Sampling Epigeal Arthropods: A Permanent, Sheltered, Closeable Pitfall Trapping Station[1]

Matthew H. Greenstone[2]

USDA Agricultural Research Service, Invasive Insect Biocontrol and Behavior Laboratory, 10300 Baltimore Avenue, Beltsville, Maryland 20705 USA

J. Entomol. Sci. 51(1): 87–93 (January 2016)

Abstract Epigeal arthropods constitute the bulk of herbivore, predator, and decomposer species in soil and litter ecosystems. Being small and difficult to observe within these sometimes densely vegetated habitats, they are inherently difficult to sample quantitatively. Further, most methods have inherent taxon, life-stage, and habitat biases, making biodiversity and other community-wide sampling problematic. Quadrat methods can be quantitative but may undercount active taxa and only work in the structurally simplest habitats. Mark-and-recapture and trapping-out methods can yield defensible quantitative estimates but are not practicable for multispecies sampling. This leaves only flooding the habitat and collecting every animal thus dislodged, an expensive and difficult expedient. Pitfall traps are inexpensive and easily deployed, but they are not quantitative. When used intensively for a sufficiently long period of time, however, they can support reliable estimates of the total number of species and other biodiversity indices. Nevertheless there are technical problems associated with the use of pitfalls, including susceptibility to precipitation and flooding, lack of simple methods to close the traps between collecting intervals, and threats to the integrity of the trapping site. Described herein is an inexpensive, permanent pitfall station that shelters the trap from precipitation and flooding, can be securely closed during inactive periods, and can remain in place indefinitely without damage to the site.

Key Words biodiversity, epigeal arthropods, sampling

Epigeal arthropods constitute the bulk of herbivore, predator, and decomposer species in soil and litter ecosystems. Pitfall traps have been used for decades to capture these animals for population and community studies, and their virtues and shortcomings have been extensively researched and debated for the last half-century (Adis 1979, Driscoll 2010, Greenslade 1964, Lang 2000, Luff 1975, Melbourne 1999, Sunderland et al. 1995, Uetz and Unzicker 1976, Whicker and Tracy 1987). It has been rigorously settled, by laboratory and field experiments, that pitfall traps cannot provide quantitative population data except where habitats are physiognomically identical, and even then not across seasons, sexes, and ages of a given species (Lang 2000, Melbourne 1999, Topping 1993). Nevertheless they are the least expensive and most convenient method for determining the incidence of species in a system, and given sufficiently long and intensive sampling can

[1]Received 24 August 2015; accepted for publication 23 September 2015.
[2]Corresponding author (email: matt.greenstone@ars.usda.gov).

Fig. 1. Components of the pitfall trap (top to bottom): reservoir, liner, collar.

provide useful estimates of the number of species and other measures of diversity for soil and litter arthropods (Gotelli and Colwell 2011, Knapp and Růžička 2012).

Pitfall traps are susceptible by their nature to dilution or loss of the catch by precipitation and flooding (Porter 2005). Also, if they are carelessly and temporarily

Fig. 2. Overhead view of collar, showing nails used to anchor it in hole (arrows).

emplaced, they can degrade the site. Here, I describe a pitfall trapping system that is permanent, is protected from precipitation and flooding, can be securely closed between sampling intervals, and can be left in place indefinitely without damage to the site.

Materials and Methods

To emplace each trapping station, a cylindrical hole 11.4 cm in diameter and ~15 cm deep was cut into the turf with a Foot Extraction Hole Cutter (Par Aide, Lino Lakes, MN). Into this were placed the nesting cylindrical components of the trap itself (Fig. 1): a collar, a liner, and the reservoir. Holes were drilled into the side of the collar, a 7.6-cm high-density polyethylene slip external snap coupling (Advanced Drainage Systems, Hilliard, OH), just below the four indentations at the top (Fig. 1, bottom). The collar was then positioned in the hole with its top just below the rim of the hole, and roofing nails were pushed through the drilled holes into the soil to permanently affix the collar in the hole (Fig. 2). The liner, a 530-ml polystyrene drinking cup (Solo Cup Co., Chicago, IL), into the bottom of which a 1.0-cm diameter drainage hole had been melted with a heated rod, was dropped into the collar, followed by the reservoir, a 240-ml polypropylene Snap-Seal container (Corning Inc., Corning, NY) from which the cap had been removed; the reservoir was firmly seated in the liner such that its bottom came to rest ~2.5 cm above the bottom of the liner. The cap was punctured several times with a dissecting needle and saved to close the trap later. With the components thus nested, the lip of the

Fig. 3. Surface of a short-term trap collection, showing a lycosid spider (*Rabidosa rabida* Walckenaer), a carabid beetle (*Scarites* sp.), and assorted collembolans. Note seamless blending of reservoir lip with interior of liner (arrow).

liner completely covers the collar (not shown), and the rim of the reservoir blends seamlessly with the inner wall of the liner (Fig. 3).

The trap was then covered by a 25-cm-diameter, 3.2-mm-thick (0.125-inch-thick) transparent polycarbonate disc (Precision Plastics, Beltsville, MD), with two 2.1-cm holes drilled opposite one another 2.5 cm from the rim to accept two 45-cm-long sections of 1.2-cm-diameter (0.5-inch-diameter) ridged steel concrete reinforcing bar ("rebar") driven ~25 cm into the soil on either side of the hole with a mallet (Fig. 4). A 0.95-cm nonmetallic twin-screw cable clamp connector (Halex, Cleveland, OH) on each of the rebar sections firmly affixed the disc to the rebar (Fig. 5), holding it ~18 cm above the ground.

