SAMPLING EFFICIENCY OF PITFALL TRAPS AND WINKLER EXTRACTOR FOR INVENTORY OF THE HARVESTMEN (ARACHNIDA: OPILIONIDAE)

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Abstract. Most soil and leaf litter invertebrates lack efficient inventory methods. We evaluated the efficiency of the pitfall traps (or Barber method) and Winkler extractor (or Winkler method) in a beech forest on limestone in southwestern Romania using harvestmen (Arachnida: Opilionidae) as target group. The aim was to test if the relative abundance, species richness and species composition differ between the two methods. The harvestmen relative abundance and species richness were different when assessed by the two sampling methods. Winkler extractor captured greater numbers of harvestmen than pitfall traps, whereas pitfall traps caught more harvestmen species. Harvestmen assemblages as determined by Winkler method were found to be more similar with natural harvestmen assemblages. If the aim of the study is to analyse the community patterns Winkler extractor could be more efficient then pitfall traps. Our study suggests that the choice of the sampling method should be applied depending on the type of the investigation.

Key words: pitfall traps, Winkler extractor, relative abundance, species richness, species composition.

1. INTRODUCTION

Soils are biodiversity hotspots (GHILAROV, 1977; GILLER, 1996). Most of the soil and litter organisms are tiny and numerous, not easy to see with the naked eye, therefore efficiently inventory of soil invertebrates requires special methods (KRELL *et al*., 2005).

A simple and handy device frequently used in ecological surveys of soil macro-invertebrate communities is the Winkler extractor (WARD, 1987; HAMMOND, 1990; OLSON, 1991; BELSHAW & BOLTON, 1994; FISHER, 1998; CHUNG *et al*., 2000). It was first invented in 1907 by Emil Moczarski in Vienna (Austria) and the present name originated from Winkler & Wagner Company, the first company that put it on the market (HOLDHAUS, 1910). The procedure consist in sieving leaf litter and top soil through a wire sieve with a mesh width of about 10 mm to exclude large particles and reduce the volume of the material. From the sifted material spread on a white cloth the macro-invertebrates are extracted and preserved.

Pitfall traps or Barber method represent another sampling method inexpensive and easy to use. Originally described by Barber (1931), pitfall traps continue to be amongst the most widely employed sampling methods for ground-dwelling macro-

invertebrate. Pitfall traps consist in cups with preserve liquid sunk into the ground flush with the surface (CLARK & BLOM, 1992).

We compared the sampling efficiency of pitfall traps and Winkler extractor for the inventory of harvestmen focusing on differences in (i) relative abundance, (ii) species richness and species composition between the two methods.

2. MATERIALS AND METHODS

The study was carried out in a beech forest on limestone located in Ponoarele Bulba karst complex, Romania (latitude N 44° 59' 52.6", longitude E 22° 47' 32.3", altitude 292 m). The sampling took place between 2nd of April and 30th of May in 2008. Eleven pitfall trap arrays consisting of groups of three in a triangle design with 2 m distance between traps were placed. The traps were 0.15 liter plastic cups with an opening of 6.0 cm diameter. They were protected from rain with 25–25 cm acrylic glass roofs. Seventy ml of 1:3 mixtures of ethylene glycol and water were added to each trap. After 29 days the traps were emptied and harvestmen transferred in 80% alcohol. Near the places where the pitfall traps were operated eleven 1-m^2 samples of leaf litter and soil were taken. The litter was collected by hand and the soil was scraped up to a depth of about 3 cm with a trowel. The samples were sieved through a Winkler extractor. After sieving the samples were spread on a white cloth (of one square meter area) and harvestmen were captured by hand and transferred to 80% alcohol. We considered a 1-m^2 quadrate for the Winkler method and a three pitfall traps array as a sample.

All adult harvestmen caught were sexed and identified to species according to MARTENS *et al*., 1978 and AVRAM, 1971.

To compare differences in relative abundance of the species caught by the two methods Kendall's rank correlation was used because assumptions for parametric test (normality Kolmogorov Smirnov test) were not fulfilled. To compare the two sampling methods according to species richness, we first tested whether the number of species collected by one method was significant different from the number of species collected by the other method using paired samples t test. Since the sampling methods differed with respect to sample size (numbers of individuals caught), we used rarefaction method to achieve comparability (Ecosim soft, GOTELLI & ENTSMINGER, 2007).

