tion and substrate (if amphibians become fossorial, Madison 1997). Thus, our distance estimates likely represent best-case scenarios of signal range for SM1-H implant transmitters.

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# Observations on Problems with Using Funnel Traps to Sample Semi-Aquatic Snakes

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Funnel traps have been shown to be an effective method for sampling snakes in many different aquatic habitats (Fitch 1999; Greene et al. 1999; Karns et al. 2000; Keck 1994). However, any technique can have biases which need to be considered when choosing an appropriate sampling method. In this note I report problems encountered using funnel traps to sample snakes. These problems include: 1) predation upon trapped Banded Watersnakes (*Nerodia fasciata fasciata*) by Eastern Cottonmouths (*Agkistrodon piscivorus piscivorus*); 2) potentially biased sex ratios of *N. fasciata* and *A. piscivorus*; and 3) predation upon trapped snakes by red imported fire ants (*Solenopsis invicta*).

I used both commercially available minnow traps of dimensions 42 cm long by 22 cm in diameter (Cuba Specialty Manufacturing Co., Filmore, New York; funnel openings enlarged to 3 cm with a rake handle), and funnel traps made from hardware cloth that were 41 x 22 cm with 5-cm funnel openings (Fitch 1987) to sample *N. fasciata* and *A. piscivorus*. The study site was the Pee Dee Research and Education Center (PDREC), a 972-ha experimental farm owned by Clemson University, located in the upper coastal plain of Darlington County, South Carolina, USA. Traps were placed in shallow water (water depth < trap diameter) along logs, in emergent vegetation, and along short drift fences. The drift fences consisted of 5-m lengths of aluminum flashing oriented perpendicular to the shoreline with two traps placed at each end. Because of low capture rates (0.007 captures/trap day [TD] in 1998 to 0.011 captures/TD in 2002), traps were checked at 48-h intervals and not on weekends. Beginning in 1998 I sampled 11 ponds, a swamp, a lake, and several drainage ditches. Sampling occurred from July–October 1998 (960 TD), May–October 1999 (4108 TD), May–July 2000 (994 TD), April–June 2001 and 2002 (810, 994 TD, respectively), and May–June 2003 (757 TD). Means are followed by ± 1 SD. An $\alpha \leq 0.05$ is considered significant in all statistical tests.

Ten female *N. fasciata* ranging from 362 to 738 mm snout–vent length (SVL, mean = 600.8 ± 102.7) were found dead in traps with live Cottonmouths, including three (19% of captures) in 1998, two (7% of captures) in both 1999 and 2000, two (18% of captures) in 2002, and one (12.5% of captures) in 2003. The largest dead specimen was found in a minnow trap with a live male conspecific (390 mm SVL) and a live *A. piscivorus*. Of six adult *A. piscivorus* trapped with dead watersnakes, four were male and all ranged from 521 to 810 mm SVL (mean = 706 ± 115.7). Necropsies of 10 dead *N. fasciata* revealed paired puncture wounds surrounded by necrotic tissue on the dorsum of eight. I was unable to find bite marks on two specimens that were in an advanced state of decomposition. Bite marks (paired puncture wounds) were located 85–502 mm (mean = 223.75 ± 156.59) posterior to the snout. One 680 mm SVL specimen was bitten twice (two pairs of puncture wounds) located 502 and 585 mm posterior to the snout. *Nerodia fasciata* has been reported in the diet of Cottonmouths (Palmer and Braswell 1995), but only two of the watersnakes (362, 595 mm SVL) appeared to have been ingested and regurgitated as evidenced by saliva on the body of the dead *Nerodia*. Upon checking the trap, the larger of these was being ingested headfirst with only the posterior 10 cm protruding from the mouth of the *A. piscivorus* (617 mm SVL male) but was regurgitated when the trap was picked up. It is unclear why not more of the *N. fasciata* were ingested, although it is possible that cottonmouths either regurgitated the *Nerodia* after becoming agitated in the traps or did not have enough space to maneuver the *Nerodia* into proper swallowing position. However, it is also possible that the *Nerodia* were bitten as a stress response.

Sex ratios are an important part of population structure. Females dominated the samples of Banded Watersnakes and Eastern Cottonmouths. The 67 *N. fasciata* sampled from this population exhibited a 1.68:1 female-biased sex ratio, which was significantly different from 1:1 ($\chi^2 = 4.83$, df = 1, P = 0.028). The primary sex ratio of 66 neonate *N. fasciata* from three litters in this population was 1.2:1, which was not significantly different from 1:1 ($\chi^2 = 4.684$, df = 2, P = 0.096; unpubl. data). I believe this female bias to be a sampling artifact because of the primary sex ratio and because observations based upon radiotelemetry suggest that male *N. fasciata* in this population frequent deeper water more often than females (pers. obs., 2002) and therefore might be less likely to encounter funnel traps restricted to the littoral zone of aquatic habitats. Secondary sex ratios for a Texas population of *N. fasciata* sampled with funnel traps also showed a female bias (Keck 1994). I found a similar trend in 63 *A. piscivorus* from the Pee Dee population, as my sample yielded a 1.52:1 sex ratio that was not significantly different from 1:1 ($\chi^2 = 3.11$, df = 1, P = 0.078). Three other populations of *A. piscivorus* had balanced or male-biased sex ratios (Blem 1981; Ford 2002; Zaidan 2001).

