AN ASSESSMENT OF THE EFFECT OF SWARD HEIGHT ON SUCTION SAMPLING EFFICIENCY FOR THE CAPTURE OF GRASSLAND INVERTEBRATES USING A G-VAC DEVICE

Sarah L. Facey[1]* and Marcel D. Torode[1,2]

[1] Hawkesbury Institute for the Environment, Western Sydney University, NSW, Australia

[2] School of Biosciences, Cardiff University, Cardiff, UK

*Corresponding author: sarah.facey@westernsydney.edu.au

Keywords: Arthropod sampling, G-vac, invertebrate sampling, suction sampling, sward height, Vortis

Introduction

Suction sampling is a commonly-adopted technique in the tool-box of grassland and agricultural entomologists (Cherrill, 2015). The use of adapted garden 'Blow & Vac' petrol-driven machines – or "G-Vacs" – for the quantitative sampling of invertebrates has been promoted as an effective and more affordable alternative to similar suction-based methods such as D-Vac or Vortis machines (Stewart and Wright, 1995). G-Vacs are readily available, portable and powerful machines, with air velocities capable of capturing higher abundances of invertebrates compared with alternative suction methods (MacLeod et al., 1994; Stewart and Wright, 1995). One potential confounding factor for suction sample-based invertebrate studies may, however, be plant architecture, as more complex swards impede air flow and reduce sampling efficiency compared with structurally simple ones (Hossain et al., 1999). Previous work has quantified the effects of sward height – a surrogate for plant complexity – on Vortis sampling efficacy for grassland invertebrates (Brook et al., 2008) although there have been no detailed studies into the effectiveness of the method. 2. We investigate the effect of effort (duration and number of suction samples, though as yet no attempts have been made to characterise such a 'sward effect' for G-Vac studies. Here, we demonstrate a strong sward height effect for G-Vac sampling and recommend the inclusion of measures of sward complexity as covariates in future invertebrate studies utilising this method.

Materials and Methods

The study was carried out at the Yarramundi paddock site in Richmond, Australia (-33.609981, 150.740157), which consists of a mixed species, former-pasture grassland. Fifteen 2 × 2m plots were selected across a variety of average sward heights (2–34 cm). Vegetation heights were measured using a sward stick in the four corners and centre of the inner 1 m^2 of each plot, and the five values averaged. Following Brook et al. (2008) small beads were scattered across the plot to act as surrogate invertebrates. We chose to use two sizes of glass beads and one size of sequins (beads: 2 mm diameter, 0.015 g; 4 mm diameter, 0.064 g, sequins: 10 mm diameter, 0.3 mm thick, 0.028 g), thereby removing any potential confounding effects of different invertebrate morphologies on sampling efficiency while still representing organisms of different sizes. We added 30 large beads (~2 g), 65 small beads (~1 g) and 30 sequins to each plot. The plots were then swept over with a G-Vac device (SH 86C, Stihl AG & Co. KG, Germany) on full throttle for 20 seconds, fitted with an organza bag to capture the dislodged materials. Sample contents were sorted to determine the amount of recovered surrogates of each of the three types.

Statistical analyses

The relationship between vegetation height and the proportion of recovery for each of the three invertebrate surrogate types (bead/sequin) was analysed using generalised linear models (GLM) with binomial error structures in R, version 3.2.3 (Brook et al., 2008; R Core Team, 2015) For sequin data, we used a quasi-binomial error structure due to evidence of overdispersion in the data. Models containing the explanatory variable of sward height were compared to intercept-only models to attain *P*-values using likelihood ratio tests (Faraway, 2006). The percentage of variance explained by sward height was calculated as: (null deviance – residual deviance)/null deviance (Espelta et al., 2008).

Results

The recovery of invertebrate surrogates of all three types (small beads, large beads and sequins) declined significantly with increasing values of sward height (Table 1, Figures 1-3). Sward height explained a minimum of 44% of the variation in the proportion of invertebrate surrogates recovered (Table 1). The recovery efficiency of small and large beads was generally very low (<20%), even in the shortest of swards (Figures 1 and 2).

Figure 1.
The proportion of small bead (2 mm) invertebrate surrogates recovered from plots of varying sward height using a G-Vac suction sampler. A total of 65 beads were added to each plot.