Then, to assess the similarity in composition of the species assemblages sampled with each method cluster analyses were performed. Species dissimilarity was calculated using the Bray-Curtis index and an UPGMA dendrogram generated using MVSP (KOVACH, 1999).

3. RESULTS

Our analyses are based on a total catch of 199 adult harvestmen. Overall, 12 species were identified, with 9 species recorded with pitfall traps and 11 species recorded with Winkler extractor, respectively. Catches from Winkler samples were strongly dominated by a single species, *Holoscotolemon jaqueti* (CORTI, 1905) (80.87%). *Nemastoma bidentatum sparsum* (GRUBER & MARTENS, 1968) (26.19%) was the dominant species in the traps samples close followed by *Paranemastoma silli* (HERMAN, 1871) (25.00%) (Table 1). Comparison among pitfall traps and Winkler samples using Kendall's rank correlation indicated no significant concordance of the species ranked according to species relative abundance caught ($\tau = 0.183$, $p = 0.479$).

Table 1

Relative abundances (*A*) and number of specimens (*N*) in both pitfall traps (Barber abbreviated B) and Winkler samples (Winkler abbreviated W), and individually in pitfall traps and in Winkler samples

Species	B		W		BW	
	A	*N*	*A*	*N*	*A*	*N*
Carinostoma elegans	10.71	9	6.09	7	8.04	16
Dicranolasma scabrum	9.52	8	2.61	3	5.53	11
Egaenus convexus	3.57	3	0.00	0	1.51	3
Holoscotolemon jaqueti	1.19	1	80.87	93	47.24	94
Lophopilio palpinalis	0.00	0	2.61	3	1.51	3
Mitostoma chrysomelas	1.19	1	0.00	0	0.50	1
Nemastoma bidentatum sparsum	26.19	22	0.87	1	11.56	23
Paranemastoma silli	25.00	21	1.74	2	11.56	23
Platybunus pinetorum	1.19	1	0.00	0	0.50	1
Trogulus closanicus	8.33	7	0.87	1	4.02	8
Trogulus tingiformis	3.57	3	0.87	1	2.01	4
Trogulus tricarinatus	9.52	8	3.48	4	6.03	12
Total	100	84	100	115	100	199

Across all samples, the asymptotic species richness estimated by Barber method was very similar to that estimated by Winkler method ($r = 0.984$, $p < 0.001$). Neither species richness estimated by both methods nor that estimated by each individual method have not reached a plateau (Fig. 1).

Number of individuals differed between methods (B: N = 84, W: N = 115). Figure 2 shows rarefaction curves, which represent the number of species expected to be detected by given the common abundance level (84 individuals).

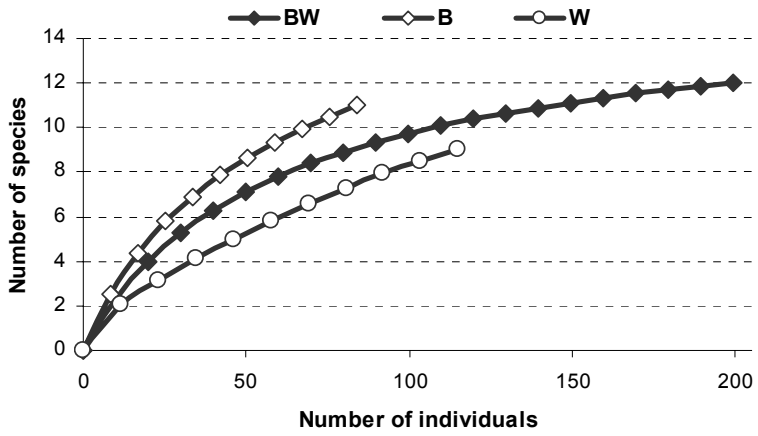


Fig. 1. – Species accumulation curve estimated from pitfall traps (Barber abbreviated B) and Winkler samples (Winkler abbreviated W) (black rhombus), and individually from pitfall traps (white rhombus) and Winkler samples (white circle) using EstimateS.