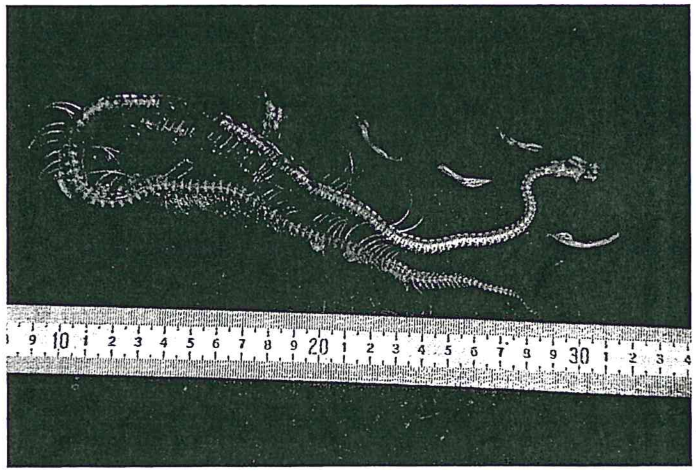



FIG. 1. Remains of a female Eastern Cottonmouth (*Agkistrodon piscivorus piscivorus*) attacked by red imported fire ants (*Solenopsis invicta*) while caught in a funnel trap at the Pee Dee Research and Education Center in Darlington, Co. South Carolina found on 9 June 1999.

Red imported fire ants (*Solenopsis invicta*) are problematic for many species of North American wildlife (Mount 1981). On 9 June 1999, a female *A. piscivorus* ca. 495 mm in length (skull and remaining vertebral column length) was found in a trap that was swarming with fire ants. The snake was reduced to a skeleton with only a small amount of viscera and the medial portions of some of the ventral scales remaining (Fig. 1). As no other cause of death was evident, it is likely that the snake was killed and devoured by fire ants. The trap had been placed perpendicular to the bank over a hole in very shallow water on 7 June 1999. If the trap had been placed in deeper water the ants probably would not have been able to attack the snake. Although fire ant predation on reptile eggs and hatchlings has been well documented for crocodilians, lizards, and turtles (Allen et al. 1994; Epperson and Heise 2003; Landers et al. 1980; Martin 1989; Moloney and Vanderwoude 2002; Mount 1981), I could find no evidence of fire ant predation on snakes in the literature. However, Tuberville et al. (2000) implicated fire ant predation in the decline of the Southern Hog-nosed Snake (*Heterodon simus*).

In conclusion, funnel traps can be an effective way to sample semi-aquatic snakes but frequent monitoring of traps, trap placement away from fire ant mounds, and possible bias in sex ratios should be considered when employing this technique.

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# Evaluation of a New Method for Measuring Salamanders


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Collection of morphometric data is essential to many field studies of amphibian populations. One of the most common measurements obtained from salamanders is snout-to-vent length (SVL), a parameter useful in studies of sexual dimorphism (Bovero et al. 2003), demography (Semlitsch 1985), and systematics (Carlin 1997). Measuring salamander lengths in the field is challenging because of their small size, slimy texture, and propensity to maintain a nonlinear body position. Time expenditure is another concern, especially when researchers process large numbers of salamanders. Different measurement techniques vary in accuracy and precision, limiting the reliability of the data so that comparisons cannot be easily performed. Here, we compare a new method of obtaining salamander SVL measurements to other commonly used methods.

To restrict salamander movement and maintain a linear body orientation, we constructed a device (the "Salamander Stick") using two equally sized polyvinyl chloride (PVC) pipes (40-cm long, with 2.5 cm outer diameter). We wrapped duct tape around both ends of one PVC piece such that a gap of 2 mm separated the two pieces when positioned parallel to each other. We then wrapped duct tape around both ends of the device, which secured the 2 mm gap. After assembly, we could pass a 23-cm wide plastic sandwich bag through the gap while prohibiting the passage of objects larger than 2 mm thick (Fig. 1a).

To obtain salamander SVL measurements, we placed a salamander into a plastic sandwich bag and fed the bag opening through the gap between the two PVC pipes. We pulled the bag through the gap until the salamander (at the bottom of the bag) reached the gap. We then manipulated the salamander through the walls of the bag to straighten it along the cranio-caudal axis and ensure that its ventral surface could be viewed. Once this was accomplished, SVL measurements were obtained with dial calipers (Fig. 1b).

We compared the precision and accuracy of the Salamander Stick to two other methods. In Method 1 (hereafter, "Freehand"; adopted from Phillips et al. 2002), a salamander was set on a table, straightened, and the SVL was measured with a plastic ruler. In Method 2 (hereafter, "Tube"; adopted from Mathis 1991), a salamander was placed into a clear plastic tube (inner diameter = 1.7 cm) and the SVL was measured by placing a ruler against the outside of the tube.

In March 2004, we captured 20 adult smallmouth salamanders (*Ambystoma texanum*) from a breeding pond in Coles County, Illinois, USA. During measurements, we housed all salamanders individually in 2 L plastic tubs in the laboratory. Salamanders were randomly selected and measured (SVL ± 1.0 mm) once with a