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A new inexpensive suction apparatus for sampling arthropods in grassland

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Abstract. 1. We describe a new technique for sampling arthropods from grassland and other vegetation, using a modified petrol-driven suction apparatus called a 'Blow & Vac'.

2. The new apparatus was tested by comparing its efficiency in extracting arthropods from vegetation with that of a conventional Dietrick, or 'D-Vac', suction sampler.

3. Unimpeded air velocity inside the suction tube was approximately 4 times that of the D-Vac.

4. In field trials on semi-natural grasslands, the Blow & Vac caught more individuals of most spider and certain beetle species compared to the D-Vac and approximately equal numbers of Auchenorrhyncha.

5. We conclude that the 'Blow & Vac' has considerable potential for sampling arthropod populations. Its low cost and weight make it a suitable alternative to the conventional D-Vac apparatus.

Key words. Suction-sampler, D-Vac, grassland.

Introduction

Several types of apparatus for estimating absolute population densities of arthropods on vegetation have been described, but those based on the 'D-Vac' suction sampler (Dietrick, 1961) have long been regarded as standard equipment for quantitative sampling in a variety of habitats, particularly grassland and agricultural crops (reviewed by Southwood, 1978). However, the equipment suffers from a number of disadvantages, especially its considerable weight, poor portability and high cost. Mechanical unreliability and maintenance difficulties are also widely reported as major problems.

We have previously described a light-weight petrol-driven suction apparatus, adapted from a machine sold for collecting garden debris called a 'Blow & Vac' (Wright & Stewart, 1992). Here we compare arthropod catches using this machine with those obtained using a conventional D-Vac type apparatus. For the latter we used a Thornhill vacuum sampler (Thornhill, 1978), manufactured by Burkhard Scientific (Sales) Ltd, Rickmansworth, Herts., U.K., which follows the American D-Vac design. The principal functional difference between the two machines is the diameter of the suction nozzle (12 cm for the Blow & Vac, 36 cm for the D-Vac). Approximate dimensions excluding collection tube are 42 × 39 × 23 cm, compared to 63 × 47 × 36 cm for the D-Vac. Engine capacities for the two machines are 31 and 98 cm^3 respectively.

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Methods

Conversion of machine to a suction sampler. We converted a 'Blow & Vac' leaf-blower (Atco Ltd, Suffolk Works, Stowmarket, Suffolk, U.K.), using the kit supplied for adapting the machine to produce a sucking action. A collection bag was constructed from fine-mesh 'nylon' netting, 38 cm circumference and 40 cm long, with the open end strengthened with a 17 cm calico cuff (Fig. 1, i). This was inserted inside the suction tube, with the cuff folded back over and held against the external surface with rubber bands, using the flange at the tube's inlet nozzle (Fig. 1, g) for anchorage. A wire mesh grille was fixed inside the tube near the basal end (Fig. 1, d) to prevent the collection bag from being sucked into the fan, should it

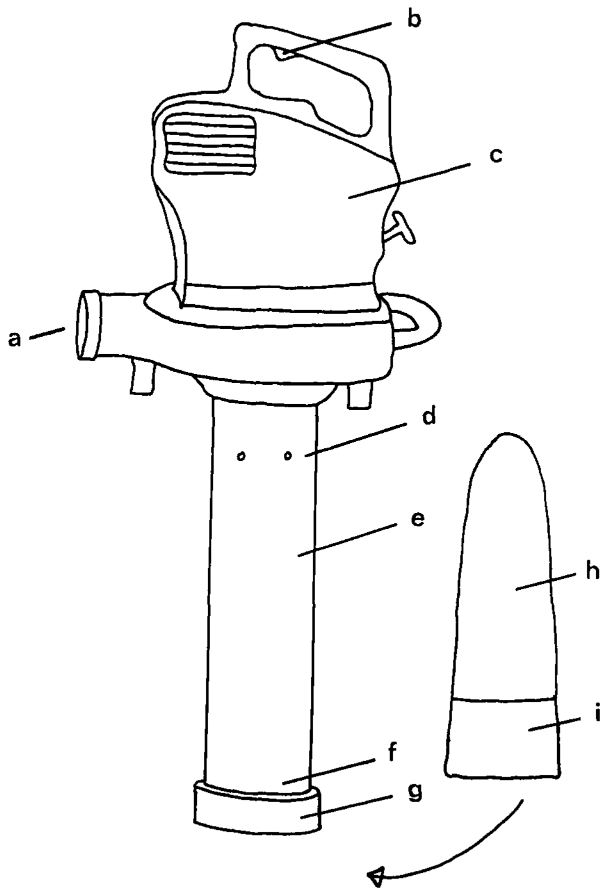

Fig. 1. Adaptation of Blow & Vac apparatus for sampling arthropods. a, air outlet; b, throttle; c, machine body housing motor, fan and petrol tank; d, position of internal wire mesh grille; e, suction tube; f, position of rubber bands for attachment of collection bag; g, external flange; h, nylon mesh collection bag; i, calico cuff for attachment of collection bag to suction tube nozzle.

accidentally work loose from its attachment at the nozzle.

