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Three factors affecting the pitfall trap catch of linyphiid spiders (Araneae: Linyphiidae)

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Summary

The effects of three factors influencing the pitfall trap catch of linyphiid spiders was investigated using polypropylene pitfall traps with ethylene glycol as the trapping fluid. Dilution of ethylene glycol did not reduce its effectiveness as a pitfall trap fluid but the addition of detergent increased the trap catch by 50 to 1000%. Some evidence was found to suggest that the daily catch of grassland spiders in pitfall traps declined as the frequency of emptying the traps decreased. Traps with rougher surfaces caught fewer spiders. The wear and tear caused by normal usage was found to reduce the catch of spiders when these traps were re-used.

Introduction

Pitfall traps are universally used to collect invertebrates, including spiders, from the ground stratum of many habitats. However, problems with their usage as an ecological sampling method have been cited by a number of authors (e.g. Adis, 1979; Desender & Alderweireldt, 1990; Topping & Sunderland, 1992). Unlike other disciplines it has not been common to test the efficiency of many sampling methodologies used in ecology, and in particular the pitfall trap. However, studies on the potential sources of error are necessary. Both activity (Heydemann, 1957) and trapability (Luff, 1975; Halsall & Wratten, 1988; Topping, 1993) are known to affect catch, but other factors such as the physical construction of the trap and placement may be equally important. This paper concerns three experiments used to assess the effects of some possible causes of error when pitfall trapping spiders.

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Trap fluid type

Spiders are soft bodied animals capable of climbing in and out of pitfall traps, thus for efficient trapping of spiders it is necessary to add a trap fluid to act as a preservative and a retaining agent. Previously used trap fluids include methylated spirits, ethylene glycol, formalin and plenyl mercuric acetate (Fichter, 1941; Uetz & Unzicker, 1976; Heydemann, 1956; Macfadyen, 1963). Formalin and ethylene glycol have been shown to be attractive to carabid beetles (Luff, 1968; Skuhravý, 1970; Holopainen, 1990), but no such effects have been suggested for spiders. It is also common practice to add a small amount of detergent to the trap solution in the hope of increasing the catch by reducing the surface tension of the trap fluid, as suggested by Basedow (1976). However, the effect of this addition on the catch of spiders has not been quantified.

Length of time the trap is operating

Long trapping periods in the field can be used to reduce over- or under-recording which could occur if the trapping period coincides with a period of unusually high or low activity. Whilst traps cannot be in the field indefinitely, it would be a waste of effort to service them frequently if less frequent sampling would provide equally good results.

Trap surface texture

It has commonly been suggested that pitfall traps with rough surfaces would catch less, owing to the ability of the animals to crawl up the rough trap sides and escape. Kudrin (1971) demonstrated this effect, while others such as Luff (1975) showed that the material from which the trap was made affected the efficiency of the trap (glass>plastic>metal). In ecological sampling the use of glass traps is prohibited by practicality and safety, so recourse has to be made to the cheaper and safer plastic pot. However, as they are used plastic traps become dirty and scratched. Since it is unlikely that traps would

Discussion

Although Waage (1985) showed that the addition of detergent to pitfall traps did not affect the catch of Coleoptera, these results show clearly that the addition of detergent to an ethylene glycol/water mixture can dramatically increase the catch of spiders. This might be explained by the fact that the linyphiid spiders encountered in this study are lighter than beetles and have long, often hairy, legs. They would therefore be less likely to break the surface tension of a trap fluid without the addition of detergent. Rank correlation and χ^2 analysis demonstrated that the addition of detergent did not increase the catch of species differentially. However, this conclusion may not be valid when considering larger spiders such as Lycosidae which may be heavy enough to penetrate the surface of the liquid without the addition of detergent. The catches of spiders from differing dilutions of trap fluid were shown not to be significantly different, with the exception of water without detergent which gave a very small catch. This suggests that traps which have been diluted by rainfall will still be as efficient as before dilution, as long as there is some detergent left in the fluid. Assuming that there is no loss of specimens owing to overflow or "splashing out", rainfall should have no effect on the number of spiders caught. The quality of the specimens will, however, be affected as the preservative qualities of the trap fluid are reduced by increased dilution. The poor catch of the water-filled traps could also be linked to decomposition of the contents and consequent increase in surface films. Since there was no difference in catch between the dilutions of ethylene glycol no evidence is provided to show that ethylene glycol was acting as an attractant or repellent towards spiders.

The results also suggest that the more frequently the pitfall traps are emptied the more spiders will be caught. However, the difference in numbers caught by monthly and fortnightly emptying was only 20% for double the effort. The extra catch would not justify the extra labour involved when the scale of the study is large (it would be easier to increase the number of traps by 20%). The decrease in catch observed in this experiment is probably caused by increased contamination of the trap fluid by trapped animals, soil and vegetation. Any contamination of this type will reduce the efficiency of the trap by increasing the number of surfaces a spider may use to climb out of the trap; it will also increase footholds on the side of the trap as suggested by Luff (1975). Since this experiment was performed on a garden lawn where disturbance was kept to a minimum this effect can be expected to be larger in more disturbed habitats (e.g. grazed pasture).

Trap type	Mean catch	S.E.
New	15.9	1.87
Old	7.5	1.11
Fine	5.6	0.93
Coarse	3.0	0.49

Table 4: Mean number of spiders trapped (per trap) for four pitfall surface texture treatments. New=new traps, old=traps used for four weeks, washed and re-used, fine=rubbed once with 1200 grade wet & dry paper, coarse=rubbed once with 120 grade wet & dry paper.

