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Suction sampling in alpine habitats: experiences and suggestions

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Abstract
Experiences regarding the first use of a cheap, light and comfortable suction sampler for density estimations of spiders, harvestmen, pseudoscorpions and carabid beetles in steep slopes of alpine habitats (Salzburg, Austria) are shared and discussed. Data from suction sampling and pitfall trapping gained under the same measured period are compared. Suggestions for future usage of this method are provided. Suction sampling in steep slope habitats involves two people, is time-consuming and thus makes the study expensive. Nevertheless, this is probably the most effective method if quantitative data on arachnids from alpine habitats is to be obtained.

Key words: Arachnida, Araneae, Opiliones, Pseudoscorpiones, Alps, density estimations, methods

INTRODUCTION

There are several methods for estimating the number of epigeic invertebrates per unit area: hand searching, use of fenced traps or emergence traps, heat extraction of soil samples, or sampling with a suction device. During the last decades data obtained by using different types of suction samplers have been published and questions about the efficiency of these samplers have been discussed (Kauri et al. 1969; Solhöy 1972; Duffey 1980; Hand 1986; Sunderland & Topping 1995; Sunderland et al. 1995). The Dietrick vacuum insect sampler or D-vac (Dietrick 1961) and related designs, e.g. the Burkhard (Duffey 1974) or the Thornhill vacuum sampler (Thornhill 1978), have mostly been replaced by the leaf-blowers or leaf-gathering suction devices for absolute density estimations (De Barro 1991; Macleod et al. 1994; Samu & Sárospataki 1995; Samu et al. 1997). Since the latter devices have never been used in steep alpine habitats, we decided to test them under such conditions. The test was performed parallel to a pitfall trap inventory of arachnid and carabid communities. This report about our first experiences includes suggestions for future suction sampler studies in the steep slopes of alpine habitats.

STUDY AREA

Five different sites within a mosaic of alpine habitats along the Grossglockner Hochalpenstrasse were chosen. The panoramic road lying between the Austrian counties of Salzburg and Carinthia crosses the Hohe Tauern National Park (1800 km^2 in the Eastern Alps) comprising crystalline rocks with a high mica and a low base mineral content. Sites I, II, and III as well as IV and V were situated close to each other between 1960 m and 2280 m a.s.l.; however,

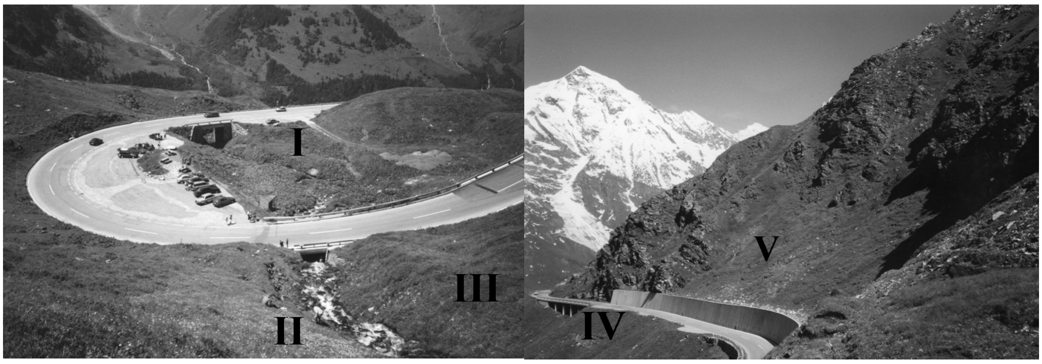

Fig. 1. The five study sites along the Grossglockner Hochalpenstrasse. I, II, and III are some hundred meters away from IV and V.

they are separated by the road and a mountain stream respectively (Fig. 1):

-Site I: site poor in plant species (*Rumex alpinus* dominates) within a bend of the road; nitrogenous soil with a thick litter accumulation; 1960 m a.s.l.; not sloping.

-Site II: peripheral area of a cattle pasture near a mountain stream; a species rich *Nardetum* with few dwarf shrubs; almost no litter; 2020 m a.s.l.; ≤ 45° slope facing WNW.

