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PRELIMINARY OBSERVATIONS ON AWARENESS, MANAGEMENT AND IMPACT OF BIODIVERSITY IN AGRICULTURAL ECOSYSTEMS

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Abstract

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Agricultural ecosystems are often considered to be biological 'deserts' because of the use of monocultures and pesticides. However, the species richness and abundance of invertebrates can be similar to that found in many natural ecosystems. This paper describes the diversity of surface-active carabid beetles and earwigs over 2 years in cropping land in the Wimmera region of Victoria and contrasts it with data from other ecosystems. Management practices such as tillage and stubble retention have an impact on some invertebrates, but extremely few studies have described effects on species considered beneficial. We present information on the relative number and likely impact of these beneficial species, particularly carabid beetles and earwigs. Information for farmers concerning invertebrates in agricultural ecosystems usually concentrates on pest species. An approach to raise awareness of invertebrate diversity is discussed.

Introduction

Agricultural ecosystems are generally less diverse than the natural ecosystems they replace because the aim of agriculture is to produce a limited number of species that we find useful (Altieri, 1994; Gerard, 1995). However, even within any given region and with a single crop type, there are many different management practices that can affect the composition of the invertebrate community. For example, use of pesticides (type, method and frequency of application), irrigation, tillage practices and rotations will often vary markedly between farms. Consequently, it is difficult to generalise about the effect of agriculture on diversity of invertebrates in even one region or crop type.

Overseas there has been research on using management practices such as encouraging populations of predatory (beneficial) insects such as carabid beetles and hoverflies on field margins (Sotherton, 1985; Asteraki, 1994; Dennis and Fry, 1992). Within fields, conservation tillage practices can change the relative abundance of some invertebrate species (Stinner and House, 1990). White snails (*Cernuella virgata*), wireworms (Coleoptera: Elateridae) and false wireworms (Coleoptera: Tenebrionidae) are pests that are often favoured by conservation tillage and stubble retention. However, little is known in Australia of the effects of conservation tillage practices on most species, including pests. Robertson et al. (1994) have described effects of tillage on a range of soil-dwelling organisms in Queensland and shown that zero tillage may enhance ecological sustainability of farms by essentially maintaining a good diversity of invertebrate species.

This paper describes the diversity of carabid beetles active on the soil surface of both conservation and conventional tilled field crops in the Wimmera (western Victoria). Numbers of carabid beetles are described and compared with results from other environments including grasslands.

The perception of invertebrates in agricultural ecosystems is often as pests, and so there are particular needs of farmers and other land managers to address regarding awareness of invertebrates and biodiversity (Horne et al., 1995). We describe the approach we have taken to increase awareness of insects other than pest species, and the value of these insects to farmers.

Materials and methods

The study site in the Wimmera was located on the Longerenong College of Agriculture and Horticulture campus (36°39'S; 142°16'E). Eight adjacent large (5 ha) blocks have been managed to demonstrate differences in cropping using different tillage practices (Williams, 1994). Our study concentrated in three of these blocks, Bl. 1 (Conventional tillage and fallow) Bl.6

(conservation tillage with stubble retention and no fallow) and Bl.7 (Conventional tillage and no fallow). Crops planted in these blocks from 1991 to 1995 were as follows: Block 1, wheat, chick peas, fallow, wheat, field peas; Block 6, faba beans, barley, chick peas, canola, faba beans; Block 7, chick peas, canola, faba beans, barley, chick peas. Crops are usually planted following autumn rains (often April) and harvested in summer (usually December or January).

Twenty pitfall traps, each consisting of a plastic container 11 cm diam. x 5 cm deep, half filled with ethylene-glycol, were placed in two parallel lines of 10 traps in each block. Traps were placed 50 m apart in the two lines, each line 25 m in from the long boundaries. Traps were run continuously from April 1993 until April 1995 and emptied weekly. Further details of methods are described by Horne and Edward (1995).

Macroinvertebrates greater than approximately 3 mm long were identified to species or morphospecies, with reference to the Museum of Victoria collection. To assist with improving farmers recognition of common invertebrates, small insect collections were made using an 8.5 x 11.5 cm clear plastic display case, containing 13 insect specimens. The insects were dried and glued to a base piece containing common names, and arranged in two groupings as "beneficial" or "pest" species. Notes with colour pictures of the insects and a short description of their biology were prepared to accompany the collection. Farmers were asked (i) whether these kits had improved their knowledge of the diversity of insects in their crops and (ii) their opinion on whether these kits would be of useful to farmers in the Wimmera.

Results

Twenty-eight species of carabid beetles (Coleoptera: Carabidae) were recorded from the study site. The total number captured per year is indicated in Table 1. The most abundant species were *Rhytisternus* sp, *Mecyclothorax ambiguus* and *Simodontus brumneus*. Another abundant predatory species at this site was *Labidura truncata* (Dermaptera: Labiduridae), with more individuals found per year than any of the carabids.

The fact that there is no replication in this part of the study means that no firm conclusions about the relative abundance of invertebrates in conventional or conservation tilled crops can be made. However, it is evident that in both tillage systems there are many carabid and other insect species present (Tables 1 and 2), and data from a replicated trial (Horne and Edward, 1996) also indicate that some carabids are more abundant in conservation tilled crops. The year catch is commonly used in studies of carabid populations to indicate the relative abundance of

Table 1. Year catch of 15 species of the most abundant carabid beetles from 20 pitfall traps in each of the three blocks sampled.

