K. Chapman, A. Erickson, J. Moriarty, and K. Vick for assistance. The United States Geological Survey's Upper Midwest Environmental Sciences Center Animal Care and Use Committee approved the final surgical procedure (UMESC SOP #TS 416.0). Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the United States Department of the Interior, United States Geological Survey. Work was conducted under Minnesota Department of Natural Resources Special Collection Permits No 9516 and 10870.

Literature Cited

Bartelt, P. E., and C. R. Peterson. 2000. A description and evaluation of a plastic belt for attaching radio transmitters to western toads (*Bufo boreas*). Northwest. Nat. 81:122–128.

Beaumont, W. R. C., B. Cresswell, K. H. Hodder, J. E. G. Masters, and J. S. Welton. 2002. A simple activity monitoring radio tag for fish. Hydrobiologia 483:219–224.

Bulger, J. B., N. J. Scott, and R. B. Seymour. 2003. Terrestrial activity and conservation of adult California red-legged frogs *Rana aurora draytonii* in coastal forests and grasslands. Biol. Conserv. 110:85–95.

Bull, E. L. 2000. Comparison of two radio transmitter attachments on Columbia Spotted Frogs (*Rana luteiventris*). Herpetol. Rev. 31:26–28.

Colberg, M. E., D. F. DeNardo, N. A. Rojek, and J. W. Miller. 1997. Surgical procedure for radio transmitter implantation into aquatic, larval salamanders. Herpetol. Rev. 28:77–78.

Goldberg, C. S., M. J. Goode, C. R. Schwalbe, and J. L. Jarchow. 2002. External and implanted methods of radio transmitter attachment to a terrestrial anuran (*Eleuthrodactylus augusti*). Herpetol. Rev. 33:191–194.

Green, D. E. 2001. US Geological Survey Amphibian Research and Monitoring Initiative standard operating procedures pertaining to amphibians, National Wildlife Health Center, Madison, Wisconsin. http://www.nwhc.usgs.gov/research/amph_dc/amph_sop.html.

Hodgkison, S., and J. M. Hero. 2001. Daily behavior and microhabitat use of the waterfall frog, *Litoria nannotis* in Tully gorge, Eastern Australia. J. Herpetol. 35:116–120.

Lamoureux, V. S., and D. M. Madison. 1999. Overwintering habitats of radio-implanted green frogs, *Rana clamitans*. J. Herpetol. 33:430–435.

———, J. C. Maerz, and D. M. Madison. 2002. Premigratory autumn foraging forays in the green frog, *Rana clamitans*. J. Herpetol. 36:245–254.

Lowe, J. 2004. Rates of tricaine methanesulfonate (MS-222) anesthetization in relation to pH and concentration in five terrestrial salamanders. Herpetol. Rev. 35:352–354.

Marty, G. D., and R. C. Summerfelt. 1986. Pathways and mechanisms for expulsion of surgically implanted dummy transmitters from channel catfish. Trans. Am. Fish. Soc. 115:577–589.

Matthews, K. R., and K. L. Pope. 1999. A telemetric study of the movement patterns and habitat use of *Rana muscosa*, the mountain yellow-legged frog, in a high-elevation basin in Kings Canyon National Park, California. J. Herpetol. 33:615–624.

McNab, W. H., and P. E. Avers. 1994. Ecological subregions of the United States, U.S. Forest Service, WO-WSA-5, Washington, DC. http://www.fs.fed.us/land/pubs/ecoregions/index.html.

Muths, E. 2003. A radio transmitter belt for small ranid frogs. Herpetol. Rev. 34:345–348.

Pilliod, D. S., C. R. Peterson, and P. I. Ritson. 2002. Seasonal migration of Columbia spotted frogs (*Rana luteiventris*) among complementary resources in a high mountain basin. Can. J. Zool./Rev. Can. Zool. 80:1849–1862.

Rathbun, G. B., and T. G. Murphey. 1996. Evaluation of a radio-belt for ranid frogs. Herpetol. Rev. 27:187–189.

