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Optimising methods for collecting Hymenoptera, including parasitoids and Halictidae bees, in New Zealand apple orchards

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ABSTRACT

We monitored four groups of Hymenoptera in organic apple orchards in New Zealand in order to assess different trapping methods. The factors assessed were trap type (pan traps vs. sticky traps), trap colour, preservative type and trap position within the orchard with regard to the shelterbelt.

Yellow sticky traps were the most effective trap type overall for sampling the order Hymenoptera, and the two parasitoid species *Anagrus* sp. and *Aphelinus mali* (Haldeman). White pan traps were best for sampling native bees from the family Halictidae. Choice of preservative in the pan traps significantly affected the catch of Hymenoptera overall and Halictidae. Most Hymenoptera were more abundant within the orchards than at the shelterbelt, except the Halictidae, which were more abundant at the shelterbelt. The results support the notion that Hymenoptera surveys should be conducted using methods appropriated for targeted taxa, due to differences in their behavioural responses and ecological trends.

Introduction

The order Hymenoptera is a frequently surveyed group in agroecosystems, as it contains many beneficial insects, e.g., parasitoids, which are one of the most important natural enemies of many insect pests, as well as native and introduced bees which pollinate many plant species. Sticky traps and pan traps are routinely used for Hymenoptera monitoring, and factors such as trap type, colour, placement and preservative (in pan traps) can influence the effectiveness of traps and the subset of species captured (e.g., Campbell and Hanula, 2007; Gollan et al., 2011). Many studies have looked at the effects of pan and sticky trap colour on Hymenoptera (e.g., Noyes, 1989; Romeis et al., 1998; Thomson et al., 2004), and many show that differently coloured traps collect different components of the local Hymenopteran fauna (Toler et al., 2005; Gollan et al., 2011; Saunders and Luck, 2013). Deville and Wheeler (1998), Calixto et al. (2007) and Uchida et al. (2007) all showed that using different preservatives in pan traps influenced insect catches within and between insect orders. Some studies investigated whether pests and non-target Hymenoptera are attracted to the same colours (McClain et al., 1990; Knight and Miliczky, 2003; Myers et al., 2009), while others looked at what colour is best with respect to diversity, richness and evenness (Hoback et al., 1999; Stephen and Rao, 2005; Gollan et al., 2011).

Much of the relevant research comes from the Northern Hemisphere ecosystems (e.g., Toler et al., 2005; Campbell and Hanula, 2007; Kwaiser and Hendrix, 2008; Wilson et al., 2008). The studies from Southern Hemisphere are more limited, and seem to suggest that behavioural responses of Hymenoptera groups are habitat- and species-specific (Gollan et al., 2011; Saunders and Luck, 2013). The studies in New Zealand have been few (Clare et al., 2000; Wallis and Shaw, 2008).

Since studies report conflicting results with regard to the most effective trap colour even within same Hymenoptera families (Gollan et al., 2011), it is clear that if a particular group needs to be monitored, preliminary studies should be undertaken to identify the most effective trapping method for local fauna. Our study targeted four groups of Hymenoptera in organic apple orchards: total Hymenoptera; native Halictidae bees (Apoidea); *Anagrus* sp. (Mymaridae) and *Aphelinus mali* (Haldeman) (Aphelinidae). The Halictidae bees make up a large proportion of native Hymenoptera community, yet little is known about behavioural responses of New Zealand species. *Anagrus* spp. are important egg parasitoids of leafhoppers, and *A. mali* are important parasitoids of the woolly apple aphid *Eriosoma lanigerum* (Hausmann) (Wallis and Shaw, 2008). The aims of the study were to determine whether the type of trap (sticky vs. pan), trap colour, trap placement within the orchard, and preservative used in pan traps has any influence on composition and yield of the catch.

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Methods

Study sites

Three certified organic apple orchards around Hastings, Hawkes Bay, New Zealand, were used for this experiment. The three apple orchards will be identified here as "Twyford", "Thompson" and "Donnelly"; the maps or coordinates that identify the orchards are deliberately omitted. The study orchards were surrounded mainly by other fruit orchards, including apple, apricot, nectarine and peach. The majority of neighbouring properties were non-organic. There were some patches of natural vegetation along the Ngaruroro River within 1 km radius from Twyford orchard; there were no significant areas of natural habitat in the 5 km radius from other two orchards. The apple trees in all three orchards were of similar age, but the apple varieties were not all the same. The apples were almost ready to harvest at the time of sampling; however, a few late flowers on the apple trees were present. Each of the three orchards had established shelterbelts (one tree wide) of river oak (*Casuarina cunninghamiana* Miq.) running perpendicular to the rows of apple trees. The management of the sward within the orchards varied slightly. "Donnelly" allowed the grass and weeds between the rows of apple trees to grow for a length of time before being cut. In "Thompson" and "Twyford" the grass between the rows of trees was mowed more regularly.

Weather data were obtained from the nearest weather station (39° 38′ 50″ S, 176° 50′ 28″ E) (NIWA "Cliflo" database). During the first week of sampling there were three periods of rain, the maximum amount was 0.4 mm and total rainfall over the week was 1 mm; the daily average air temperature was 28.2 °C and the nightly average was 15.9 °C. Wind speed varied between 1 and 4.6 m/s, and averaged 2.7 m/s. Wind direction was not available.

