Research Notes

A comparison of *Drosophila* assemblages in conventional, integrated, and organic apple production.

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Introduction

A number of studies have assessed the differences in arthropod assemblages between different regimes of fruit production (*e.g.*, Moreby *et al.*, 1994; Carcamo *et al.*, 1995). Drosophilids are a significant component of fruit production systems and do not constitute a primary menace to fruit growers, although they can accelerate the transfer of moulds from damaged fruit and increase the frequency of fruit spoil (Butler and Bracker, 1963; Moller and DeVay, 1968; Michailides *et al.*, 1992; Hodge *et al.*, 1997).

With pressure from international markets on fruit producers to minimize their use of agrochemicals (Wratten *et al.*, 1998), the sustainability of agro-ecological systems is of rapidly growing interest (Wratten *et al.*, 1997). As measures of the 'health' of a system, various invertebrate bioindicators have been proposed (McGeoch, 1998). *Drosophila* meet many of the criteria listed by McGeoch (1998) for suitability as an environmental bioindicator (*e.g.*, sampled easily, abundant, taxonomy well described, baseline data on biology and autecology, cultured easily in the laboratory *etc*). Also, *Drosophila* are frequently used as a model organism in evaluating the toxicity of agrochemicals and the development of pesticide resistance (*e.g.*, Prevec *et al.*, 1992; Kumar *et al.*, 1995; Windelspecht *et al.*, 1998). As well as using single species, the structure of communities in terms of the distribution of individuals between species has also been suggested as being of use in indicating the effects of toxins, with contaminated or disturbed sites being associated with high dominance of one species (see Gray, 1987).

The aim of this investigation was to examine various regimes of apple production (from agrochemically-intensive conventional fruit production through to organic management) to assess whether different horticultural practices influenced the density, species richness and dominance of the drosophilid assemblage.

Methods

Field sites. The *Drosophila* surveys were carried out in apple orchards in the Horticultural Research Area, Lincoln University, Canterbury, New Zealand, in 1998 and 1999. There are four methods of apple (var. 'Braeburn') production on this site. These are:

(i) Conventional fruit production (CFP): produces apples to meet requirements for export to the USA. Four post-bloom applications of organophosphate insecticides (azinphosmethyl, chlorpyrifos) are used to control leafroller larvae (Lepidoptera: Tortricidae) and weed-free strips (2 m wide) are maintained around the trees using residual herbicides. A mown ryegrass understorey is maintained between the rows of trees.

(ii) Integrated Fruit Production (IFP): uses no traditional insecticides but an insect growth regulator ('Mimic'; tebufenozide) is used to combat lepidopteran larvae. A 1m wide weed-free strip is maintained around trees using a knock-down herbicide and a mixed herb layer between rows is developed to provide a refuge for natural arthropod predators.
(iii) Biological Fruit Production (BFP): uses no insecticides or herbicides, though an occasional copper application is used to control fungus. A peastraw mulch is used to prevent weed growth near to trees and a mixed herb layer is cultured between rows to provide a refuge for arthropod predators.
(iv) Organic Fruit Production: uses no agrochemicals and a mulch and floral layer (including umbellifers, artemesias and clovers) is planted around the trees to attract hymenopteran parasitoids for biocontrol. A rye-free mixed grass and herb layer is maintained between the rows to provide a refuge for arthropod predators.

Each system of fruit production was replicated three times. The CFP, IFP and BFP treatments were arranged in a three by three random block design and each plot consisted of an area of land 50 m x 50 m containing 10 rows of trees, each row being 17 trees long. These blocks were planted in 1995 and were 3 years old at the time of the survey. The organic blocks were separated from the other three treatments by approximately 50m. These organic trees covered a total area of 0.4 ha and were approximately 20 years old at the time of the survey.

