A Survey of Anuran Distribution in a Costa Rican Cloud Forest

By Toby Jacobs

Project Title

Distribution and Abundance of Anuran Populations in Disturbed Areas and Primary Forest in Cloudbridge Nature Reserve, Costa Rica

Summary

This study will gather data on the anuran population at a mid-elevation nature reserve in Costa Rica. An inventory and count of frogs and toads at selected locations will provide the data for an analysis of species richness and diversity with respect to other reserves in which similar surveys have taken place. The results will enable an evaluation of field research methods and provide a baseline for further studies at Cloudbridge and elsewhere. These studies are crucial to implementing an intelligent and informed approach to conservation. A total of 13 species were observed during the course of this study, mostly small, diurnal leaf litter frogs. Evidence of many more exists, but is awaiting expert analysis. Similar records from other reserves (including Parque Nacional Chirripo) have not yet been obtained, but will later aid in comparative analysis. The visual survey method (discussed below) proved to be the most effective field technique for ground-dwelling species.

Principal Investigator

Toby Jacobs

jacobsts@jmu.edu

Context and Goals

The Cloudbridge Nature Reserve represents a small part of the Talamanca – Bocas del Toro corridor, extending from mid-Costa Rica to northeastern Panama (CEPF Portfolio). This is one of the three main intact natural areas in the MesoAmerica "hotspot," a broader area which is consistently recognized as one of the top five hotspots in the world with respect to species richness and endemism but also level of threat (CEPF Portfolio). Numerous anthropogenic forces have been identified, which appear to be affecting biodiversity in such areas, and various organizations have begun providing grants and conducting research, so that these areas may be better understood, and conservation efforts can be made more concerted and efficient. It follows that studies that profile specific areas within the corridor represent valuable resources, providing insight into forest types, species composition, and ecological relationships.

An average temperature of 17.5 degrees Celsius and annual rainfall of approximately 3,300 mm places the Cloudbridge Reserve on the cusp between lower montane wet forest and montane wet forest, according to the Holdridge System (Holdridge 1967). This type of environment is associated with a dense understory, a 25-30 meter canopy level, and a relatively high number of epiphytes (Savage 2002). Additional traits of the area can be predicted from its classification as a cloud forest (Kappelle 2001).

The fog and mist that persist in cloud forests are caused by a combination of tropical weather phenomena. Warm air from the Pacific lowlands rises, and as it does so it is blown by the trade winds towards the mountains. The high elevation causes water in the air to condense, thereby providing an excess of moisture in the form of rain and mist to the mountainside (Savage 2002). The term "cloud forest" has been applied to a number of different areas, but is not well-defined outside of a few generalities. Some universal characteristics include the following: The phenomenon of cloud forest formation tends to be fairly localized (Gomez 86), resulting in narrow altitudinal zones, persistent, frequent, or seasonal cloud cover at the level of vegetation, and tends to provide enough moisture in the air so as to suppress evapotranspiration and provide significant precipitation in addition to rain (Hamilton et al. 1993). Additionally, cloud forests tend to have a very high biomass of epiphytes, and endemism is common. Despite these guidelines, forests occurring in an extremely wide range of temperatures and precipitation levels are classified as cloud forest (Hamilton et al. 1993). Ultimately, the Holdridge system, in conjunction with the current knowledge of cloud forests, fails to provide an acceptable profile of the ecosystem.

Despite difficulties in classifying the forest, both general and specific information concerning the Cloudbridge area bespeak the fragile nature of the ecosystem and the need for conservation. The combination of disturbance and the probable high level of endemism in this area suggest that more should be known about the current state of various species groups in the Reserve. Such information is crucial to implementing an intelligent and informed approach to conservation.

Anurans in the Cloud Forest

For reasons to be discussed below, knowledge of the state of anurans in any biome provides a basis for understanding the ecosystem as a whole. Thus an inventory of the richness and diversity of anuran species in the Reserve is an important step in the process of categorizing the forest type and grasping the underlying processes and trends occurring within it.

Anurans constitute an important part of the ecosystem for a variety of reasons. They tend to accumulate very high population densities due to their combination of small size and the efficient energy use associated with ectothermy (Pough 1983). As abundant prey in the larval stage, and predators as adults, they are important regulators of arthropod populations (Savage 2002, Guyer 1990). They are eaten by almost all larger predators, and some species of snakes rely solely on anurans for sustenance (Savage 2002).

Frogs and toads tend to be highly versatile, having survived as a taxon for 150 million years (Savage 2002). They occupy a wide variety of macro- and micro-habitats, ranging from fossorial, to aquatic, to terrestrial, to canopy species. Anurans are also able to endure a wide temperature range, unlike other ectotherms like reptiles (Savage 2002). However, despite the many-faceted nature of their adaptations and proven evolutionary success, anuran populations worldwide have declined in the past 20 years, and they have been shown to be important bioindicators for a number of reasons.

Much of the susceptibility of anurans stems from their biphasic life cycle (Savage 2002). Contamination in either the aquatic or terrestrial part of the environment can have a serious effect on whole populations. Also, sub-cutaneous breathing (through the gills/lungs and skin) and nearly universally aquatic larvae represent a permanent dependence on water. Any change in water quality can be to toxic to anurans, while a lack of water, even for a short time, induces dehydration (Savage 2002).

