Anuran species diversity and density as measured through mating calls at the Firestone Reserve for Restoration Ecology in Barú, Costa Rica

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ABSTRACT

Given the vast amount of deforestation that has taken place as a direct result of human destruction, it is important to study the restoration progress of ecosystems. Studying anuran activity in forest restoration areas is very useful in determining the health of the ecosystem. Amphibians are good indicators of the status of the forest restoration progress due to their dualistic aquatic and terrestrial lifestyle. Their extremely porous skin makes them very susceptible to the solutes present in their aqueous environment. A typical tropical anuran species requires a clean freshwater source, consistent food, rain, sunlight, and healthy flora. Rates of restoration directly correspond to rates of increasing biodiversity. The following study looks at anuran biodiversity during a 10 minute period at dusk time at the recovering Firestone Center for Restoration Ecology in Barú, Costa Rica. It was hypothesized that an increase in species diversity and density would indicate a healthier ecosystem. The diversity and density of anurans was measured by identifying mating calls of the males at each of the four man-made ponds on the reserve. The calls were recorded with an automated digital recording system and positively identified by taking the Fast Fourier Transform (FFT). The FFT transforms the oscillogram of the anuran call to a graphical representation of the dominant call frequencies. Each species has different dominant call frequencies, making it possible to positively identify each species based on solely audio data. At each pond, the present species were identified and the average call rate (calls/minute) calculated. It was found that the dominant species during dusk time throughout the ponds were *Agalychnis callidryas, Leptodactylus pentadactylus*, and *Hypsiboas rosenbergi* (Chi-square test, $p<0.0001$).

INTRODUCTION

Restoration ecology is a very important field of biology given the immense amount of land that has been altered or destroyed as a direct result of manmade development. By studying an area of land that has been dramatically altered from its primary state, one is able to use that information towards other similar ecosystems. In the case of the 60 hectare property, the Firestone Center for Restoration Ecology (FCRE), it is getting closer each year to its complete restoration of moist lowland rainforest. Located in southwestern Costa Rica, near the town of Dominical and adjacent to the 330 hectare Hacienda Barú Reserve, FCRE was once transformed into grassland for cattle farming. There were a few patches of riparian forest preserved. Since the 1990's it has been a site of restoration, and now it consists mainly of secondary moist forest. The ponds tested in the study reside on the upper reaches of the property at elevations averaging 100 meters above sea level. Two of the ponds, Basilisk and Frog, reside within the bamboo forest on the property. Creek is on the outskirts of the bamboo forest and Duck Pond has one border consisting of bamboo while the other consisting of secondary forest.

The restoration process is slow and gradual; however, one is able to measure the degree of restoration by

studying different aspects of the ecosystem. Looking at what kind of fauna the ecosystem is able to support is a great way of measuring healthiness. Particularly, amphibians are great indicator species of the health of an ecosystem because of their dual terrestrial and aquatic lifestyles (USGS, 2004). Given their lifestyle there must be adequate sources of water for reproduction as well as constant food sources. At the FCRE, by studying the anuran diversity at the four man-made ponds over time, it will be possible to track the population changes of the anurans. This study was started in the summer of 2006, and the following data was collected in the summer of 2007. In the 2006 study, 14 species of frogs were identified on the property as well as handful of calls. In this previous study, one night's data at Duck Pond was analyzed.

The easiest and most efficient way of determining which species are present at a given time is to record the males' mating calls at the site of choice. One is then able to properly identify which species are present and determine the relative population of that species. This is a long-term study and as more data is collected and analyzed, it will be possible to quantify the restoration progress as through anuran species diversity. The dominant species at 6 P.M. throughout the four ponds were analyzed in this study.