-Site III: grassy site (*Anthoxanthum alpinum, Deschampsia cespitosa, Juncus trifidus, Nardus stricta, Poa alpina*) interspersed with dwarf shrub species *Vaccinium myrtillus, V. gaultherioides*, and *Calluna vulgaris*; near a mountain stream; low litter accumulation; 2020 m a.s.l.; ≤ 45° slope facing WNW.

-Site IV: artificial embankment below the road with herbaceous vegetation dominated by *Alchemilla vulgaris* agg., *Geranium sylvaticum, Pimpinella major, Silene vulgaris* and some grasses (*Agropyron repens, Festuca rubra, Phleum pratense*); low litter accumulation; 2200 m a.s.l.; ≥ 45° slope facing SW.

-Site V: grass-dominated site (*Agropyron repens, Carex sempervirens, Deschampsia cespitosa, Festuca rubra, Juncus jackquinii, Poa alpina*) some meters above a concrete embankment wall

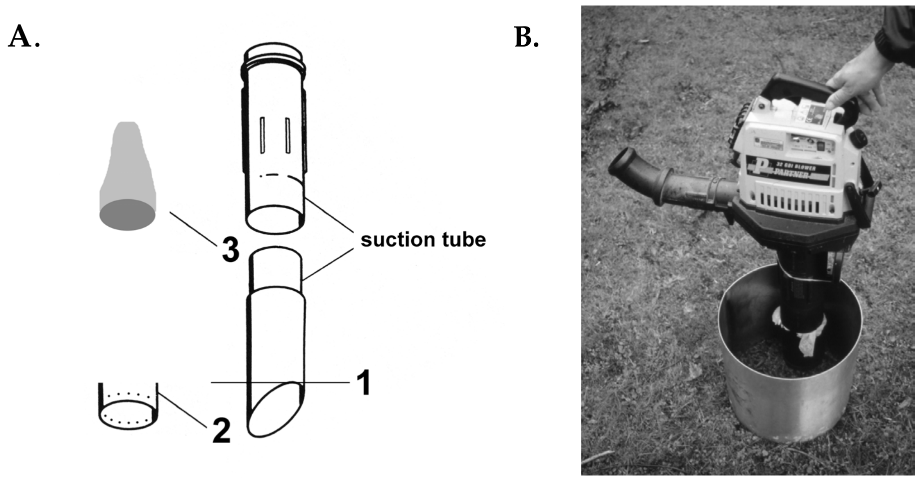

Fig. 2. The Partner 32 GBI suction sampler: assembly **(A)** and usage **(B)**. 1: slanting end of nozzle cut off (see 2); 2: holes (5 mm diameter) drilled around nozzle end; 3: collecting net, to be fitted between the two parts of the suction tube.

along the road; low litter accumulation on a stony underground; 2280 m a.s.l.; ≥ 45° slope facing SW.

MATERIAL AND METHODS

Suction sampling

The suction sampler used was a petrol driven Partner 32 GBI Blower: ca. 6 kg, 32 cm^3 air cooled engine operating at 7600 rpm and 86 dB maximum, nozzle width 0.01 m^2. The distal part of the suction tube needed modification (Fig. 2): The slanting end of the nozzle was cut off so that the sampler can be used in a perpendicular position (1 on Fig. 2A). Several holes (ca. 5 mm diameter) were drilled around the nozzle's end (2) to allow a continuous air-stream also when the suction-tube is firmly pressed down to the ground. A collecting net (3) can easily be fitted between the two parts of the suction tube. A metal cylinder enclosure (Fig. 2B) was made (ca. 7 kg solid steel which allowed us to press it some cm into the soil). It was dimensioned with an area of 0.1 m^2 and 0.5 m height.