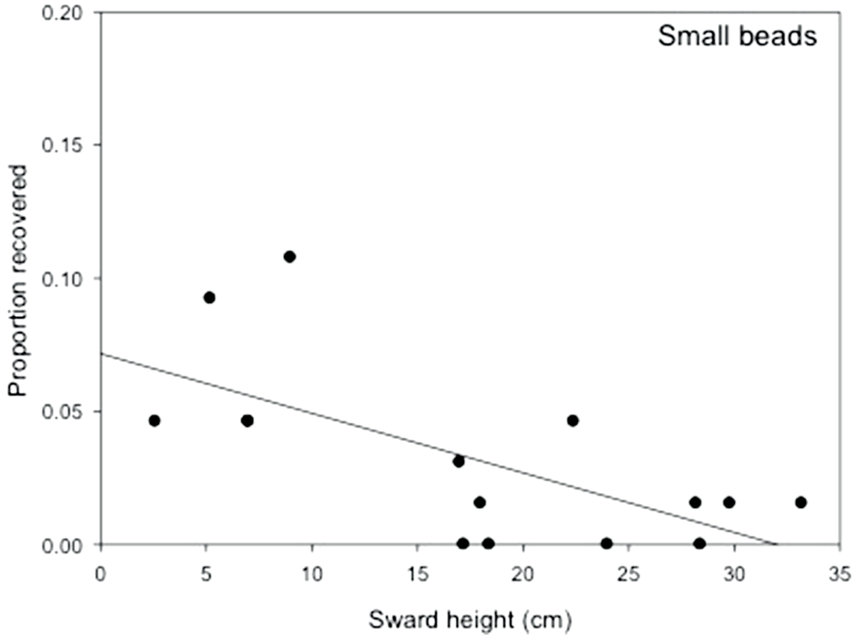


Figure 2.
The proportion of large bead (4 mm) invertebrate surrogates recovered from plots of varying sward height using a G-Vac suction sampler. A total of 30 beads were added to each plot.

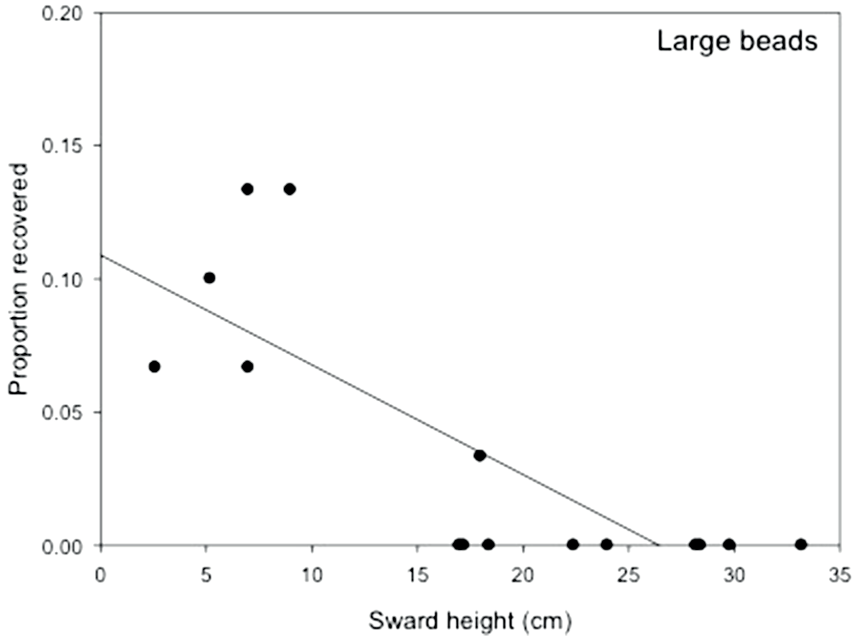
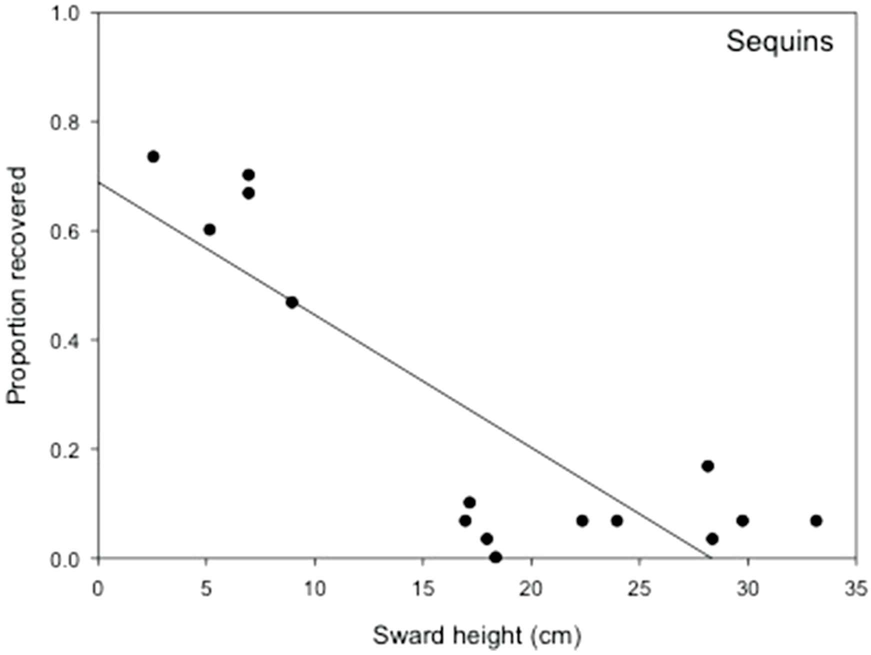


