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Innovative Techniques for Sampling Stream-inhabiting Salamanders

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Although salamanders are excellent indicators of environmental health, the ability to catch them efficiently without substantially disrupting their habitat is not always practical or even possible with current techniques. Ripping open logs and raking leaf packs onto shore (Bruce 1972) are examples of such practices that are disruptive but widely used by herpetologists who have no other means of efficient collection. Drift fences with pitfall traps are effective in catching animals moving within or between habitats but are time consuming and require an initial financial investment and constant upkeep to maintain functionality and prevent animal fatalities (Gibbons and Semlitsch 1981). One current alternative to drift fences is the use of coverboards (Grant et al. 1992), which require less maintenance and sampling effort than drift fences. However, coverboards do not integrate captures over a long time period and often result in a lower number of captures per trap (Grant et al. 1992).

The purpose of our study was to evaluate the effectiveness of a new trap design for sampling stream-inhabiting salamanders. The traps were designed to be non-destructive to the habitat while being economical and time efficient. The new trap, a combination of PVC pipe and coverboard (PC trap), was specifically designed to take advantage of the tendency of species in habitats near water to run toward the water when their cover is disturbed and then remain motionless amongst the detritus. The coverboard of PC traps was used to create a habitat for the salamanders that could be efficiently surveyed and replaced. The other "traps" (coverboards and sections of PVC pipe) were used as comparisons. We predicted that the PC trap would have a higher number of captures per trap than coverboards or sections of PVC used separately. Although the techniques tested are being referred to as "traps," they are designed to be "escapable" and thus able to be left in place unaltered and unchecked indefinitely without causing mortality to salamanders or non-target species.

The study site, a seep-fed spring that originated at the bottom of a gorge and terminated at a constructed pond, spanned approximately 365 m of mixed hardwood forest near the Fall Line in Richmond County, Georgia. Twenty arrays were placed at 12.4-m intervals along the spring's banks. An array consisted of one of each trap type placed in random order at 1.8-m intervals. Randomness was achieved by designating each trap with a number (PVC = 1, coverboard = 2 and PC = 3) and then using a random number table to select their order. Each interval was measured from the closest edge of each trap. All traps were 73 cm in length. Arrays were numbered from 1 to 20 starting at the beginning of the spring and each trap was labeled by array number and type. For example, type "A" (PVC), type "B" (coverboard), and type "C" (PC) in array 15 were labeled as "15A," "15B," and "15C," respectively. Arrays were checked, in order, from the downstream end (array 20) to the upstream end (array 1).

The PVC trap consisted of a 73 cm section of 18 cm polyvinyl chlorate (PVC) with holes drilled on each end for "stakes" (wire insulation supports) to anchor it into the spring bed. These were placed in the middle of the spring and were checked internally before being rolled over on each survey date. Coverboards were composed of a 73 cm × 73 cm section of 11-mm plywood. These were placed parallel to the spring with approximately 18 cm of the board overhanging the spring or in the spring to mimic the amount of overhang associated with the PC trap.

The novel trap, PC, was a "PVC-coverboard hybrid" made of two independent parts (Fig. 1). The first part of the PC trap was a section of 11 mm plywood identical to that of the coverboards. This was used in conjunction with a 73 cm section of lengthwise-halved 18 cm PVC. Wire screen (gutter guard) was cut to fit each end of the PVC halves and was attached to the pipe with six zip ties that were drawn through six small, evenly spaced holes on each end of the PVC. The halved PVC of PC traps were anchored with the same "stakes" as PVC traps. These halved pipes were anchored by pushing the "stakes" into the ground on the terrestrial side of the pipe and bending their ends to catch the lip of the pipe. The pipe halves of PC traps were placed inside the spring parallel to and touching the bank with their terrestrial edge as tightly fitting with the bank as possible. The terrestrial side was always somewhat lower than the spring side, which allowed salamanders to enter and leave at will. While it was possible for the salamanders to navigate in and out of the halved pipe, once they fled to the water, they would remain motionless in the bottom of the pipe and would not move unless disturbed. The plywood was then placed on the bank with enough overhang (18 cm) to cover the halved-pipe. After lifting the board in the same manner as used for coverboards, the inside of the pipe was examined for salamanders and, if present, the salamanders could be lifted out of the water while still in the pipe and then could be handled one at time while the others remained in the pipe. The space under the pipe was also checked either by sight or, for best results, by using the PVC halve in place to scoop out anything underneath it. Time and money invested into each trap were estimated by creating a sum of all steps and parts associated with the trap type (cutting boards, constructing half pipes, material prices, etc.).

