COMPARISON OF SUCTION AND BEATING TRAY SAMPLING FOR APPLE PESTS AND THEIR NATURAL ENEMIES

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ABSTRACT

A beating tray and suction sampler were compared for their efficiency in sampling apple trees, and at determining the diversity of arthropods present in an apple orchard block managed for biological fruit production. Arthropods were identified to "recognisable taxonomic units", and the Shannon-Wiener diversity index was calculated. The suction sampler consistently recovered significantly greater species diversity. Another experiment investigated the efficiency of the suction sampler, in relation to a subsequent destructive sample of foliage. The suction sampler collected *ca.* 60-70% of the taxa present on apple foliage under biological, integrated, or conventional fruit production. Suction sampling offered practical advantages but required greater laboratory input. Both methods could be used if their limitations are recognised, and require 10-15 samples for reasonable precision.

Keywords: apple, insect, diversity, sampling, sustainability

INTRODUCTION

Apple pest management in New Zealand export orchards is currently achieved through the use of broad-spectrum organophosphate insecticides. However, this system is increasingly seen as undesirable, due to the potential for adverse trade implications (Christie 1993). The development of alternative systems with reduced environmental impact has been underway for some time (e.g. Wearing *et al.* 1993). One prerequisite for "sustainable production" is the development of a workable definition of this widely-discussed concept. Such a definition is crucial for the measurement of progress towards this goal.

A measure of the ecological impact on pests and non-target organisms is likely to be an important component of any definition of sustainable management. Ecological impact can be measured in different ways, but the development of sound methods of sampling foliage inhabiting insects is an essential part of this process. Orchard pests can be sampled using a range of methods (e.g. Teulon and Penman 1986; Burnip and Thomas 1993). Such methods need to be reliable, representative, efficient, precise, and be easy to use. The beating tray (placed beneath tree branches to catch falling insects) is a relatively simple, fast technique for sampling a range of pest and beneficial insects. However, this method favours certain insect groups of low mobility which drop readily from branches, and we considered it necessary to investigate the efficiency of this method.

A method we have not seen previously reported for use on tree fruits, is the suction sampler, which we describe below. Suction samplers have been used extensively in field crops and grasslands, and the type of engine used here ("Blower-Vac") appears to offer advantages over the earlier "D-Vac" model (Stewart and Wright 1995).

This paper reports a comparison of the suction and beating tray sampling methods, and compares the efficiency of the suction sampler to a destructive sample of apple branches. Apple foliage was used as the sampling substrate because it is the "natural habitat unit" (Shelton and Trumble 1991). We have used the number of taxa defined as "recognisable taxonomic units", as well as the widely used Shannon-Wiener diversity index (Magurran 1988) to summarise the results.

METHODS

A suction sampler was developed by the authors (Fig. 1), adapted from a design used to sample ground cover foliage (Arnold 1994). The sampler was petrol-driven and back-pack mounted, with a flexible tube (10 cm diameter) which allowed the operator to remove arthropods from apple foliage. Insects and mites were drawn into the air stream of this tube (9 m/s, or *ca.* 70 L/s), and deposited into a sample jar. Field use was later achieved by an experienced operator working alone, although two operators were used during the time trial.

FIGURE 1: Schematic diagram of the suction sampler.

The beating tray method involved placing a white metal tray (50 x 50 cm) below an apple branch, and dislodging arthropods onto the tray with a single blow by a padded pipe. It was necessary to quickly collect invertebrates off the tray using an aspirator. Two operators were required for this method.

Experiment 1. Suction and beating tray samples

The aim was to compare the suction sampler and the beating tray, using a quantitative assessment of the number of different taxonomic groups found, and their

diversity. Samples were collected on five occasions, at two to three week sampling intervals (30/11/95-1/2/96), from the same 20 sample trees (chosen at random with two exterior guard rows). Each tree was sampled with the beating tray technique on one side of the tree, and the suction sampler on the opposite side, with half of the samples on each occasion from the east and half from the west side of each tree. The side of the tree used for each sampling technique was alternated on every sampling date. The total sampling time per occasion with each technique was *ca.* one hour in the field (during 08:00 - 10:30 hrs). The suction hose was applied to approximately the same area of foliage as the beating tray (*ca.* 0.25 m²) for *ca.* 30 secs, which was sufficient to thoroughly cover the area.

