ON PITFALL TRAPPING INVERTEBRATES[1]

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ABSTRACT: This paper represents a concise guide to pitfall trapping, including recommendations on preservatives. Techniques are based on some 10,000 traps set worldwide over the past decade.

The following methods are reliable, efficient, inexpensive and based on extensive field tests in terrains from arctic tundra to rainforest and desert conditions. Many of the present observations are covered in the literature compiled by Dunn (1989) on the subject. Although my principal quarry are carabids in the Genera *Calosoma*, *Carabus*, and *Cychrus/ Scaphinotus*, there are typically substantial bycatches of Scorpionidae, Phalangidae, other arachnids, Rhaphidorphorinae, Tenebrionidae, formicine ants etc., making the methods of more widespread interest. In a typical season, I set anywhere from 1000 to 2000 traps, many of which are experimental to help determine what is most efficient for a particular set of conditions or area. Much of the information below is gleaned from trial and error although various colleagues have been instrumental in sharing ideas which are, to the best of my knowledge, unpublished. The bottom line is that there is no universal "best" design, but the following may help the beginner and even improve the efficiency of more advanced collectors.

MATERIALS AND METHODS

Although various tins, bottles, etc. will work, plastic cups much like those of Morill (1976), but smaller (200ml-250ml) are more practical. The major advantage of small cups is that they are easier and faster to install where digging is difficult, and take up less storage space, so that when travelling to third-world countries or even hiking into remote areas in North America, 200 in the suitcase or backpack require little space and add minimal weight. A further advantage (or disadvantage, depending on the quarry) is that small cups allow most lizards, shrews and other small vertebrates to escape, but will hold the largest beetles regularly encountered in the USA, e.g. prionine cerambycids. Even the small cups do catch salamanders and some shrews if there is ample liquid in the bottom of the cup, but the number is greatly reduced in comparison with larger cups. In a recent experimental series, ten 500ml and ten 250ml

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cups interspersed in the same area yielded comparable numbers of carabids, but only 4 shrews in the small cups compared to 31 in the larger ones (binomial $P<0.001$). Silphids attracted to shrews in the larger cups actually served as a deterrent to carabids, as those cups with an abundance of silphids contained little else.

About Cups

Plastic cups on store shelves come in two general shapes: shallow (depth roughly the same as the diameter) and "deep" (depth 1.5 times the diameter). The deep ones, as they can hold more rain, are harder to escape from, and can tolerate a few leaves in the bottom before organisms can climb out. These come in several grades: clear stiff ones tend to crack/break as they are forced into holes. Most colored stiff ones are fairly expensive, 20-40/$1.00 but keep their shape well, and only become brittle after a year or two. Finally, the cheapest 100/$1.00 are very thin-walled and can readily be forced into holes with protruding roots and take well to the contours of the hole one provides. The latter hold up to only one use. I alternate between economy and heavier duty cups but have no brand affinity. Buy whatever is most economical at the time. Paper cups are not recommended.

Cup Modifications

A common problem is that following a heavy rain, the cups are filled to the rim with water and specimens may spill out, plus the cup becomes ineffective for further trapping. In areas where this difficulty is anticipated, the solution consists of small holes in the wall on opposite sides about 3cm from the bottom. These need not be much larger than pinholes, and are better if made by melting with a hot wire than by punctures, as the latter are more prone to tearing. It is most efficient to prepare the cups in advance at the campfire or at home. Keep hole sizes below 1 mm because larger holes afford footholds for potential escape and shrews can shred the cup starting at the hole. Such holes allow excess liquid to drain and the trap remains functional.

Pitfall Placement

A common difficulty lies in relocating traps several months after their initial placement—a good field notebook here is essential, and diagrams are useful. Notes should be precise enough to allow others with access to the notes to find the traps for themselves! Some collectors routinely leave traps in areas where they will not personally return, but give directions to colleagues who will be in the area for servicing. If notes are good enough for others to find the traps, then it should be easy to find them yourself. My own success at relocations this season averaged about 99%, but has been as low as 80% where I set traps in open woodland in the late-winter only to return and find a one meter high undergrowth on the next summertime check, or where traps were buried under snow, yet could still be found in spite of surroundings bearing no resemblance to the first visit.

