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Technical note

A simple design for a rain-resistant pitfall trap

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Summary. Heavy rain causes major problems with using pitfall traps to collect ants and other surface-active arthropods. A simple design for a rain-resistant pitfall trap is described. The trap is constructed by grinding a hole in the side of a plastic vial and then covering it with fine-gage wire screen. This hole allows excess water to drain out the side of the trap. A method for quickly setting small-diameter pitfalls into the ground with an auger and a battery-powered drill is also described.

Key words: Pitfall trap, collecting techniques, Formicidae.

Introduction

Pitfall traps are a standard method for assessing the relative abundance and distribution of ants (Bestelmeyer et al., 2000) and many other terrestrial arthropods (Southwood, 1978). Litter samples are more effective for collecting ants in dense forest litter (Bestelmeyer et al., 2000); however, pitfalls are much less labor intensive and they are also effective in terrestrial habitats without litter where litter samples would not be possible.

Small-diameter plastic vials are generally recommended for studies of ant abundance and diversity (Bestelmeyer et al., 2000) because they are easier to transport, install, store, and sort. Most importantly, more small pitfalls do a better job of sampling ants than fewer large pitfalls (Abensperg Traun and Steven, 1995); this is because displacements of even 30–50 cm can dramatically affect trap catch of surface-active ants.

A basic assumption of unbaited pitfall traps is that they produce a random collection of organisms that accidentally fall into the trap. In practice this is not usually true. Some organisms are motivated by or otherwise attracted to the 'dig-in effect' of freshly turned soil (Greenslade, 1973). Other organisms are less sure-footed and more likely to slip into a pitfall trap (Adis, 1979; Marsh, 1984; Seifert, 1990). Trap catch can be affected by the structure of the surrounding habitat (Melbourne, 1999). Also, silphid beetles and other sarcophages can be attracted if trapped organisms begin rotting. Nevertheless, pitfalls are often the best single method for assessing ant species richness and relative abundance as long as users recognize the limitations and do not over interpret the results.

A major problem with using pitfall traps is that heavy rain and the resulting surface runoff can quickly fill the pitfalls with water so that they no longer function as traps. This is a serious problem when the traps are being used for assessments of arthropod abundance. If more than a few traps are flooded, then the whole set of traps may need to be reset. Frequently, rainy weather can result in resetting plots several times or even in abandoning the effort entirely.

One strategy to avoid flooded traps is to reduce the time that they are placed in the field from 5–7 days to 1–3 days. The disadvantage of this is that fewer organisms are trapped and the vagaries of daily weather are averaged over fewer days. A second strategy is to use rain covers over each trap. The disadvantages of rain covers are that they substantially change the microenvironment, they make the traps obvious to vandals, raccoons, and other animals, and they usually add considerable time and trouble to setting out and picking up the pitfalls. Most importantly, covers are not effective in stopping surface runoff of water during heavy rains. Nevertheless rain covers may be useful in limiting dilution of pitfall trap preservatives when traps are left out for a week or more in rainy weather.

This paper describes a simple rain-resistant pitfall trap that usually does not fill up during rains and drains quickly, even after surface runoff (Fig. 1 A).

Methods

Rain-resistant traps were constructed from small polystyrene plastic snap-cap vials (e. g.; 30 by 85 mm; Thornton Plastic Co., Salt Lake City, Utah, USA) by grinding a 6–8 mm hole in the side about halfway up with a handheld rotary tool. A rounded square (~12 mm) of 80 mesh stainless steel or brass screen (31 wires/cm, opening width of ~0.16 mm; McMaster-Carr, Atlanta, Georgia, USA) was attached to the

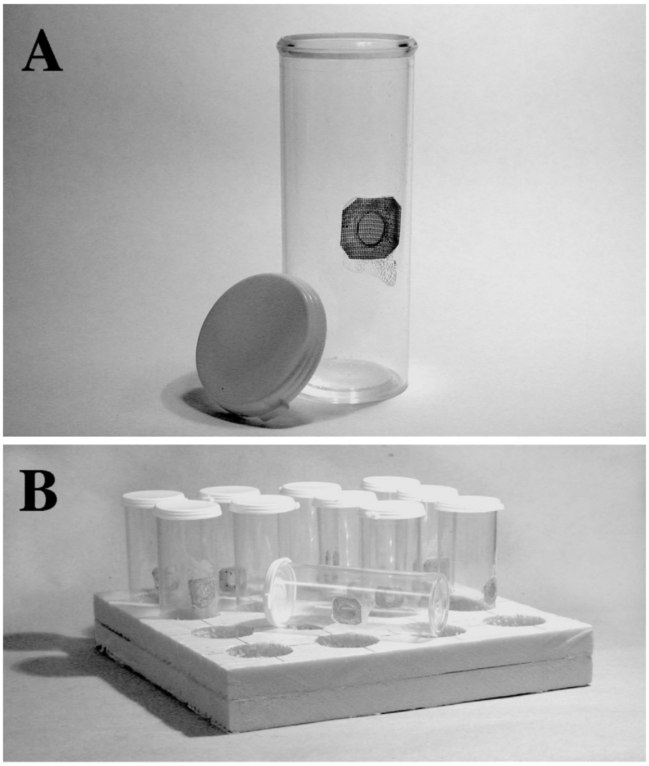

Figure 1. A) Rain-resistant pitfall trap constructed by melting fine mesh wire screen over a drain-hole in the side of a snap-cap plastic vial. **B**) Use of a light-weight vial holder (constructed out of foam board) allows pitfall traps to be transported in an upright position so the fluid does not drain out

plastic vial so it covered the hole and prevented organisms which fell into the trap from escaping through the hole (Fig. 1 A). The screen was attached to the vial by placing the screen on the corner of a hot plate and slowly rotating the vial over the hot screen while it melted into the plastic. Each trap takes only about a minute to build.