Air velocity. Unimpeded air velocities produced by each machine were measured using a pitot static tube (Airflow Developments Ltd, High Wycombe, Bucks., U.K.) inserted through the side wall of the suction pipe close to its junction with the engine housing and connected to a sensitive manometer. Overall air velocity in the pipe with the sampling bag in place was calculated from velocities measured at four points across its diameter.

Sampling technique. Sampling with a D-Vac involves placing the collection nozzle vertically over the vegetation for a fixed time period; we standardized on 20 s. However, as the cross-sectional area of the Blow & Vac nozzle is considerably smaller, this technique was considered inappropriate. Instead, we delimited an equivalent area of ground by placing an open cylinder (60 cm high, 36 cm diameter) vertically over the vegetation. A fine mesh sheet secured to the top of the cylinder prevented flying insects from escaping. The Blow & Vac suction tube was inserted through a slit in this sheet and standardized samples were taken by passing the inlet nozzle repeatedly across the vegetation for 20 s. The sample was then removed by inverting the collection bag into a plastic bag. The length of the collection bag allowed this to be done without detaching it from the inlet nozzle.

Most leaf-blower machines have only a simple trigger mechanism to control the throttle, so it is not possible to produce standardized intermediate engine speeds. Consequently, as with the D-Vac, the Blow & Vac was operated on full power, which we assumed would produce a constant engine speed and air flow. Our interest was primarily in comparing Blow & Vac catches with those obtained using a conventional D-Vac, rather than the *absolute* efficiency of either machine; therefore we made no attempt to quantify the number of arthropods left behind, as done by some previous authors (Henderson & Whittaker, 1977; Duffey, 1980). Dead plant material and soil sucked up during sampling was later separated from the arthropod material, air-dried and weighed. Four contrasting semi-natural grasslands were used, with an equal number of samples being collected with each of the machines at each site. Mean vegetation height at each site was estimated by taking twenty drop-plate (Cherrill & Rushton, 1993) measurements at arbitrarily chosen points within the sampling area.

Results

The air velocity produced by the Blow & Vac machine (45.6 m s^{-1}) was approximately 4 times that for the D-Vac (10.6 m s^{-1}), explained largely by the 9-fold difference in inlet cross-sectional area. This greater suction power of the Blow & Vac machine is reflected by the 10–60-fold greater weight of debris collected (Table 1). Summary data for three arthropod groups are presented in Table 1, together with totals for the most abundant species. Hereafter, figures in parentheses refer to Blow & Vac catches expressed as proportions of D-Vac catches (both summed across sites).

The Blow & Vac caught substantially more Coleoptera at two sites, whereas differences at the other two sites were not significant (1.69). The differences were caused primarily by the staphylinid *Tachyporus hypnorum* Fab., of which the Blow & Vac caught greater numbers at all sites (3.86). The Blow & Vac caught significantly more *Longitarsus* Lat. sp. at the one site where large numbers occurred (1.74). Significantly more *Sitona lineatus* (L.) were caught in Blow & Vac samples at two sites but this difference was reversed at a third (1.07). Combined totals of adult Auchenorrhyncha were similar for each machine at all sites, as were the totals for most individual species. Exceptions to this pattern involved three species, each at separate sites but in comparatively low numbers. The Blow & Vac caught significantly more adult (3.07) and immature (2.55) spiders, the majority of which were Linyphiids. At Sharpenhoe, where spider catches were largest, the Blow & Vac caught significantly more adults of all species for which totals allowed a statistical comparison and the combined total for all species was 4.8 times that

Table 1. Total numbers of three arthropod groups caught by the D-Vac (D) and Blow & Vac (B) sampling methods at four grassland sites.