Survey #1 - comparison of Drosophila *found in CFP, IFP and BFP.* Plastic containers (60 mm high; 40 mm diameter) were used as trapping vessels. Nine holes (4mm diameter) were drilled into the plastic lids to allow entry of flies. The traps were baited with pieces of banana (≈ 20 g)

Table 1. Results of survey #1. Species richness, dominance and numbers of *D. immigrans*, *D. melanogaster* and *D. pseudoobscura* caught in each class of fruit production (mean ± SE; N=3). Data based on three traps per replicate, collecting for a total of 8 weeks.

	CFP	IFP	BFP	$F_{(2, 6)}$	P
Richness	0.9 ± 0.3	1.2 ± 0.1	1.2 ± 0.2	1.01	>0.40
Dominance	0.81 ± 0.11	0.82 ± 0.09	0.82 ± 0.09	0.03	>0.95
D. immigrans	2.7 ± 1.4	3.3 + 1.9	6.3 ± 3.8	0.28	>0.75
D. melanogaster	1.0 ± 1.0	2.0 ± 0.6	2.3 ± 1.9	0.40	>0.65
D. pseudoobscura	26.0 ± 9.9	27.7 ± 4.8	29.0 ± 14.8	0.03	>0.95
Total *Drosophila*	29.7 ± 8.6	33.0 ± 2.5	38.3 ± 20.6	0.05	>0.95

Table 2. Results of survey #2. Species richness, dominance and numbers of *D. immigrans, D. melanogaster* and *D. pseudoobscura* caught in each class of fruit production (mean ± SE; N=3). Data based on four traps per replicate, collecting for a total of 10 days.

	CFP	IFP	BFP	Organic	$F_{(3, 8)}$	P
Richness	2.0 ± 0.0	1.7 ± 0.3	2.0 ± 0.6	2.0 ± 0.0	0.25	>0.86
Dominance	0.76 ± 0.02	0.75 ± 0.14	0.87 ± 0.08	0.75 ± 0.05	0.50	>0.65
D. immigrans	4.0 ± 3.5	2.0 ± 0.6	4.3 ± 2.3	7.0 ± 1.5	0.81	>0.50
D. melanogaster	0.3 ± 0.3	0.0 ± 0.00	0.3 ± 0.3	0.0 ± 0.0	0.67	>0.55
D. pseudoobscura	3.7 ± 0.3	2.0 ± 1.00	7.0 ± 4.2	2.7 ± 1.2	0.88	>0.45
Total *Drosophila*	8.0 ± 3.5	4.0 ± 1.2	11.7 ± 4.8	9.7 ± 2.7	1.20	>0.35

which was renewed once every two weeks. Three traps were put into each of the CFP, IFP and BFP blocks, placed at the bases of trees in the centre of the middle row. The traps were emptied of flies once each week for eight weeks (from March to May, 1998). The specimens caught in the traps from each block were pooled and treated as a single replicate.

Survey #2 - comparison of Drosophila found in CFP, IFP, BFP and organic apple production. The same plastic containers described above were used as the trapping vessel. Four traps were placed in each block of CFP, IFP, BFP and organic fruit production. The traps were baited with 1-week old banana and placed at the bases of four different trees in the centre of each block. The traps were left for 10 days and then checked for *Drosophila.* The specimens caught in the four traps from each block were pooled and treated as a single replicate.

Results

Only three species of *Drosophila* were found: *D. pseudoobscura*, *D. melanogaster* and *D. immigrans*. Primarily as a result of there being so few species present, there were no significant differences in the richness of *Drosophila* between the different categories of fruit production (Tables 1 and 2). The dominance of the *Drosophila* assemblages (where, d = abundance of most common species / total number of *Drosophila*) was not affected by the fruit production system. In both surveys, the abundance of any one species did not differ between fruit production systems. Similarly, there were no differences in the total number of *Drosophila* collected between each fruit system.

Discussion

No differences were found in the drosophilid faunas in each of the various regimes of fruit production and it would appear that the whole area shared a common assemblage. This suggests that the pertinent features of each system of fruit production (*e.g.*, the use of insecticides, provision of a diverse herb flora between rows) were not affecting populations of drosophilids on a local scale. It is possible that any short term negative effects of insecticide application are rapidly compensated by immigration of drosophilids from unaffected areas nearby.

