AN IMPROVED FUNNEL TRAP FOR DRIFT-FENCE SURVEYS

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Abstract—The objective of this study was to investigate effectiveness of a common drift-fence trap, the single-funnel trap, in comparison with a new one-way double-funnel design. We expected this new design to decrease escapes over standard trapping techniques and, therefore, increase efficiency of sampling using drift fences. Five 15-m, linear, drift-fence arrays with three 15-m, Y-shaped arrays were placed at two field sites in central Texas and a single 15-m, linear array was placed at a field site at Seabrook Island, South Carolina. Each array contained an equal number of the single-funnel and double-funnel traps. One-way double-funnel traps caught and retained significantly more reptiles, total herpetofauna, and total vertebrates than did single-funnel traps. Our results indicated that double-funnel traps offer an improved trapping technique when compared with the typical single-funnel trap.

Resumen—El objetivo de este estudio fue investigar la eficacia de trampas comunes de un solo embudo usadas con cercas de desvío en comparación con una trampa de diseño nuevo de doble embudo de una sola vía. Se esperaba que con este nuevo diseño se obtuviera una reducción de escapes en comparación con los métodos estándares de captura, y por ende, incrementar la eficiencia al muestrear con cercas de desvío. Un grupo de cinco complejos de cercas de desvío lineales de 15 m más un grupo de tres complejos de cercas de desvío en forma Y con brazos de 15 m fueron localizados en dos sitios separados en el centro de Texas. Una sola cerca de desvío lineal de 15 m fue puesta en un sitio de campo en Seabrook Island, South Carolina. Cada complejo tuvo un número igual de trampas de un solo embudo y de doble embudo. Las trampas de doble embudo y de una sola vía capturaron y retuvieron significativamente más reptiles, herpetofauna en total y vertebrados en total que las trampas de un solo embudo. Nuestros resultados indicaron que las trampas de doble embudo ofrecen un método mejor de captura cuando se comparan con la trampa típica de un solo embudo.

Drift-fence sampling is a common technique applied to survey populations of amphibians, reptiles, and small mammals. Success of drift-fence sampling can be affected by weather, season, trapping method, and response of animal (Greenberg et al., 1994; Jorgensen et al., 1998; Enge, 2005; Todd et al., 2007). Effectiveness of different trapping methods remains an important issue inclusive of trapping success, predation on captives, and risks of mortality. Drift-fence arrays typically contain single-funnel, two-way double-funnel, or pit-fall traps.

Studies have compared effectiveness of pitfall and single-funnel traps (Enge, 2001), and some also have included two-way double-funnel traps (Greenberg et al., 1994). Enge (2001) reported that funnel traps could be used as the sole trapping method, except when looking for fossorial and semi-fossorial squamates that are caught more frequently in pitfall traps. Others have compared small and large pitfall traps and funnel traps, concluding that while funnel traps caught more species, they were most effective when paired with large pitfall traps (19 L; Maritz et al., 2006; Todd et al., 2007).

Each trapping method has its strengths and weaknesses. Pitfall traps typically are less effective at catching larger species, but more effective at catching smaller, fossorial, and semi-fossorial species. Pitfall traps can be fitted with anti-predator devices to reduce predation without influencing rates of capture (Ferguson and Forstner, 2006). However, some efforts intended to improve overall performance and to increase safety of animals in pitfall traps actually can impact other aspects of trapping. Pitfall traps made with a flip-top lid for catching turtles result in reduced captures of other species (Christiansen and Vandewalle, 2000). Rates of capture of target animals also can be skewed where alterations are made to prevent mortality of non-target animals (Karraker, 2001).