The upper part of the vegetation was vacuumed first, then cut, and the plants were searched for remaining specimens. Afterwards, the sampling was continued by repeatedly pressing down the nozzle, so that the area within the cylinder was completely covered. Depending on the vegetation and soil type the collecting net had to be emptied after varying numbers of sub-samples to maintain the suction power of up to 66 m/s. We emptied the collecting net by lowering the suction power to a minimum using the throttle lever while the nozzle was held over a plastic bucket. The material was transferred into a glass with ethanol. We finished the sampling procedure within one enclosure when no more specimens could be found either in the sub-sample material or on the soil surface. Five enclosures were sampled in each of the five sites on 07.08.1998. The sampling duration for one enclosure was up to 20 minutes on average.

Pitfall trapping

Between 13 July and 8 September 1998 five pitfall traps (7.5 cm Ø, 0.25 l) with 4% formalin solution (and detergent) were placed in the centre of each of the habitat sites either in a row (sites I-III) or within a 6 x 6 m square (IV and V). The traps were placed about 3 m apart, protected by aluminium covers and emptied every two weeks (28 July, 11 Aug., 24 Aug., and 8 Sept.).

RESULTS

Time consumption

Starting with collecting in the field and finishing with a simple species list, the time needed for one suction sampling and one pitfall trapping period (28.07. - 11.08.98), was approximately the same. Suction sampling had to be done by two persons, because of the steepness of the sites: 12.6 h (field work) + 6 h (identification) = 18.6 h for pitfall traps vs. 16.9 h (field work) + 2.2 h (identification) = 19.1 h for suction sampling. Thus our suction sampling effort resulted in 0.148 m^2/h covered. The difference of 0.5 h less for gaining pitfall trap results can be subtracted from the time needed for an extra travel to the study site, since pitfall traps have to be installed and emptied.

Suction sampling

A total of 177 arachnids and 1 carabid were captured. Of the arachnids 20.9% were adult and belonged to 10 spider, 2 harvestman, and 1 pseudoscorpion species (Table 1). The density of spiders was highest with a median of 6 specimens/m^2 in III, and lowest with a median of 2 specimens/m^2 in II (Fig. 3). The density of adult spiders was highest with a median of 2 specimens/m^2 in V. Harvestman density was highest in the herbaceous sites I and IV and lowest in the grassy sites, especially in II, where not even one specimen was sampled.

Suction sampling precision

The coefficient of variation (CV = SD/mean) is a dimensionless measure of sampling variability that allows comparison between sites and years. For adult spiders it was 0.32-0.61, for adult harvestmen 0.66-1.00. It was within the same

Tab. 1. Species recorded at five sites in 25 suction samples (0.1 m² each) on 07.08.1998 as well as with 25 pitfall traps (28.07. - 11.08.1998). Species captured only with pitfall traps are not listed. The number of juveniles are given in brackets.

FAMILY/Species	Pitfall	Vac
CLUBIONIDAE		
Clubiona sp.	-	(1)
LINYPHIIDAE		
Gen. sp.	(3)	(11)
ERIGONINAE		
Ceratinella brevipes (WESTRING, 1851)	1	3
Diplocephalus latifrons O.P.-CAMBRIDGE, 1863	2	1
Erigonella subelevata (L. KOCH, 1869)		4
Pelecopsis radicicola (L. KOCH, 1872)	11	5
Walckenaeria alticeps (DENIS, 1952)		1
Gen. sp.	(4)	(9)
LINYPHIINAE		
Bolyphantes luteolus (BLACKWALL, 1833)		(5)
Centromerus pabulator (O.P.-CAMBRIDGE, 1875)	19	6
Meioneta rurestris (C. L. KOCH, 1836)	20	6
Gen. sp.	(34)	(31)
LYCOSIDAE		
Pardosa oreophila SIMON, 1937	224 (33)	4 (78)
NEMASTOMATIDAE		
Nemastoma triste (C.L. KOCH, 1835)	57	2
PHALANGIIDAE		
Mitopus morio (FABRICIUS, 1799)	139 (223)	4 (5)
NEOBISIIDAE		
Neobisium noricum BEIER, 1939		1
CARABIDAE		
Calathus micropterus (DUFTSCHMID, 1812)	3	1
Total adults (juveniles)	476 (297)	38 (140)

range for total spiders, but the minimum with 0.41 was lower for total harvestmen.

