FOREST REMNANTS: THEIR POTENTIAL AS A SOURCE OF NATURAL ENEMIES IN AGRICULTURE

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SUMMARY

Some schools of ecological theory predict that predator species abundance will be greater in patches of more mature habitat than in earlier successional habitats such as pasture. To examine this, ground active invertebrates were sampled by pitfall trapping between December 1992 and January 1994 in five habitats of increasing successional age; pasture, gorse, manuka, regenerating podocarp and a mature podocarp remnant in the Northern Wairarapa. Diversity of predators increased through early successional sites, peaked in mid successional stages, and declined in later successional sites. Individual predator numbers were highest in the pasture and declined through habitats of increasing succession in most months.

Keywords: natural enemies, forest reserves, ecological theory

INTRODUCTION

Both theoretical (Murdoch *et al.* 1985) and empirical work (Winder *et al.* 1994) indicates that polyphagous arthropod predators can achieve significant levels of control of insect pests within agroecosystems. However, most studies investigating generalist predators in agriculture have relied on manipulating the habitat, eg. field margin refuges and intercropping to increase entomophage abundance within agroecosystems (Dennis and Fry 1992; Herzog and Funderbunk 1986; Letourneau 1990).

Current economic trends in extensively managed pastoral systems have seen a concentration of resources into more productive land, encouraging the retirement of erosion prone and major weed problem areas. Conservation efforts by the government and private landowners have also seen many remnants of native vegetation set aside. Studies of predator assemblages in pasture, crop and orchard habitats from both overseas (Reichart and Lockley 1984; Adams 1984) and in New Zealand (Death unpublished data) indicate that spiders, opiliones, centipedes, and carabids may be the potentially important predators in such systems. These are the same invertebrate predators that can be very common in retired land and native forest remnants (Butcher and Emberson 1981) and are potentially important in agricultural systems. If forest reserves do harbour more natural enemies which have the capacity to move into neighbouring agricultural land, they may offer a ready source of predators for exploitation in agroecosystems.

Price (1991) in a recent review of forces important in structuring insect communities suggested that predator diversity and abundance should increase as habitat age and complexity increases. In this study we examine the potential of such retired land to act as reservoirs of beneficial entomophages and whether or not this potential increases with successional age of the remnant as predicted by Price.

METHODS

The study sites were located within a 5 km radius in pastoral farmland within the northern Wairarapa. Dominant vegetation types found at the study sites roughly correspond to habitats of increasing successional age found in the Wairarapa (McQueen 1991). Thus vegetation in order of increasing successional age were: pasture (20 years since last cultivated), gorse (25 years old), manuka (30-40 years old), regenerating

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broadleaf/podocarp forest (100 years since cleared by fire) and mature podocarp forest. Biotic and abiotic characteristics of the study sites are given in Table 1.

TABLE 1: Biotic and abiotic characteristics of study sites recorded between December 1992 and January 1994.

Site	Annual rainfall (mm)	Grass minimum temperature °C	Area (ha)	Dominant vegetation	Leaf litter (cm)
Pasture	1002	-1→9	1.6	white clover ryegrass	nil
Gorse	1002	-1→6	1.0	gorse	3-15
Manuka	1759	-.5→14	200	manuka, mahoe silver fern	nil
Broadleaf/ podocarp	1002	0→11	4.16	tawa, titoki pukatea, kahikatea	2-5
Podocarp	720	-1→11	6.25	rimu, tawa, matai kahikatea	1-4

Ground active invertebrates were sampled at monthly intervals between December 1992 and January 1994 by pitfall trapping. Although pitfall traps measure a combination of activity and density, predator activity is more likely to reflect predation rates than density *per se* (Abrams 1993) and this in turn is more likely to reflect their potential in pest control. Five replicate traps (plastic containers, 11 cm diameter and 10 cm deep) were sunk level with the surrounding ground at each site approximately 10 m apart along a 50 m transect. Traps were filled with 300 ml of 70% ethylene glycol and a few drops of detergent to break surface tension, and covered with galvanised iron covers (20 X 20 cm) raised 3 cm above the traps to prevent rain entering. Samples were sieved to 500 µm, sorted, and enumerated as RTUs (recognisable taxonomic units) under x10 magnification. The RTUs were subsequently identified to family. Statistical analysis was performed with the GLM procedure of SAS (SAS 1985), using log transformed data.

