

Population Ecology of the Pacific Tree Frog, *Hyla regilla*, in Corn Lily (*Veratrum californicum*) Meadows Near Yuba Pass, California

Abstract

We examined aspects of the population ecology of the Pacific Tree Frog (*Hyla regilla*) in a meadow of Corn Lily (*Veratrum californicum*) in the Sierra Nevada Mts. during July 2000. Using mark-recapture techniques we estimate the abundance of *H. regilla* to be 25 ± 6.8 individuals which translates into a population density of 223.2 ± 60.7 individuals per hectare. The sex ratio of the population of animals captured was strongly female biased and the distribution of captured animals was significantly aggregated.

Introduction

The Pacific Tree Frog, *Hyla regilla*, occurs in western North America over a wide range of elevations. Breeding occurs in marshes, lakes, ponds, roadside ditches, and slow streams in woods, meadows, and grasslands from January to July. Mature frogs occupy low vegetation near water (Stebbins 1966, 1972). We studied a population of *H. regilla* in a high altitude (2167 m) meadow in the Sierra Nevada Mountains ($39^{\circ} 38' 53''$ N and $120^{\circ} 31' 01''$ W) between July 11-13, 2000. Our goals were: 1) to estimate the abundance and population density, 2) to determine the sex ratio, and 3) to assess the degree of aggregation of mature frogs within corn lily patches.

Methods

To estimate the abundance of Pacific Tree frogs, we surveyed a region covered with a dense population of corn lily (*Veratrum californicum*). We chose this region because we had previously observed *H. regilla* to perch on corn lily plants during the afternoon. Our study region consisted of a 0.112 ha patch with its long axis (50 m) oriented north-south. The western side of the study patch was adjacent to Fir forest, and the eastern side was adjacent to a grassy meadow. The main axis of the study patch was oriented down slope toward a willow-lined stream. A pond with standing water in which tadpoles of Pacific Tree frog and new metamorphs were abundant was located approximately 100 m northeast of the study patch.

Estimating Corn Lily Density - To characterize the density of Corn Lily in our study plot we randomly tossed a 0.25 m^2 quadrat 10 times within the study patch. We counted the number of stems found within each quadrat and report the means and standard error of the number of stems per m^2 .

Capturing Animals - Pacific Tree frogs were sampled on two days (July 11-12). Both capture periods occurred from approximately 10:30 am until 2:00 pm PDST. On each day the study patch was surveyed by three observers who haphazardly walked the patch from the northern to the southern end. Capture techniques were similar among us in that 1) the movement of the frogs allowed for visual identification and 2) the frogs themselves were visually sighted on and along the Corn Lily patches. Once sighted, the frogs were then hand-captured and placed into sealable plastic bags. The bags and location, marked with flags, were given numbers for later

identification. The Capture Efficiency (CE) for both days was determined by dividing the number of individuals by total caught. The CE for Day 1 was 86% and for Day 2 was 88%.

Recognizing Recaptured Animals - To identify re-captured animals, we recorded mass, length from anterior to posterior ends, head width, and dorsal markings of each animal. Mass, length, and width of Pacific tree frogs are moderately variable. Dorsal spotting in Pacific tree frogs is highly variable. We recorded mass using a digital scale to the nearest tenth of a gram, length and width using calipers to the nearest millimeter, and dorsal markings by sketching any significant spotting.

Estimating abundance and density of *Hyla regilla* - We estimated the abundance of *H. regilla* using the Lincoln population estimator. Since we anticipated that our exhaustive search of the study patch would not lead to a complete enumeration of the population, we wished to apply an estimator that would not be biased toward under estimating the abundance of tree frogs. On day one of our study we captured and marked 12 animals ($n_1 = 12$, using individuals specific spot patterns). On day two we captured 7 animals ($n_2 = 7$), 3 of which were recaptures ($m = 3$). Given the small size of the marked population we used these values and calculated our estimate of abundance (\hat{N}) using Chapman's biased corrected formula for the Lincoln estimator as:

$$\hat{N} = \frac{(n_1 + 1)(n_2 + 1)}{(m + 1)} - 1,$$

with variance and standard errors given below:

$$Var(\hat{N}|N) = \frac{(n_1 + 1)(n_2 + 1)(n_1 - m)(n_2 - m)}{(m + 1)^2(m + 2)},$$

and

$$SE(\hat{N}|N) = \sqrt{Var(\hat{N}|N)}$$

(Skalski and Robson 1992). We estimated density (number per ha) by scaling our abundance estimate to the size of our study area (0.112 ha).