	Sharpenhoe		Maulden		Rothamsted		Bricket Wood	
National Grid Reference:	TL063296		TL059383		TL123129		TL125028	
Mean sward height (cm):	12		33		11		15	
Sampling apparatus:	D	B	D	B	D	B	D	B
No. of samples taken	15	15	15	15	20	20	20	20
Mean dry weight of debris material (g)	0.03	1.48***	0.06	0.58***	0.02	1.18***	0.09	3.08***
Coleoptera								
Bembidion obtusum Serville	1	8	0	0	0	0	0	0
Tachyporus chrysomelinus (L.)	2	4	3	3	0	0	0	2
Tachyporus hypnorum (Fab.)	19	131***	12	20	14	28	5	14*
Aleocharinae	12	18	1	0	7	0	0	0
Meligethes aeneus (Fab.)	0	0	0	0	3	3	0	0
Atomaria sp.	0	0	0	0	7	2	0	0
Cortinicara gibbosa (Herbst)	9	7	0	0	6	2	0	0
Longitarsus sp.	0	1	19	24	2	7	92	165*
Apion sp.	0	0	19	11	1	0	1	2
Sitona lineatus (L.)	0	12***	*59	30	5	22*	4	9
Other spp.†	3	16	12	6	10	7	3	6
Total	46	197***	125	94	55	71	105	198*
Auchenorrhyncha								
Neophilaenus lineatus (L.)	0	0	1	4	0	0	6	11
Agallia ribauti Ossi.	0	0	0	0	0	0	17	29
Aphrodes albifrons (L.)	0	0	0	5	0	0	3	18*
Aphrodes makarovi Zakh.	0	0	0	1	0	0	1	4
Deltocephalus pulicaris (Fall.)	0	2	2	7	3	4	67	86
Errastunus occellaris (Fall.)	0	0	0	0	0	1	186	265
Arthaldeus pascuellus (Fall.)	24	23	30	15	10	4	44	58
Psammotettix confinis (Dahlb.)	38	26	2	0	87	66	25	40
Euscelis incisus (Kbm)	14	25	101	129	1	1	9	2
Euscelis lineolatus Brullé	7	6	0	0	0	0	0	0
Streptanus sordidus (Zett.)	0	0	0	1	0	1	2	10
Macrosteles sexnotatus (Fall.)	5	3	0	0	0	0	8	8
Eupteryx notata Curt.	0	0	0	0	*26	10	0	0
Zyginidia scutellaris (H.-S.)	3	1	*15	3	1	0	270	207
Javesella pellucida (Fab.)	1	1	13	9	0	1	0	0
Other spp.†	0	0	5	4	0	1	3	9
Total	92	87	169	178	128	89	641	747
Araneae								
Adults								
Pachygnatha degeeri (Sundevall)	1	3	9	1	2	0	5	8
Oedothorax fuscus (Blackwall)	16	79***	0	0	0	0	5	10
Oedothorax retusus (Westring)	0	21**	0	0	0	1	8	6
Oedothorax apicatus (Blackwall)	5	4	0	0	0	0	0	0
Pelecopsis parallela (Wider)	0	0	0	0	0	0	5	13*
Erigone atra (Blackwall)	1	13**	1	0	0	3	1	2
Meioneta rurestris (C. L. Koch)	8	34***	0	0	2	4	0	0
Bathyphantes gracilis (Blackwall)	3	20**	6	8	1	7	0	0
Lepthyphantes tenuis (Blackwall)	6	29**	7	10	5	9	1	4
Other spp.†	3	4	3	2	1	11	0	16
Total adults	43	207***	26	21	11	35**	25	59**
Immatures								
Linyphiidae	73	262***	40	65*	31	44	3	58***
Lycosidae	1	2	33	16	9	15	20	55**
Thomisidae	0	2	2	1	0	1	0	2
Other families†	39	135***	38	32	12	19	2	10
Total immatures	113	401***	113	114	52	79	25	125***
Total	156	608***	139	135	63	114**	50	184***

Nomenclature for Coleoptera, Araneae and Hemiptera-Auchenorryhncha follows Pope *et al.* (1977), Roberts (1987) and Le Quesne & Payne (1981), respectively.

Significance levels in Mann-Whitney 'U' tests (Siegel, 1956): * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

† Combined totals for species represented by less than five individuals at each site.

caught by the D-Vac. Similar differences for both adult and immature spiders were apparent at two other sites, with approximate parity at the fourth.