The catch of pitfall traps was inversely related to the roughness of the trap surface. One of the most important aspects of these results was that traps which had been used for a period of four weeks caught less than half as much as new traps, even though they were washed before use. In long term studies, if new traps are set at the beginning of the season and are then emptied and re-used a number of times, abrading of the trap surface will occur as the season progresses and soil and other debris enters the trap. As a result the early catches may be taken from traps which are acting at twice the efficiency compared with later samples. These results may at least partly explain the "installation effect" (Greenslade, 1973; Joose, 1965), whereby traps will always catch more when newly installed, if they were new when first placed.

Conclusions

To maximise pitfall catches of spiders a trap fluid containing detergent should be used. However, care must be taken to prevent the trap contents becoming soiled with debris and decomposing matter, or allowing the trap fluid to become diluted to the extent that its preservative properties will be lost. The rate at which these problems occur may depend on the climate and the type of habitat being sampled. If catches are to be compared between plots or treatments, then it is important to keep the traps operating at the same efficiency, perhaps by increasing the frequency with which they are serviced and deliberately roughening the surface of new traps.

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	Twice-weekly collection	Weekly collection	Fortnightly collection	Monthly collection
Trap 1	69	54	57	50
Trap 2	58	61	46	63
Trap 3	83	65	81	50
Trap 4	70	60	41	24
Mean	70.0	60.0	56.2	46.7

Table 3: Number of spiders trapped by a pitfall trap for four collection regimes over a period of one month.

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be in such plentiful supply that they could be discarded, they are usually re-used. If this process roughens the trap surface then this may affect the capture efficiency of the trap.

Materials and methods

Three separate experiments were conducted on an area of closely mown lawn at the University of Newcastle Field Station, Heddon on the Wall, Northumberland. All pitfall traps used were a standard size (polypropylene pots 85 mm in diameter and 110 mm deep); trapping fluid was added to a depth of 25 mm. Ethylene glycol was chosen as the trap fluid because of the ease of handling (cf. formalin) and because it does not evaporate in warm weather (cf. methylated spirits).

Effects of varying concentrations of ethylene glycol trap fluid and the addition of detergent

Sixty clean, used pitfall traps were placed in two blocks of five rows of six at 0.5 m intervals. Six treatments were randomly allocated to each row:

(1) Undiluted ethylene glycol;
(2) Ethylene glycol:Water 1:24;
(3) Water;
(4–6) As 1–3 but with the addition of 2 cm^3 $litre^{-1}$ domestic detergent.

Undiluted ethylene glycol and water were chosen to represent the extreme conditions possible, while the dilution of 1:24 was used as a possible dilution expected after the traps have spent a number of weeks in the field. The traps were left for four weeks before collection, when the individual trap catches were recorded.

Frequency of emptying

Four rows of four new pitfall traps were placed at 1 m intervals. One trap in each row was emptied twice weekly, weekly, fortnightly or after four weeks. Trap fluid was replaced when the trap was emptied. In order to compensate for differences in positioning the traps were rotated by one place within each row at the end of each week; thus at the end of the experiment each trap had occupied each position within each row for one week and all traps had been trapping for a period of four weeks. After each collection the number of spiders caught by each trap was determined.

Trap surface texture

Ten sets of four pitfall trap treatments were placed 1 m apart in five rows of eight traps. Two replicates of each of the four treatments were randomly allocated to each row. The traps were left for a period of four weeks before collection. The treatments were (a) new traps, (b) traps which had been used in the field for a period of four weeks and had been washed and re-used, (c) new traps rubbed round once inside with 1200 grade wet & dry paper (fine), used dry, and (d) as "c" but using 120 grade wet and dry paper (coarse).

Results

Effects of varying concentrations of ethylene glycol trap fluid and the addition of detergent

The experiment yielded a total catch of 1548 adult spiders comprising 19 species. All data were transformed by Ln(x)+0.5 before analysis by three-way analysis of variance. There were highly significant differences between the catch of fluids containing detergent and those without (the addition of detergent increased the catch by 50–1000%) ($F=59.81$, df=1,48, $p<0.001$). There was no marked difference in catch between the dilutions of trap fluid used, but the interaction between dilution and presence/absence of detergent was significant ($F=8.94$, df=2,48, $p<0.001$). This was largely due to the very poor catch of those traps containing water and no detergent (Table 1). The addition of detergent did not differentially affect the numbers of the three most abundant species (Table 2) ($\chi^2=0.390$, $0.50>p>0.10$), all being 2–3 times more abundant in the traps containing detergent. The fourth most abundant species comprised only 1.3% of the catch and could not be used for the analysis. Many of the specimens from traps with water as the trap fluid were in an advanced stage of decay.

Frequency of emptying

There was a slight trend towards reduced catch with decreased frequency of emptying as shown by the mean number of spiders caught (Table 3). However, the small sample size precluded further statistical analysis.

Trap surface texture

The total catch was 320 adult spiders comprising 14 species. One-way analysis of variance showed a significant difference between catches of the different types of trap ($F=24.50$, df=3, $p<0.01$). SNK tests demonstrated that the catch of the new traps was different from all the other types of trap, and these showed a gradation in catch reduction from old to 1200 grade roughened traps to the 120 grade roughened traps (Table 4).

Fluid type	Ethylene glycol	Diluted ethylene glycol	Water
Detergent	39.8	29.8	41.5
No detergent	19.8	19.3	4.3

Table 1: Mean number of spiders trapped (per trap) by ten pitfall traps containing six different trap fluids over a period of four weeks.

Species	With detergent	Without detergent
***E. dentipalpis* (Wider)**	641	250
***O. fuscus* (Blackwall)**	254	113
***E. atra* Blackwall**	152	47
Others	62	29

Table 2: Numbers of the three most abundant spider species (and all other spiders) caught in pitfall traps (summed for ten traps with each of three dilutions of ethylene glycol), with and without the addition of detergent.