European Arachnology 2000 (S. Toft & N. Scharff eds.), pp. 285-290.
 ISBN 87 7934 001 6
(Proceedings of the 19th European Colloquium of Arachnology, Århus 17-22 July 2000)

Testing the efficiency of suction samplers (G-vacs) on spiders: the effect of increasing nozzle size and suction time

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Abstract

The efficiency of two G-vacs (Ryobi RSV 3100 and Flymo BVL 320) was tested to examine the effects of increasing the suction nozzle area and the sampling time whilst keeping total sampling area constant (0.49 m^2). We tested an *a priori* hypothesis that increasing nozzle area was significant but that reducing sampling time was not, using a planned comparisons approach. We found that when the nozzle diameter was doubled in size, significantly fewer species and individuals of spiders and numbers of *Pachygnatha degeeri*, *Centromerita concinna* and *Lepthyphantes tenuis* were collected. However, the effect of increasing the suction time tenfold did not significantly increase numbers collected. This indicates that a significant proportion of the catch is collected in the first second of sampling. We conclude that in studies of short grasslands, small differences in suction time are unlikely to introduce confounding effects of under-sampling. Increasing the nozzle area may have serious and unwanted effects. G-vac users should be encouraged to give as much detail about their machines and their sampling method as possible and should see that reporting the nozzle size is paramount.

Key words: suction sampling, G-vac, D-vac, nozzle size, suction time, spiders

INTRODUCTION

Suction samplers have long been used in entomological studies, typically these have either been Dietrick (D-vac) or Burkhard machines (e.g. Dietrick 1961; Duffey 1974). These types of sampler are expensive, heavy and cumbersome and there is some suggestion that they have low suction speeds (Stewart & Wright 1995). Aware of the numerous limitations of these old style suction samplers, a different type of machine was required. Stewart & Wright (1995) describe a method of converting a garden 'blow & vac' machine to a modified D-vac, commonly referred to as a 'G-vac'. G-vacs are a quick and easy method of collecting invertebrates (Stewart & Wright 1995), although they cannot be used during wet weather or on grasslands with a heavy dew (Sunderland et al. 1995). G-vacs provide a good estimate of the population density (Dinter 1995) and are particularly useful in homogenous vegetation in which there are a number of small inactive species.

To date there have been many experiments

which have tested the efficiency of suction samplers against other methods such as sweep-nets (e.g. Churchill 1993; Samu & Sárospataki 1995), pitfall traps (e.g. Churchill 1993; Samu & Sárospataki 1995; Topping & Sunderland 1992), heat extraction (e.g. Curry & O'Neill 1979; Dinter 1995) and some papers have tested effects between D-vacs and G-vacs (e.g. Macleod et al. 1994; Stewart & Wright 1995). However, there has been very little research into different methods of using a G-vac to sample invertebrates (but see Samu et al. 1997). Here, we add to this limited knowledge and examine the effects of sampling time and nozzle size on the number of spiders caught.

MATERIALS AND METHODS

Study Site

The White Peak limestone grasslands cover an area of about 350 square kilometers rising to 500 metres above sea level. The White Peak is the southern section of the Peak District National Park in northern England, so named because of the white limestone geology which sometimes becomes exposed. The commonest National Vegetation Classification (NVC) stand type is the CG2d (*Festuca ovina – Avenula pratensis* grassland *Dicranium scoparium* subcommunity) which occurs on south facing slopes with shallow soils (Rodwell 1992). High Dale (grid reference: SK 155 719), in the central northern part of White Peak, was used for the experiment as it displayed large areas of CG2d. In this way, we were able to control the habitat type and assume stand type homogeneity.

Methods

High Dale was sampled on the 29.9.1998 using two G-vac machines. A Ryobi RSV 3100 G-vac (engine capacity 31 cm^3) with a nozzle diameter of 13 cm was used alongside a Flymo BVL 320 (engine capacity 32 cm^3) which had a nozzle diameter of 25 cm. Collection nets to catch the invertebrates were made from fine mesh nylon netting which fitted inside both suction nozzles. This net overlapped the external flange on the Ryobi model so that it could be secured with elasticated cord to prevent it being sucked through the machine. However, the net for the Flymo was secured between the main nozzle and the detachable rim, which is the standard method of attachment on D-vac machines.

Three treatments were used in this experiment: a one-second sample with a small nozzle; a ten-second sample with a small nozzle; and a ten-second sample with a large nozzle. Ten replicates were allocated to each of the three treatments. To test the effect of sampling time, only the Ryobi was used: one-second samples were compared with ten-second samples. To test the effect of nozzle area, ten-second samples taken with the Ryobi were compared with ten-second samples taken with the Flymo.