Patterns (i.e. straight line, loop), with a fixed number of paces between cups can go a long way toward letting you know exactly where to look for a missing cup. Beware, however, and do not underestimate the ability of vertebrates to figure out patterns, especially where cups are only a few paces apart. Hence individual patterns of more than ten cups are not recommended.

Barrier pitfalls are more productive than simple holes in the ground (Gibbons and Semlitsch 1981), however they sometimes attract unwanted attention and suffer molestation, plus they are quite labor-intensive to install. Nonetheless, the extra effort in installation may be warranted where the traps will function over long periods of time, and where it is known that the exact site will yield the desiderata. A compromise is to place traps in or next to natural paths or obstacles, thereby getting the benefits of a barrier without the labor. Good places are alongside large rocks, next to fallen logs, around tree stumps, along cut banks, in ravines, etc. Man-made obstacles should not be ignored: stone walls along property boundaries and building foundations can be exceedingly productive, especially near permanent light sources such as campground outhouses. Where no obstacles are available, as in scrub/semi desert situations, try placing traps near the bases of small bushes, which provide shade or shelter. If it takes an equal amount of labor to put out five simple cups or one short barrier, then cups are better as they will be sampling more microhabitats and allow one to more quickly zero in on the exact places where items of interest are found, then set barriers later to collect series.

Trap Installation

Obtain a small garden trowel, preferably one with a long, pointed, and stiff blade to cut through small roots and pry rocks without bending. Cookie cutter/plug cutting devices to remove cylindrical plugs of the dimensions to fit the trap sound good in the lab, but are nightmarish to use in the field. These require perfectly homogeneous soil without large roots or stones, so the trowel is just as efficient under those conditions, and infinitely easier in difficult soils. Just insert and twist to produce a hole suitable for a small cup.

In arid conditions or in loose sand, the sides of the hole often cave in as one digs. This can be remedied with some water in the hole.

To force thin walled cups into holes, take the whole stack and push down then lift, leaving the bottom cup in the hole. The other cups add rigidity to prevent the cup being installed from becoming mangled. Alternatively, use fingers pushing against the bottom of the cup from the inside. In sphagnum, or very soft ground, and loose sand, it is often not necessary to dig, just push the cups into the substrate.

Once the trap is set, be sure that the lip of the cup is flush with the ground, otherwise smaller species will be missed, and even larger ones are partially deterred.

How long to set?

An obvious disadvantage of pitfall collecting is that one is forced to either return or spend a long time in one place—unless conditions are exactly right and the desiderata can be baited. While one may not always have a choice of return times, the greatest proportion of the take generally comes in the first few weeks to a month. Longer intervals between servicing are only undertaken when the optimal time of year is unknown or unpredictable as in deserts where success is linked with rain. It is best to return at intervals of not longer than one month in areas with moderate precipitation.

Preservatives

Although ethylene glycol is the overwhelming favorite choice in North America and is probably best for truly long intervals, rock salt or table salt may be an attractive alternative. This is a much more environmentally acceptable and cheaper preservative than antifreeze (also more readily available in the third world, plus it can tolerate the same amount of dilution as ethylene glycol. Simply add an equal volume of salt crystals (1-2 cm in the bottom of the cup), then add water to barely cover the salt (more in arid areas, less where much rain is anticipated). The longest I have run traps and obtained good specimens from salt brine is 8 months. For such long sets, however, a roof is essential, and ethylene glycol is a must in arid areas. Salt brine acts as a good preservative but it is not useful if it dries out completely, and the truly long sets with salt require rather special weather conditions, where there is neither so much rain that the traps flood regularly, nor so little that they dry out completely. Salt is best for two- to five-week sets. Specimens thus preserved should be soaked in vinegar for a couple of days to let the salt diffuse out of specimens, otherwise it may precipitate out as the specimens dry. If this should happen, a quick (5 second), rinse in freshwater does no harm and dissolves the precipitate completely. Salamanders, annelids, and other soft-bodied organisms, will become completely dehydrated in salt brine, but will regain their original shape within hours if placed in water before fixing with formaldehyde.

