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Efficacy of Three Funnel Traps for Capturing Amphibian Larvae in Seasonal Forest Ponds

RICHARD R. BUECH
and
LEANNE M. EGELAND
USDA Forest Service, North Central Research Station
Forestry Sciences Lab, 1831 Highway 169 East
Grand Rapids, Minnesota 55744, USA
e-mail: rbuech@fs.fed.us

Among the many techniques that have been used to study amphibians, funnel traps are commonly recommended to determine species presence, breeding success, and relative abundance of amphibian larvae in aquatic habitats. Several authors have discussed the advantages and disadvantages of funnel traps for sampling amphibian larvae (Adams et al. 1997; Fronzuto and Verrell 2000; Shaffer et al. 1994). However, recent reviews of methods for studying amphibians (Heyer et al. 1994; Olson et al. 1997) make it clear that more research is needed on the species-specific effectiveness of methods that have been proposed.

A variety of funnel traps have been tried and tested including commercially available cylindrical traps constructed of 6 mm mesh galvanized wire, box funnel traps made of 3 mm mesh galvanized wire (Mushet et al. 1997), traps made from plastic beverage bottles (Calef 1973; Griffiths 1985; Richter 1995), collapsible nylon mesh traps (Adams et al. 1997), and traps constructed with acrylic plastic sheet (Smith and Rettig 1996). Some authors have compared the effectiveness of funnel traps of different styles and materials. Smith and Rettig (1996) compared the efficacy of three homemade funnel traps constructed of PVC pipe, acrylic plastic sheet, and plastic beverage bottles. Mushet et al. (1997) compared the effectiveness of cylindrical 6 mm mesh galvanized wire traps to their 3 mm mesh galvanized wire box traps. Fronzuto and Verrell (2000) compared the efficacy of cylindrical 6 mm mesh galvanized wire and cylindrical 2–4 mm mesh plastic funnel traps. Our objectives were to: 1) determine the efficacy of commercially available funnel traps for catching aquatic amphibian larvae living in small seasonal forest ponds, and 2) determine if net leads would enhance the efficacy of funnel traps.

We conducted the study on a selection of seasonal forest ponds in northern Minnesota on the Sucker Lakes Watershed in Cass County and on the Rice River Watershed in Itasca County. In 1997, we compared capture rates of commercially available plastic versus metal funnel traps and investigated the effect of adding net leads. The plastic funnel trap [Nylon Net Company, Memphis, Tennessee; MT1 at US $6.90 each in orders of six or more] consisted of two halves fastened in the middle of the trap; one half was colored blue and the other white. Dimensions of this near cylindrical trap were 43.2 cm long, 22.9 cm maximum diameter, and a 2.4 cm entrance centered in an 11.4 cm deep funnel positioned on each end of the trap. Mesh size of the plastic trap ranged from 4 x 6 mm where the trap halves join, to 3 x 4 mm at the trap ends. The metal funnel trap [Cuba Specialty Manufacturing Co., Fillmore, New York; G-40 at US $7.80 each] also consisted of two halves clipped together in the middle of the trap. Its dimensions were very similar to the plastic trap, only its length was slightly shorter (41.9 cm) and the dimension of its entrance was variable (2.2–2.4 cm). Metal traps were constructed of galvanized hardware cloth, which had larger openings (four holes per 2.5 cm, or 6 x 6 mm mesh size) than those of the plastic traps.

In 1997, we trapped amphibians in 29 ponds for three consecutive days each, from 18 June through 7 August. Metal and plastic traps were paired side-by-side in shallow water perpendicular to shore in water deep enough to submerge the trap entrance, yet still provide air for amphibians to breathe. Three trap pairs were spaced roughly 3–6 m apart along the shore in each pond, regardless of pond size. A net lead was positioned between the plastic and metal traps of the central pair. The net lead consisted of a 3.0 m long minnow seine staked from a position located between the traps out into deeper water. Traps were not baited and were set out during the day on Mondays, checked daily the following three days, and removed on the last day. Captured amphibians were identified to species, counted, and released.