A standard area of 0.49 m^2 was sampled in all three treatments. To achieve this, the number of sucks, which constituted a sample, differed between the G-vacs because of the different diameters of the two nozzles. Ten sucks constituted one sample for the Flymo, but 37 were required to make one sample for the Ryobi. Samples were taken alternately across the daleside in which samples were distributed evenly along a 50 m transect (i.e. treatments were not clumped in one part of the dale, but spread across the dale, one after the other). An invertebrate sample was taken by placing the nozzle on the ground at 1 m intervals for a specified time and frequency, depending on the G-vac and question under investigation. Between samples the G-vac ran on idle, whilst during samples (i.e the put-downs), the G-vac ran on full throttle. Once the sample was finished, the machine was then turned upside-down and the contents of the net was then emptied into an undiluted methanol solution.

Statistical Methods

All data were transformed using log(x+1) and then tested using Kolmogorov-Smirnov to see if the data differed significantly from the expected normal distribution (Sokal & Rohlf 1995). The Kolmogorov-Smirnov test is often conservative, but is a suitable test for detecting

Table 1. Log(x+1)-transformed numbers (means ± SE) of species and individuals caught with G-vacs depending on nozzle area (Flymo or Ryobi) and suction time, and One Way ANOVA with Contrast Analysis for Planned Comparisons.

	Effect of nozzle area				Effect of sampling time			
	Large nozzle	Small nozzle	$F_{1,27}$	P	1 second	10 seconds	$F_{1,27}$	P
Community effects								
Number of species	0.765±0.046	1.010±0.034	21.31	<0.0001	0.973±0.031	1.010±0.034	0.49	0.4895
Number of individuals	1.525±0.051	2.044±0.035	75.35	<0.0001	1.953±0.039	2.044±0.035	2.32	0.1386
Species effects								
Pachygnatha degeeri	0.258±0.091	0.928±0.114	20.92	<0.0001	0.981±0.105	0.928±0.114	0.13	0.7206
Centromerita concinna	0.614±0.074	1.258±0.063	47.78	<0.0001	1.191±0.060	1.258±0.063	0.58	0.4782
Lepthyphantes tenuis	0.576±0.088	0.951±0.036	19.59	<0.0001	0.884±0.042	0.951±0.036	0.62	0.4366

dispersion, skewness and location (Sokal & Rohlf 1995). All transformed data were found to be normally distributed.

We established an a priori hypothesis within the experimental design, that: increasing nozzle area decreases the number of spiders caught in the samples, but increasing the sampling time has no effect. These were tested as planned comparisons using a one-way ANOVA with contrast analysis. Planned comparisons necessitate the use of contrast over post hoc analysis because of the principle that an a priori hypothesis is being tested. Contrast analysis expresses the difference, if any, in terms of treatment effects by coding the data using +1, 0, -1 integer values to extract only the desired comparisons (Scheiner & Gurevitch 1993). In this experiment, the results are equivalent to separate one-way ANOVAs between treatments, the difference being that they are calculated within a larger ANOVA design. This approach does not require a Bonferroni correction for inequality (Sokal & Rohlf 1995).

We first tested the effect of nozzle size and suction time on the total number of individuals and the total number of species collected, and referred to later as 'community effects'. Three species occurred in large enough numbers to test separately: *Centromerita concinna* (Thorell); *Lepthyphantes tenuis* (Blackwall), both species from the Linyphiidae, and *Pachygnatha degeeri* (Sundevall) (Tetragnathidae). The contrast analyses on each of the three spider species are referred to later as 'species effects'.

RESULTS

The treatments gave consistent results for both types of effects tested. When the nozzle diameter was doubled in size, the Flymo sample demonstrated that both the number of species and number of individuals were collected in significantly fewer numbers (Table 1). This was also true for the species effects, despite their differences in body size and overall general appearance (*Centromerita concinna* (Thorell) and *Lepthyphantes tenuis* (Blackwall) are small linyphiid spiders between 2-3 mm body length; *Pachygnatha degeeri* Sundevall is a medium size, bulky spider between 2.5-4 mm body length). When the size of spider increases to over 4 mm, a relatively large spider such as *Pardosa pullata* (Clerck) (4-6 mm body length) was not sampled at all by the Flymo (the large nozzle) but equal numbers (10) were recorded in the two Ryobi (the small nozzle) samples. The effect of increasing the sampling time tenfold did not significantly influence any of the community or species effects measured. We reject the null hypothesis and accept the alter-

native hypothesis (H_A) that increasing nozzle area decreases the number of spiders caught in the samples; but increasing the sampling time has no effect (H_0 not rejected).

