RESEARCH NOTE

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Walking Trails in a Nature Preserve Alter Terrestrial Salamander Distributions

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ABSTRACT: Humans are increasingly altering forested habitats, in part by forestry practices, but also in more subtle ways such as creation of recreational trailways through forested areas, especially in nature preserves and parks. The effect of these trails on wildlife has only recently begun to be addressed. In this paper, I hypothesize that trails alter the distribution of terrestrial salamanders in forested habitats. The routine clearing of fallen trees from trailways may act to increase microhabitat availability for salamanders around trails, and thus move salamanders closer to the trails, or salamanders may simply stay away from trails in general to avoid disturbance associated with humans. To address this issue, I conducted a 3-month study in a nature preserve in northeast Georgia, using standardized, paired surveys of cover objects (logs and stones) in 78 m^2 plots along trails and in similar plots 25 m away from trails. I found significantly more logs in along-trail plots versus off, but there was no difference in stone abundance. There were more salamanders under logs in along-trail plots versus off-trail, but on a per-log basis, there was no significant difference between along- versus off-trails, suggesting that trails result in more microhabitats for salamanders around them, not that salamanders move closer to trails per se.

Index terms: logs, microhabitat, nature preserve, terrestrial salamanders, trailways

INTRODUCTION

Terrestrial salamanders are a secretive, yet important component of any forest ecosystem. They are most active at night and during rain, eating small invertebrates from the forest floor, while also being prey for larger animals. During the day, they hide underneath stones, logs, and debris allowing a straightforward method of surveying. In fact, the presence of woody debris has recently been shown to be important to populations of terrestrial salamanders (Moseley et al. 2004). Further, where there is increased density of cover objects (i.e., logs and stones), there is a corresponding increase in densities of salamanders (Grover 1998).

Humans are increasingly altering forested habitats. The effect of various forestry practices (e.g., logging) is well studied in terrestrial amphibians. It has long been known that the number of salamanders in areas altered by forestry is lower than in those left untouched (Pough et al. 1987). However, we now know that even the act of creating the roads through forested areas can have an effect on terrestrial amphibians (deMaynadier and Hunter 2000; Semlitsch et al. 2007), with some species negatively and some positively affected (Cromer et al. 2002). In addition, normal forest roads (i.e., those not used for logging) can negatively affect the abundance of some species of terrestrial salamanders but not others (Marsh and Beckman 2004). At a smaller scale, humans are also increasingly creating paths through forested areas for recreational activities, including hiking, nature walks, and mountain-biking (Pauley 2005). These trails make up an important component to any nature preserve or national park. Only recently have the effects of such trails on wildlife been examined (Fairbanks and Tullous 2002). There is little information, however, on what effect these trails have on terrestrial salamanders. Human trails may act to shift the distribution of salamanders toward or away from them because of two possibilities. In an established nature preserve or park, a trail system is usually maintained by park or maintenance personnel, and this maintenance primarily involves keeping the trails cleared of fallen trees. Fallen trees are normally cut into manageable pieces and thrown to the side of the trail (A.K. Davis, pers. observation). If these logs subsequently act as daytime refugia for terrestrial salamanders, then it is possible that more terrestrial salamanders would be found next to trails versus in the forest, because of this increase in microhabitat availability. Alternatively, if salamanders normally avoid humans, the daily activity of humans on the trails may serve to keep salamanders away from trails, regardless of any refugia. I addressed this question by conducting a 3-month study in a nature preserve in northeast Georgia, using standardized, paired surveys of cover objects on trails and 25 m off trails to determine what effect, if any, walking trails have on terrestrial salamander abundance.

METHODS

Study Site

The Sandy Creek Nature Preserve is a 200 ha parcel of land located 2 km north of Athens, Georgia. The preserve hosts a wide range of habitats, including upland hardwood and pine forests, wetlands, and rivers. There are approximately 5 km of walking trails in the preserve, which pass through or near most areas of the preserve. Further, the trails are frequently used by joggers, dog walkers (dogs are allowed on leashes), and nature enthusiasts, especially on weekends (A.K. Davis, pers. observation). The preserve is managed by the municipal government of the city of Athens, and as such, has a small staff of full-time employees who, among other duties, oversee the maintenance of trailways within the preserve. The trails are well established in the preserve, so maintenance of the trailways primarily involves keeping the trails free of fallen trees (A.K. Davis, pers. comm. with Sandy Creek staff). Trails in the preserve consist of beaten paths that are approximately 1 m wide throughout, with wood bridges crossing over any water bodies.

