Preliminary Estimation of Capture Rates for Red-Backed Salamanders at the Randolph-Macon College Environmental Field Station, Doswell, Virginia

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Introduction

As concerns for the conservation of amphibian species rise, there has been an increased effort on the part of biologists to develop methods to better monitor populations (Pounds et al. 2006, Adams et al. 2013). Rigorous monitoring methods are especially needed for salamander populations as information is lacking on the long-term population trends of these species (Hyde and Simons 2001, Bradford 2005). This lack of information is, in part, due to the difficulty of detecting salamanders in their habitats. Capture rates for salamanders can be expected to vary substantially across habitats and seasons (Bailey et al. 2004a). In light of this variability, there is value in determining important capture rate patterns for specific salamander populations that have potential for long-term monitoring in regions or habitats of interest.

Virginia represents a hotspot for salamander diversity (55 species: Mitchell and Reay 1999), so there is a particular need for more region-specific studies within the state assessing salamander life history and monitoring parameters, such as capture rates, particularly in the piedmont regions where fewer population studies have been conducted. Previous studies have focused on the red-backed salamander (Bailey et al. 2004b, Williams and Berkson 2004), which is common in much of the state, including the piedmont (Mitchell and Reay 1999). Bailey et al. (2004b) estimated detection probabilities for this species for populations within the Great Smoky Mountains National Park using model selection techniques with Program MARK (White and Burnham 1999), and were able to develop a credible model holding for approximately half their experimental units. Given this level of success, I wished to see if I could use their basic methodology for a study site in the York River watershed of Virginia. As a preliminary to developing models for estimation in MARK which require large amounts of data to estimate multiple survival, migration, and detection probabilities, I wished to determine whether certain basic aspects of the study design might affect naïve capture and recapture rates (average captures and recaptures across the study period).

Specifically, my objectives were to estimate initial capture and recapture rates of red-backed salamanders over an extended study period at the Randolph-Macon Environmental Field Station (EFS) in Hanover County, Virginia; and to determine whether certain age classes (adult *vs.* juvenile) tended to be captured at higher rates on upland or riparian areas. Secondarily, I wished to determine whether search techniques differed in their effectiveness in relation to upland and riparian sites.

Study Site

Fourteen of Virginia's salamander species (approximately 28% of Virginia's species) occur within the York River drainage (Mitchell and Reay 1999). The Randolph-Macon College Environmental Field Station (EFS) encompasses a small ridge located within this drainage, bordered by the Little River in Doswell, Virginia. Elevation ranges between 150 – 220 m. The

EFS is a 26.7 hectare (66 acres) property in northern Hanover County, Virginia, located about 5 kilometers from Ashland, Virginia (Randolph-Macon College 2010).

Methods

In the spring and summer of 2011, six 25m^2 silt fence enclosures were established at the EFS. Enclosure location was determined by placing a transect line at a random location perpendicular to the Little River on the south side of the property. This transect bifurcated the flat area next to the river (riparian zone) and a rise leading up to the ridge running roughly east-west along the property (upland zone). Three enclosures were placed in the riparian zone, and three enclosures were placed in the upland zone. Enclosures were offset from the initial transect by a random distance of 0 – 50m. If an enclosure occurred within 25m of another enclosure, a new location was determined for it. Silt fences were buried at least 15 cm deep to block movement of salamanders attempting to travel outside the enclosure.

Enclosures were sampled according to Pollock's Robust Design (1982), which has two levels of sampling, a primary sample composed of a short series of secondary samples. Primary samples may be separated by long time periods, but secondary samples must occur over a short enough timespan that the assumption of population closure holds. Primary samples were taken between 17 August – 4 December of 2011, 16 February – 23 May of 2012, 3 October – 6 December of 2012, and 26 February – 8 May 2013; and were separated by a 10-day period on average. They were comprised of 3 secondary samples that took place over a 3-4 day period.

Within enclosures, two types of searches were conducted for secondary samples: a natural cover search, where all cover objects were searched by looking under rocks and woody debris; and a leaf litter search, where five 1m^2 randomly placed quadrats were searched by carefully raking through leaf litter by hand in small parallel strips until all leaf litter had been removed from the quadrat (Hyde and Simons 2001, McGhee and Killian 2010). In fall, when leaf density was high, leaves were removed in smaller sections to increase the likelihood of finding individuals within the leaf layer itself rather than lying between the ground and the leaf layer. All leaf litter was replaced when searches were completed. Captured red-backed salamanders were anesthetized using a 1g/L of maximum strength Oragel® - water solution (Cecala et al. 2007), and measured for total length (TL) and snout-vent length (SVL) to determine age class (juvenile < 65 mm TL, adults >65 mm TL: Petranka 1998). They were then marked with a single fluorescent elastomer tag (Northwesy Marine Technology, Inc., Shaw Island, Washington, USA). Although other studies have used multiple tags per salamander to uniquely identify individuals (Davis and Ovaska 2001, Bailey et al. 2004a), many of salamanders captured in this study were juveniles, and were too small (<25 mm TL) to carry multiple tags. To ensure that individuals could be identified with a single tag, I used four colors (red, pink, orange, green), and varied the location at which tags were placed at one of four locations (at the base of each limb: Davis and Ovaska 2001, Heemeyer et al. 2007). The use of 4 colors and 4 limbs allowed for 16 unique identifiers per enclosure. In addition, the presence of the red dorsal stripe, common to red-backed salamanders (Petranka 1998), but which was absent in a portion of individuals was used in conjunction with elastomer tags as an identifier. When warranted for a particular enclosure, however, captured individuals > 45 mm TL received injections at two limb locations. Alcohol was used to sterilize the needle between marking new individuals. Captured individuals were bathed in distilled water, given time to recover then released back into the enclosure.