Richards, S. J., U. Sinsch, and R. A. Alford. 1994. Supplemental approaches to studying amphibian biodiversity: radio tracking. *In* W. R. Heyer, M. A. Donnelly, R. W. McDiarmid, L. A. C. Hayek, and M. S. Foster (eds.), Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians, pp. 155–158. Smithsonian Institution Press, Washington, D.C.

Rudolph, D. C., S. J. Burgdorf, R. N. Conner, and R. T. Zappalorti. 1998. Snake mortality associated with late season radio-transmitter implantation. Herpetol. Rev. 29:155–156.

Summerfelt, R. C., and F. Smith. 1990. Anesthesia, surgery, and related techniques. *In* C. B. Schreck and P. B. Moyle (eds.), Methods for Fish Biology, pp. 213–272. American Fisheries Society, Bethesda, Maryland.

Watson, J. W., K. R. McAllister, and D. J. Pierce. 2003. Home ranges, movements, and habitat selection of Oregon spotted frogs (*Rana pretiosa*). J. Herpetol. 37:292–300.

Waye, H. L. 2001. Teflon tubing as radio transmitter belt material for Northern Leopard Frogs (*Rana pipiens*). Herpetol. Rev. 32:88–89.

Werner, K. J. 1991. A radiotelemetry implant technique for use with *Bufo americanus*. Herpetol. Rev. 22:94–95.

Herpetological Review, 2005, 36(4), 421–424.

A Successful Trap Design for Capturing Large Terrestrial Snakes

SHIRLEY J. BURGDORF [1]
D. CRAIG RUDOLPH
RICHARD N. CONNER
DANIEL SAENZ [2]
and
RICHARD R. SCHAEFER

Wildlife Habitat and Silviculture Laboratory
(in cooperation with the Arthur Temple College of Forestry, Stephen F. Austin State University)
Southern Research Station, U.S. Forest Service
506 Hayter Street, Nacogdoches, Texas 75965, USA

[1] *Present Address:*
U.S. Fish and Wildlife Service, Lacey, Washington 98503-1263, USA

[2] *Corresponding author; e-mail: dsaenz@fs.fed.us*

Large scale trapping protocols for snakes can be expensive and require large investments of personnel and time. Typical methods, such as pitfall and small funnel traps, are not useful or suitable for capturing large snakes. A method was needed to survey multiple blocks of habitat for the Louisiana Pine Snake (*Pituophis ruthveni*), throughout its historic range in Louisiana and Texas, to obtain presence-absence data and to obtain specimens for radio-telemetry studies (Himes et al. 2002; Rudolph and Burgdorf 1997; Rudolph et al. 2002).

We required a method that was feasible with respect to cost of materials, time necessary to service traps, ease of installation, and efficiency in capturing snakes. The trapping method needed to capture large, mobile species, but not small, litter-dwelling species. We ultimately designed a large four-entrance funnel trap, with extensive drift fence arms to guide snakes toward the trap opening. These traps have been in use since 1993 to survey large snakes in Arkansas, Louisiana, and Texas. This trap design also was used to examine the impact of roads and vehicle-related mortality on large snakes (Rudolph et al. 1999).