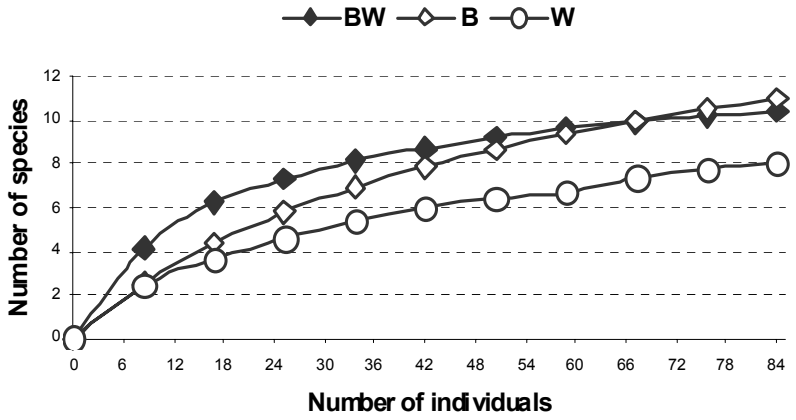
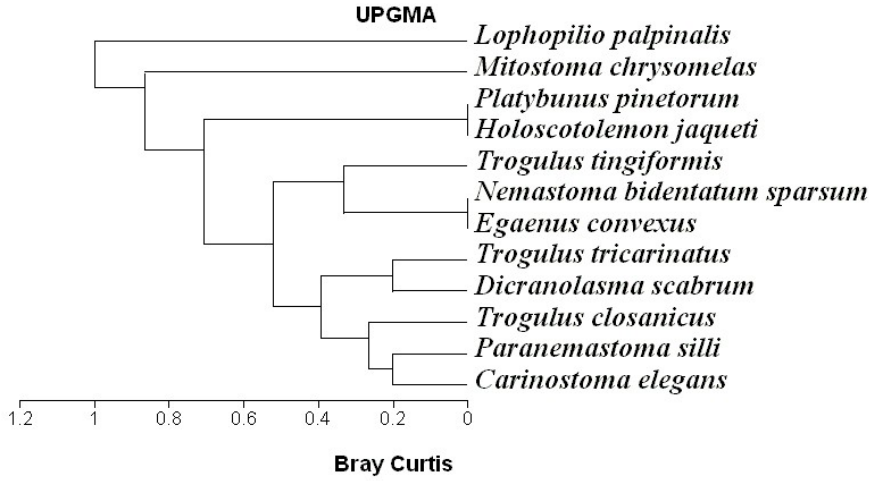


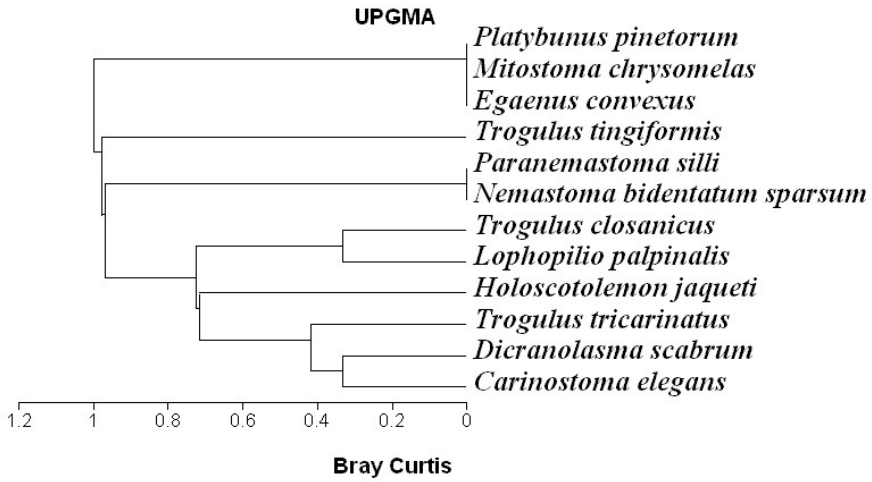
Fig. 2. – Effect of the number of individuals sampled on expected species numbers obtained by the sampling methods. Curves obtained by rarefaction from pitfall traps (Barber abbreviated B) and Winkler samples (Winkler abbreviated W) (black rhombus), and individually from pitfall traps (white rhombus) and Winkler samples (white circle).

