-4) days before capture and the mean of the day of capture and one day before (d01)till 4 days before capture (d01234). VPD = vapour-pressure-deficit. * = p< 0.05; ** = p< 0.01

Weather parameters	d0	d01	d012	d0123	d01234	d-1	d-2	d-3	d-4
Min day temp (°C)	0.057	0.07	0.10	0.17	0.21	0.06	0.11	0.25	0.24
max day temp (°C)	-0.34*	-0.30*	-0.27	-0.20	-0.15	-0.18	-0.14	0.05	0.08
mean day temp (°C)	-0.25	-0.36*	-0.32*	-0.25	-0.16	-0.40**	-0.15	0.03	0.19
Precipitation La Chonta (mm)	-0.04	0.20	0.26	0.18	0.07	0.36*	0.21	-0.11	-0.24
Precipitation Guarayos (mm)	-0.10	-0.02	0.10	0.05	-0.03	0.07	0.22	-0.07	-0.20
Humidity (%)	0.08	0.22	0.23	0.22	0.19	0.34*	0.21	0.16	0.07
air pressure (hPa)	-0.03	-0.12	-0.28	-0.36*	-0.41**	-0.19	-0.48**	-0.42**	-0.33*
VPD (Kpa)	-0.14	-0.26	-0.26	-0.24	-0.21	-0.37**	-0.22	-0.15	-0.06

Table 6. Correlation of number of caught amphibians with weather conditions on the day of capture (d0), one day before capture (d-1), 2 days before capture (d-2), and 3 (d-3) and 4 (d-4) days before capture and the mean of the day of capture and one day before (d01)till 4 days before capture (d01234). VPD = vapour-pressure-deficit. * = p< 0.05; ** = p< 0.01

Weather parameters	d0	d01	d012	d0123	d01234	d-1	d-2	d-3	d-4
Min day temp (°C)	0.06	0.09	0.10	0.15	0.20	0.09	0.09	0.21	0.24
max day temp (°C)	-0.43**	-0.38**	-0.36*	-0.3*	-0.23	-0.25	-0.21	-0.02	0.05
mean day temp (°C)	-0.34*	-0.44**	-0.41**	-0.34*	-0.25	-0.46**	-0.21	-0.05	0.15
Precipitation La Chonta (mm)	0.03	0.29*	0.36*	0.28	0.17	0.44**	0.25	-0.06	-0.19
Precipitation Guarayos (mm)	-0.04	0.06	0.18	0.15	0.07	0.14	0.27	-0.02	-0.17
Humidity (%)	0.17	0.31*	0.32*	0.30*	0.27	0.43**	0.28	0.21	0.10
air pressure (hPa)	-0.04	-0.15	-0.32*	-0.42**	-0.47**	-0.23	-0.55**	-0.48**	-0.36*
VPD (Kpa)	-0.23	-0.35*	-0.35*	-0.32*	-0.28	-0.45**	-0.29*	-0.21	-0.89

Reptiles did not seem to respond to weather conditions in the same way amphibians did (Table 7). The amount of reptiles caught in the traps is negatively correlated to precipitation in Guarayos and La Chonta and humidity (Table 7). The response of reptiles to mean day temperature is shown in Figure 8D as a comparison to the response of amphibians in Figure 8C. Reptiles show the highest correlation with weather events which occurred 3 or 4 days before capture (Table 7).

Table 7. Correlation of number of caught reptiles with weather conditions on the day of capture (d0), one day before capture (d-1), 2 days before capture (d-2), and 3 (d-3) and 4 (d-4) days before capture and the mean of the day of capture and one day before (d01)till 4 days before capture (d01234). VPD = vapour-pressure-deficit. * = p< 0.05; ** = p< 0.01

Weather parameters	d0	d01	d012	d0123	d01234	d-1	d-2	d-3	d-4
Min day temp (°C)	-0.07	-0.06	-0.00	0.06	0.06	0.11	0.01	0.17	0.03
max day temp (°C)	0.34*	-0.33*	0.35*	0.37**	0.34*	0.25	0.27	0.28	0.12
mean day temp (°C)	0.35*	0.31*	0.32*	0.35*	0.34*	0.20	0.23	0.30*	0.18
Precipitation La Chonta (mm)	-0.28	-0.35*	-0.36*	-0.39**	-0.40**	-0.30*	-0.15	-0.19	-0.19
Precipitation Guarayos (mm)	-0.24	-0.31*	-0.34*	-0.38**	-0.37**	-0.26	-0.17	-0.20	-0.15
Humidity (%)	-0.35*	-0.36*	-0.34*	-0.32*	-0.29*	-0.33*	-0.28	-0.22	-0.12
air pressure (hPa)	0.06	0.12	0.18	0.22	0.23	0.16	0.24	0.22	0.13
VPD (Kpa)	0.35*	0.34*	0.33*	0.31*	0.28	0.29*	0.26	0.22	0.11