In general, funnel traps capture a wider array of species, typically require less field work during installation, they can maintain the safety of captured individuals, and they can be paired with pitfall traps when a complete sampling of herpetofaunal diversity is required (Todd et al., 2007). Funnel traps were first described by Imler (1945) in his effort to control populations of bullsnakes (*Pituophis sayi*) and have since been modified to reduce cost (Hall, 1967), and for use in capturing aquatic (Calef, 1973; Casazza and Wylie, 2000) and arboreal species (Vogt, 1987). Funnel traps are particularly suitable for catching snakes; however, amphibians, insects, mammals, and other reptiles also are captured (Dargan and Stickel, 1949). Potential for escape is not an aspect that is addressed often. Increased retention of captured individuals can allow for an increased number of captures and an increased number of species, offering a more accurate depiction of an area over the same amount of time as current trapping methods.

We have made extensive use of these methods and provide an improved funnel-trap design that increases rates of capture by improving retention for numerous taxa, particularly snakes. The one-way double-funnel design is simple to construct and will improve trapping retention of captured individuals. This one-way double-funnel design has one entrance funnel with an additional funnel facing the same direction located within the trap (Fig. 1; see Yantis, 2005, for construction details). The second funnel effectively captures individuals twice, seeking to reduce the number of individuals that manage to escape after initial capture. We have not included more complete construction details because we believe an important benefit of this design is that most single-funnel traps can be modified into one-way double-funnel traps. This can be accomplished by opening the end of a single-funnel trap and attaching it to the funnel opening of another single-funnel trap using metal clips or rubber cement.

Drift-fence arrays were placed at three field sites, two in central Texas and one on Seabrook Island, South Carolina. Five 15-m, linear, drift-fence arrays, constructed of aluminum flashing, were within a 10-ha area in Guadalupe County, Texas. Traps at this location were open for a total of 16 days during 7–22 October 2007. Three 15-m, Y-shaped arrays, constructed of aluminum flashing, were placed within a 2,025-ha area in Bastrop County, Texas. Traps at this location were open for 34 days during 15 March–3 May 2009. A single, 15-m, linear array, constructed of

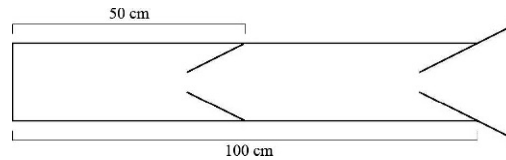

FIG. 1—Configuration and dimensions of a one-way double-funnel trap that can be used to increase rates of capture in drift-fence surveys.

silt fencing, was within the 1,820-ha Seabrook Island off the coast of South Carolina. Traps at this location were open for 15 days during 27 February–13 March 2009. A minimum of 80 m separated each array at all sites.

At each trapping site, an equal amount of single-funnel and one-way double-funnel traps were placed flush with the ground at either the middle or end of the fencing. The different traps were always placed in the same position to ensure equal trapping probability at each array. We placed sponges in all traps and watered the sponges daily to prevent mortality of amphibians. Shades were placed over traps to reduce heat stress (Hobbs and James, 1999). Amdro (Ambrand, Atlanta, Georgia) was deployed near traps to prevent predation from red imported fire ants (*Solenopsis invicta*). Captured individuals were identified to species and released ≥15 m from the drift fence.

We statistically analyzed captures of amphibians, reptiles, herpetofauna, and vertebrates. These categories represent typical groups upon which drift-fence studies usually focus. To determine differences in rates of capture between traps, we used a one-tailed, paired *t*-test for each category. A one-tailed test was used because the new design only alters the potential for escape once trapped, and has no bearing on initial rate of capture; therefore, the new design should either retain the same amount of captives (no significant difference) or should retain more (significant difference). All statistical analyses were performed using R (R Foundation for Statistical Computing, Vienna, Austria).

Eleven amphibians were captured in single-funnel traps, whereas 18 were captured in one-way double-funnel traps (Table 1). Only 13 reptiles were captured in single-funnel traps compared with 39 reptiles in one-way double-funnel traps (Table 1). Eight hispid cotton rats (*Sigmodon hispidus*) were captured in single-funnel traps, whereas one-way double-funnel

Table 1—Number of individuals captured in single-funnel and one-way double-funnel traps used in drift-fence surveys.