Formaldehyde is also an effective preservative in pitfalls, but there are limitations to its use. However, formaldehyde-based traps usually are relatively free of molestation by vertebrates (see section on animal disturbance). Salt or vinegar spills in the car are nothing serious—formaldehyde is! Specimens taken with formaldehyde in traps (or preserved in ETOH) come out stiff, brittle, and unsuitable for genitalic preparation. These can be relaxed/salvaged, however, by soaking in dilute digestive enzymes such as pepsin for a few days (Persohn, pers. comm.). Since enzymes from pharmaceutical companies are not always readily available or inexpensive, an alterntive may be a solution of commercial meat tenderizer which contains digestive enzymes to achieve the same breakdown of muscle fibres.

Vegetable oil may prove to be an alternative to antifreeze in very arid conditions. This will not work well where there is much rain, as the oil floats. A mix of salt and oil, may work, but long-term results are not yet available. This method seems promising as it does not pose the environmental hazard of ethylene glycol. Specimens can be recovered from oil in the same manner as from antifreeze, with a kitchen strainer, and a detergent bath to get them clean. Cost is comparable to antifreeze, but it is more available.

Bait

Depending on the quarry, baits can be very effective for very short-term sets, even just overnight. The possibilities here are virtualy endless. The Europeans are particularly fond of red wine vinegar as an attractor and short-term conservator. Ripe banana also attracts a wide spectrum of invertebrates including many that are typically considered to be strictly carnivorous. Meats, (e.g. squid) can also be effective, but any smelly bait is asking for trouble from vertebrate carnivores. Messy/sticky bait e.g. molasses, is best kept in small separate receptacles inside the trap so that specimens and traps are not soiled (see Fig. 1a).

Roofing

It is always a good idea to add a roof, in part to keep out unwanted debris and excess water, but also to obscure cups from curious larger vertebrates. In a mature forest, simply peel bark from fallen trees and use the bark as in Fig. 1b. Where stones are available they can also make an effective roof (Fig. 1c) and where nothing is locally available, corrugated fiberglass roofing material cut into appropriately sized squares or rectangles, also makes for lightweight, compact portable roofs (Staven pers. comm.). Where there is much wind, however, it is advisable to weight these roofs with soil or sand to keep them in place. An alternative heavier roof can be fashioned from standard composite roofing material which is available free in unlimited quantities wherever somebody is having their roof redone. Leaves make poor roofing. Although roofs may appear to restrict access, many invertebrates crawl under in search of shelter!

What if traps are disturbed regularly?

Vertebrate disturbances are particularly annoying in the Eastern U.S., and the remedy depends on the nature of the culprit. Typically, this can be diagnosed from the nature of the disturbance.

Case 1: Cups still in the hole, but pushed up just enough so that the rim is no longer flush with the soil tend to be caused by moles or voles whose passage has been obstructed—if you push the trap down, and it is back up the next day — then move the trap a short distance to resolve the problem.

Case 2: Cups completely out of the hole, contents spilled but clean and not chewed. This typical of squirrels burying/digging up nuts. Usually only one or two out of a series of twenty cups will be affected, but virtually never the entire line. One is helpless against squirrel disturbance.

Case 3: Cups (often the whole line) out and chewed or mangled. Opossum and raccoon are inquisitive and intelligent. Traps near waterways are particularly vulnerable to discovery, and even roofs do not help much as raccoons routinely turn stones in search of invertebrates. Deer and raccoon damage is not easily distinguished, except that the former tends to occur more in open forest situations and the latter near streams. If the raccoon decides that it likes the trap contents there is little to be done except to be sure the preservative is odorless (i.e. salt), and traps are far enough apart that the raccoon does not discover a pattern and systematically take out the whole line. If the whole line is taken out, there is little point in trying the exact site again that season. Instead, put out