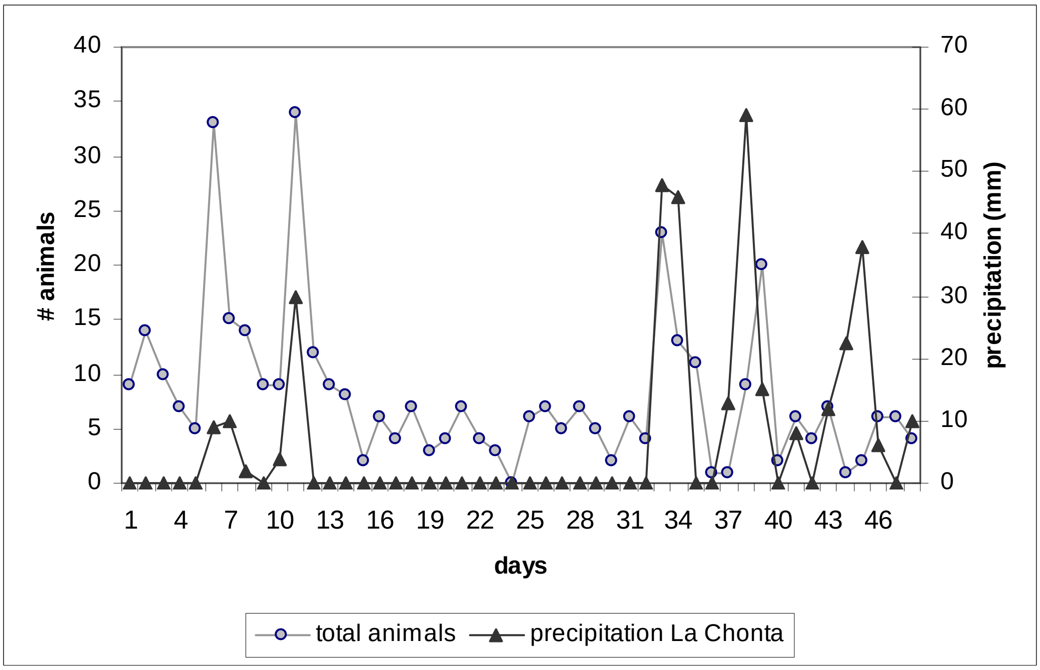

Figure 6. Amount of animals captured per day and precipitation per day during the animal collection period (day 1 till 48).

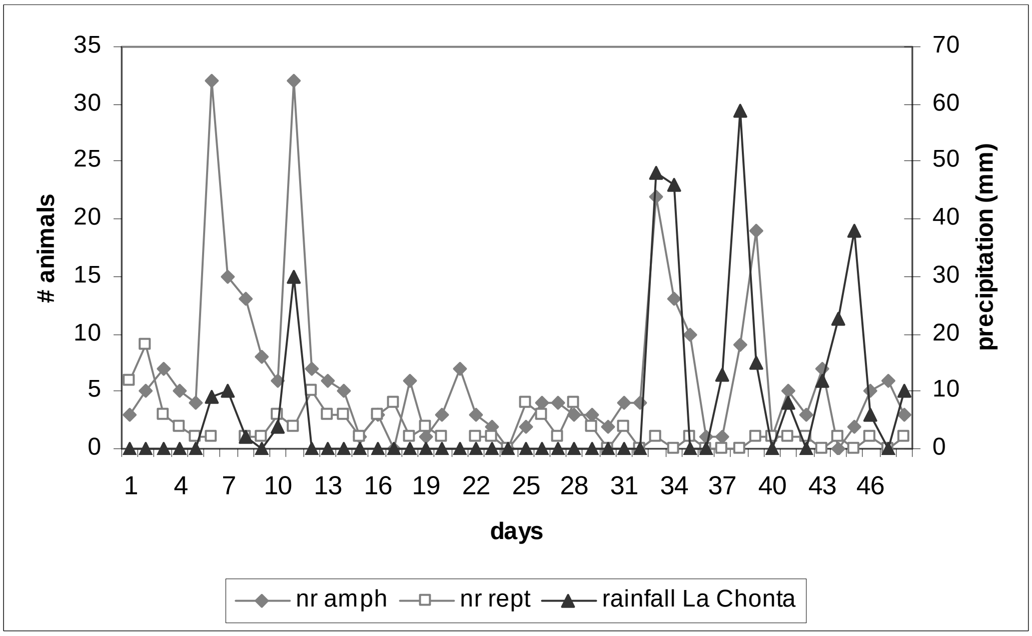

Figure 7. Amount of amphibians (grey diamond) and reptiles (white square) captured in relation to precipitation (mm) at the saw mill of La Chonta (black triangle) during the collection period (day 1 till 48).