Traps consisted of 121.9 x 121.9 cm (48 x 48 in.) tops and bot-

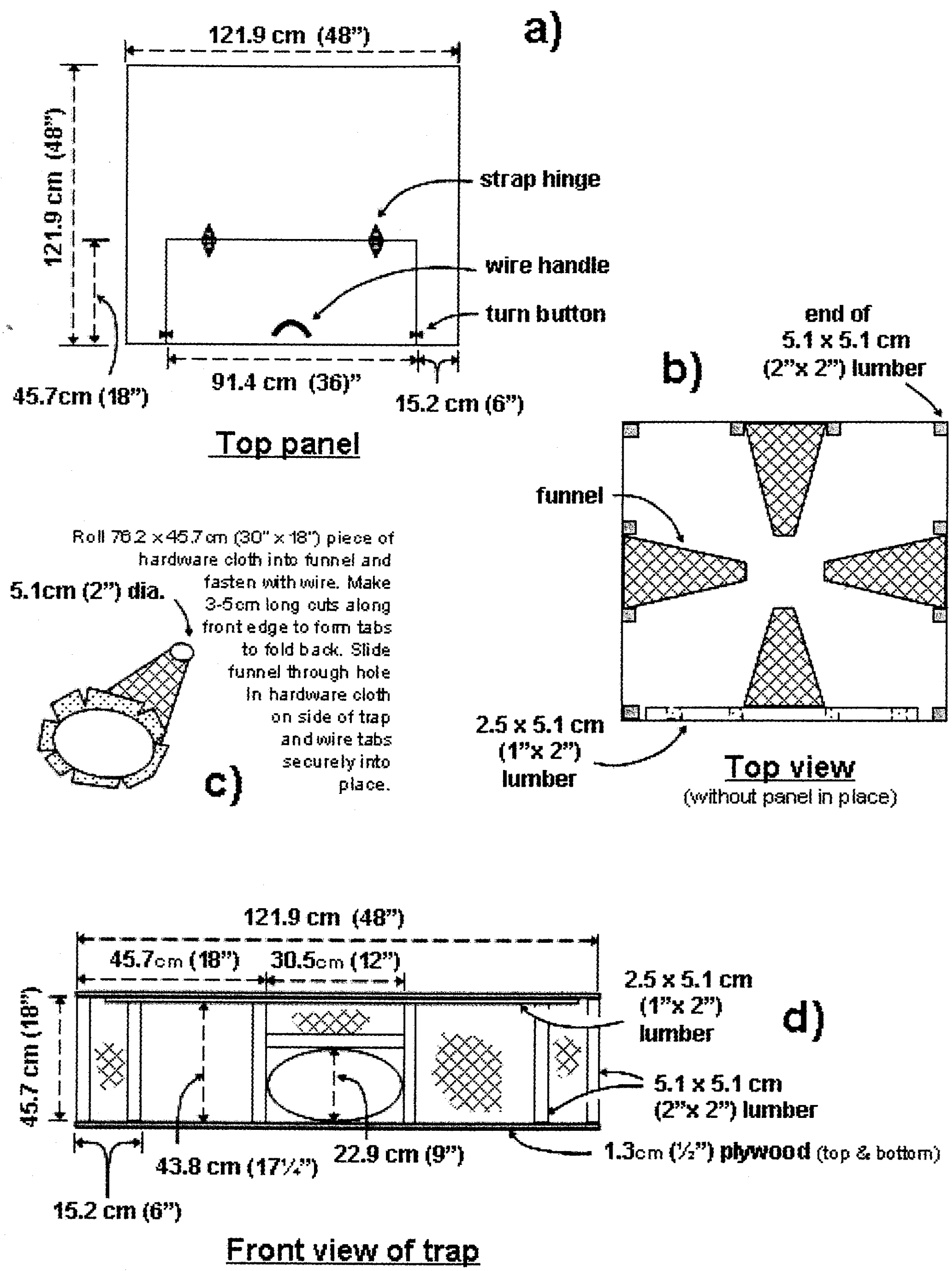


FIG. 1. Schematics of a successful trap design to capture large, mobile species of terrestrial snakes in eastern Texas a) top view of the trap b) top view of trap without top panel in place to show position of funnels c) an individual funnel and d) front view of trap. Trap dimensions and components are shown in English units of measurement to facilitate purchase from local building supply stores.

toms constructed of 1.3 cm (1/2 inch) treated plywood supported by wooden uprights 45.7 cm (18 inches) in height (Fig. 1). The sides were screened with hardware cloth (0.64 cm [1/4 inch] mesh). One or two hinged doors in the top of the trap allowed access for retrieval of snakes. Four funnel entrances of 64 cm (1/4 inch) mesh hardware cloth wired to the box at midpoint of each side allowed entrance of snakes (Fig. 1). Minimum diameter of the inner portion of the funnel was approximately 5.1 cm (2 inches).