Pitfall trapping

In the period from 28.07. - 11.08.98, 941 arachnids and 42 carabids were captured with 25 pitfall traps. Among 412 spiders (79.9% adults), 529 harvestmen (52.7% adults), and 42 carabids were 24 spider, 5 harvestman, and 14 carabid species. In Table 2 the number of specimens is given only for species also captured by suction sampling.

Relative effectiveness

A total of 28 spider, 5 harvestmen and 1 pseudoscorpion species were captured by both methods. In the suction samples 4 spider and 1 pseudoscorpion species were exclusively taken. Thus more specimens and species were captured with pitfall traps. In the suction samples the number of juveniles was higher than the number of adults, whereas in pitfall traps it was vice versa. More juvenile and female erigonines were captured by suction sampling, whereas linyphiids, lycosids, harvestmen, and carabids were better represented in pitfall traps (Table 1).

DISCUSSION

Experiences

In agreement with previous studies these results from alpine sites demonstrate that pitfall traps result in a better return of species and specimens per unit effort. But pitfall trapping cannot be used as a substitute to give an index of abundance because the relationship between pitfall catch and density is unreliable (Sunderland & Topping 1995). For studies where the age structure of a population is needed or where at least relative density estimates are important, techniques such as the suction sampling are probably preferable. After Merrett & Snazell (1983) many other large-scale comparisons of the results of pitfall trapping and suction sampling have been made, especially regarding farmland spiders. A comparison not only provides information about the collecting methods, but also indicates differences in the ecology or behaviour of species which render them more susceptible to capture by one method or the other, as reported for example by Flatz (1986) from high-mountainous sites. Method-specific species were regularly found with both sampling methods. Thus both techniques contribute to assessing species assemblages in lower vegetation strata as reported by Standen (2000).

The efficiency of the sampling method, the area sampled, and the amount of samples per site are factors which influence the accuracy of density estimations (Meyer 1981). The efficiency itself is dependent on the duration of suctioning and on the vegetation height (Henderson & Whitaker 1977). Since these factors vary in the previously published studies on density estimations in alpine habitats, comparisons are difficult or impossible. Sometimes even a description of the method or vegetation type is missing or important details are lacking. Hence, the results gained by soil extractions in a Kempson apparatus (Meyer 1980, 1981) are more accurate. The latter reference mentions densities of 7-78 Araneae/m², 3-5 Opiliones/m², 52 Pseudoscorpiones/m², and 4-26 carabids/m² (adult specimens only) for 6 cm deep soil samples taken at the beginning of August within different sites (1850 - 2300 m a.s.l) in the Hohe Tauern National Park. A density of 35 adult spider specimens/m² is stated by Puntscher (1980) for a site in the Ötztaler Alps (2650 m a.s. l.) sampled with a Burkhard Univac at the beginning of August. The comparison with our data reveals an enormous difference in the carabid and pseudoscorpion density which is lower in our study, since we only sampled the soil surface.

The density estimation method used here was less labour-intensive than the combination of methods used by Sunderland et al. (1987) in winter wheat: 0.15 m²/h vs. 0.1 m²/h covered. The combination of suction sampling and hand-searching by Topping & Sunderland (1994) in a cereal crop was even much less labour-intensive (1.66 m²/h covered). Thus the suction sampling presented here seems to be a preferable method also if time is limited. However, the suggestions below should be taken into account in future studies.

Suggestions

This cheaper, lighter and more comfortable alternative to the former generation of suction samplers and to less absolute, uncontrolled, time consuming or more destructive methods can be recommended for density estimations of arachnids also in steep alpine habitats. As a result of the experiences made by previous users (De Barro 1991; Mcleod et al. 1994; Samu & Sarospataki 1995; Samu et al. 1997) we tried to increase the efficiency. Thus we excluded oversampling with the use of an enclosure and we made varying numbers of sub-samples until no remaining specimen could be found either in the sub-sample material or on the soil surface.