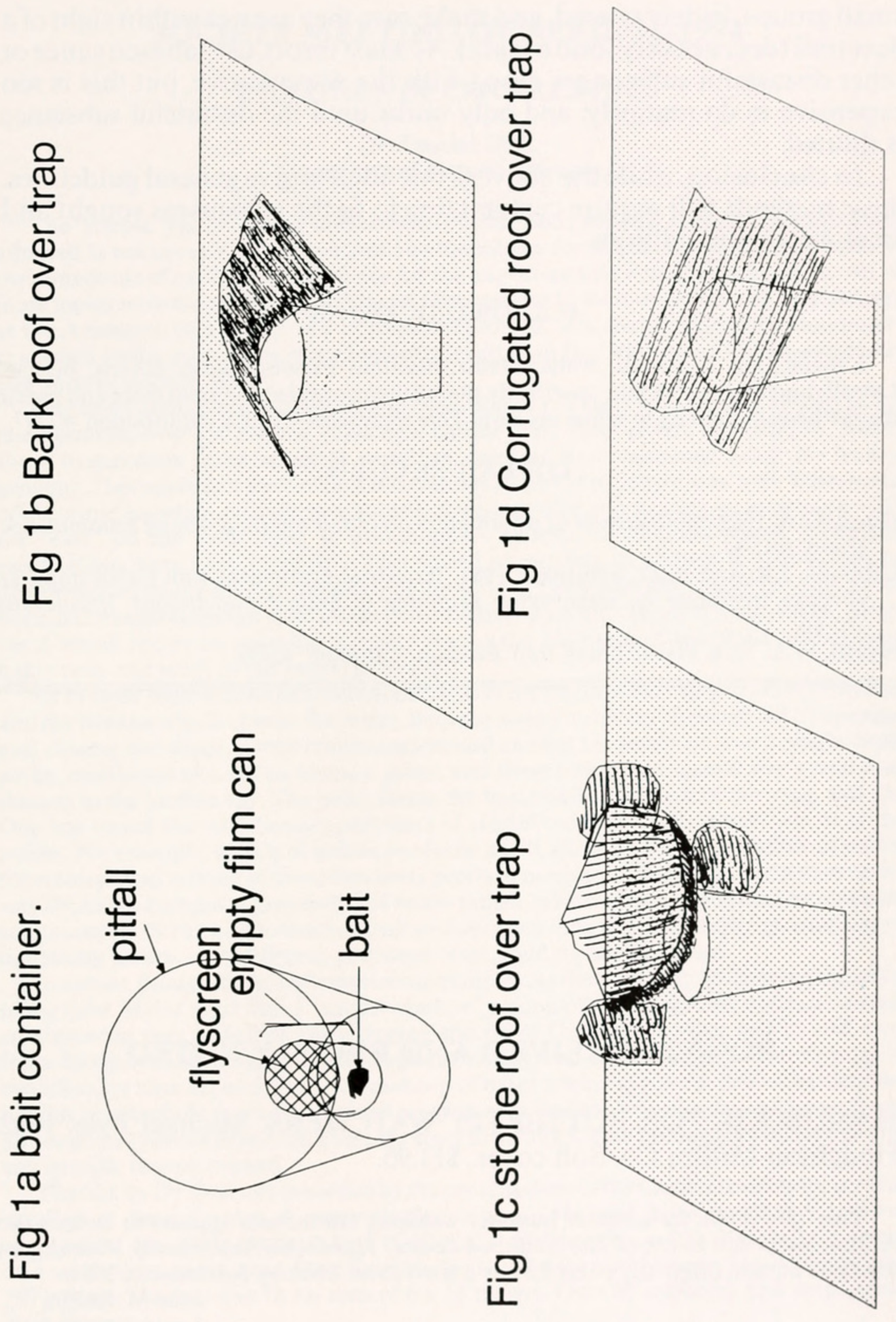

Fig 1a bait container.

Fig 1b Bark roof over trap

Fig 1c stone roof over trap

Fig 1d Corrugated roof over trap

small groups, widely spaced, and make sure they are not within sight of a deer trail (deer are very fond of salt!). As a last resort, use tabasco sauce or other distasteful substances along with the preservative, but this is too expensive to do routinely, and only works until the distasteful substance is diluted.

In conclusion, while the above is intended to give general guidelines, these methods will require customizing to fit the organisms sought and local weather conditions.

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BOOKS RECEIVED AND BRIEFLY NOTED

HANDBOOK FOR BUTTERFLY WATCHERS. Michael Pyle. 1992. Houghton Mifflin Co. Soft cover. $11.95.

This 'new' book for amateur butterfly watching enthusiasts appears to be an exact reprint, but in soft cover, of *The Audubon Society Handbook for Butterfly Watching* by the same author, originally published as a hard cover book by Scribners in 1984.

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