Traps were installed by placing them on a soil surface that had been previously cleared and leveled. Excess soil was used to fill any gaps that would allow snakes access beneath the traps. Drift fences were constructed of 6.4 mm (1/4 inch) mesh hardware cloth approximately 15 m (50 feet) in length and 61 cm (2 feet) in height (Fig. 2). Longer drift fences could be used if desired. Drift fences were installed perpendicular to each side of the trap beginning at the midpoint of the funnel entrance. Fences were buried approximately 10 cm in depth and braced with wooden stakes or short pieces of iron reinforcement bar as required. Small pieces of hardware cloth were cut to fit, inserted part way into the funnel opening and wired to the drift fence to keep snakes from going around the terminus before entering the funnel (Fig. 2). Mesh size, height, and length of drift fences could easily be varied to capture snake

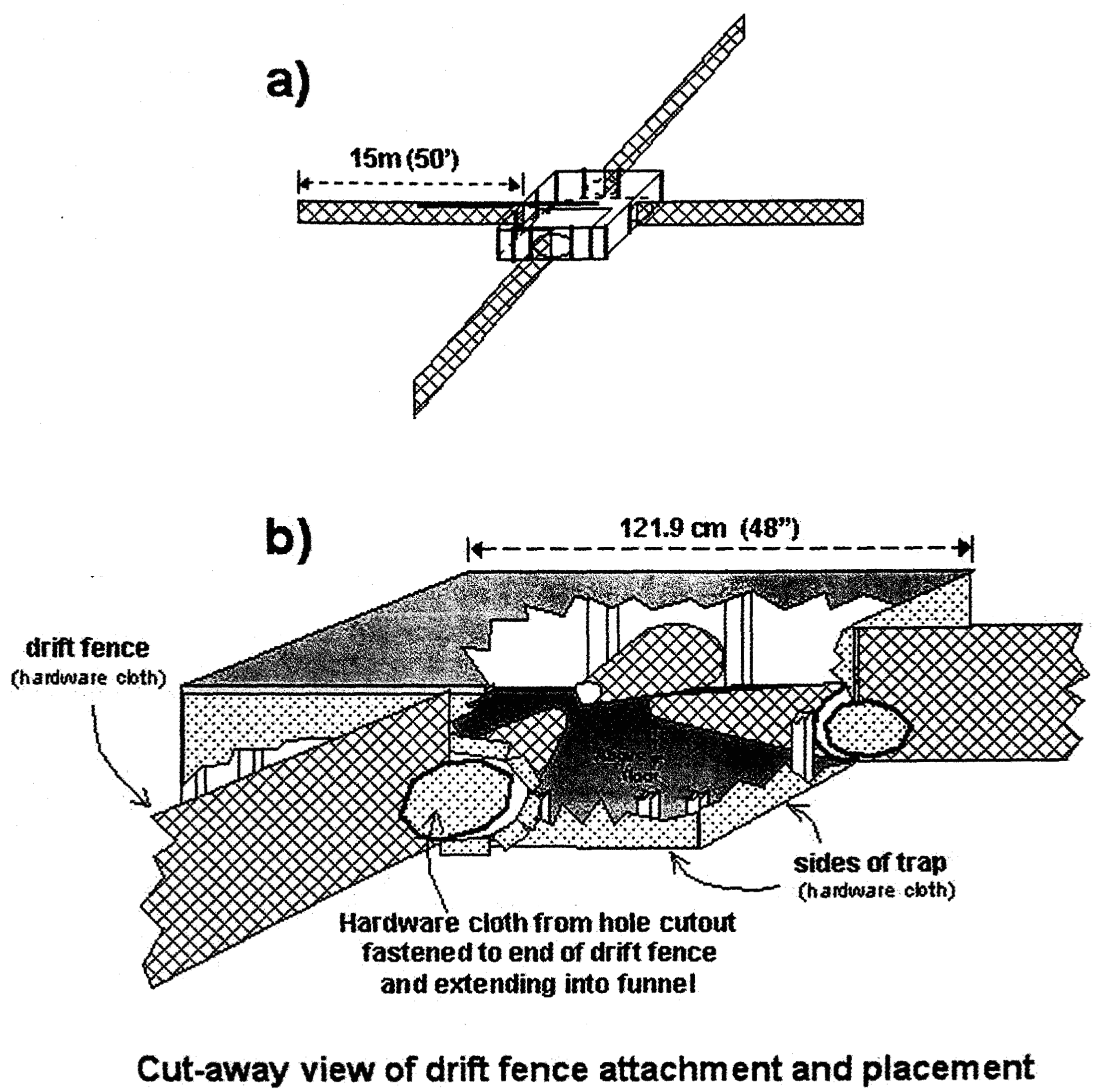


FIG. 2. More schematics of the trap design a) full view of the trap and drift fences and b) a cut-away view of drift fence attachment and placement.

