EUROPEAN EARWIG PHENOLOGY AND EFFECT OF UNDERSTOREY MANAGEMENT ON POPULATION ESTIMATION

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ABSTRACT

European earwigs (*Forficula auricularia* L.) were sampled in a Canterbury apple orchard over two growing seasons using shelter traps comprised of corrugated cardboard rolls. Adult activity peaked during December and January in both seasons, while activity of nymphs peaked two weeks earlier. Earwig counts were consistently higher in a block receiving herbicide treatments, compared with an adjacent block receiving pea straw mulch. Competition between the sampling unit and the surrounding pea-straw habitat probably explains this effect. Factors affecting the sampling method used are discussed, and the need for an alternative sampling system that better reflects absolute abundance is concluded.

Keywords: Biological control, predation, European earwig, apples.

INTRODUCTION

The European earwig (*Forficula auricularia* L.) is widely distributed in New Zealand, and is omnivorous, feeding on both plant material and arthropods. In soft-fleshed tree-fruit crops, e.g. summerfruit, it is regarded as a pest. However, in pipfruit it is an important predator. It can feed on eggs and active stages of a wide range of species of Lepidoptera, Coleoptera, Diptera, Homoptera, Hymenoptera and Collembola (Buxton 1974). Asgari (1996) described *F. auricularia* as particularly voracious predators of aphids, and more efficient than chrysophids or coccinellids. Its ability to maintain woolly apple aphid below economic thresholds in apple orchards has been widely demonstrated (e.g. Blommers 1994). European earwigs can also regulate populations of other orchards pests, such as oystershell and apple mussel scales (McLeod & Chant 1952), European red mite (Phillips 1981), pear psyllid (Solomon et al. 2000) and Lepidoptera eggs, including those of codling moth (Causse 1976).

Organo-phosphate and carbamate insecticides are highly disruptive to orchard earwig populations (Epstein et al. 2000), with chlorpyrifos and carbaryl recommended for European earwig control in Australian stonefruit orchards (Bower 1992). Both these insecticides remain a component of integrated fruit production (IFP) in New Zealand (Walker et al. 1997). In contrast, earwig abundance was unaffected when the insect growth regulating (IGR) insecticides, tebufenozide and lufenuron, were field tested in a Central Otago IFP managed apple orchard (Wearing et al. 1999). However, this requires further clarification as orchard use of another IGR insecticide, diflubenzuron, has been reported to reduce earwig abundance and indirectly increase woolly apple aphid numbers (Ravensberg 1981). Additionally, studies of the sub-lethal effects of diflubenzuron suggest a reduction in predation efficiency in a range of orchard beneficial insects, including European earwigs (Solomon et al. 2000).

Earwigs are nocturnal and positively thigmotactic, seeking out cool, relatively dry and dark crevices in which to shelter during the day. This behaviour has been exploited to develop trapping methods (Lamb 1975). During spring, over-wintered adults demonstrate parental care for eggs and young nymphs, rearing broods of young in subterranean nests. During this "nesting phase", adults and nymphs may forage in trees at night, always returning to the nest to shelter during the day. Nymphs leave the nest after their first

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moult and enter a “free-foraging phase”, when active stages may remain in trees during the day, depending on shelter availability. This paper describes earwig phenology in a Canterbury apple orchard, and compares trap catches under various understorey management options.

MATERIALS AND METHODS

Cardboard shelter traps

Corrugated cardboard (ca 100 x 850 mm) was rolled to form cylinders (ca 60 mm diameter) with longitudinal corrugations. Spaces between and within corrugations provided crevices for earwigs to shelter. Rolls were fitted with rain caps cut from styrene fruit packaging trays and held in place using a wire peg inserted through the roll centre. The peg also held the roll in its desired location. These traps are functionally similar to the grooved boards used elsewhere by those studying earwigs (e.g. Helsen et al. 1998). Earwig counts were obtained by weekly examinations of traps placed in the field. After earwig numbers were recorded, earwigs were released onto the ground and the shelter trap reassembled with a fresh, previously unused cardboard roll.

Study

Shelter traps were placed in the understorey near the base of apple trees in two sites at Lincoln University, from spring to autumn, during the 2000-01 and 2001-02 growing seasons (26 September-3 May and 26 October-19 April, respectively). Sampling was stratified across different habitats within these sites formed by blocks of apple and shelter trees, and traps were randomly placed within these habitats. The first site was located within the Biological Husbandry Unit, under “organic” management since 1976 (Bio-gro 2001). The blocks had a species diverse understorey, and included plantings of Granny Smith, Sturmer, and mixed apple cultivars (n = 2 & 6 traps, during 2000-01 and 2001-02, respectively). Blocks were separated by shelter buffers, comprising extensive and species diverse tree plantings (n = 2 traps during both seasons).

The second site incorporated nearby apple blocks managed to IFP standards (Walker et al. 1997) (n = 4 & 10 traps, during 2000-01 and 2001-02, respectively). This included a block of cv. Fuji, which was divided into two halves, both similar except for the understorey. The tree-line in one half was mulched with pea-straw, and in the other half the tree-line was bare ground, maintained through herbicide use. This site also included a block of mixed Braeburn, Royal Gala and Cox’s Orange cultivars, where herbicide was used to maintain a bare ground tree-line. This block of mixed cultivars was separated from the Fuji block by poplar shelter trees (n = 2 traps), which also had a bare ground tree-line maintained with herbicide use. During 2000-01, earwigs were trapped weekly beneath alternate trees, forming a transect through both understorey types of the Fuji block (n = 16 traps). Transect data were excluded from the analysis presented in Figures 1 and 2. No organo-phosphate or carbamate insecticides were used within this IFP site during the period of the study.