METHODS

Recording System

The recordings were obtained at the four upper ponds on the property: Duck, Creek, Basilisk, and Frog Ponds. The ponds share the same relative elevations. The specific moon phase of the nights recorded are unknown, all the nights recorded received adequate precipitation in the day and/or evening time. The mating calls were recorded using a Sony Minidisc Walkman and a specially designed programmed controller. The controller plugged directly into the Walkman, and controlled when the Walkman would turn on and record. The recording device would be placed at the pond of choice and turned on, half an hour later, it would start recording for ten minutes. It would then cease to record for fifty minutes, and then turn back on and record for another ten minutes. This process was repeated a total of six times, producing a total of an hour of raw audio data. In this study, only the first ten minute recordings were analyzed at each of the four ponds.

Data Analysis

The main method of analyzing the data consisted of listening to the audio and individually indentifying the anuran species second by second using the signal program Audacity. It was possible to identify most of the species by listening to the call library created from the previous study and by obtaining mating call audio files from reputable sources and then comparing them to the raw data. However when it was not possible to audibly identify the species, taking the Fast Fourier Transform (FFT) of the audio signal was necessary. An FFT is a mathematical algorithm that when applied to an audio signal, displays the dominant frequencies of that audio signal. Using the software Sigview, the dominant frequencies were obtained and compared to values obtained from JM Savage (Savage 2002). Each anuran species has specific mating call frequencies, therefore taking the FFT of a mating call is very precise and accurate in positively identifying the anuran species. The average calls per minute was calculated when all species were positively identified. A Chi-square test was used to analyze the data.

RESULTS

It was found that at the 6 P.M. time interval, *Agalychnis callidryas, Leptodactylus pentadactylus*, and *Hypsiboas Rosenbergi* (Chi-square test, $p<0.0001$) were the most dominant calling species between the four ponds. *Hypsiboas rosenbergi* was initially an unknown species, but when the FFT was taken, it was positively identified as *H. rosenbergi (Figure 2)*. Mr. Jay Savage personally confirmed this species given the FFT data and an audio sample of the call.

Table 1. Average calls per minute of each identified species at the four ponds at dusk time (n=10)

Species Name	Duck	Creek	Basilisk	Frog
H. rosenbergi	N/A	105.3 ± 5.0	155.6 ± 1.8	147.8 ± 2.8
A. callidryas	41.3 ± 6.6	24.3 ± 1.9	37.9 ± 1.6	63.1 ± 3.0
L. pentadactylus	48.5 ± 3.3	N/A	44.1 ± 0.9	25.7 ± 1.8
B. marinus	4.8 ± 1.8	N/A	5.7 ± 0.9	N/A
H. microcephala	13.6 ± 3.6	N/A	N/A	N/A
H. diastema	N/A	30.9 ± 2.2	N/A	N/A
H. ebraccata	1.9 ± 0.8	9.9 ± 0.5	N/A	N/A

Table 2. Total number of calls made during the ten minute dusk time period

Species Name	Total Calls	% of Total Calls
H. rosenbergi	4,086.0	51.7
A. callidryas	1,799.0	22.8
L. pentadactylus	1,184.0	15.0
H. ebraccata	383.0	4.9
H. diastema	309.0	3.9
H. microcephala	68.0	0.9
B. marinus	67.0	0.8

DISCUSSION

It was found that at dusk time there were three dominant calling anuran species: *H. rosenbergi*, *A. callidryas*, and *L. pentadactylus* (Chi-square; $p<0.001$). At this time period, throughout the ponds, *H. rosenbergi* held the majority of the total amount of calls. It is not possible to difinitively state that there were more individuals of *H. rosenbergi* present than other species because each species calls per minute is different. *H. rosenbergi* has very high calls/minute, averaging 58 (Savage 2002). Therefore according to Figure 1, the number of calling individuals recorded was approximately two. The goal of determining which species are present and their relative abundance at the different ponds was achieved. By being able to compare species abundance at different ponds, then it is possible to discern why there are those differences. Each pond has a different ecosystem from one another, and knowing which characteristics promote higher biodiversity and abundance is very important in improving the restoration progress at FCRE. Future work will consist of expanding the data set through recording at different locations and at different times throughout the night.

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