pecies of varying body sizes. Other commonly used drift fence ıaterials such as sediment cloth or metal flashing could also be sed. Funnel traps may be placed at distal ends of each rift fence to increase capture rates. In addition, each trap 'as supplied with a 3.8 liter (1 gal.) chick watering source. /hen possible, traps were installed in situations that proided some shade to further reduce stress on captured indiiduals. Snake traps were constructed using treated wood, ıaking them very durable. We have had traps in the field ɔntinuously in use for up to 6 years, in both wet and dry ɹrest situations. These traps are in good condition and are ill serviceable. See Table 1 for list of materials.

Trap success varied depending on site characteristics. owever, in the upland pine habitat where most of our efɾt has been directed, we captured an average of 7.5 snakes ırge species only) per trap per season during the early arch to late October trapping period (240 trap days). ıake capture data for an array of 15 traps located in acogdoches Co., Texas, from 1999–2002, approximately ,920 trap days, indicate the diversity of species captured (Table 2). These data documented a significant range extension for the Glossy Snake, *Arizona elegans* (Collins et al. 2001), and

TABLE 1. Snake trap materials.

Materials	Quantity
1.3 cm (1/2 in.) thick sheet, treated plywood	1
5.1 x 5.1 cm (2 x 2 in.) treated lumber, 2.4 m (8 ft) long	4
2.5 x 5.1 cm (1 x 2 in.) treated lumber, 1.2 m (4 ft) long	1
0.64 x 0.64 cm (1/4 x 1/4 in.) mesh, hardware cloth 61 cm (24 in.) wide	
30 m (100 ft) roll for drift fences	2
8.5 m (28 ft) piece for trap & funnels	1
7.6 cm (3 in.) strap hinge	2
turn button	2
20-gauge galvanized wire 15 m (50 ft)	1
nails (or screws), box of 100	1
heavy duty staple gun and box of staples	1

TABLE 2. Snakes captured in 15 traps located in Nacogdoches County, Texas from 1999 to 2002.

Scientific name	Common name	No. Captured
Arizona elegans	Glossy Snake	4
Coluber constrictor	Racer	10
Elaphe obsoleta	Eastern Ratsnake	44
Heterodon platirhinos	Eastern hog-nosed Snake	1
Lampropeltus calligaster	Yellow-bellied Kingsnake	11
Masticophis flagellum	Coachwhip	79
Nerodia fasciata	Southern Watersnake	1
Agkistrodon contortrix	Copperhead	49
Agkistrodon piscivorus	Cottonmouth	7
Unidentified species	Skeleton in trap	18

suggested that the Louisiana Pine Snake, *Pituophis ruthveni*, might not occur at this site.

The trapping protocol resulted in some snake mortality, primarily because of occasional infestations of imported fire ants (*Solenopsis invicta*). We used a variety of commercially available ant poisons to treat all visible mounds within approximately 10 m of the traps. This was generally sufficient to control ants within the traps. During the four-year period of trapping, 30 snakes died in our traps, an average of 7.5 snakes per year, or 13.3% of the snakes captured. We also suspected that ophiophagous snakes such as Common Kingsnakes (*Lampropeltis getula*) and Prairie Kingsnakes (*L. calligaster*) occasionally entered traps and consumed other captured snakes.

The design of our traps resulted in few small litter-dwelling species being captured. This presumably resulted from their reluctance to leave the litter surface and ascend the inclined funnel to enter the trap, and the fairly large mesh size that allowed very small individuals to pass through. Adjustments in funnel orientation and mesh size would easily allow the trap to be tailored to specific needs. The use of 3.2 mm (1/8 inch) mesh hardware cloth for the trap, funnels and drift fences would permit the capture of smaller species of snakes. However, it should be noted that the finer mesh hardware cloth tears easily compared to the 6.4 mm (1/4 inch) mesh hardware cloth and requires more support when used for drift fences.