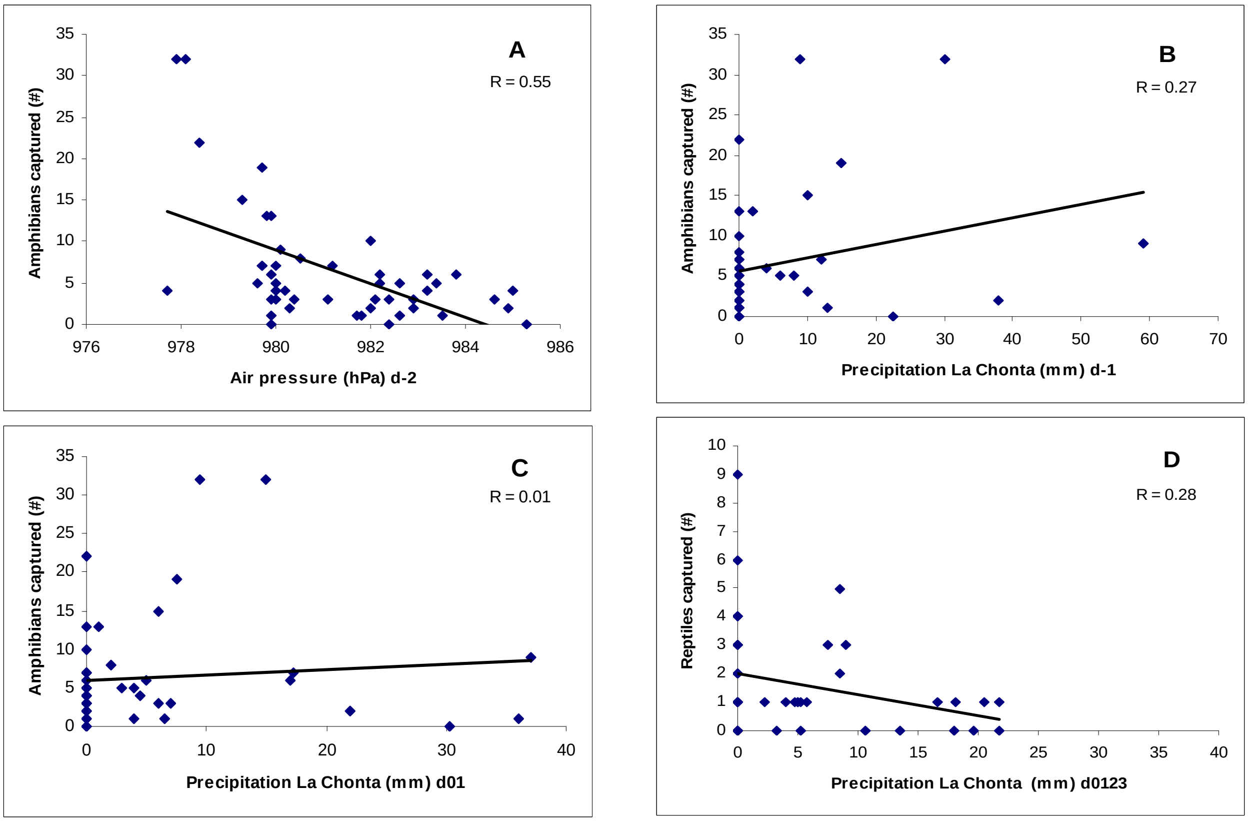

Figure 8. Correlations between different weather variables and number of amphibians (A, B, C) and reptiles (D) captured. These significant weather parameters were also included in a model using a forward multiple regression analysis (see Table 8 for more details).

The most important weather factors predicting the amount of amphibians captured were air pressure two days before capture, precipitation in La Chonta one day before capture and the mean of the precipitation in La Chonta on the day of and one day before capture (Table 8, Figure 8A, B, C). On the other hand, reptile capture was negatively affected by the mean value of precipitation in La Chonta during the day of capture and the 3 previous days (Table 8; Figure 8 D).

Table 8. Forward multiple regression analysis for the total amount of captured amphibians and reptiles the weather parameters with the highest correlations ($p<0.010$) mentioned in Table 6 and 7. ‘Beta’ stands for the parameter ‘b’ in the equation: $y = a + b x$; which predicts the amount of animals found in the traps.

	b	R^2	p
Amphibians		0.42	<0.001
Air Pressure d-2	-0.51		
Precipitation La Chonta d-1	0.60		
Precipitation La Chonta d01	-0.43		
Reptiles		0.16	0.006
Precipitation La Chonta d0123	-0.39		

Animal allometry

One of the differences between lizards and frogs and toads is their body morphology; lizards have a long elongated body and frogs and toads have a more 'square' body form, with their legs folded underneath their body. The data collected in this study confirm these observations (Figure 10). Lizards (*Prionodactylus eigenmani*, *Ameiva ameiva* and *Stenocercus caducus*) have small (hind) legs compared to their body. The hind legs of the toads (*Chaunus schneideri* and *Rhinella margaritifera*) are quite similar to the hind legs of the frogs. *Leptodactylus mystaceus* has the longest legs compared to their body size, allowing it to jump forward for about 1 m (C.W. Lasthuis; personal observation).

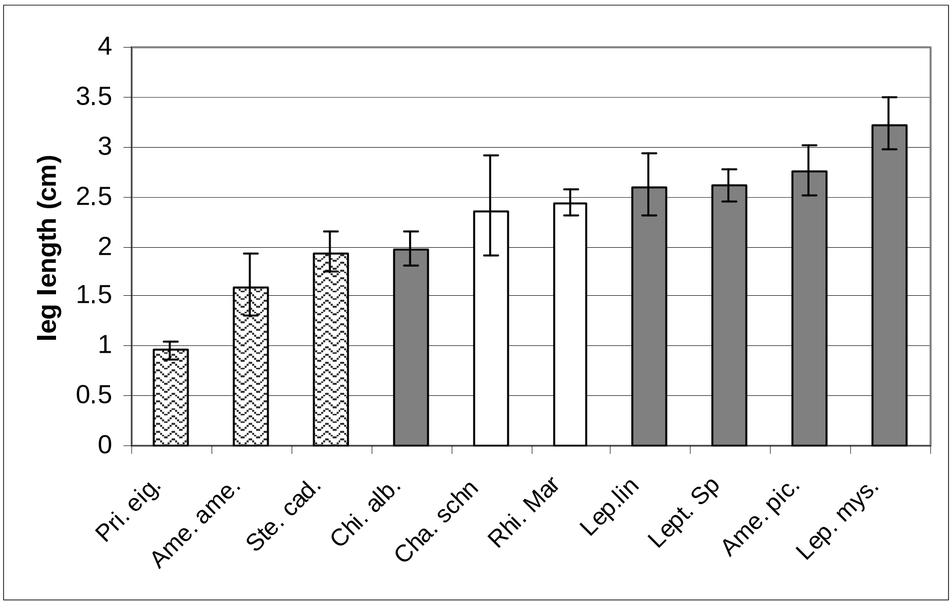

Figure 10. Leg length (cm) at body length = 3.54 cm for the different species with n>5. Lizards (striped columns): Pri. eig. = *Prionodactylus eigenmani*; Ame ame.= *Ameiva ameiva*; Ste. cad.= *Stenocercus caducus*; Chi. alb. = *Chiasmocleis albopunctata*; Toads (white columns) Cha. schn. = *Chaunus schneideri*; Rhi. mar. = *Rhinella margaritifera*; Frogs (dark columns) Lep. lin. = *Leptodactylus lineatus*; Letp. Sp = *Leptcodactylus spp*; Ame. pic. = *Ameerega picta*; Lep. mys. = *Leptodactylus mystaceus*.