These results have problematic implications when determining the use of drosophilids as bioindicators. It could be concluded that drosophilids are no use as bioindicators as they do not accurately illustrate the difference in fruit production regimes. Alternatively, it may be that there really was no difference in the 'environmental health' of the four fruit systems, as suggested by their similar drosophilid faunas. The correlation of drosophilid responses with those of other - more well established - indicator species would help evaluate the usefulness of drosophilids as a bioindicators. As population responses were not identifiable in this system, the development of sublethal biomarkers in *Drosophila* (*e.g.*, cholinesterase, cytochrome P450 activity) to identify low levels of contamination may be of some value.

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The system of ecdysteroids is a component of the stress-reaction in *Drosophila* adults.

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In order to study the mechanism of the insect stress reaction we have created the model that consists of two lines of *Drosophila virilis* contrasting in their reaction to stressor effects. Individuals of wild type line 101 respond to stressors (high temperature, crowded culture, insufficient diet, mechanical and chemical stimuli) by a stress-reaction enabling them to adapt to unfavorable environmental conditions. Mutant flies of line 147 do not possess this response (Rauschenbach *et al.*, 1991). We have revealed the main components of the stress reaction in adults: the systems of juvenile hormone, dopamine and octopamine (Rauschenbach *et al.*, 1993, 1995; Hirashima *et al.*, 1999). We study here whether a system of ecdysteroids is a component of the reaction.

Cultures were raised on standard medium at 25°C and adults were synchronized by eclosion. Adults (24-h old) were subjected to stress by placing them at 38°C for 60 min. Thereafter they were frozen in liquid nitrogen and stored at –85°C. Contents of ecdysone (E) and 20-hydroxyecdysone (20HE) were measured by radio-immunoassay according to Chang and O'Connor (1979).

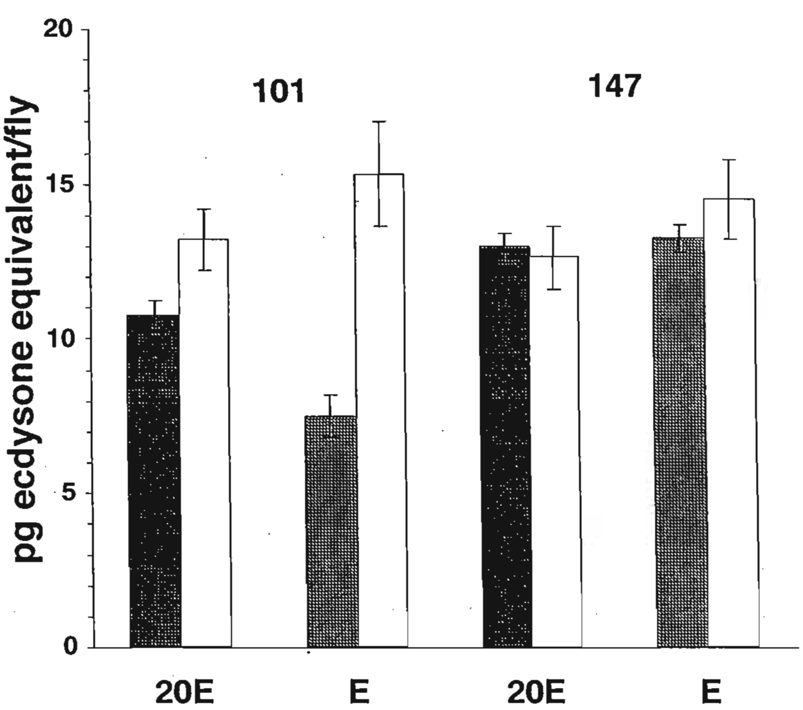

Figure 1. The contents of E and 20HE in 24-h old females of lines 101 and 147 under normal (25°C) and heat stress (38°C, 60 min) conditions. Closed bars - control, open bars - stress.