I used mark and recapture data to determine naïve capture and recapture rates per enclosure. I compared average capture rates (captures/number of primary sampling periods) and recapture rates (recaptures/number of primary sampling periods-1) between riparian and upland sites using a t-test. I compared juvenile and adult captures in upland and riparian sites by ANOVA. I compared the effectiveness of natural cover searches and leaf litter searches between riparian and upland sites using a Pearson's χ^2-test. For all statistical tests, $\alpha = 0.05$.

Results

Between 17 August 2011 and 8 May 2013, I sampled 12 – 23 primary capture periods and 334 secondary capture periods for all 6 enclosures. One enclosure (Riparian 3) failed to produce any salamanders in the first year of the study, and so was not sampled in the second year. Similarly, the Upland 3 enclosure only produced one red-backed salamander in the first year, and was not sampled in the second. Twenty-one adults and 48 juvenile red-backed salamanders were captured during the study. Twenty-five percent of captures were unstriped morphs (Petranka 1998). Mean SVL for captured adults was 40.07 mm ± 1.13 SE, while mean SVL for juveniles was 23.87 mm ± 0.94 SE. Mean TL for captured adults was 79.00 mm ± 2.48 SE, while mean TL for juveniles was 39.23 mm ± 1.80 SE. Mean capture rates were 0.38 ± 0.09 SE, while mean recapture rates were 0.05 ± 0.02 SE (Table 1). Capture rates were greater than recapture rates ($t = 3.5585$, df = 10, $P = 0.0043$). Primary capture rates did not differ between upland and riparian enclosures ($t = 0.7273$, df = 4, $P = 0.2749$). Recapture rates also did not differ between upland and riparian enclosures ($t = 1.6029$, df = 4, $P = 0.1085$). There was no difference in the number of adults and juveniles in both upland and riparian enclosures ($F_{3,9} = 0.4912$, $P = 0.6321$). Natural cover searches resulted in more captures than leaf litter searches for both upland ($\chi^2 = 9.3077$, df = 1, $P = 0.0023$) and riparian ($\chi^2 = 6.7209$, df = 1, $P = 0.0095$) enclosures.

Discussion

Preliminary results indicate a trap-shy effect in red-backed salamanders, such that individuals are considerably less likely to be recaptured after their first capture. Bailey et al. (2004b) found a similar effect in their most commonly selected model for red-backed salamander populations in the Great Smoky Mountain National Park, USA. Both Bailey et al. (2004b) and I used fluorescent marking which requires significant handling time (Davis and Ovaska 2001). Because of the length of time required to handle these animals, this procedure may stress individuals resulting in migration to the lower soil layers or simply away from the natural cover object they had inhabited upon capture for an extended period.

I found more salamanders using natural cover searches rather than leaf litter searches within enclosures. Hyde and Simons (2001) had a similar result, reporting good capture success with low sampling variability compared to other methods. Natural cover searches are likely to be more effective than leaf litter searches for a variety of habitats, but sampling variability, though lower than for other capture methods, is still high (Hyde and Simons 2001). There is a need to determine what conditions affect natural cover search capture rates.

Location of enclosures (riparian vs. upland) appeared to have little effect on capture rates. These were generic categories, representing the combined effects of drainage, soil type, vegetation, and temperature, but are related at least in part to elevation as well. Bailey et al. (2004a) were able to detect an elevation effect on capture probabilities, but only between their mid and high-level categories, and these categories encompassed distances much greater than ours (330m vs. 22m). My riparian and upland sites may not have been different enough to produce a difference in capture rates. Similarly, neither age group was captured in greater numbers. These non-significant results may be a result of the generally low capture rates at the site.

My analysis assumes that capture and recapture rates for enclosures were constant, but this is unlikely to be the case. While Bailey et al. (2004b) did indeed find that their best model assumed constant rates of capture and recapture. This only held true for 54% of their experimental units. It's likely that these detection probabilities will, in most cases, differ according to important environmental and population level cues, such as region, season, precipitation frequency, soil moisture, vegetative cover, population density, prey density, or predation risk. As captures are likely to be low for most sites, making estimation of these critical probabilities difficult, I recommend a continued analysis of detection probabilities for red-backed salamanders in multiple regions.

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Table 1. The number of primary and secondary sampling periods conducted per enclosure with capture and recapture rates per transect. Data was collected between fall 2011 – spring 2013 at the RMC Environmental Field Station in Doswell, VA.

Location	Primary Sampling Periods	Secondary Sampling Periods	Capture Rate	Recapture Rate
Upland 1	23	69	0.55	0.14
Upland 2	23	66	0.55	0.05
Upland 3	12	34	0.25	0.09
Riparian 1	23	69	0.41	0.05
Riparian 2	22	63	0.52	0.00
Riparian 3	12	33	0.00	0.00