The (hind) leg circumference tells us something about the amount of muscles present in that leg. The lizards *Prionodactylus eigenmani* and *Ameiva ameiva* have smaller leg circumferences than the toads and frogs, while the lizard *Stenocercus caducus* has a leg circumferences in between that of the reptiles and amphibians. Since especially frogs, but also toads, move around by propelling themselves forward with their hind legs, we would expect them to have a higher leg circumference compared to lizards. This pattern was indeed observed in our dataset (Figure 11).

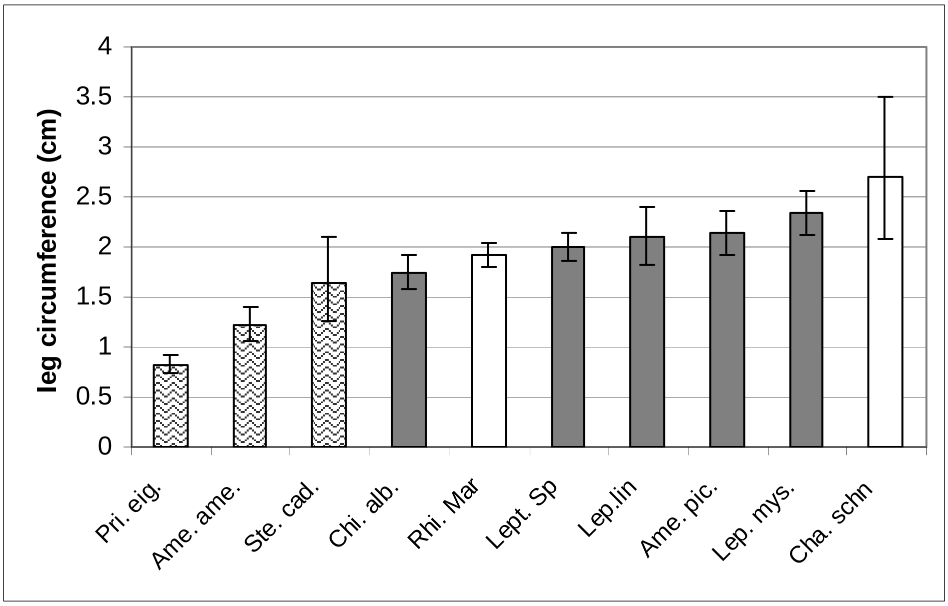

Figure 11. Leg circumference (cm) of the different species (n>5) at lnbody length= 1.24 cm; (body length = 3.47 cm). Striped columns are for lizards, white columns for toads and dark columns for frogs. See figure 10 for explanation of the species names.

In table 9 the different allometric correlations between different body parts are shown. It is interesting to see that there does not seem to be a correlation between the different body parts of *Prionodactylus eigenmani* (n= 12 or 13). In the case of *Ameerega picta* there was a correlation between body length and leg circumference, while in the case of *Chiasmocleis albopunctata* there was correlation between body length and leg length. *Chiasmocleis albopunctata* and *Leptodactylus lineatus* have both a negative correlation between leg length and leg circumference. The toad *Rhinella margaritifera* grows most evenly; all the measured body parts are positively correlated with each other. The same pattern is also observed in the frogs *Leptodactylus mystaceus* and *Leptodactylus spp*, of which *Leptodactylus mystaceus* looks the most 'toad–like' of all frogs (C.W. Lasthuis, personal observation). *Ameiva ameiva* (n= 5 or 6) has the best correlation between the measured body parts for the investigated reptile species, whereas *Prionodactylus eigenmani* shows no correlative growth for the measured body parts. *Stenocercus caducus* has a positive correlation between its body and leg length and body and combined body and tail and body length.

Table 9. Correlations between different allometric parameters measured for several species (n ≥ 5). Body-leg = body and leg length, body- circ = leg circumference and the body length, leg-circ = leg length and the leg circumference, body-bodytail = body length and the body length including the tail.

Group	Species	Body-leg (r)	p	Body-circ (r)	p	Leg-circ (r)	p	Body-body-tail (r)	p
Frogs	*Ameerega picta*	0.36	0.161	0.63	0.007	0.07	0.777		
	Chiasmocleis albopunctata	0.59	0.006	0.10	0.687	-0.43	0.061		
	Leptodactylus lineatus	0.19	0.659	0.56	0.148	-0.44	0.278		
	Leptodactylus mystaceus	0.76	<0.001	0.86	<0.001	0.81	<0.001		
	Leptodactylus spp	0.45	<0.001	0.39	0.001	0.26	0.035		
Toads	*Rhinella margaritifera*	0.80	<0.001	0.79	<0.001	0.75	<0.001		
	Chaunus schneideri	0.71	0.076	0.40	0.377	0.60	0.153		
Lizards	*Ameiva ameiva*	0.96	0.002	0.93*	0.021	1.00	<0.001	1.0	<0.001
	Prionodactylus eigenmani	-0.112	0.715	-0.18	0.559	0.09	0.763	-0.37	0.232
	Stenocercus caducus	0.747	0.000	0.409	0.130	0.51	0.052	0.82	0.000