Survey Protocol

During the months of February, March, and April of 2006, I conducted 125 surveys for herpetofauna along the Sandy Creek trails. On each visit to the preserve, I selected one of the trails and walked a randomly generated distance along the trail to the survey point. When the point was reached, I marked the center of the trail and then measured a circle around the center point with a 5 m rope, thus delineating a 78-m^2 survey plot centered on the trail. I next searched the plot for fallen logs and stones, which I turned over. Any salamanders found under either were recorded. To be included in the survey, logs and stones had to meet certain criteria, which were determined a priori. Logs had to be greater in girth than 5 cm, had to be touching the ground (i.e., not leaning), and had to be intact (i.e., not decayed to the point that they crumbled upon turning over). Meanwhile, stones had to be larger than 10 cm in diameter. If I could not lift any log or stone, it was not included in the survey. Once the survey was finished, I then randomly chose a direction off the trail (left or right), and walked 25 m perpendicular to the trail in that direction, and at the end point of the 25 m, the off-trail survey was conducted in exactly the same manner as the along-trail survey. Since identical surveys were conducted both along and off the trails within 25 m of each other, both surveys should have sampled the same habitats along or off the trail. Thus, this paired survey design was intended to eliminate, or at least reduce, the impact of variations in habitat throughout the preserve and allow me to focus on any possible effects of trails on the salamander distributions. On subsequent visits to the preserve, I selected different trails to survey so that most of the trails in the preserve were sampled at least once during this study.

Data Analysis

I used univariate ANOVAs to examine the possible effect of trails on herpetofauna abundance within my survey plots. The number of salamanders found was the dependent variable; survey location as a dichotomous variable (along- or off-trail) along with month and the interaction between month and location were the independent variables. I also compared the number of logs and stones found in along- versus off-trail plots using paired t-tests. Data was log-transformed (+1) prior to analyses. All tests were performed using SPSS software (SPSS 2005) and significance was accepted when $p<0.05$.

RESULTS

During this 3-month study, I found and turned over 147 stones and 474 logs (in 125 along-trail, 125 off-trail plots) and recorded 15 terrestrial salamanders under them (Table 1). Of these, the majority (12, or 80%) were slimy salamanders (*Plethodon glutinosus*). There was also one red eft (*Notophthalmus viridescens*) and two marbled salamanders (*Ambystoma opacum*). The total number of salamanders per stone was 0.01 and per log was 0.03.

There were significantly more logs found in along-trail plots versus off (t_{124}=2.44, p=0.016; Figure 1A). However, there was no difference in the number of stones encountered in along-trail plots versus off (t_{124}=0.18, p=0.857). Not enough salamanders were found under stones (two individuals) to warrant statistical testing for the effect of trails, but there were enough data to test for differences in numbers under logs. I found a significant effect of survey location on the number of salamanders found under logs ($F_{1,244}$=4.46,

Table 1. Summary of survey effort and salamander abundance during this study. A total of 250 plots (125 along-trail, 125 off-trail) were surveyed over the three-month period. Number of logs and stones refer to the number of each type encountered and overturned. Sals./Stone and Sals./Log are the number of salamanders found under each cover type divided by the number of stones or logs encountered.

Month	# Stones	# Logs	Salamanders Under Stones	Salamanders Under Logs	Sals./Stone	Sals./Log
February	104	271	1	2	0.01	0.01
March	37	95	0	3	0.00	0.03
April	6	108	1	8	0.16	0.07
Total	147	474	2	13	0.01	0.03