In 1998, we trapped amphibians in 45 ponds for three consecutive days each, from 3 through 25 June, to compare capture rates of metal funnel traps of two different mesh sizes; 4 openings per 2.5 cm (6 x 6 mm mesh) and eight openings per 2.5 cm (3 x 3 mm mesh). Traps with 3 mm mesh were substantially more expensive than traps with 6 mm mesh [Cuba Specialty Manufacturing Co., Fillmore, New York; US $19.53 (G-48M) versus US $7.80 (G-40).] Traps were not paired as in 1997 but instead, were evenly spaced around the pond, alternating mesh sizes from a random start. We set 2 to 6 traps (1 to 3 traps of each mesh size) in ponds; the number of traps chosen so as to approximate an equivalent effort per unit of pond surface area. As in 1997, unbaited traps were set out Monday, checked the following three days, and removed. Captures were handled as in 1997.

Data were first converted from counts of larvae in each trap over the three trap night period to a daily capture rate for each trap and species (total number of individuals captured for a species divided by three trap nights). Repeated measures ANOVA was used to determine if 1997 daily capture rates of three species differed between trap types (plastic versus metal) and between trap pairs with net leads versus those on either side that lacked net leads. These analyses were conducted using square root transfor-

TABLE 1. Descriptive statistics for analysis of the efficacy of two funnel trap types (plastic versus 6 mm mesh, metal hardware cloth) and efficacy of net leads for capturing amphibian larvae of three species. Number of traps, median capture rate (CR) [number of individuals captured per night in each trap, averaged over three trap nights], and interquartile ranges are reported. N = number of ponds where species was trapped out of 29 possible ponds.

Species	Statistic	All Plastic	All Metal	Plastic Net	Plastic Without Net	Metal Net	Metal Without Net
Rana sylvatica	Number of traps	66	66	22	44	22	44
N = 21	Median CR	0.67	0.83	0.33	0.67	1.17	0.67
	Interquartile range	0.00, 1.33	0.33, 2.67	0.00, 1.33	0.00, 1.50	0.33, 2.67	0.33, 3.67
Ambystoma laterale	Number of traps	42	42	14	28	14	28
N = 14	Median CR	0.33	0.00	0.17	0.33	0.00	0.00
	Interquartile range	0.00, 1.00	0.00, 0.33	0.00, 1.00	0.00, 0.83	0.00, 0.33	0.00, 0.33
Pseudacris crucifer	Number of traps	12	12	4	8	4	8
N = 4	Median CR	0.00	0.00	0.00	0.00	0.00	0.00
	Interquartile range	0.00, 1.17	0.00, 0.00	0.00, 0.17	0.00, 2.00	0.00, 0.33	0.00, 0.00

mations to normalize the data. Data for 1998 were summarized as a daily capture rate for each trap type (6 mm versus 3 mm mesh) in a pond. Wilcoxon signed ranks tests were used to determine if 1998 daily capture rates differed between the two trap mesh sizes for three species (the simplified 1998 experimental design allowed use of this test and avoided assumptions about normality of data). All analyses were conducted using SYSTAT 8.0.

TABLE 2. Analysis of the efficacy of funnel traps constructed with hardware cloth of two different mesh sizes (6 mm versus 3 mm openings) for capturing amphibian larvae. For each species, a capture rate per night was calculated for each trap type in each pond by averaging the total number of larvae captured for each trap type in each pond (N = 1 to 3 traps per pond) over a 3-day period. Tests of significance were derived from a Wilcoxon signed ranks test.

Species	Statistics	6 mm Mesh	3 mm Mesh	Z	P
Rana sylvatica	No. ponds where captured	33	35	-1.028	0.304
[Present in 35 ponds]	Median pond capture rate	4.1	3.8		
	Interquartile range	0.9–24.2	0.9–16.4		
Ambystoma laterale	No. ponds where captured	2	15	3.308	0.001
[Present in 15 ponds]	Median pond capture rate	0.0	0.3		
	Interquartile range	0.0–0.0	0.2–0.9		
Pseudacris crucifer	No. ponds where captured	5	14	3.023	0.003
[Present in 15 ponds]	Median pond capture rate	0.0	0.3		
	Interquartile range	0.0–0.2	0.2–1.1		

In 1997, wood frog (*Rana sylvatica*) larvae were captured in the most ponds, followed by blue-spotted salamanders (*Ambystoma laterale*), and spring peepers (*Pseudacris crucifer*) (Table 1). The median daily capture rate of wood frog larvae in metal traps was 0.83 per trap compared to 0.67 in plastic traps, whereas median daily capture rates of blue-spotted salamander and spring peeper larvae were lower than those of wood frog larvae in either type of trap (Table 1). Trap type was a significant variable in explaining daily capture rates of wood frog ($F_{1,20}$ = 13.92, $P < 0.001$), but not blue-spotted salamander or spring peeper larvae ($P > 0.20$ for both species). Neither net leads ($P > 0.55$ for all species) nor an interaction of net leads and trap type ($P > 0.30$ for all species) affected daily capture rates of any species.