I was able to calculate the longest distance moved for only 4 species; the lizard *Stenocercus caducus*, the toad *Rhinella margaritifera* and the frogs *Ameerega picta* and *Leptodactylus spp*. For the lizard *Stenocercus caducus* leg length was positively correlated with longest distance moved (Table 10), while for the toad *Rhinella margaritifera* leg circumference was positively correlated with longest distance moved. The frog *Ameerega picta* shows a positive correlation for body length and leg length with longest distance moved. Finally, none of the body parts of *Leptodactylus spp* were correlated with distance moved (Table 10).

Table 10. Correlations of longest distance moved with body length, leg length, leg circumference and for the lizard *Stenocercus caducus* also body and tail length; within species. * = $p < 0.05$

Group	Species	body length (r)	leg length (r)	Leg circumference (r)	body and tail (r)
Lizard	*Stenocercus caducus*	0.58	0.66*		0.57
Toads	*Rhinella margaritifera*	0.52	0.55	0.65*	
Frogs	*Ameerega picta*	0.69*	0.65*	0.05	
	Leptodactylus spp	0.14	0.57	-0.40	

When body length and longest distance moved were related to each other at the species level, *Stenocercus caducus*, the lizard with the longest body length, had moved the longest distance as well. The frogs and toads, differing in body size with about 2 cm, had more or less moved the same mean distance (Figure 12).

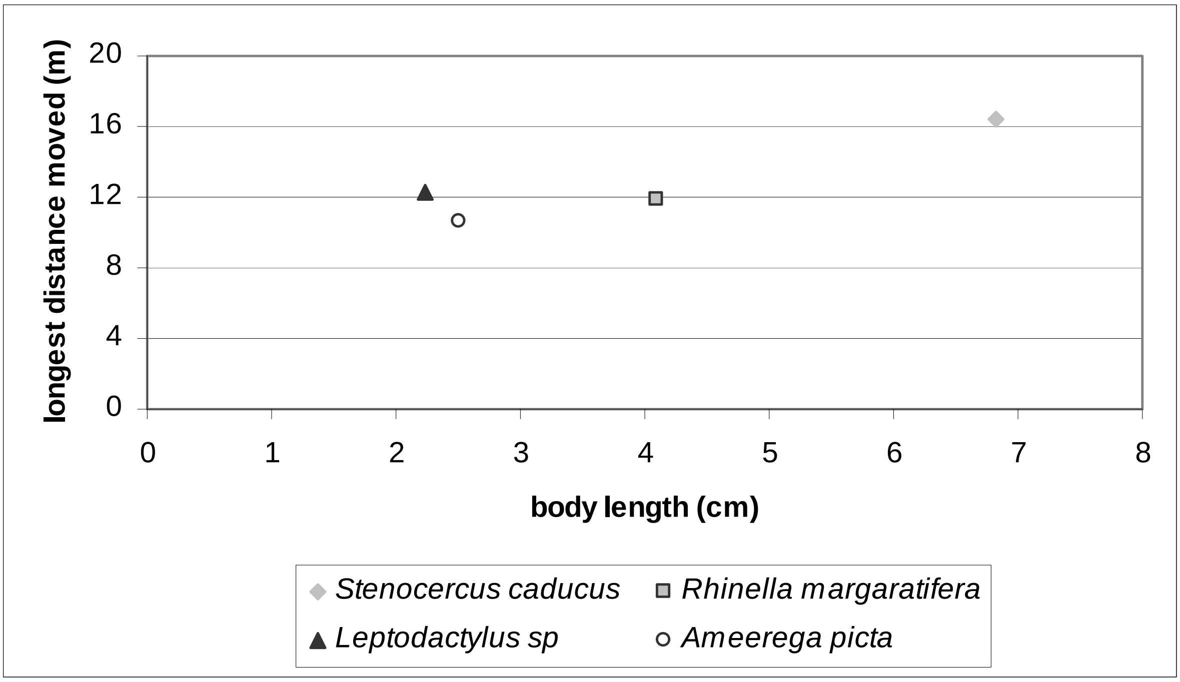

Figure 12. Maximum distance moved versus body length for the lizard *Stenocercus caducus*, the toad *Rhinella margaritifera* and the frogs *Ameerega picta* and *Leptodactylus spp.*

Discussion

Abundance and species richness of amphibians and reptiles in 2 different microhabitats

Amphibians both at the abundance and species richness level showed a preference for forest river sites over forest matrix sites (Figure 4). This result is in accordance with another study carried out in the same study area (Fredericksen & Fredericksen 2004), in which it was found that the amphibian species abundance near the stream peaks during the dry season. This result led the authors to suggest that the amphibians move to the rivers to spend the dry season. As I started capturing animals just after the dry season, it is well possible that the first captured animals could be migrating from the river back to their normal areas during the wet season. This could explain the higher amount of amphibians captured (30 – 35 individuals) after a rainfall incident in the first weeks, but only 20 individuals after a few weeks during a period without rain (Figure 6 and 7), and the low amount of recaptures. Van Gijn (Van Gijn 2007) found in the same study sites a negative relationship between both amphibian abundance and species richness and distance to the stream, and a positive relationship between both reptile species abundance and species richness and distance to the stream. This is comparable with what was found in this study and with Peltzer and colleagues who found a positive relation between anuran presence and pond area (Peltzer *et al.* 2006).