Nevertheless, it was far from being an 'absolute' density estimation, because of inaccessibility of some spiders, harvestmen and carabids which have retreats in the stony underground.

Our sampling was restricted to one date and five replicates per site. In the future, sampling should be done more extensively. Although the coefficients of variation are relatively low

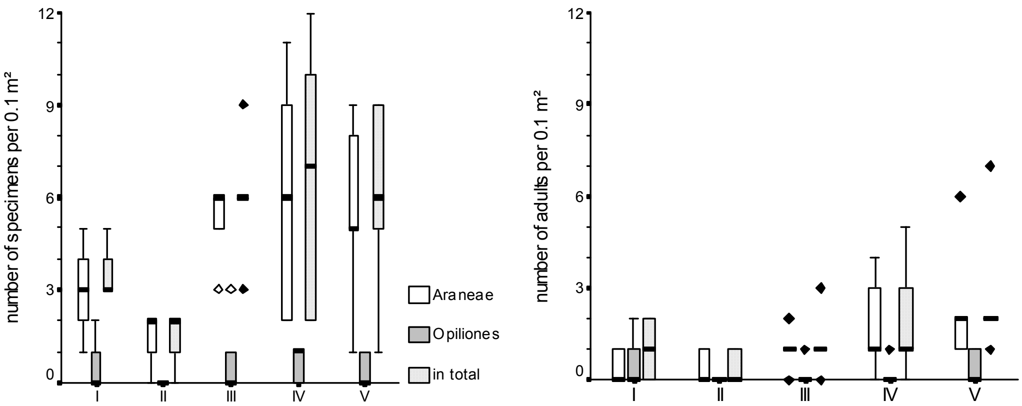

Fig. 3. Box plots relating to the 25 suction samples at the five sites (I-V) on 07.08.1998. They describe the first quartile, the median, the third quartile, the range, as well as the outliers (◊) and extremes (w) for the specimens: (A) all specimens (Araneae, Opiliones, in total) excl. pulli of lycosids and (B) adults (Araneae, Opiliones, in total) per 0.1 m²

(Sunderland & Topping 1995), more replicates should be made on at least three dates during the short season in the alpine region from June to September. Since suddenly changing weather conditions in the Alps limit the time for optimal sampling in dry vegetation, i.e. there are often rain showers in the afternoon, the dew in the morning and intensive snowfall periods during summer, respectively, these factors have to be taken into account when scheduling such a study in the alpine region. Hence, we suggest a lower number of sites than presented here.

Using a wider cylinder would be difficult on the stony and uneven ground of alpine slopes. Of course it would also be more time-consuming, much heavier and more inconvenient to carry and handle. The enclosure's height of 50 cm is appropriate for alpine areas. In any case, it should be of solid steel, so that it can be rammed down into the stony soil.

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REFERENCES

De Barro, P.J. 1991. A cheap lightweight efficient vacuum sampler. *Journal of the Australian Entomological Society* 30, 207-208.

Dietrick, E.J. 1961. An improved backpack motor fan for suction sampling of insect populations. *Journal of Economic Entomology* 54, 394-395.

Duffey, E. 1974. Comparative sampling methods for grassland spiders. *Bulletin of the British Arachnological Society* 3 (2), 34-37.

Duffey, E. 1980. The efficiency of the Dietrick vacuum sampler (D-vac) for invertebrate population studies in different types of grassland. *Bulletin of Ecology* 11 (3), 421-431.

Flatz, U. 1986. Zur Biologie und Ökologie epigäischer Wiesenspinnen des Innsbrucker Mittelgebirges (Nordtirol, Österreich). In: *Actas X Congreso Internacional de Aracnologia, Jaca (España)* (J.A Barrientos ed.) I, pp. 225-230.

Hand, S.C. 1986. The capture efficiency of the Dietrick vacuum insect net for aphids on grasses and cereals. *Annals of Applied Biology* 108, 233-241.

Henderson, I.F. & Whitaker, T.M. 1977. The efficiency of an insect suction sampler in grassland. *Ecological Entomology* 2, 57-60.