Pitfalls were installed in the ground with the aid of a 1 to 1 1/4 inch (25–32 mm) spiral wood auger driven by a cordless drill motor, an idea conceived by Tim Lockley (USDA, APHIS, Gulfport, Mississippi, USA). For big projects, I recommend a drill motor with at least an 18 volt rechargeable battery and several replacement battery packs. A hand-powered brace can be used as a backup for the drill motor if the batteries become exhausted. Use of a battery powered drill motor usually allows a trap to be set into the ground in 15–30 seconds. Use of the auger greatly reduces 'dig in' effects associated with a shovel or trowel. Newly drilled holes should be several centimeters deeper than the vial so that loose dirt does not block installation of the vial. Vials are best set level with the soil by covering the opening of the vial with the palm of the hand and pressing the vial down until the palm presses firmly against the ground. This technique compacts the ground around the pitfall and results in little or no detritus in the bottom of the vial. Vogt and Harsh (2003) describe a novel device for extracting this kind of vial without kneeling down.

The draining time of rain-resistant pitfall traps were examined with simulated rain in dry and wet soil conditions. A quantitative test of trap effectiveness was also conducted by setting out two rain-resistant pitfall traps and two standard pitfall traps at each of 20 plots (80 total traps) in a large pasture with high fire ant (*Solenopsis invicta* Buren) densities. One standard and one rain-resistant trap in each plot were filled to the brim each day to simulate heavy rain. Plots were chosen haphazardly, but none were located closer than 1 m to a fire ant mound. The four traps were spaced out 1 m from a central marker flag that marked the location of each plot. The trapping solution consisted of about 2 cm of a pink antifreeze solution (about 25 % propylene glycol) sold for waterlines in trailers and recreation vehicles with about 10 drops of dish soap added per liter to break surface tension of the antifreeze. Propylene glycol was used rather than ethylene glycol because propylene glycol is not poisonous and is not an environmental hazard to dispose. The traps were left out for 5 days in May 2004. After collecting, the number of fire ants in each pitfall was counted. Resulting data were analyzed with a 2-way randomized block ANOVA where the four pitfall treatments were the fixed treatments and the 20 plots were randomized blocks.

Results and discussion

This new pitfall trap design generally drained faster than rain falls. Heavy rain or runoff can fill the vial, but the water usually drains out several minutes afterwards when the surrounding soil is dry, and several hours when the surrounding soil is wet. The trap would, of course, not be effective if the study area was actually flooded or if the soil became completely saturated with water. Another problem is that floating organisms could be washed out of the trap during strong runoff; however, this would be less likely in rain-resistant pitfalls and most arthropods sink to the bottom so they would likely remain in the trap anyway. Rainfall would also dilute propylene glycol and most other preservatives used in the trap. Dilution was generally not a problem for ants left in pitfalls for 5 days, but it could result in serious decay for pitfalls left out longer in rainy weather. The final problem is that after the vials are removed from the ground, the preservation liquid (but not the arthropods) will leak out if vials are tipped on their side. This problem can be resolved by constructing a light-weight vial holder out of foam board with a thin plastic bottom (Fig. 1 B) or simply by stacking the vials upright in a small tray as they are collected.

Data from field trials comparing the catch of fire ants in rain-resistant vials and standard vials were square-root transformed to normalize the data and equalize the variance. Standard vials filled with water every day collected about 40 % fewer fire ants than the other three treatments (Table 1, $P < 0.02$). About 0.5 cm of water evaporated out of the standard pitfalls each day after they had been filled. This was apparently enough for them to function at 60 % of the rate of pitfalls not filled with water each day. Neither of the rain-resistant pitfall treatments were significantly different from standard pitfalls

Table 1. Mean number of fire ants (*Solenopsis invicta*) collected in standard and rain-resistant pitfalls topped off with simulated rain (H_2O) or without simulated rain

Pitfall Treatment (n)	Fire ants trapped ± SE	Significant differences[1]
Standard + H_2O (20)	133 ± 17	A
Rain-Resistant + H_2O (20)	205 ± 27	B
Standard (20)	217 ± 21	B, C
Rain-Resistant (18)[2]	263 ± 28	C

[1] Fisher's Protected LSD multiple range test ($P \leq 0.05$)
[2] Two pitfall traps were deleted as outliers because they were more than five standard deviations from the mean

without simulated rain (Table 1, $P > 0.05$). However, the difference between rain-resistant pitfalls and rain-resistant pitfalls with added water was marginally significant ($P = 0.047$) indicating that the addition of water to the rain-resistant pitfalls may have decreased catch; nevertheless, the lack of separation between this treatment and the standard pitfalls makes this uncertain. In short, simulated rain substantially decreased trap catch in the standard pitfalls, but the effect on rain-resistant pitfalls was either greatly reduced or non-existent.

In conclusion, the use of rain resistant pitfall traps should benefit scientists doing quantitative arthropod surveys by improving the dependability and productivity of pitfall sampling during rainy weather.

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