Amphibians did not only show a preference for the river sites but a specific preference for forest river site 2R (Figure 4). Although I have not found any relation between amphibian abundance and richness with any vegetation cover parameter, it seems that river site 2R had the most closed canopy above the traps at a height of 0-2 m (Table 11). In another research done at the same site it was found that river site 2R had the highest density of small plants, the highest understory density (probably related) and the least amount of fern species (Van Gijn 2007). Especially the first two variables might explain the extra preference of amphibians for forest river site 2R because amphibians captured in this study live in the understory or are ground dwelling species.

Reptiles do not show a specific preference for forest matrix sites over forest river sites except for forest matrix site 2M (Figure 4). This preference may be related with the fact that forest matrix site 2M seems to have the most open canopy at the level of 2 – 15 m and the most open canopy, if openness of all three height levels are combined, compared to the other sites (Table 11). Due to this openness, more direct sunlight could be able to penetrate to the forest floor, which gives reptiles the opportunity to bask and warm their bodies to become active. The reptile preference for site 2M could indicate a preference for open areas over closed vegetation and contradicts the idea that reptiles would not show a preference for different forest sites with closed vegetation.

Table 11. Canopy openness above the individual traps scored per site (1R, 2R, 1M and 2M) for individual traps (42 per site). 0-2 meters above the traps, 2-15 meters and 15 meters and higher and the combined heights.

	0-2 m				2-15 m				15 m and higher				Combined heights			
	1R	2R	1M	2M	1R	2R	1M	2M	1R	2R	1M	2M	1R	2R	1M	2M
Open	14	6	15	5	0	1	2	11	25	12	18	18	39	19	35	34
Semi-open	23	22	26	26	16	16	16	12	13	13	14	9	52	51	56	47
Closed	5	14	1	11	26	25	24	19	3	16	10	15	34	55	35	45

In La Chonta a monitoring program is being implemented to assess the effect of logging in species richness and abundance of amphibians and reptiles. This study is being carried out in the experimental plots of the Long-term Silvicultural Research Program, and it uses a different trap design and evaluation regime (Figure 13). After 2 years of monitoring the logging effect study had found 29 species, 14 amphibian and 15 reptile species. During the period (November 6th till November 25th 2006) in which both studies had the traps opened simultaneously, 21 species (10 amphibian and 11 reptile species) were found in the logging effect study and 20 species (12 amphibian species and 8 reptile species) in this study. Additionally the amount of trapped animals in this period differed largely between the studies; 182 individuals in the logging effect study vs 119 individuals in this study (Table 12). There are, however, no clear patterns among species regarding their abundances as some species were abundant in both studies, while others were more common in one of the studies or even just present in one studies (Table 12). The different amount of animals captured in the two studies could be the effect of the trap designs. The traps used in the logging effect study sampled a larger area per bucket (10.8 m^2) than the area being sampled per individual buckets in this study (0.20 m^2). This might explain the higher amount of captured animals in the logging effect study. However, it does not explain the disproportionally high capture success of animals in this study; 3.6 animals per m^2 compared to 1.5 animals per m^2 for the logging effect study. This difference in capture success suggests that different forest areas in La Chonta vary in animal density.

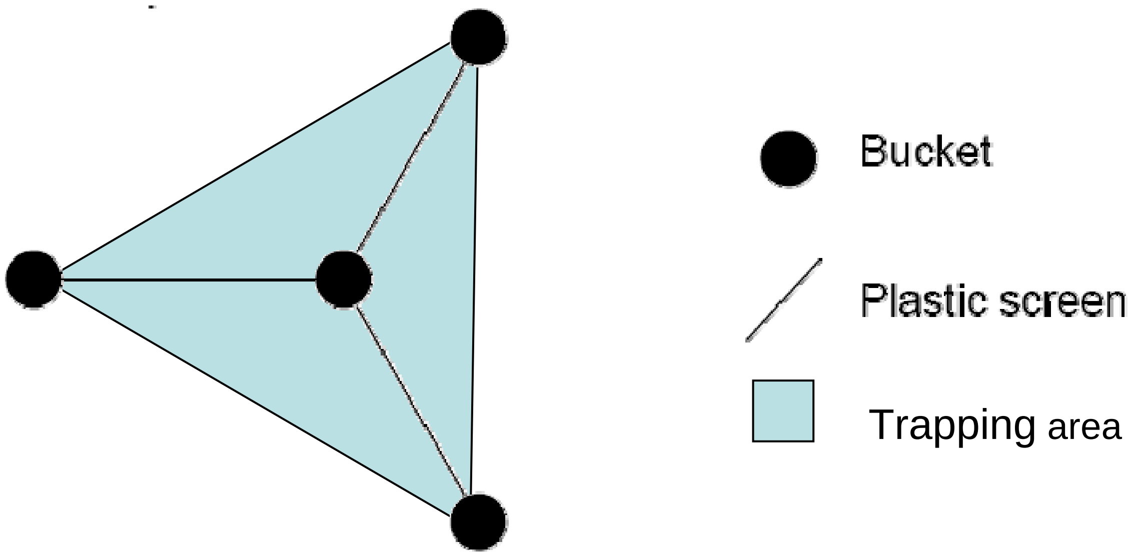

Figure 13. Trap design of the logging effect study.

Table 12. Species and number of individuals found in this study compared to the species found in the logging effect study by Mayra Maldonado. The data refer to the trapping period of November 6th till November 25th of 2006, period in which traps of both studies were opened simultaneously. Species number '⊗' means the species has been found in that particular study but no individuals were captured in this specific period.