Testing for Non-random Spatial Distribution of Captured *H. regilla* - To determine if the distribution of *H. regilla* captures suggested that animals were either aggregated or repulsed in their spatial distribution we measured the nearest neighbor distance between captures on each sample day. To determine if the observed mean nearest neighbor distances differed from that expected under independent random placement, we generated the expected distribution of mean nearest neighbor distances for our study patch using Monte Carlo methods. For each day's captures we generated the expected distribution of mean nearest distances by choosing the observed number of capture locations within the study patch independently and at random, recording the nearest neighbor distances between each simulated capture, and calculating the mean nearest neighbor distance for each iteration. The expected distribution of mean nearest

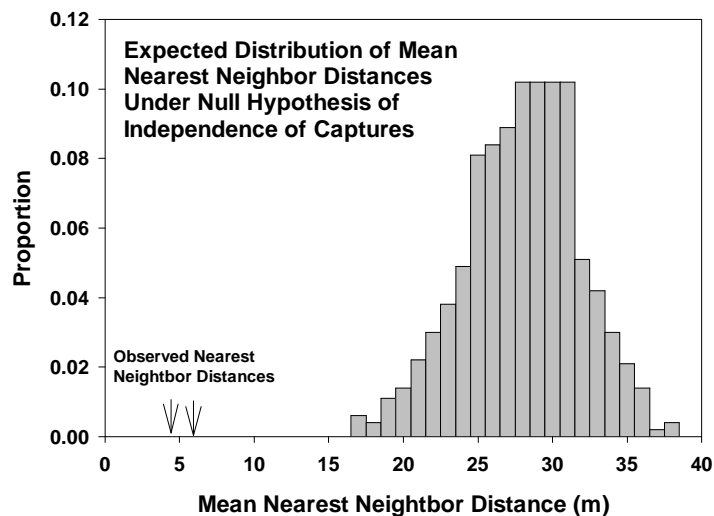
neighbor distances for each sample day was generated using 1000 iterations of this process. We then compared the observed mean nearest neighbor distance for each day to the percentiles of their respective expected distributions to determine if the population of captures each day were aggregated or repulsed.

Test for Equality of Sex Ratio - To determine the sex of captured Pacific tree frogs, we observed the throats of each animal. A wrinkled, olive colored throat indicated male animals. These were recorded. To determine if sex was equally distributed in the population of Pacific tree frogs, a goodness of fit (chi squared) test was used with Yates Correction for Continuity. This would determine the acceptance or rejection of the null hypothesis.

Results

Our estimate of the abundance of *H. regilla* in our study patch was 25 ± 6.8 individuals. This abundance estimate translates into a density estimate of 223.2 ± 60.7 individuals per hectare. The density of corn lily in the study patch was 34.4 ± 9.41 stems per m^2 . The observed mean nearest neighbor distance for the two sample days was 4.4 m and 6.4, respectively. The probabilities of obtaining mean nearest neighbor distances as small as the observed values under the null hypothesis of independent random placement was $p < 0.001$ (Figure 1). Therefore, we reject the null hypothesis in favor of the alternative that the spatial distribution of captures within sample days was aggregated. Of the 16 individual animals captured, only one could be conclusively identified as male. Under the assumption that the remaining individuals were female, one would reject the null hypothesis of equality of sex ratio ($\chi^2 = 12.3$, $df = 1$, $p < 0.0001$).

Figure 1.



Discussion

At Bear Trap Meadows, adult *H. regilla* appear to be concentrated on the meadow forest ecotone in dense vegetation. Furthermore, captures of animals appear to be aggregated suggesting that individuals frogs prefer similar habitat or that they may be interacting socially. While new metamorphs (approximately 1 cm in length) were observed leaving the pond on the north side of the meadow, none were detected in the dense patches of corn lily. However, this may simply reflect our inability to detect these animals, not their absence from these habitats. Without estimates of abundance from other sites, it is impossible to determine if the population of *Hyla regilla* in Bear Trap meadows is unusually large or small.

Literature Cited

- Skalski, J.R. and D.S. Robson. 1992. Techniques for Wildlife Investigations. Academic Press: San Diego, CA.
- Stebbins, R.C. 1966. Field Guide for Western Reptiles and Amphibians. Houghton Mifflin: Boston.
- Stebbins, R.C. 1972. California Amphibians and Reptiles. University of California Press: Berkeley, CA.