Figure 3.
The proportion of sequin invertebrate surrogates recovered from plots of varying sward height using a G-Vac suction sampler. A total of 30 sequins were added to each plot.



Discussion

In this study we have shown that the recovery of three different invertebrate surrogates by G-Vac sampling was strongly impeded by increasing levels of plant structural complexity. The generally low recovery rates of beads of both small and large sizes may be a result of the density of the glass beads being far higher than that of the invertebrates they serve to imitate. Also, given the high density and weight of the beads, they readily fell to the ground making their recovery more likely to be impeded by the vegetation above (as discussed by Brook et al., 2008). This may have led to an overestimation of the sward effect in our study; however, the same sward effect was also witnessed for the sequins which did not behave in the same way, being less dense and sitting higher in the vegetation profile.

Thus, our findings suggest that differences in sward height may confound treatment effects in invertebrate studies, confirming work on other suction samplers (Brook et al., 2008) although there have been no detailed studies into the effectiveness of the method. 2. We investigate the effect of effort (duration and number of suction samples. This may be especially true where applied treatments have strong impacts on the underlying plant structure such as fertilisation or irrigation-based experiments (Brook et al., 2008) although there have been no detailed studies into the effectiveness of the method. 2. We investigate the effect of effort (duration and number of suction samples. The true abundances of invertebrates may be under-reported from complex swards compared with structurally simple ones. As suggested by Brook et al. (2008), we therefore recommend the inclusion of measures of plant architectural complexity as covariates in statistical analyses of G-Vac suction-sample generated data, such as average sward height or biomass (where available), to control for this confounding effect.

Table 1.
Results from likelihood ratio tests between GLMs containing sward height as an explanatory variable and null, intercept-only models for the different invertebrate surrogate types.

Response variable (proportion recovery)	$\chi^2_{(d.f)}$	*P*	Variance explained by sward height (%)
Small beads	$14.98_{(1)}$	<0.001	44.16
Large beads	$23.49_{(1)}$	<0.001	70.30
Sequins	$144.67_{(1)}$	<0.001	79.27

References

Brook, A. J., Woodcock, B. A., Sinka, M., and Vanbergen, A. J. (2008). Experimental verification of suction sampler capture efficiency in grasslands of differing vegetation height and structure. *J. Appl. Ecol.* 45, 1357–1363. doi:10.1111/j.1365-2664.2008.01530.x.

Cherrill, A. (2015). Suction sampling of grassland invertebrates using the G-vac: Quantifying and avoiding peripheral suction effects. *Eur. J. Entomol.* 112, 520–524. doi:10.14411/eje.2015.058.

Espelta, J. M., Cortes, P., Molowny-Horas, R., Sanchez-Humanes, B., and Retana, J. (2008). Masting mediated by summer drought reduces acorn predation in Mediterranean oak forests. *Ecology* 89, 805–817.

Faraway, J. J. (2006). *Extending the linear model with R: generalized linear, mixed effects and nonparametric regression models*. Boca Raton, Florida: CRC Press.

Hossain, Z., Gurr, G. M., and Wratten, S. D. (1999). Capture efficiency of insect natural enemies from tall and short vegetation using vacuum sampling. *Ann. Appl. Biol.* 135, 463–467.

MacLeod, A., Wratten, S. D., and Harwood, R. W. J. (1994). The efficiency of a new lightweight suction sampler for sampling aphids and their predators in arable land. *Ann. Appl. Biol.* 124, 11–17. doi:10.1111/j.1744-7348.1994.tb04110.x.

R Core Team (2015). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Stewart, A., and Wright, A. (1995). A new inexpensive suction apparatus for sampling arthropods in grassland. *Ecol. Entomol.* 20, 98–102.