Traps

Two trap types were used: pan traps and sticky traps. For the sticky traps, four colours were used — blue, white, yellow and transparent. The white, yellow and blue traps were made by enclosing a piece of coloured paper (14.5 × 20.5 cm) in an A4 sheet of overhead projector transparency film folded in half. The three edges of the transparencies were then heat sealed. The transparent traps had no paper enclosed. The blue colour of the paper used in the traps was called "cobalt" and the yellow was "intensive yellow". The colours of the paper were chosen to match the colours of the pan traps as closely as possible. The sticky traps were attached to the top of 1.2 m fibreglass poles with transparent parcel tape with the short side uppermost, and the poles hammered into the ground. A layer of Tangletrap® 1–2 mm thick was applied to the surface of the trap. Measured from the top of the trap, all sticky traps were 1 m off the ground.

The pan traps were 2 L square ice-cream containers (17 ×17 × 9 cm) containing one of two preservatives. Three different colours were used for the pan traps — blue, white and yellow. The blue was the common bright, cobalt blue. Yellow ice-cream containers were not obtainable so white containers were spray-painted with the bright yellow from the "Dupli-color vinyl and fabric paint" range. An 8 mm hole was drilled into each pan trap 2.5 cm from the top to prevent overflow in case of heavy rain and a piece of metal gauze (1 mm mesh) glued over the holes to prevent loss of insects if there was outflow. Two different preservatives were used in the pan traps — sodium benzoate and propylene glycol. For the sodium benzoate traps, 1 L of sodium benzoate solution at a concentration of 10 g/L water was used in each trap, with 0.5 mL of apple-scented dishwashing liquid added to break the water tension. For the propylene glycol traps, 300 mL of the Fleetguard™ PGPlus Engine Coolant was used in each trap without detergent. The pan traps were placed on the ground and anchored in place by two metal pegs over opposite corners.

The traps were put out on 3 February 2009 and left for four weeks. The traps were serviced once every seven days and yielded very many insects, so only the data for the first week of sampling was examined and will be presented here. Pan traps had all the insects removed by draining the contents through CHUX® Superwipes® dish cloths and sticky traps were removed completely and replaced. The holes in the dish cloth measured 1.6 × 0.9 mm, so when filtering the insects out of the pan traps some of the smaller specimens may have been lost; because of this, pan trap catches were not analysed for *Anagrus* sp., which had particularly low catches in the pan traps (11 individuals in all three orchards).

Trap layout

In each orchard, 8 transects were set up at ~10 metre intervals along the shelterbelt, slight variation in transect intervals was due to the spacing between rows of apple trees not being the same in each orchard. Transects ran perpendicularly to the shelterbelt extending 30 m into the orchard (Fig. 1). Transects ran in a north easterly direction in "Thompson" and "Donnelly" and in a south easterly direction in "Twyford". Traps were placed at 0, 10, 20 and 30 metre distance from the shelterbelt. Some traps had to be moved slightly to accommodate the placement of irrigation outlets or trees. Sticky traps and pan traps were placed in pairs of matching colours. Where there was a transparent sticky trap, no pan trap was put out. Trap colours were allocated to positions as shown in Fig. 1. Pan traps were filled with sodium benzoate in odd-numbered rows and with propylene glycol in even-numbered rows. The same trap layout was reproduced in all orchards.

Identification and data analysis

In all traps, counts of Hymenoptera were recorded. In pan traps, counts of Diptera and other flying insect orders (Coleoptera, Hemiptera and Thysanoptera) were also recorded. Within Hymenoptera, Halictidae, *Anagrus* sp. and *Aphelinus mali* were identified using keys from the Fauna of New Zealand series (Noyes and Valentine, 1989a,b; Donovan, 2007) and counted. A subset of 20 Halictidae individuals from sticky traps and all Halictidae from Donnelly pan traps were keyed out to a species level using Donovan (2007) and were found to be male or female *Lasioglossum sordidum* (Smith). As not all Halictidae were identified to species level, there may have been some other species present, although it is likely that *L. sordidum* made up the majority of the catch. Males and females were not distinguished in the counts for this group. *Anagrus* and *Aphelinus* were keyed out to a genus level from five male and five female individuals each using Noyes and Valentine (1989a,b). It was presumed that the *Aphelinus* species was *A. mali*,

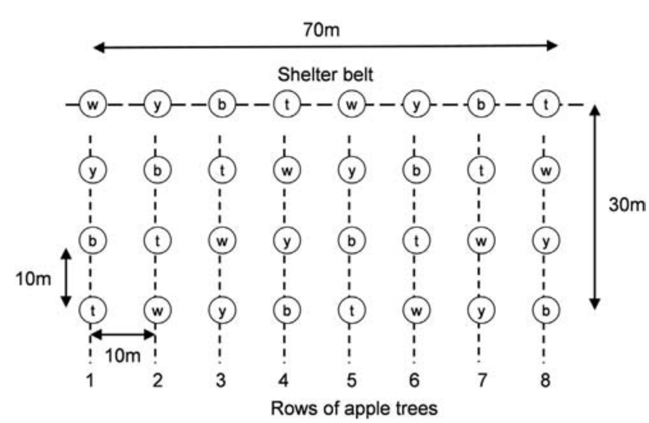

Fig. 1. Trap layout in the apple orchards. Sticky traps and pan traps were placed in pairs of matching colours. Trap colours: w — white, y — yellow, b — blue, t — transparent (there were no transparent pan traps). Pan traps in rows 1, 3, 5 and 7 contained sodium benzoate, while rows 2, 4, 6 and 8 contained propylene glycol. The shelterbelt is one tree-wide.