In 1998, wood frog larvae were again captured in the most ponds (35 ponds), whereas blue-spotted salamander and spring peeper larvae were found in 15 ponds each (Table 2). Traps with 3 mm mesh correctly recorded species occurrences in all but one instance (3 mm mesh traps failed to record spring peepers in one pond). In contrast, 6 mm mesh traps did a poor job in recording the presence of species with small larvae (i.e., blue-spotted salamander and spring peeper). Median daily capture rates of wood frog larvae were slightly higher in 6 mm than in 3 mm mesh traps, but not significantly so ($P = 0.30$). In contrast, daily capture rates of spring peeper and blue-spotted salamander larvae were greater ($P < 0.005$) in traps constructed with 3 mm versus 6 mm mesh hardware cloth.

Funnel traps of many styles and materials have been used by investigators to sample amphibians in aquatic settings. It is clear from their collective experiences that several factors impinge on the efficacy of funnel traps in capturing amphibians. For example, effectiveness is known to vary by species, trap characteristics, size of larvae, and habitat conditions (Adams et al. 1997; Fronzuto and Verrell 2000; Shaffer et al. 1994). Our results support these findings with regard to species, trap characteristics, and size of larvae.

Trap characteristics had a significant effect on capture rates of amphibian species found in our small, seasonal forest ponds. Our 1997 results demonstrated that 6 mm mesh metal traps were more effective than plastic traps in capturing wood frog tadpoles. We did not determine why this was so; e.g., we do not know if the plastic trap's blue and white color or physical appearance lowered wood frog capture rates. In contrast, plastic traps had slightly higher capture rates of blue-spotted salamanders than metal traps. Although this difference was not statistically significant, it makes sense that the smaller mesh size of plastic traps would reduce the likelihood of the smaller salamander larvae escaping from these traps. These observations were consistent with Fronzuto and Verrell (2000) who reported that some long-toed salamanders (*Ambystoma macrodactylum columbianum*) escaped from metal funnel traps with 6 mm mesh size, but not from plastic funnel traps that had a smaller mesh size.

In 1998, we confirmed the importance of mesh size. Metal traps with 3 mm mesh were better at capturing species with small larvae (i.e., blue-spotted salamander and spring peeper) than traps with 6 mm mesh openings. At the same time, captures of larger wood frog larvae in 3 mm versus 6 mm mesh traps were similar. These results suggest that 6 mm mesh hardware cloth might not adequately sample small larvae. We conclude 3 mm mesh funnel traps would provide a more unbiased assessment of the relative abundance of amphibian larvae living in our seasonal forest ponds.

Net leads, drift fences, and drive nets have been used to enhance capture of a variety of fish (Hubert 1983) and wildlife (Day et al. 1980) species, including herps in terrestrial settings (Heyer et al. 1994). These devices intercept the movement of animals and direct their travel towards traps. Because net leads are very effective in fisheries surveys, we thought they might also enhance the efficacy of unbaited funnel traps in catching amphibian larvae. Our result that they were not effective in directing amphibians into traps was surprising and is worthy of further study. The larvae of some amphibians school or diurnally migrate in response to light, temperature, and oxygen concentrations (Duellman and Trueb 1986). Perhaps amphibian species that live in small forest ponds are more sedentary than these amphibians or fishes, and thus their capture is less likely to be affected by net leads.

In summary, of the funnel traps we tested, we recommend using metal traps constructed of 3 mm mesh hardware cloth for sampling amphibian species whose larvae or adults are small, or when assessing the relative abundance of species in communities that include species with such characteristics. If one is sampling only species with large larvae or adults, 6 mm mesh might be adequate or possibly preferable. Net leads did not enhance capture rates of larvae of the amphibian species we encountered in small forest ponds, perhaps because their larvae are relatively sedentary. The same might not be true for larvae of other amphibians, especially those that live in larger aquatic habitat types. This possibility has implications for amphibian methodology, sampling design, and understanding of larval behavior. We suggest that these be explored further to understand the mechanisms underlying our results using net leads.

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