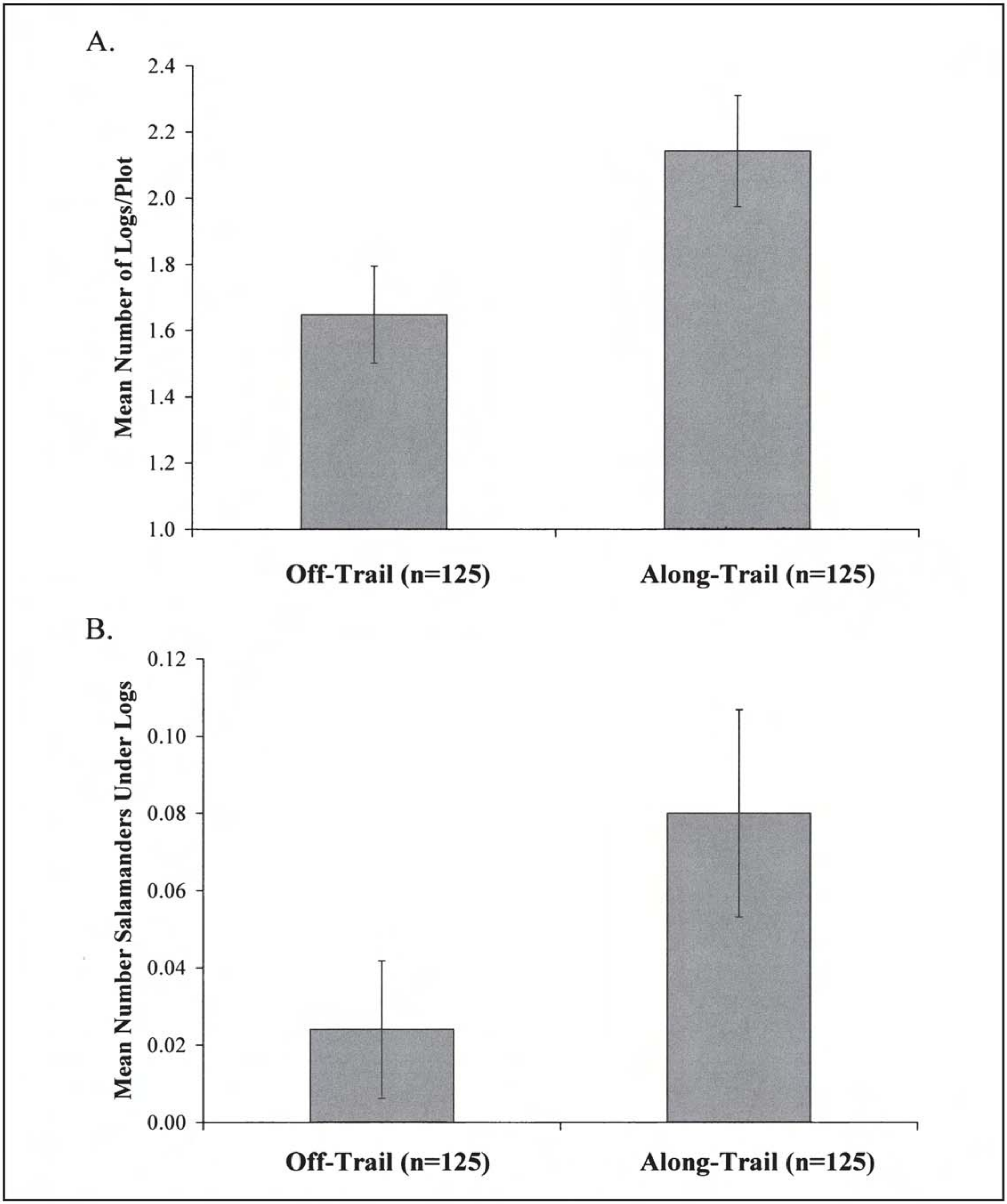

Figure 1. Mean number of logs found per plot, along and off trails (A) and mean number of salamanders found under logs along and off trails (B). Plots were a circle with a radius of 5 m (78.5 m^2). Error bars represent standard errors.

Figure 2. Picture, taken by the author, of a trail in the Sandy Creek Nature Preserve that had been recently cleared of a fallen tree. During the clearing process, the tree is usually cut into small pieces and cast to the side of the trail.

p=0.036), with more salamanders found in the along-trail plots versus off-trail (Figure 1B). There was also a nearly significant effect of month (p=0.051), with an increasing number of salamanders found from February through April. However, the interaction term between month and location was not significant (p=0.616), so that the main effect of survey location did not differ between months.

Finally, to examine the possibility that salamanders could have had a tendency to be next to trails because of some preference for these locations, I compared the number of salamanders found under logs in along-trail versus off-trail plots on a per log basis, using a paired t-test. I found no significant difference between the numbers of salamanders per log in along-trail versus off-trail plots (t_{124}=1.28, p=0.205).

DISCUSSION

In this study, I found that the act of clearing and maintaining trailways through forested areas appears to create higher amounts of cover objects (specifically logs) for terrestrial salamanders near the trailways. This in turn leads to more salamanders being found in close proximity to trails, not because of any preference for trail refugia per se, but simply because of the higher availability of cover objects near trails. On average there were approximately three salamanders under every 100 logs at the Sandy Creek Nature Preserve, and there were simply more logs located next to trails at this preserve.

It is interesting to note here that the overall encounter rate documented during the course of this study (three salamanders per 100 cover objects) is similar to that of another study of terrestrial salamanders in Georgia. Houze and Chandler (2002) found 2.3 salamanders per 100 (natural) cover objects at several forested study sites approximately 185 km southeast of the Sandy Creek Nature Center. Similarly, slimy salamanders were one of the most frequently encountered species in that study as well. Thus, although the objectives of these two projects differed (Houze and Chandler were evaluating sampling techniques for terrestrial salamanders), their similar capture rates suggest that the actual numbers of salamanders in forested areas in Georgia should be close to the numbers found in each study (between 2-3 individuals per 100 cover objects).

Finally, the results of this study can be added to a growing body of work on the effects of trailways on wildlife. Trails have recently been shown to affect wolves (*Canis* spp.) by altering their movement behaviors (Whittington et al. 2004) and to alter the distribution of pronghorn (*Antilocapra americana* Ord) (Fairbanks and Tullous 2002). In these cases and in the present study, the effect of the trails was not clearly negative (i.e., with trails causing declines in the number of animals, for example), but was more subtle by causing alterations in the normal distribution or behaviors of animals. Clearly, the results of this study with respect to the effects of trailways are one more example of how humans have affected wildlife – in this case by altering the distribution of salamanders in forested habitats.

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Andrew Davis is a PhD student in the Wildlife Ecology and Management program of the Warnell School of Forestry and Natural Resources at the University of Georgia. His doctoral research examines how amphibians are used as bioindicators of habitat quality.

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