DISCUSSION

There was no attempt made for the collection to reflect the total number of spiders that could be gathered within the sampled area, as this would require a much more intensive effort. Although G-vacs collect a large number of specimens, they should not be considered to be an absolute method (Samu et al. 1997). Some spiders will undoubtedly be missed by the G-vac because they are inaccessible (e.g. stone-dwellers and clubionids which may be hiding within silken cells) and others because they are too mobile and tend to escape when disturbed (e.g. lycosid spiders). Another source of error arises with dense vegetation, which can interrupt airflow and cause a filter to develop, under which predators can hide and avoid capture (Sunderland et al. 1995). However, whilst recognising these constraints, the species collected in this experiment were representative of CG2d grasslands in the White Peak (Bell 1999).

The effect of suction time

Table 1 indicates that there were no significant community or species effects between the one-second and ten-second samples. This would indicate that the majority of the animals were collected within the first second of sampling, with few individuals, if any, added when the suction time was increased tenfold. Macleod et al. (1994) found similar results in their study, suggesting that a fivefold increase in sampling time does little to enhance the catch. These results do not imply that all G-vac sampling henceforth should rely on a one-second sample to collect spiders, as suction time is dependent on habitat: the longer the vegetation and the more complex the structure of the sward, the more likely it is that a longer suction time will be required to collect a fauna representative of the habitat under investigation.

One problem with G-vacs is that suction time errors can be made inadvertently, caused by lack of concentration by the user or difficult terrain. We have shown that if sampling time errors are made (i.e. ~10% error), then these are unlikely to have any statistical ramifications (i.e cause type I or II errors) when generating estimates of the population.

The effect of nozzle size

Significantly fewer individuals and species were collected by the larger nozzled Flymo when compared to the Ryobi (Table 1). When the engine capacity was not allowed to vary, but the nozzle size was doubled, there was effectively a reduction in suction power. Under a lower suction power, the Flymo was unable to dislodge spiders from their webs and retreats. Even if the Flymo was successful in removing animals, then it was clearly unable to retain them in the collection net until the sampling was completed.

Although the Flymo collected significantly fewer individuals, the Ryobi may have over-sampled the area because of an increased edge effect. Samu et al. (1997) established that edge effects are caused by differences in the diameter of the nozzle: the smaller the size of the nozzle, the greater the edge effect. The Ryobi G-vac may be forcing a significant result by over-sampling due to the smaller nozzle area (Samu et al. 1997). This phenomenon is not testable here because invertebrate quadrat sampling, which would verify the extent of edge effect, was not taken. However, it is probably a combination of edge effect (Samu et al. 1997) and a change in suction power (Macleod et al. 1994) which significantly increased the catch in the two Ryobi samples. Lack of suction power may account for the absence of *P. pullata* from any of the Flymo samples, but edge effect may, in part, be contributing to the increased abundances of *C. conccina*, *L. tenuis* and *P. degeeri*.

To test the effect of increasing the nozzle area, two different machines were used. Small variation in the fan shape and size, and in engine capacity did occur. However, at least for engine capacity, the Flymo was the larger of

the two machines and would, if any bias occurred, be in favour of this machine and not the Ryobi. Thus, it is unlikely that a type I error has occurred in this experiment.

Recommendations

Suction samplers are one of the most useful field methods for collecting spiders (e.g. Dinter 1995; Samu et al. 1997) as they are cheap to purchase, easy to use and quick to produce results which are worthy of statistical analysis. Sampling designs which use either an enclosure or other methods, such as transect surveys, are an efficient way of collecting spiders (Samu et al. 1997). However, in light of the results presented here, enlargement of the nozzle should be avoided. To establish the correct suction time, it is possible to plot gradual increases in suction time against numbers of animals collected (e.g. see Macleod et al. 1994): either choose the suction time at the curve's asymptote or the point at which an acceptable proportion of the fauna has been collected (e.g. 75%). As a broad generalisation, a ten-second suction time for each put-down should be sufficient for most transect surveys. Quadrat surveys are the recommended approach to avoid oversampling caused by the edge effect (Samu et al. 1997), but these require much longer suction times to collect all the animals (e.g. 30 minutes, G.J. Bergthaler pers. comm.).

It would be desirable to report the make of the G-vac, its engine size (cm^3), nozzle diameter (cm), the sample area (m^2), suction time (seconds), and the design of the experiment (transect/quadrat/random) in all ecological investigations. Additionally, F. Samu (pers. comm.) suggests that the net design should not interfere so as to restrict airflow inside the nozzle, especially when large amounts of soil and detritus are prevalent in the samples. The net should be emptied frequently if a blockage is developing in the nozzle. We recommend that the design of the net should be tapered or a blunt spear shape, rather than conical, and longer (>30 cm) rather than short.

ACKNOWLEDGEMENTS

We would like to thank the Ted Locket Memorial Fund for supporting this research. Mr. S. Allen allowed us access to High Dale and English Nature were helpful in more ways than can be described here.

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