Carabidae	Block 1 1993–94	Block 1 1994–95	Block 6 1993–94	Block 6 1994–95	Block 7 1993–94	Block 7 1994–95	Total
Rhytisternus sp.	376	169	371	219	353	112	1600
Mecyclothorax ambiguus	161	179	39	6	156	15	556
Simodontus brumneus	135	77	33	100	121	41	507
Geoscaptus sp.	53	11	43	54	67	17	245
Clivina planiceps	129	48	4	1	4	0	186
Nemaglossa australis	81	22	12	7	36	8	166
Platia miniina	3	17	16	42	21	66	165
Sarticus sp. 1	15	8	20	7	10	11	71
Harpalinae spp.	5	9	4	1	30	6	55
Promecoderus sp.	2	3	6	7	10	4	32
Chlaenius australis	2	0	16	0	7	0	25
Anomotarus sp.	0	1	3	0	11	3	18
Apotomus australis	2	3	1	6	2	2	16
Catadromus (lacordairei)	1	1	2	1	3	2	10
Clivina nr. *dilutipes*	5	2	0	0	0	0	7
Zuphium australe	1	0	0	3	1	2	7

Table 2. Year catch of key species, 1993–94 and 1994–95.

Species	Block 1	Block 6	Block 7
Rhytisternus sp (Beneficial carabid)			
1993–94	376	371	353
1994–95	169	219	112
Labidura truncata (Beneficial earwig)			
1993–94	3,227	1,752	3,610
1994–95	800	1400	1244
Pterohelaeus darlingensis (Pest tenebrionid)			
1993–94	568	913	773
1994–95	825	1,014	1,380
Gonocephalum adelaidea (Pest tenebrionid)			
1993–4	475	295	441
1994–5	516	188	969

different species. The year catch over two consecutive years indicates that populations of carabid (and earwig) species, in Block 6 (conservation tillage) may be more stable than in the conventionally tilled blocks (Table 2). That is, although the numbers of *Rhytisternus* and *L. truncata* were not always higher in Block 6, their numbers remained similar between years. Numbers of these species in Blocks 1 and 7 changed markedly over the same period. The numbers of the carabids *Simodontus brumneus* and *Geoscaptus* captured from Block 6 also either increased from 1993–94 to 1994–95, or else decreased by a much smaller percentage than corresponding populations from Blocks 1 and 7 (Table 1).

Despite the abundance of carabid beetles, there was little or no awareness of their presence by the farmers with whom the results were discussed. Carabid beetles are just one group of invertebrates that are likely to have an impact on pest species. The poor awareness of these beetles was interpreted by us as indicative of the low level of awareness of invertebrate biodiversity in general. To address this problem we prepared and distributed to farmers small insect collections containing a few of the most abundant pest and beneficial species. Farmers' comments on the insect kits were favourable in that they believed they had improved their knowledge of what was of benefit in their crops and that not all insects were pests. They were seen as being particularly useful in identifying non-pest species and also prompted a greater interest in the invertebrate fauna of their crops.

Discussion

Agriculture is a major land-use in Victoria and other States in Australia. We believe that it is important that discussions on biodiversity do not only concern conservation areas or natural ecosystems, but should include agricultural ecosystems. It is generally accepted that agricultural activities such as ploughing reduce the biodiversity of fields but the biodiversity of agricultural ecosystems can be similar to other natural systems (Paoletti et al., 1992). If we consider just the Carabidae, some estimates of species richness from different environments are; 178 species in arable agricultural land in Ontario (Rivard, 1964, 1965), 127 species in South Dakota field crops (Kirk, 1971), 114 species in Italian forest (Pizzolotto and Brandmayr, 1990), 68 species in an urban Ruderal system in Germany (Gruttke and Weigmann, 1990), 59 species in English grasslands (Luff, 1990) and 22 species in Finnish taiga (Niemela, 1990). We found 28 species in the Wimmera, which is a significant native fauna (resident and transient) using these croplands. There is no estimate of the carabid fauna in nearby, undisturbed habitats with which to compare these figures.

Conservation-tilled areas have been found to increase invertebrate biodiversity when compared to conventionally-tilled areas (Stinner and House, 1990; Robertson et al., 1993). The stability of crop ecosystems is increased by reducing tillage and so conservation-tilled crops would be expected to provide habitat for more species than regularly disturbed land. The results of our

study are consistent with these findings, but also, we suggest that beneficial species are favoured by conservation tillage. At present farmers perceive a close link between conservation tillage and pests.

We suggest that there is reason to expect longer term benefits from conservation tillage in enhancing and maintaining stable populations of predatory species. Carabid beetles are well-known predators of a range of invertebrates and contribute to the biological control of insect pests in agricultural environments. If farmers' management practices result in increased numbers of carabid beetles then improved biological control of some pests should result. That is, based on the results of the Wimmera study, the improved management of the resident macro-invertebrate fauna will lead to better pest control for the farmer.

Many of the predatory species have an annual life-cycle and so it could also be expected that they could be relatively slow to respond to changes in pest (prey) populations. Farmers may quickly perceive a pest problem associated with conservation tillage but not notice a slower improvement in predatory species. It is important, if maintaining invertebrate biodiversity in agricultural ecosystems is an aim, to document the relative abundance of pest and beneficial species under different tillage regimes and to provide information on beneficial species to farmers. The approach of using insect kits and notes has been well received by farmers and advisors in our study. We recommend it to others looking to promote invertebrate biodiversity and conservation.

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