Discussion

A variety of suction samplers have been designed for extracting insects and other arthropods from natural vegetation and agricultural crops (Johnson *et al.*, 1957; Dietrick, 1961; Henderson & Whittaker, 1977; Summers *et al.*, 1984; Holtkamp & Thompson, 1985; De Barro, 1991). These vary widely in the efficiency with which they sample different arthropod groups. Additionally, various extraneous factors associated with the type of vegetation sampled, environmental conditions (especially moisture on the vegetation and wind) and the sampling technique adopted are likely to affect extraction efficiencies (Hand, 1986).

Very few previous studies using the D-Vac sampler have estimated the air velocity generated in the suction tube, although Richmond & Graham (1969) and McLeod *et al.* (1994) have independently reported very similar figures (5.0 and 5.7 $m\,s^{-1}$ respectively). However, both estimates are approximately half that achieved in the current study (10.6 $m\,s^{-1}$) and all are substantially below the 27 $m\,s^{-1}$ that Southwood (1978) suggests is required to gain high rates of extraction. This apparent sub-optimal performance by D-Vac suction samplers has important implications for the many studies of arthropod densities in both agricultural and semi-natural habitats that have been carried out using this type of equipment.

The air velocity generated by the Blow & Vac in this study (45.6 $m\,s^{-1}$) is a significant improvement on previous estimates for machines using similar aperture nozzles: 41.3 $m\,s^{-1}$ for a 10 cm diameter nozzle (Turnbull & Nicholls, 1966), 14 $m\,s^{-1}$ for a 14.5 cm diameter nozzle (Holtkamp & Thompson, 1985) and 16 $m\,s^{-1}$ for a similar apparatus to ours (McLeod *et al.*, 1994).

The Blow & Vac was particularly efficient at extracting animals known to inhabit the litter and lower layers of the vegetation. For example, it caught significantly greater numbers of the Linyphiid spiders *Erigone atra* (Blackwall), *Lepthyphantes tenuis* (Blackwall), *Bathyphantes gracilis* (Blackwall) and *Oedothorax fuscus* (Blackwall), all of which attach their webs to the soil or the base of plant stems (De Keer & Maelfait, 1987, 1988; Thornhill, 1983). Perhaps the most striking contrast involved greatly improved catches by the Blow & Vac of the staphylinid beetle *Tachyporus hypnorum*. This species is normally found most abundantly in the litter layer and on the soil surface, although it is known to climb plant stems nocturnally in search of its prey (Vickerman & Sunderland, 1975). Similarly, the Blow & Vac caught sixteen carabids, half of which were *Bembidion obtusum* Serville, while the D-Vac caught only one. Auchenorrhyncha in the genera *Aphrodes* Curtis, *Streptanus* Ribant and *Agallia* Curtis generally occupy the lower layers of the vegetation, as demonstrated by studies that report more in pitfall traps compared to sweep net catches (Novotny, 1992; Payne, 1981). Blow & Vac catches for these three genera comprised seventy-three individuals of eight species across all sites, compared with twenty-three individuals of four species for the D-Vac samples. Unbiased sampling of all layers of the vegetation is particularly important in groups such as the Auchenorrhyncha which are known to be vertically stratified (Andrzejewska, 1965).

Most species known to occupy the middle or upper layers of the vegetation were caught in approximately equal numbers by the two machines. Of the six most numerous species of Auchenorrhyncha (where combined catches across sites exceeded fifty), five species were caught in approximately equal numbers by both machines at all sites. Fewer *Zyginidia scutellaris* H.-S. were caught by the Blow & Vac at one site, but the difference between catches was not significant at another site where much larger numbers were taken. Notable examples where the Blow Vac proved more effective than the D-Vac included flea beetles in the genus *Longitarsus*. Data for the comparatively heavy *Sitona lineatus* are harder to interpret, because the Blow & Vac caught significantly more at two sites but fewer at a third. Duffey (1980) found that this species was undersampled by the D-Vac method, possibly because of its weight.

Two of the three cases of under-sampling by the Blow & Vac occurred at Maulden, where the sward was tallest. Cooler temperatures during sampling at this site may also have had an effect on suction efficiency. It would be instructive to examine further the effect of these and other extraneous factors (Hand, 1986) on the relative efficiencies of the two machines. The greater amounts of debris collected by the Blow & Vac demonstrates its greater suction power, but also increases the time subsequently required to sort the arthropods from this material. However, this is a minor drawback given the improved sampling efficiency for many arthropod groups. Notwithstanding these considerations, the equipment has considerable potential, especially as it is relatively inexpensive (£200, compared to £2300 for the D-Vac; 1993 prices). Its light weight (8 kg, compared to 30 kg for the D-Vac) will appeal particularly to fieldworkers working on remote sites and in hot and humid climates.

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