To activate the trap, the reservoir was filled to the 150-ml line with a 50% solution of propylene glycol (MWI Veterinary Supply, Boise, ID) in tap water as preservative. At the end of the trapping interval, the reservoir was removed from the trap by lifting out the liner and pushing a pencil up through the drain hole to unseat the reservoir, which was then lifted out so the catch could be removed for sorting in the laboratory. The trap was then securely closed with the snap seal and replaced in the liner to await the next trapping interval. Upon reopening, the level of preservative in the trap was checked, evaluated for evaporation or inundation, and returned to ~50% propylene glycol concentration by adding water or propylene glycol as needed.

To test the design, 48 trapping stations were deployed in the turf of ornamental plots at the U.S. National Arboretum (USNA) in Washington, DC, during the 2012

Fig. 4. Oblique view of trapping station, showing deployment of polycarbonate cover, festooned with droplets from a recent rainfall.

and 2013 field seasons. These have remained in place with the reservoirs removed, and their condition has been checked regularly.

Results and Discussion

The design of the pitfall, comprising three nesting collars, makes it simple to deploy reproducibly, and drops any wandering arthropod that crosses the boundary of the hole into the space bounded by the smooth surfaces of the reservoir and liner, which offer no purchase for escape. The trapping stations operated intensively for two field seasons captured the expected assortment of predators (e.g., wolf spiders [Araneae: Lycosidae] and ground beetles [Coleoptera: Carabidae]; Fig. 3). The cap makes it possible to close the reservoir in place, the pinholes allowing the air above the preservative to expand and contract without popping it open, and the fluid level markings enable proper maintenance of preservative level and concentration.

The trapping stations have been in place at the USNA for 3 yr with no deterioration except for some of the liners, which are easily and inexpensively replaced. The soil and turf around the traps are also little changed. The drainage hole in the liner, which keeps any water that inundates the hole at least 5 cm below the bottom of the reservoir, has prevented the reservoirs from flooding or being lifted out of the liner despite some periods of heavy rain.

Fig. 5. Detail of cable clamp holding polycarbonate cover to rebar support.

The apparatus described is built from parts that are widely available in North America. However, its simple nesting and modular design features lend it to being crafted from similar off-the-shelf parts available in most parts of the world.

Acknowledgments

I thank Marshall Carson for fabricating the metal and polycarbonate parts of the trap shelter, Jon Lundgren for identifying the *Scarites* individual in Fig. 3, and Paula Shrewsbury for lending me the hole-cutter.

References Cited

Adis, J. 1979. Problems of interpreting arthropod sampling with pitfall traps. Zool. Anz. 202: 177–184.

Driscoll, D.A. 2010. Few beetle species can be detected with 95% confidence using pitfall traps. Austral Ecol. 35:15–23.

Gotelli, N.J. and R.K. Colwell. 2011. Estimating species richness, Pp. 39–54 *In* Magurran, A.E. and B.J. McGill (eds.), Frontiers in Measuring Biodiversity. Oxford University Press, New York.

Greenslade, P.J.M. 1964. Pitfall trapping as a method for studying populations of Carabidae (Coleoptera). J. Anim. Ecol. 33: 301–310.

Knapp, M. and J. Růžička. 2012. The effect of pitfall trap construction and preservative on catch size, species richness and species composition of ground beetles (Coleoptera: Carabidae). Eur. J. Entomol. 109: 419–426.

Lang, A. 2000. The pitfalls of pitfalls: A comparison of pitfall trap catches and absolute density estimates of epigeal invertebrate predators in arable land. J. Pest Sci. 73: 99–106.

Luff, M.L. 1975. Some features influencing the efficiency of pitfall traps. Oecologia 19: 345–357.

Melbourne, B.A. 1999. Bias in the effect of habitat structure on pitfall traps: An experimental evaluation. Aust. J. Ecol. 24: 228–239.

Porter, S.D. 2005. A simple design for a rain-resistant pitfall trap. Insect. Soc. 52: 201–203.

Sunderland, K.D., G.R. de Snoo, A. Dinter, T. Hance, S.J. Helenius, P. Jepson, J.-A. Lys, F. Samu, N.W. Sotherton, S. Toft and B. Ulber. 1995. Density estimation for beneficial predators in agroecosystems, Pp. 133–162. *In* Toft, S. and W. Riedel (eds.), Arthropod Natural Enemies in Arable Lands. I. Acta Jutland. 70. Aarhus University Press, Aarhus, Denmark.

Topping, C.J. 1993. Behavioural responses of three linyphiid spiders to pitfall traps. Entomol. Exp. Appl. 68: 287–293.

Uetz, G.W. and J.D. Unzicker. 1976. Pitfall trapping in ecological studies of wandering spiders. J. Arachnol. 3: 101–111.

Whicker, A.D. and C.R. Tracy. 1987. Tenebrionid beetles in the shortgrass prairie: Daily and seasonal patterns of activity and temperature. Ecol. Entomol. 12: 97–108.