The Mann-Whitney *U* test was used to identify differences in earwigs caught in transect traps.

RESULTS AND DISCUSSION

Phenology

The pattern of seasonal abundance of earwigs sampled from earwig shelter traps is presented in Figure 1. Adult numbers peaked during mid-December, and nymphs several weeks earlier, during late November. The bi-modal distribution of earwig counts is possibly explained by unseasonably cool temperatures and rainfall during late December/early January of the 2001-02 season. Reproductive biology is also a possible explanation, as although European earwigs are univoltine in both temperate and tropical habitats (Solomon et al. 2000), a proportion of females in each generation produce a second brood, making seasonal abundance complex. A generally similar pattern of earwig

phenology was evident between the two seasons studied, with active stages present in the field from mid-October until the end of April (Fig. 2). A total of 5285 and 7227 earwigs were caught during 2000-01 and 2001-02, respectively. Numbers of active stages decreased from mid-December during the 2001-02 season, and remained low in comparison to the previous season (Fig. 2). The variability in these samples reflects the difficulty in using this type of sampling method to measure earwig population densities. The sample size was increased from 10 to 20 traps in the second year, in an effort to reduce this variability.

FIGURE 1: Mean seasonal abundance ($\pm$ SE) of European earwig nymph and adult stages trapped in groundcover ($n=20$) beneath apple and shelter trees within Lincoln University orchard during 2001-02 (sum of all sites).

Understorey influence

Fewest earwigs were caught at the organically managed site for both seasons (677 and 990 earwigs, respectively). At this site one might expect greater earwig numbers because of abundant and diverse earwig food sources due to the presence of species diverse plantings and absence of disruptive insecticides. However, greater numbers of

FIGURE 2: Variation between two seasons in number of earwig active stages ($\pm$ SE) trapped within apple orchard understorey at Lincoln University (sum of all sites).

earwigs were caught in the IFP managed site during these two seasons (2228 and 1202 earwigs, respectively), comprising fungicide and insecticide sprayed apple trees, herbicide sprayed tree-lines and mown grassed alleyways. It is not considered likely that direct or indirect effects from insecticides used at this site could account for this result.

The effect of understorey on earwigs was demonstrated in the first season (2000-01), in two adjacent plots of cv. Fuji apples that differed only in their herbicide-treated, or pea-straw-mulched tree lines. Comparison of mean weekly earwig catches identified a highly significant difference (Mann-Whitney $W=41.0$; $P<0.01$) between the two understorey treatments, with more earwigs caught in the herbicide-treated plot (3453 earwigs) than in the pea-straw-mulched plot (2084 earwigs) (Fig. 3). Exclusion of the one apparent outlying data point (trap no. 17) from the analysis had little effect on this result. This result was further tested the second season, when traps were operated in both understorey treatments for the entire season (28 September – 8 March). A similar result was obtained, with nine-fold more earwigs trapped under trees with herbicide-treated tree lines than under trees with pea-straw-mulched tree lines (1540 and 175 earwigs, respectively).

FIGURE 3: Mean weekly earwig counts ($\pm$ SE) under alternate trees in a transect across adjacent blocks with pea-straw-mulched and herbicide-treated tree lines at Lincoln University from 29 December 2000 to 12 April 2001.

These data may be explained by a) a real difference in earwig preference between the two understorey management systems, or b) changes in sampling unit efficiency. One possible explanation is that sampling unit efficiency was affected by cardboard rolls competing poorly with pea straw shelter sites, but offering superior shelter alternatives in herbicide treated plots. However, initial efforts to quantify earwig numbers sheltering in the pea straw have been unsuccessful. This result highlights the difficulties of selecting a sample unit that accurately reflects absolute earwig abundance within spatially and temporally diverse situations. While shelter traps successfully measured phenological changes within the various habitats, confounding factors made this sampling method inappropriate to directly compare populations between these different habitats. This issue of competition between shelter based sampling units, surrounding habitat and earwig biology is discussed by Lamb (1975) and Helsen et al. (1998). Lamb & Wellington (1974) utilised the mark, release, recapture method of population estimation, citing benefits of this technique outlined by Southwood (1966). This sampling method appears to overcome many problems associated with methods that provide relative population estimates, such as grooved boards and corrugated cardboard rolls, which rely on "attractiveness".

Earwigs possess a volatile aggregation pheromone (Walker et al. 1993), and recent experiments in our laboratory indicate that earwigs prefer shelters releasing this pheromone (G. Karg, unpubl. data). The presence of an aggregation pheromone in shelter traps introduces the potential for further variability in trap catch, and for this reason, this factor was excluded from our sampling method by replacing cardboard rolls weekly. However, the potential exists to increase artificial shelter attractiveness using this pheromone, and it may be possible to enhance the biological control of orchard pests using this approach.

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