Kauri, H., Moldung, T.J. & Solhöy, T. 1969. Turnbull and Nicholls' 'quick trap' for acquiring standing crop of evertebrates in high mountain grassland communities. *Norsk Entomologisk Tidsskrift* 16, 133-136.

Macleod, A., Wratten, S.D. & Harwood, R.W.J. 1994. The efficiency of a new lightweight suction sampler for sampling aphids and their predators in arable land. *Annals of Applied Biology* 124, 11-17.

Merrett, P. & Snazell, R. 1983. A comparison of pitfall trapping and vacuum sampling for assessing spider faunas on heathland at Ashdown Forest, south-east England. *Bulletin of the British Arachnological Society* 6, 1-13.

Meyer, E. 1980. Ökologische Untersuchungen an Wirbellosen des zentralalpinen Hochgebirges (Obergurgl, Tirol). VI. Aktivitätsdichte, Abundanz und Biomasse der Makrofauna. Abundanz und Biomasse von Invertebraten in zentralalpinen Böden (Hohe Tauern, Österreich). *Veröffent-lichungen der Universität Innsbruck* 125, *Alpin-Biologische Studien* XIII. Innsbruck University, Innsbruck.

Meyer, E. 1981. Abundanz und Biomasse von Invertebraten in zentralalpinen Böden

(Hohe Tauern, Österreich). In: *Veröffentlichungen des Österreichischen MaB-Hochgebirgsprojektes Hohe Tauern 4: Bodenbiologische Untersuchungen in den Hohen Tauern 1974-78*, pp. 153-178. Universitätsverlag Wagner, Innsbruck.

Puntscher, S. 1980. Ökologische Untersuchungen an Wirbellosen des zentralalpinen Hochgebirges (Obergurgl, Tirol). Verteilung und Jahresrhythmik von Spinnen. *Veröffentlichungen der Universität Innsbruck* 129, Innsbruck University, Innsbruck.

Samu, F. & Sarospataki, M. 1995: Design and use of a hand-hold suction sampler, and its comparison with sweep net and pitfall trap sampling. *Folia Entomologica Hungarica* 56, 195-203.

Samu, F., Németh, J.& Kiss, B. 1997: Assessment of the efficiency of a hand-held suction device for sampling spiders: improved density estimation or oversampling? *Annals of Applied Biology* 130, 371-378.

Solhöy, T. 1972. Quantitative invertebrate studies in mountain communities at Hardangervidda, South Norway. I. *Norsk Entomologisk Tidsskrift* 19, 99-108.

Standen, V. 2000. The adequacy of collecting techniques for estimating species richness of grassland invertebrates. *Journal of Applied Ecology* 37, 884-893.

Sunderland, K.D. & Topping, C.J. 1995. Estimating population densities of spiders in cereals. In: *Arthropod natural enemies in arable land. I. Density, spatial heterogeneity and dispersal.* (S. Toft & W. Riedel eds.), pp. 13-22. Aarhus University Press, Aarhus.

Sunderland, K.D., Hawkes, C., Stevenson, J.H., McBride, T., Smart, L.E., Sopp, P.I., Powell, W., Chambers, R.J. & Carter, O.C.R. 1987. Accurate estimation of invertebrate density in cereals. *Bulletin SROP/WPRS* 10, 71-81.

Sunderland, K.D., De Snoo, G.R., Dinter, A., Hance, T., Helenius, J., Jepson, P., Kromp, B., Lys, J.-A., Samu, F., Sotherton, N.W., Toft, S. & Ulber, B. 1995. Density estimation of arthropod predators in agroecosystems. In: *Arthropod natural enemies in arable land. I. Density, spatial heterogeneity and dispersal.* (S. Toft & W. Riedel eds.), pp. 133-162. Aarhus University Press, Aarhus.

Thornhill, E.W. 1978. A motorised insect sampler. *Pest Articles and News Summaries* 24, 205-207.

Topping, C.J. & Sunderland, K.D. 1994. Methods for quantifying spider density and migration in cereal crops. *Bulletin of the British Arachnological Society* 9, 209-213.