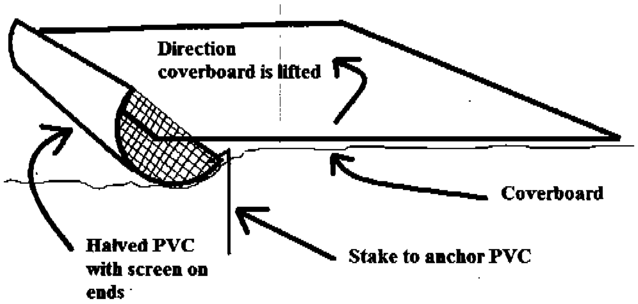

FIG. 1. PC trap as used in a spring at the study site.

TABLE 1. Total trap captures of each species and totals for each trap type. Surveys were conducted daily from 24 December 2003 to 3 January 3 2004, and on 1 February 2004 and 8 March 2004.

Species	PVC	Coverboard	PC traps	Total
Larval *Pseudotriton ruber*	6	16	59	81
Adult *Pseudotriton ruber*	0	3	2	5
Eurycea guttolineata	0	1	1	2
Eurycea cirrigera	0	2	3	5
Desmognathus conanti	0	5	0	5
Desmognathus auriculatus	1	1	3	5
Eurycea spp. Larvae	0	2	5	7
Totals	7	30	73	110

All traps were set on 22 December 2003 and checked daily from 24 December 2003 to 3 January 2004 and then again on 1 February 2004 and 8 March 2004 for a total of 13 days. Traps were checked, in order, from array 20 to array 1. We recorded the number and developmental stage of each species of salamander seen. Prior to release at the site of capture, each salamander was given a temporary ID by toe clipping, to keep track of recapture levels and movements. The same data for captures resulting from lifting or rolling natural cover within 1 m of the spring were collected, and the location was marked with an orange utility flag bearing information on species, date and time, ID number, and developmental stage. Cover that had been lifted or rolled for surveying purposes was replaced as close to the original position as possible and was checked on each successive survey. All larval salamanders considered too small for toe clipping were captured, noted, and released.

At the conclusion of trapping, 121 salamanders had been marked and were recaptured 57 times for a total of 178 captures. Species captured were *Desmognathus auriculatus*, *D. conanti*, *Eurycea cirrigera*, *E. guttolineata*, and *Pseudotriton ruber*. Larval *P. ruber* were captured most frequently (Table 1). Total number of salamander captures for the PVC, coverboard, and PC traps were 7, 30, and 73, respectively.

Each step in construction was done all at once (wood cutting, pipe sawing, etc.) and was timed along with assemblage to estimate overall construction times (Table 2). We used a hacksaw to cut through the PVC, which added time onto PVC and PC traps. PVC was the least effective of the three types in terms of both time and money invested per capture. Coverboards were the most efficient in terms of construction time invested per capture. The most efficient trap in terms of money invested per capture was the PC trap. Recently metamorphed *Rana clamitans* (N = 9) hibernated under the coverboards and PC traps. Only one snake, a *Nerodia fasciata* under trap 17B on 8 March 2004 (ca. 24 cm SVL), was found during the survey as it occurred during the winter season when they were inactive. Small crayfishes under 15 mm were occasionally found under boards and halved pipes of traps closer to the springhead.