RESULTS

Of the predatory species collected the greatest diversity was recorded amongst spiders (85 species), staphylinids (27 species), harvestman (15 species) and predaceous coleopteran larvae (15 species). A smaller number of other predatory species were also collected including Carabidae, ants, centipedes, pseudoscorpions and Reduviidae. Some species of spiders, staphylinids, carabids and opilions were restricted to only one habitat. However, all other species were found at a number of sites.

Site differences in both predator species richness and abundance were highly significant (Table 2). The largest differences occurred at either end of the successional spectrum with species richness lowest in both the early (ie. pasture) and late successional stages (ie. mature podocarp). Maximum diversity occurred in the gorse, manuka and broadleaf/podocarp habitats. In contrast the number of predatory arthropods was highest in the pasture and declined through increasing successional stages.

Abundance (Fig 1) and diversity (Fig 2) of predators also changed seasonally at the study sites, with the lowest number of individuals and species recorded in the winter months. Differences between the sites in species richness were consistent across seasons although there was a significant interaction between site and season in the abundance data (Table 2). This was a result of very low numbers of insects in the pasture between June and December, in contrast to the other sites during this period. Greater availability of microhabitat refuges (eg. logs, rank grass and leaf litter) from low winter temperatures in later successional habitats may in part explain the reduced abundance in the pasture throughout winter.

Figure 1: Number of individual predators in habitats of increasing successional age between December 1992 and January 1994.

Figure 2: Predatory species found in habitats of increasing successional age between December 1992 and January 1994.

TABLE 2: Mean abundance and diversity of predators pitfall trapped, per site and per month, and results of Analysis of Variance.

	Sites		Seasons		
	No./site ¹	Std Error	Month	No. individuals/ month ²	No. species/ month
Species					
Pasture	1.817	0.240	Jan	30.90	2.441
Gorse	2.772	0.327	Feb	29.95	3.123
Manuka	2.879	0.278	Mar	23.73	2.927
Broadleaf	3.090	0.318	Apr	30.20	2.144
Podocarp	2.518	0.347	May	33.56	2.693
			Jun	18.80	2.450
Individuals			Jul	21.16	2.500
Pasture	28.04	3.944	Aug	15.04	1.985
Gorse	24.83	2.862	Sep	15.68	2.518
Manuka	21.62	6.304	Oct	18.48	2.379
Broadleaf	18.98	5.069	Nov	18.95	3.010
Podocarp	16.40	3.375	Dec	14.68	2.787
			Jan	20.84	2.176
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Analysis of Variance		F	df	P	
No. of species					
Site	15.78	4	<0.001		
Season	6.39	12	<0.001		
Site Season interaction	1.32	46	0.09		
Error		252			
No. of individuals					
Site	13.85	4	<0.00		
Season	9.19	12	<0.001		
Site Season interaction	1.90	46	0.001		
Error		252			

¹ Mean number trapped over 13 months² Mean from all sites

DISCUSSION

The peak in invertebrate predator diversity in patches of mid-successional age corresponds to that found by Brown and Southwood (1987) in successional grasslands, and fits within the framework of general ecological theory (Petraitis *et al.* 1989), although not within the predictions of Price (1991) for invertebrate communities. In contrast, individual predator abundance was found to decrease as the age and complexity of the habitat increased. Thus early successional sites were characterised by high numbers but low diversity of predators such that one or two species were very abundant (lyniphid and lycosid spiders in this case). Later successional sites showed concomitant declines in total number of predators and, in the very late stages, a decline in diversity.

The decline in predator diversity in the climax forest may be the result of competitive exclusion between predators which has not had time to reach completion in the earlier stages of succession. Studies of ground beetles (Carabidae) have shown interspecific competition can be important in structuring carabid assemblages (Niemela 1993). This seems to be the case in our study with only one species of carabid

(*Megadromus capito*) in the late succession forest compared to 3–4 species (*Mecodema simplex*, *Holcopsis oedinema*, *Plocamostethus pleniussculus*) found in mid successional sites.

In contrast to the predictions of Price (1991), it seems that reserves of mid-successional age offer the greatest potential source of predator diversity although pasture has the highest density of predatory species. Whether the species found in pasture are those species most effective in controlling pasture pest species, or if species found in some of the vegetation refuges are more effective, is currently being evaluated. Furthermore, if such a relationship is established the capacity for predators in these systems to migrate into the pasture to feed on pest species requires investigation. However, it does seem that vegetation remnants of mid-successional age do offer considerable potential as sources of an array of predators that may be useful in agroecosystems.

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