Amphibians	Logging effect	This study	Reptiles	Logging effect	This study
Ameerega picta	21	20	*Ameiva ameiva*	1	5
Caecilia sp.	⊗		*Amphisbaena fuliginosa*	2	⊗
Ceratophrys cornuta		1	*Anolis sp.*	1	
Chaunus schneideri	3	2	*Bachia dorbignyi*	1	⊗
Chiasmocleis albopunctata	7	10	*Chironius sp.*	1	
Eleutherodactylus sp.	2		*Colubrido sp.*	⊗	
Hamptophryne boliviana	6	1	*Helicops sp.*	⊗	
Leptodactylus enanos	⊗		*Kentropics*		⊗
Leptodactylus leptodactyloides	49	⊗	*Leptotyphlops sp.*	1	
Leptodacatylus lineatus	1	2	*Mabuya cf. frenata*	7	3
Leptodactylus mystaceus	15	9	*Micrurus annulatus*	⊗	
Leptodactylus spp.	24	32	*Micrurus lemniscatus*	1	
Leptodactylus syphax	⊗		*Prionodactylus eigenmani*	4	8
Physalaemus albonotatus		⊗	*Stenocercus caducus*	34	25
Physolaemus biligonigerus		1	*Typhlops sp.*	⊗	
Proceratophrys sp.	⊗		*Teidae Tupinamis*		⊗
Rhinella margaritifera	15	18	*Waglerophys sp.*	1	
Total	128	78	Total	54	41

Is the abundance and species richness defined by biotic conditions and abiotic conditions?

Biotic conditions

Both amphibians and reptiles showed no preference for vegetation openness as measured in this study (Table 4). The simple measurement of understory density done by Van Gijn (Van Gijn 2007) for the same study sites do not show either a significant relationship with amphibian and reptile abundance and species richness. However, these results contradict the more specific research results obtained by van Gijn (Van Gijn 2007) when more detailed data on understory vegetation was collected (*Pteris* sp. cover, woody debris, seedling count, Costaceae abundance). The different results obtained in the two studies could be due to the way vegetation was measured. Van Gijn (Van Gijn 2007) took very detailed measurements of the vegetation in terms of density and species composition, while I only visually assessed the openness of the vegetation surrounding the traps. This explanation is also supported by the fact that other studies taking also more detailed vegetation data have found significant correlations between the abundance and species richness of amphibians or reptiles and vegetation parameters (e.g., for amphibians in the Atlantic Rainforest in Brazil (Sluys & Vrcibradic 2007); for anuran diversity in Argentina (Peltzer *et al.* 2006)).

Abiotic conditions

Contrary to our hypothesis amphibian abundance was not mainly determined by humidity but by air pressure, precipitation the day before capture, and average precipitation between the day of capture and the day before (Table 8 and Figure 8). These weather conditions are, however, indicative of high moisture levels in the atmosphere. The fact that air pressure has the highest correlation with the amount of amphibians in the traps is probably caused by the negative relation between air pressure humidity and precipitation (Table 8, Appendix 6). High air pressure areas can, but seldom do bring rain with them (KNMI). Amphibians reacted negatively to high air pressure, which is a good predictor of dry weather. Given amphibians are ectothermic animals with a moist skin (deMaynadier & Hunter 1998; Duellman & Trueb 1994; Hickman *et al.* 1997a) and that their skin needs to be kept moist, so that the animals are able to breathe through their skin, it is likely that they prevent desiccation by hiding and seizing to move in unfavourable weather conditions (Duellman & Trueb 1994). This is probably the reason for the fact that hardly any amphibians were caught in the 3 weeks in which no precipitation had fallen in the experimental period (Figure 6 and 7). Other studies have also found similar results in China (Hong Qian 2007), in Australia (Brown & Shine 2002), and in the USA (Todd 2006).

Also contrary to our expectation reptiles did respond negatively to rainfall in Guarayos and in La Chonta (Table 7 and 8). Since rain events can be very local, the precipitation at the sawmill of La Chonta was a better predictor for reptile movement than precipitation in the town of Ascensión de Guarayos (Table 8). The best predictor for reptile capture was actually the mean precipitation in La Chonta between the day of capture and the 3 previous days, probably because by then the air humidity was very low, making circumstances most favourable for reptiles to get warm and move around. This requirement of warming up (Pough 2001) might also explain the positive correlation of reptile capture and high day temperature (Table 7). Another study has also found temperature variables explaining more species richness for reptiles than for amphibian species (Hong Qian 2007).

As predicted in our hypothesis amphibians and reptiles reacted differently to weather conditions, probably mostly due difference in their skin (deMaynadier & Hunter 1998; Duellman & Trueb 1994; Hickman *et al.* 1997a, b; Pough 2001).

Bucket colour

Both amphibians and reptiles did not show a colour preference for the buckets (Table 3). Amphibians have 2 types of rods and 2 types of cones as sensory cells in their retina. Consequently, they have a photoreceptive range for 432 nm (blue), 502 nm (green) and 580 nm (yellow) (Duellman & Trueb 1994). In a study with anoline lizards, they discovered 4 types of cones in the retina (Fleishman *et al.* 1993). The cones have a maximum absorption of 565 nm, 495 nm, 450 nm, and 365 nm. The range of these lizard cones are within the same range of the amphibian rods and cones, with the exception of the 365 nm cone that is associated with ultraviolet light (Fleishman *et al.* 1993). Assuming that the different colour plastic buckets do not have different uv-emittance; it is likely that amphibians and lizards can see the difference between green and blue buckets but red buckets will probably look grey to them as they do not have photoreceptors for red (700 nm). In this study only few green buckets were used, compared to blue buckets. But since amphibians and reptiles do not show a colour preference for the different coloured buckets, I think there is no problem in using different colour buckets to trap amphibians and reptiles.