In the laboratory, the suction samples required the removal of extraneous plant material, which was an additional step (not needed for the beating tray) before insect identification was possible. Insects and mites were classified into a range of recognisable taxonomic units, reflecting their perceived importance within the orchard pest complex. Major pests and their natural enemies were identified to species, while less important groups were identified to genus, or family. The results included all arthropods collected from apple foliage. The time taken to obtain a result in the field and in the laboratory with each technique was recorded.

Samples were taken in the biological fruit production block at Lincoln University (dates in Fig. 2). The pest and disease management consisted of applications of *Bacillus thuringiensis* to reduce the incidence of leafroller damage (Yates Thuricide HP, applications on 28/11/95, 21/12/95, 9/1/96, 9/2/96), along with sulfur, copper and hydrated lime for black spot and powdery mildew.

Experiment 2. Suction sampler efficiency

The suction sampler was used to estimate the arthropod diversity on single branches (0.8 m long, 2-5 cm diameter). Samples were taken on 1/2/96 on trees managed under three fruit production regimes (biological, integrated and conventional fruit production, below). A sample size of 10 branches on different trees was chosen after inspection of the results from the first experiment. Branches were sampled for *ca.* 30 seconds. The branches were then bagged, removed from the tree, and chilled for laboratory inspection within one day.

The destructive surveys of the fauna remaining after suction sampling on whole branches occurred in three blocks, including the biological fruit production block described above. The integrated fruit production block received applications of the selective insecticide tebufenozide for leafrollers and codling moth (Mimic 70W) on 15/12/95, 9/1/96, and 9/2/96, with no other insecticides. Disease control was achieved by minimal use of conventional fungicides, and hydrated lime. The conventional block received applications of azinphos-methyl (Gusathion M35) on 24/11/95, 10/1/96, 9/2/96, and 22/3/96, with chlorpyrifos (Lorsban 50W) on 18/12/96. Conventional fungicides were applied at calendar intervals.

RESULTS

Experiment 1. Suction and beating tray samples

Both sampling methods were successful in collecting a wide range of taxonomic groups (31 different taxa were discriminated). The number of taxa recorded on apple foliage on each occasion was significantly higher with the suction sampler on each date (Fig. 2), ($P < 0.01$, t-test on mean value). In general, the beating tray sampled groups that were also detected by the suction sampler. However, the suction sampler was more efficient at collecting winged insects, such as leafhoppers, Hymenoptera, Diptera, and fungus beetles (Lathridiidae).

The Shannon-Wiener index, which also takes into account the number of individuals of each type (Magurran 1988), was also higher for the suction sampler ($P < 0.05$) (Fig. 3). The number of samples required to reach a stable value of either the number of taxa present per tree, or the Shannon-Wiener index was in the range of ten to fifteen (fifteen in Fig. 4, other dates not shown for brevity). The standard error of the mean reached a stable value (*ca.* 5% of the mean) with 10 replicate samples in most cases.

FIGURE 2: Changes in the number of recognisable taxonomic groups (taxa) of insect species found, as a function of sample date and method.

FIGURE 3: Changes in insect diversity per tree as a function of sample date and method.

The values of the mean number of taxa and the diversity index at low sample sizes (<5) fluctuated markedly, and were a result of the random order of the individual replicates chosen for the calculation of cumulative means.

The sampling time in the field was similar for each of the two methods, when two people were involved (Table 1). A slight decrease in total sampling time was later achieved with one operator, which made suction sampling more efficient than the beating tray, which requires two operators. This increase in efficiency was not included in the analysis. However, the removal of extraneous plant material from the suction samples required *ca.* three-fold more time before insect identification was possible (Table 1). The saving of time in the field did not offset the additional laboratory work. Importantly, beating of branches resulted in fruit drop (0-10 per tree), particularly towards harvest.

TABLE 1: The time taken per sample in the field and laboratory (person-minutes), for suction and beating tray samples (n=20).