It is fairly easy to predict how certain anthropogenic forces, such as cattle farming in the Cloudbridge area, could induce such changes in the ecosystem. However, much of the observed population declines have been due to some other agent, the origin and exact cause of which is still not universally agreed upon (Blaustein & Wake 1990). Serious declines began in the mid 1980's, and even populations in isolated, protected areas were affected. The pattern of population decline in Central America has been interpreted to represent an epidemic (Lips 98), probably stemming from a skin disease called chytridemiosis, caused by a water-borne fungus (Berger et al 1998). In Central America, there have been 40 recorded cases of extirpation/extinction of anuran species with nine total families and 30 genera also showing effects (Young et al. 2001). When one considers the severity of the threat in a region where endemism is already high and across-the-board anuran declines are taking place, the current lack of, and future need for, scientific study becomes apparent (Young et al 2001). The realization of the extent of the damage that has already occurred as well as the threat of future losses has been very recent (Wake 98), and this is likely due to the lack of availability of baseline data (McCoy 94). In addition to the threat level throughout Central America, declines appear to markedly increase at about 500 m elevation (Young et al. 2001).

All attributes of Cloudbridge point to its candidacy as an at-risk area harboring high diversity and abundance, as well as a high likelihood of endemic species. Developing an inventory of species and their respective abundances will help to further understand the current state of anurans in the reserve from a conservation standpoint. Additionally, it will provide an avenue by which Cloudbridge and other geographically similar and/or "cloud" forests can be statistically compared. Jay Savage (2002) sums up the substantial role that anuran study can play in the greater goal of Cloudbridge: "Since amphibians are the most sensitive vertebrate bioindicators of environmental health, the Costa Rican examples will illuminate issues in evaluating and conserving tropical biodiversity overall".

Assessment of Collection Methods

There are at least ten principal survey methods used in projects of this scope, in which the goal is to encounter as many different species as possible (Rocha et al. 1994). However, because of constraints related to available field time, personnel, and equipment/funding, only the following will be considered for this study:

1) *complete manual inventory*: a comprehensive manual search of the horizontal and vertical aspects of an area, including minor disturbances, such as digging up leaf litter and moving rocks/logs (Rocha et al. 1994).

2) *patch sampling*: searching for all of the anurans in a particular type of habitat within an area e.g., inside all tank bromeliads (Heyer et al. 1994).

3) *visual survey:* a complete, but non-intrusive search in which an individual must be seen to be counted. This can be done in transects, plots, or randomly to represent a larger area.

4) *pit-fall traps with drift fence*: a plastic fence, about a meter off the forest floor, is arranged so as to form two sides of a triangle, the base being a stream or cliff, the tip being a receptacle dug into the ground. Standing water would be present in at least part of the receptacle in case an entire night or day passes before it is checked. (Rocha et al. 1994)

5) *audio sampling*: audio strip transects (Zimmerman 1994) can be set up along a stream or other lentic water source. The imaginary lines of the transect are formed either by the radius formed by what the researcher can hear or the radius formed by what recording instrumentation is able to pick up. A number of methods of digital recording and consequent computer analysis are being researched and developed to complement this mode of data collection. Less formal audio sampling will also be conducted.

A study of the relative efficiencies of various surveying methods in the resting environment in Brazil found that richness and abundance (per minute of fieldwork) were maximized by a complete manual inventory (Rocha et al. 94). No anurans were collected using the pit-fall trap. However, the pit-fall trap method has been shown to be very effective in dense, primary forests in past studies (Heyer et al. 1994). These contrasting findings, based on radically different habitat types, can perhaps be applied to analogous differences between cattle pastures and intact forests that are present in the Cloudbridge area.

Restinga and cattle pastures both tend to be open, flat, with at least a small amount of water present. This type of terrain and increased visibility makes the job of researchers conducting a complete manual inventory fairly simple, because there is only one vertical habitat layer and the terrain permits an extensive search. The manual inventory method is less effective in primary forests because of the vastly larger number of micro-habitats to be searched, as well as the difficulty maneuvering through dense vegetation.

Pit-fall traps, however, have several advantages within primary forest sampling sites. First, the apparatus is set up, left overnight, and then checked each morning. Thus, collection time is maximized without the actual field presence of the researchers. Also, once specimens are caught they are easily contained. Thus, more thorough diagnostic information can be taken, permitting easier identification (Heyer et al 1994). Pit-fall traps are also a good way to find the rare species that are sometimes encountered in the primary forest (Rodel and Ernst).

Introduction Concluded

When completed, this study will yield a data set that can be compared to other established study sites based on overall species richness, as well as habitat preferences. In addition, a relatively complete list of species for the area will be compiled from a variety of methods applied to the different forest types encountered within Cloudbridge. The data from the study will provide an excellent base for future anuran investigation in the area, and the relative successes of the various methods will also help to construct an effective and efficient protocol for future projects. A more thorough understanding of the anurans in Cloudbridge and the specific role they play will aid our understanding of the cloud forest ecosystem and will allow us to more effectively focus efforts of conservation.