Species	Single-funnel	One-way double-funnel
Amphibians		
Acris crepitans	0	1
Bufo valliceps	5	4
Gastrophryne olivaceus	0	5
Rana catesbeiana	4	5
Rana sphenocephala	0	2
Scaphiopus holbrookii	0	1
Scaphiopus hurteri	2	0
Total	11	18
Reptiles		
Agkistrodon contortrix	4	0
Coluber constrictor	1	4
Elaphe obsoleta	1	2
Nerodia rhombifer	0	3
Thamnophis proximus	1	11
Cnemidophorus sexlineatus	3	0
Sceloporus olivaceus	1	2
Sceloporus undulatus	2	12
Scincella lateralis	0	5
Total	13	39
Mammals		
Sigmodon hispidus	8	19
Total herpetofauna	24	57
Total vertebrates	32	76

traps captured 19 individuals (Table 1). One-way double-funnel traps caught significantly more individuals in three of the four categories (amphibians, $t = -1.793$, $df = 8$, $P = 0.055$; reptiles, $t = -2.953$, $df = 8$, $P = 0.009$; herpetofauna, $t = -3.209$, $df = 8$, $P = 0.006$; vertebrates, $t = -3.626$, $df = 8$, $P = 0.003$). Amphibians was the only group captured in one-way double-funnel traps significantly more often than in single-funnel traps; however, raw numbers show more amphibians were captured in one-way double-funnel traps.

There were several reasons for testing this new design. Pitfall traps are difficult to install, difficult to protect from predation by mesocarnivores (Ferguson et al., 2008), and they collect a low diversity of taxa. Therefore, when pitfall traps are used, they need to be paired with funnel traps to accurately sample an area to determine diversity of amphibians, reptiles, and small mammals. In addition to the statistical differences, direct observations indicated that many individuals are capable of escaping from funnel traps, especially snakes. During our study, we witnessed two snakes travel from the interior funnel to the front funnel. If the snakes were in a typical single-funnel trap this would have resulted in an escape. Shed skin, feces, and regurgitated food also have been observed in other studies using single-funnel traps, but with no animal in the trap to account for the evidence left behind. These observations indicate that a better trapping method would have been desirable.

We believe that the second funnel significantly improved the design of funnel traps. A problem with single-funnel and two-way double-funnel traps was that they captured individuals in a single chamber giving the individual one or more potential routes of escape. One important qualitative result from our study was that all but one individual caught in the one-way double-funnel traps were observed within the interior section. One explanation for this was that once an individual is captured in a one-way double-funnel trap, the path of least resistance is always the interior section. In a typical funnel trap, if the animal finds the opening of the funnel after it is captured, it can escape. However, to escape from the one-way double-funnel trap, an individual must escape the interior section, then avoid being recaptured by the second funnel, and then find the entrance to the first funnel.

One-way double-funnel traps successfully captured and retained significantly more individuals than single-funnel traps. This suggests the use of one-way double-funnel traps in place of single-funnel and two-way double-funnel traps could produce more accurate results and reduce time spent on drift-fence surveys. In addition, one-way double-funnel traps can be constructed as easily as single-funnel traps, and in many cases single-funnel traps could be altered into one-way double-funnel traps.

We thank F. W. Weckerly for comments and useful discussion concerning the manuscript. Additionally, we thank C. Campbell for help with the Spanish translation. We also thank S. Mickletz for assistance with field work. Additionally, comments by two anonymous reviewers greatly improved the quality of the manuscript. This project was conducted under scientific collecting permit SPR-0102-191 and protocol 0715-0428-07, which was approved by the Institutional Animal Care and Use Committee at Texas State University, San Marcos.

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Submitted 18 November 2008. Accepted 5 December 2009.
Associate Editor was Richard T. Stevens.