

# Population Ecology of the Pacific Tree Frog, *Hyla regilla*, in Bear Trap Meadows Near Yuba Pass, California, July 2001

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## Abstract

We examined aspects of the population ecology of the Pacific Tree Frog (*Hyla regilla*) in a meadow in the Sierra Nevada Mts. during July 2001. Tree frogs were captured most frequently in patches of Corn lily (*Veratrum californicum*) along the meadow-forest ecotone. Using mark-recapture techniques and Chapman's biased corrected version of the Lincoln estimator and the Model M(0) from the program "Capture," we estimated the abundance of *H. regilla* to be  $22 \pm 7.37$  individuals and  $32 \pm 16.0$ , respectively. When scaled for the area sampled, July 2001 densities were between 48-68 animals ha (Chapman's estimator =  $47.99 \pm 15.84$  ha, estimate from Model M(0) from Capture =  $68.77 \pm 34.4$  ha). If estimates are scaled only for the areas of sample blocks with dense populations of Corn lily, then population densities in 2001 were approximately 50% lower than in July 2000. Differences in moisture availability between years probably account for the observed differences in the abundance of *H. regilla*. The pond in Bear Trap meadows held water and tadpoles on 13 July 2000, but had been dry for some time by 9 July 2001. Furthermore, Corn lily patches were smaller in area, and individual plants much shorter in height in July 2001 in comparison to July 2000, hence providing less cover and foraging substrate.

## 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° 38' 53" N and 120° 31' 01" W) between July 10-12, 2001. Our goals were: 1) to estimate the abundance and population density, and to assess the degree of aggregation of mature frogs within the study area.

## Methods

To estimate the abundance of Pacific Tree frogs, we surveyed a region on the meadow-forest ecotone covered in spots with a dense population of corn lily (*Veratrum californicum*) and in other areas only sparsely vegetated. We chose this region because we had previously observed *H. regilla* occur in this area in July 2000. Our study region consisted of a 0.4653 ha patch with its long axis (205 m) oriented north to 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 dry pond from which metamorphs of the Pacific Tree Frog presumably emerged was located approximately 100 m northeast of the study patch.

Capturing Animals - Pacific Tree frogs were sampled on two days (July 11-12). Both capture periods occurred from approximately 10:00 am until 1:30 pm PDST. On each day the study patch was surveyed by ten 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 the ground and on vegetation. 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.

Recognizing Recaptured Animals - To identify re-captured animals, we photographed each animal from the dorsal side and recorded unique markings. Size and overall color of Pacific Tree Frogs are moderately variable, but variation in the size and shape of dorsal spotting made individual identification possible. Photographs from the first day of capture were compared to those obtained on the second day to determine the number of re-captured animals.

**Figure 1. Variation in markings of Pacific Tree Frogs.**



Estimating abundance and density of *Hyla regilla* - We estimated the abundance of *H. regilla* using the Lincoln population estimator and using the Program "Capture" (Otis et al. 1978, White et al. 1978). 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). Using the program Capture, we first tested the assumption of closure for our population, and used the model selection algorithm to choose the best model to fit to the data (Otis et al. 1978, White et al. 1978). We estimated density (number per ha) by scaling our abundance estimate to the size of our study area (0.4653 ha) or to the size of regions with patches of Corn Lily (0.1841 ha).

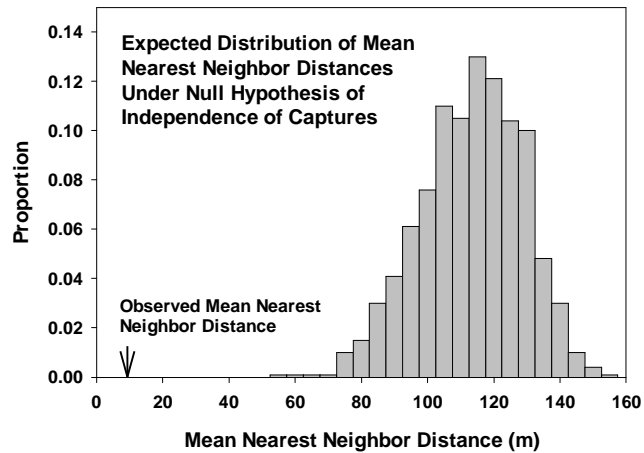
Testing for Non-random Spatial Distribution of Captured *H. regilla* - To determine if the distribution of *H. regilla* captures suggested that animals were either aggregated or repulsed in their spatial distribution we measured the nearest neighbor distance between the combined set of captures from the two sample days. 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. 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 was generated using 1000 iterations of this process. We then compared the observed mean nearest neighbor distance to the percentiles of their respective expected distributions to determine if the population of captures were aggregated or repulsed.

## Results

Our estimate of the abundance of *H. regilla* in our study patch was using Chapman's estimator was  $22 \pm 7.4$  individuals. The Program Capture indicated that the assumption of closure for our population was not reasonable. However, the model selection algorithm suggested that Model M(0) (one with a constant probability of capture) was most reasonable. The capture probability was estimated as  $\hat{p} = 0.2623$ , and the estimated abundance of *H. regilla* as  $32 \pm 16.01$ . These abundance estimates translate into density estimates of  $47.99 \pm 15.84$  and  $68.77 \pm 34.4$  individuals per hectare, respectively, across the entire study area. However, if estimates are scaled only to include sample blocks with Corn lily patches then the density estimates are

121.27±40.02 and 173.79±86.9 individuals per ha, respectively. The observed mean nearest neighbor distance across the two sample days was 6.95 m. 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.

**Figure 2. Nearest neighbor analysis.**



## 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. 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. If abundance estimates are scaled only for the areas of sample blocks with dense populations of Corn lily, then population densities in 2001 were approximately 50% lower than in July 2000. Differences in moisture availability between years probably account for the observed differences in the abundance of *H. regilla*. The pond in Bear Trap meadows held water and tadpoles on 13 July 2000, but had been dry for some time by 9 July 2001. Furthermore, Corn lily patches were smaller in area, and individual plants much shorter in height in July 2001 in comparison to July 2000, hence providing less cover and foraging substrate.

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