Report on the Study

Methods

The already established pit-fall trap and visual survey methods were used in the former part of the study, and random audio sampling was used in the latter. It would have been useful to have explored some of the other methods for comparative analysis, and hopefully they can employed by researchers in future studies.

The pitfall-trap array was set up in the following fashion: a drift fence, approximately 10 m long and 50 cm high was buried under the leaf litter, perpendicular to the slope of the hill. Buckets were buried, flush with the level of the soil, at either end of the fence, and a bucket was also placed flush with the fence in its center on either side. This entire apparatus is known as the pit-fall trap array (Figure 1). Five arrays were set up in the Smithsonian hectare – one in the center of each of the corner quadrats (1, 6, 21, 25) and one in the center quadrat (13) (Figure 2). Traps were checked and emptied for a period of 6 and then 4 consecutive mornings. In between the sampling periods was a 3-day span intended for re-acclimation.

Visual surveys were conducted at the same time as pit-fall sampling, the transect route being a relatively straight path between each pit-fall array in the following order: 21, 25, 5, 1, 13. Any encountered individuals were captured by hand, and were often collected for a short time to aid in identification.

Most identification of individuals encountered using these methods was done using the keys and descriptions in Savage's seminal 2002 work, The Reptiles and Amphibians of Costa Rica. Dr. Mason Evans provided some additional expertise. Audio sampling was conducted on three separate dusk/nights. The first was around the Casa Amanzimtoti area, the second was in the hectarem (primary forest), and the third was in a single canopy tree in the hectare. There was no defined area inside of which sampling occurred, but an attempt was made in each recording to target a specific conspicuous sound.

Analysis of audio samples was conducted by digitally shortening and enhancing the targeted calls and recording relevant data: frequency (range), pitch, and pulse rate. Various experts and Savage's book are being consulted to aid in identification.

Figure 1 – Pit-fall Trap Array

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Figure 2 – Pit-fall Array Set-up in Hectare

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o o--------------o o				o o--------------o o

A1 F1

Results

12 different species have been found (Table 1). Audio analysis is ongoing.

Table 1 – Species Found

Species	**Method**	**Location**	**Temporal Habit**
Eleutherodactylus crassidigitus	Visual survey	Mediation Garden	Diurnal
E. podiciferus	Visual survey/Pitfall trap	Hectare	Diurnal
E. cruentus	Visual survey	Hectare	Nocturnal
E. ridens	Visual survey	Amanzimtoti/Hectare	Diurnal/Nocturnal
E. stejnegarianus	Visual survey/Pitfall trap	Hectare	Diurnal/Nocturnal
E. gollmeri	Visual survey	Hectare	Diurnal
E. fitzingeri	Visual survey/Pitfall trap	Hectare	Diurnal
Craugastor (E.) bransfordii	Pitfall trap	Hectare	Diurnal
Craugastor melanostictus	Visual survey	Hectare	Diurnal
Bufo marinus	Visual survey	Amanzimtoti	Nocturnal
Unknown #1	Visual survey	Amanzimtoti	Diurnal
Unknown #2	Visual survey	Hectare	Diurnal

Discussion

Any discussion of the ecological implications of this survey would, to be curt, be preliminary and unfounded. This is owing to the relative simplicity of the experiment, small sample size, short duration of the survey, and lack of relevant comparative resources at this time. However, the relative merits and drawbacks of each of the utilized methods can indeed be analyzed at this time.

The most carefully and consistently employed survey method was the pitfall trap. Only four species were caught in the traps, only one of which was unique across all methods. However, the pitfall is the only type of survey which will reliably present a cross-section of nocturnal species. Main drawbacks include the potential to catch only leaf-litter individuals, as well as sampling a very limited area.

Visual surveys yielded the most species, curiously including some that are thought to be nocturnal. If employed persistently, this probably represents the most reliable way to identify the most common diurnal, leaf-litter species. Shortcomings of this method would be encountered if one were interested in organisms not in this category, which according to established records, could be upwards of twenty additional species. Planned night-time visual surveys in the hectare yielded just one species, another individual of which was also encountered during the day.

Clearly, there are some large spatial and temporal gaps remaining before this survey can be considered complete. Audio sampling seemed to be a revolutionary and efficient way to really nail down the rest of "what's out there." The recording and editing process went fairly smoothly, but meaningful analysis has proved both elusive and frustrating. There appears to be a severe lack of accessible expertise in this relatively young field, though it is still being sought.

Conclusion

Despite the short sampling time and limited space, it is very possible that many or all of the diurnal, leaf-litter species have been identified. I recommend repetition of the same methods in the same areas of the Smithsonian hectare, as well as other regions within Cloudbridge to help confirm and expand upon these preliminary results. I believe that audio sampling will, for the time being, prove fruitless – other methods of sequestering and/or identifying rare/canopy/nocturnal species should be explored. I believe that this study represents a good general knowledge base of Cloudbridge's anurans, and I am optimistic that future baseline surveys and subsequent specific studies will continue to enrich the reserve and the rest of the scientific community.

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