Taxa other than snakes were frequently captured in the traps. The capture of invertebrates, amphibians, and reptiles presented few problems. However, the capture of birds and small mammals resulted in considerable mortality. Birds, in particular, had very short survival times in the traps, as they tended to injure themselves attempting to escape. Reducing the size of the funnel entrance from 8–10 cm to < 5 cm prevented larger mammals (skunks, opossum, squirrels) and most game birds (quail) from entering the traps, and had no obvious impact on capture rates for snakes. Small passerines could still get in the traps. However, more frequent checking on a daily basis would reduce mortality of trapped animals.

This trap design, especially in conjunction with the long drift fences, was quite effective at capturing large terrestrial snakes. The large size of the trap itself and the water source was intended to limit the number of trap visits to once per week. However, in our study we had a higher mortality rate of captured snakes than expected, largely because of fire ants that are common in our region. More frequent trap visits and fire ant eradication would have likely reduced the amount of mortality. We suggest that our trap design in conjunction with efforts to reduce snake mortality, such as ant control, placing traps in shade when possible, and daily trap visits, should maximize success in capturing large terrestrial snakes.

Acknowledgments.—We thank J. Keel for several design and construction improvements that improved trap utility. Research was conducted under Texas collecting permit (SPR-0490-059). Initially, in 1993 we checked traps weekly because we assumed that the large trap design and watering system would limit mortality and allow longer intervals between checks. However, our observations of mortality in traps checked weekly support the recommendation to check traps daily as suggested in the ASIH Animal Care Guidelines (see Guidelines for Use of Live Amphibians and Reptiles in Field Research, American Society of Ichthyologists and Herpetologists; http://www.asih.org/pubs/herpcoll.html.).

LITERATURE CITED

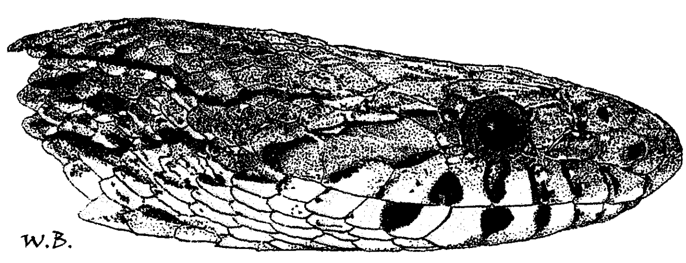
COLLINS, C. S, D. C. RUDOLPH, D. SAENZ, T. TREES, AND T. J. HIBBITTS. 2001. *Arizona elegans arenicola*. Herpetol. Rev. 32:194.

HIMES, J. G., L. M. HARDY, D. C. RUDOLPH, AND S. J. BURGDORF. 2002. Growth rates and mortality of the Louisiana pine snake *Pituophis ruthveni*. J. Herpetol. 36:683–687.

RUDOLPH, D. C. AND S. J. BURGDORF. 1997. Timber rattlesnakes and Louisiana pine snakes of the West Gulf Coastal Plain: hypotheses of decline. Texas J. Sci. 49(3) supplement:111–122.

———, ———, R. N. CONNER, C. S. COLLINS, D. SAENZ, R. R. SCHAEFER, T. TREES, C. M. DURAN, M. EALY, AND J. G. HIMES. 2002. Prey handling and diet of Louisiana pine snakes (*Pituophis ruthveni*) and black pine snakes (*P. melanoleucus lodingi*) with comparisons to other selected colubrid snakes. Herpetol. Nat. Hist. 9:57–62.

———, ———, ———, AND R. R. SCHAEFER. 1999. Preliminary evaluation of the impact of roads and associated vehicular traffic on snake populations in eastern Texas. *In* G. L. Evink, P. Garrett, and D. Zeigler (eds.), Proceedings of the Third International Conference on Wildlife Ecology and Transportation. FL-ER-73-99, pp. 129–136. Florida Department of Transportation, Tallahassee, Florida.



Elaphe guttata (Cornsnake), adult male. USA: Virginia: Greene County. Pen and ink illustration by Will Brown (http://www.blueridgebiological.com/).