3. Is the longest distance moved affected by the body (part) size of the species?

Due to the very little amount of data I was not able to use real home range statistics like the minimum convex polygon (Franzreb 2006). Instead I calculated the longest distance moved for the species for which I had recaptured at least 5 individuals. This calculation helped to learn a little about animal movements but it still needs further improvement to be able to use it to estimate animal density.

As I captured most of the recaptured individuals only twice, it is unclear if I captured them in their home range or if they were just moving from the river areas used during the dry season (Fredericksen & Fredericksen 2004) to the areas used during the wet season. For the animals captured more than twice it is uncertain if the longest distance moved is the size of the home range or if this is a measurement within their home range. It could be that the animal was not captured at the edges of its home range or that the measured edges were the edges of the experimental area.

It was expected that the home range of the animal would increase with body size. Although I could not really test this hypothesis, it seems that the longest distance moved was indeed positively related to body length. The frog *Ameerega picta* has both its body as well as its leg length correlated with the longest distance moved, while the body parts of *Leptodactylus spp* do not correlate with the longest distance moved (Table 9). These results suggest that it is likely that smaller individuals of *Ameerega picta* have smaller home ranges than bigger ones but that individuals of *Leptodactylus spp* different in size would not necessarily differ in home range size. More data is needed to be able to make stronger generalizations about these types of relationships.

Conclusions

The research in the 4 newly established trapping sites in La Chonta show a four times higher capture rate of amphibians over reptiles. Amphibian species and individuals have a preference for forest near streams over forest matrix microhabitat. Abundance and species richness of reptiles however is highest in forest matrix site 2. This preference could be due to the more open vegetation structure in this site, compared to the other 3 sites. This is however not proven by the vegetation analysis.

The presence of amphibians and reptiles in a specific site is not caused by the differences in vegetation preferences as measured in this research. The amount of captured animals was significantly dependent on weather events. Especially rain events show a positive correlation with the amount of amphibians in the traps. The created model to predict the amount of amphibians in the traps is dependent on air pressure 2 days before capture, precipitation in La Chonta one day before capture and the mean amount of precipitation in La Chonta from the day before and the day of capture. Of these 3 parameters only precipitation in La Chonta one day has a positive influence. For the reptile capture model has only one parameter; the mean amount of precipitation from 3 days before till the day of capture which has a negative influence.

Assuming that longer legs or thicker thigh muscles (measured as leg circumference) produce more jump velocity in frogs or run capacity in lizards, longer legs or stronger thighs could lead to a larger maximum distance moved. This seems to be true for the frog species *Ameerega picta* which correlates longer body and leg length to a larger distance moved. The largest distance moved is correlated with the leg circumference for the toad *Rhinella margaritifera*. Leg length is correlated with the largest distance moved for the lizard *Stenocercus caducus*. When these species are analysed together larger body size indeed leads to a larger distance moved, the only measurement I could make for home ranges with these data.

Recommendations

Based on my experience with this type of research I would like to provide the following recommendations for similar studies:

- The next time the bucket-grid system is used, small mammal data can also be obtained and analysed, since many small rodents and marsupials are trapped in the buckets as well as amphibians and reptiles. The small mammals can be marked in the same way as the reptiles and the amphibians, by cutting toes in different sequences. The toes could be used for DNA-research to determine, for example, if animals from different sites are related to each other.

- For further research on amphibian movement and weather conditions I think it would be better to measure the weather conditions (humidity, temperature, precipitation) at the same place as the animals are captured. Especially rain data would be nice to obtain on site as this can differ within very short distances. I suspect that reptile movement depends mostly on sun shine on basking places, which is harder to measure as basking places can be really small areas. Canopy openness or the amount of sun penetrating to the forest floor combined with cloudiness might be good predictors for reptile movement.

- When new trapping sites are established, I would strongly recommend paying special attention to preserve the current vegetation as much as possible. Another possibility would be to leave the sites for some time after trap establishment to let the vegetation recover before the first trapping event. Also series of trapping events could be held without clearing the sites before trapping to see if the species richness and composition change over time in an undisturbed environment.

- To have trapping periods of at least 30 days to heighten the chance of having as much rainy days and recaptures as possible to gather enough data to establish home range sizes of amphibians. Trapping periods to establish the home range for reptiles are probably best held in the dry season, optimizing the amount of sunny days and lizard movement, although reptiles seem to be less abundant and therefore caught less often than amphibians.

- It would be nice to compare (re)capture data from just after the drought period and some months into the raining season; both in the forest and near the streams. Animals that have moved to the stream to survive the dry season can be separated from the animals that have their home ranges near the stream.

- For better comparable results about lizard home range or ecology it would be better to not only measure the body length, but also the body weight of the animals, as most research on lizard size has been done comparing body weight.

- In the search of an umbrella species to monitor the effect of logging on certain animal groups the frog species *Leptodactylus spp* and the lizard species *Stenocercus caducus* might be interesting for further research. The frog species *Ameerega picta* and *Leptodactylus mystaceus* however are able to get out of the traps by themselves through climbing or jumping which makes them unsuitable as indicator species.

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Appendix

1. Map of the permanent experimental plots of IBIF in La Chonta