TABLE 2. Construction cost and time invested per trap and per capture.

	Construction Cost	Construction Time	Cost/ Capture	Time/ Capture (min)
PVC	2.39	4	$6.81	11.4
Coverboard	1.62	5	$1.07	3.3
PC Traps	3.22	15	$0.88	4.1

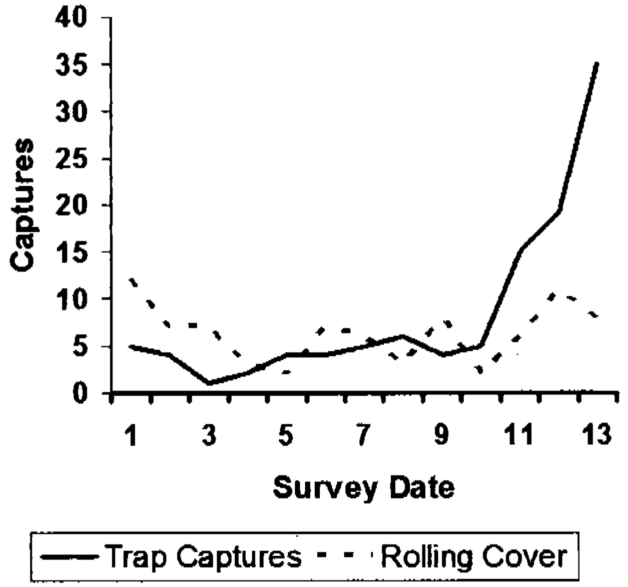

FIG. 2. Number of salamanders captured on each survey date (24 December 2003–3 January 2004, 1 February 2004 and 8 March 2004) resulting from trapping efforts and rolling natural cover present within 1 m of the spring.

The number of trap captures was few at the inception of the survey in comparison to the number of captures resulting from the rolling of natural cover. However, the number of trap captures increased as the project continued until they accounted for most daily captures (Fig. 2). The initial decrease in the numbers of salamanders in traps and under natural cover may have resulted from their refugia being disturbed on a constant basis for the first eleven survey dates. On the last three survey dates, which were each a month apart, the number of salamanders under each type of refugia increased and the number of salamanders under natural cover approached pre-survey levels. This positive trend is probably due to the decrease in disturbance to refugia as well as a possible increase in activity. The PC traps were more effective than all other traps in terms of total captures and became the most overall productive method as the study continued. This trend may be the result of salamanders having more time to find the traps and use them as refugia. Forty-six (63%) of the 73 salamanders found in the PC traps were either in or under the PVC, which may indicate a microhabitat preference.

A potential bias of the PC trap is that it depends on animals to select it as refugia and may not be equally effective for species with differing microhabitat preferences. This bias is evident in the number of the total larval *P. ruber* that were found in PC traps (N = 59) as compared to the combined total of coverboards and PVC traps (N = 22). Another possible bias was exhibited by *D. conanti*, which were present only under coverboards.

One major advantage of the PC trap was that it could be left unattended for an indefinite amount of time without any mortality because the animals were able to escape. This allows much more flexibility in trapping schedule and much less constant upkeep when compared to techniques such as drift fences that must be checked daily (Gibbons and Semlitsch 1981). Although drift fences are an effective way of collecting species moving from one finite area to another such as a seasonal wetland, they may not be practical to use in long and thin habitats such as springs and streams that cannot be surrounded easily. Drift fences may also fail to capture salamanders that are able to climb out of pitfalls or over fences. Ryan et al. (2002) suggested that a combination of census techniques should be used when monitoring herpetofaunal communities to account for the maximum number of species. The PC trap, while efficient in sampling salamanders in its immediate area and habitat, is not designed to be an all-inclusive, mass sampling technique such as a drift fence. Instead, it is most useful when sampling fully or semi-aquatic salamanders in or in very close proximity to water on a sporadic sampling schedule.

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