	Beating tray		Suction	
	Mean	SEM	Mean	SEM
Field	2.39	0.19	2.21	0.10
Laboratory	6.25	0.82	18.75	1.60

Experiment 2. Suction sampler efficiency

Suction samples taken in the three orchard blocks under different management regimes recorded a similar proportion of the total taxa (63-72%, Table 2), indicating that this method does not appear to introduce major bias between these pest management treatments. However, several arthropod groups were not fully represented in the suction samples, compared to their incidence on some branches, when these were destructively sampled. These included apple leafcurling midge larvae, leafhoppers (mainly *Edwardsiana crataegi*), mites, *Sejanus albispinata*, *Orius vicinus*, thrips, and leafroller larvae.

TABLE 2: Mean number of taxa found per branch, as a function of each treatment on 1/2/96.

Treatment	Suction sampler		Whole branch after suction		% total taxa found by suction
	Mean	SEM	Mean	SEM	
Biological	2.60	0.50	1.50	0.27	63
Integrated	3.30	0.30	1.40	0.31	70
Conventional	3.10	0.43	1.20	0.44	72

DISCUSSION

The beating tray was not a good method for catching certain taxa, such as very small or mobile species. Small insects were difficult to see on the tray, but included important parasitic Hymenoptera. Highly mobile leafhopper adults were also better sampled by the suction sampler, than the beating tray. Neither sampling system was efficient at collecting some life stages, such as leafhopper nymphs, despite an abundance of adults. It is also possible that certain apple pest groups not detected at Lincoln, such as mealybugs and scale insects, would be missed with the suction sampler.

The suction sampler had greater sensitivity in detecting biodiversity (Figs. 2 and 3), with an average of 1.5-fold more taxa than the beating tray (6.5 and 4.3 taxa per replicate, respectively). However, if the sum of time taken in field and laboratory

FIGURE 4: Insect diversity (taxa per tree and the Shannon-Wiener Index) as a function of the number of trees sampled on 1/2/96.

processing (Table 1), is used to calculate an efficiency per taxon without regard to maximising the number of taxa detected, then the beating tray is a better investment of time by 50%. This was mainly due to the much greater length of time taken in laboratory processing of specimens. It may be possible to develop automatic sorting systems, as has been done for grassland work (Moore *et al.* 1993).

The suction sampler tended to collect larger numbers of each taxa, suggesting that the probability of detecting rare arthropods would be greater. However, the effect of the numbers of each common group that were collected was unlikely to be very important on the Shannon-Wiener index, based on the relatively close tracking of this index with the number of taxa collected (Fig. 4). Both sampling systems detected some less abundant taxa, although their low incidence prevented direct comparisons of sampling efficiency with the two techniques for these groups. Examples of this include two potentially important biological control agents, *S. albispinata* (Burnip and Thomas 1993) and *O. vicinus* (Wearing and Larivière 1994).

The suction sampler was inefficient for routine assessment of phenology of some species that could be better collected by the beating tray, because of the time involved in laboratory assessment. The efficiency of sampling of some species might vary according to the time of the day and temperature, although this was not examined here.

The beating tray was simpler to use and less time consuming overall than the suction sampler. However, it appears that the beating tray did not find *ca.* 50% of the taxa present, based on the two experiments. This took into account the lower efficiency at arthropod collection of the beating tray compared to the suction sampler (Fig. 2), and the percentage of the taxa detected by the suction sampler compared to the whole branch surveys (Table 2). The cost of equipment was substantially higher for the suction sampler (*ca.* \$2000), which would limit its suitability for certain types of sampling programmes (e.g. on-orchard decision making). However, the loss of fruit from beating branches may also limit the use of this technique. Further, the suction sampler may be less subject to operator differences than the beating tray, because it does not rely on reaction time with an aspirator.

In conclusion, both the beating tray and suction sampling methods captured sufficient numbers of arthropods to permit estimation of the biodiversity present on apple foliage. Both subsampled the fauna, with some biases. The problem of bias

appeared to be greater for the beating tray, which was inefficient at collecting winged and highly mobile insects. A sample of 15 replicates appeared to be enough to capture most of the diversity detectable with both methods. Further work will need to address the application of these methods to assist the development of more sustainable orcharding systems, including the potential use of suction sampling to quantify pest or natural enemy density.

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