Given identical abundance level, expected species number for Barber method was significant higher than respective values for Winkler method ($t = 5.193$, $p < 0.001$).

A cluster analysis based on degree of dissimilarity (Bray–Curtis) among the harvestmen assemblages collected in both pitfall traps and Winkler samples was done. Harvestmen assemblage as determined by the Barber method differed considerably in species composition from that obtained from the Winkler method (Fig. 3a,b).



a)



b)

Fig. 3. – Species assemblages as recorded by a) the Barber method and b) the Winkler method.

4. DISCUSSION

Both methods tested are simple to use and relative cheap not requiring a complex infrastructure. They tend to be used when time is limited and when a rapid extraction method is required.

Pitfall traps have been used in study concerning community composition (CURTIS, 1980; CULIN & YEARGAN, 1983; BONTE *et al*., 2002; RUSSELL-SMITH, 2002), density (NIEMELÄ *et al*., 1992) spatial distribution (HENGEVELD, 1979),

relative abundance (SPENCE & NIEMELÄ, 1994; STOYAN & KUSCHKA, 2001) and species richness estimation (EDWARDS, 1997; STANDEN, 2000).

Winkler extractors generally have been used to characterize point diversity at the sampling time for ecological surveys (KRELL *el al*., 2005).

Both methods were useful in specific circumstance indicating that the goals of the study dictate the methods (Table 2).

Table 2

Effectiveness of sampling methods for collecting specific type of data

Data or design study	Barber method	Winkler method
Estimating relative abundance	Acceptable	Recommended
Estimating species richness	Recommended	Acceptable
Estimating species assemblages	Poor	Recommended
Time consuming	Acceptable	Poor
Cost	Affordable	Inexpensive

The tested sampling methods were differed in relative abundance of the species. When the aim is to catch relative abundance for certain species (*Holoscotolemon jaqueti*) Winkler extractor proved to be more appropriate method whereas Barber method yielding more highly quantitative results for overall species (Table 1).

As suggested by the shapes of species accumulation curves (Fig. 1), the sampling did not detect all the harvestmen species occurring in the Bulba Ponoare beech forest. Sampling methods differed in species numbers detected, even at equal standardized common abundance level. Pitfall traps proved to be more efficient than Winkler extractor if the aim of the study is recording species richness.

But pitfall trapping bears many sources of error (ADIS, 1979): depend on temperature (RAWORTH & CHOI, 2001; MOLS, 1993), vegetation structure and density (TOPPING & SUNDERLAND, 1992; MELBOURNE, 1999; BONTE *et al*., 2002), season (RAWORTH & CHOI, 2001; TOPPING & SUNDERLAND, 1992), prey availability (MOLS, 1993) and activity of ground-dwelling species. Furthermore, the catches are also influenced by the duration of sampling (RIECKEN, 1999; JAMES, 2004), the killing agent used (WEEKS & MCINTYRE, 1997) and by species specific escape abilities (HALSALL & WRATTEN, 1988).

Harvestmen assemblages determinate by the Winkler method indicated a more appropriate pattern of natural species assemblages. The last four species jointed in dendrogram are relatively moderate hygrophilous species, found usually in forest as well in open habitats, whereas the most species jointed in the sixth cluster are species that prefer moist forest habitats, except *Trogulus tricarinatus* (LINNAEUS, 1767) a species that was found also in open karren fields.

As time Barber method is more time consuming than Winkler. Pitfall traps must let operate between one and several weeks. Also Barber method needs at least two visit al study area whereas Winkler just one. The equipment for Barber method is more expensive relative to the other method tested here but provides a permanent record during the survey period.

From the above discussion, several recommendations can be made for the future harvestmen inventory studies: selection of a single sampling method requires sufficient information to justify such a decision, Winkler method is more appropriate for species composition assessment whereas Barber method will give a more accurate estimation of species richness and relative abundance indices.

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