SHORT COMMUNICATION

Species richness of indigenous beetles in restored plant communities on Matiu-Somes Island, Wellington Harbour, New Zealand

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Abstract: Previous studies have shown that indigenous beetle diversity reflects indigenous plant diversity in modified and remnant habitats. This study examines the indigenous: introduced relationship at a locality where degraded pasture has been progressively revegetated. Pitfall traps were used to collect beetles from three revegetated sites of different ages (5, 17 and 100 years) and in a coastal *Muehlenbeckia* habitat on Matiu-Somes Island (25 ha), Wellington Harbour, New Zealand. A total of 78 morphospecies were found over 12 months. The indigenous: introduced status of 74 species were determined; 67 were classified as 'indigenous', and 7 as 'introduced'. A positive trend was found between the proportion of ground-dwelling indigenous beetle species collected and the proportion of indigenous plant species present at a study site. As the revegetated site matured, the proportion of indigenous beetle species increased. We collected 20 (83%), 37 (88%) and 48 (92%) indigenous beetle species from the 5-year scrubland, 17-year shrubland and 100-year forest, respectively.

Keywords: Coleoptera; succession; indigenous species; introduced species; species richness; disturbance; restoration.

Introduction

The decline or extinction of indigenous species is most likely to occur when community composition has been altered by habitat modification or through the introduction of alien species (Suarez *et al*, 1998). With the increasing movement of people and goods to New Zealand, the number of foreign insect species in all biotypes (particularly modified ones) will continue to increase (Kuschel, 1990). The exact number of introduced insect species in New Zealand is uncertain, but is estimated to be more than 1100 species (Taylor & Smith, 1997). Since degraded indigenous habitats support most of the alien biodiversity, we could expect that restoration programmes, designed to re-create indigenous biota in such areas, might run the risk of being overwhelmed by already-resident alien species. The present study uses the species richness of beetles to address the question: does the balance between indigenous and alien species improve in favour of the indigenous species as replanted native vegetation develops toward maturity?

Two previous New Zealand studies (Kuschel, 1990; Crisp *et al*, 1998) have investigated the ratio of indigenous to introduced beetles in degraded indigenous habitats and those with a high proportion of alien plants. Both found that indigenous beetles require indigenous plants to flourish. A 15-year study by Kuschel (1990) in Auckland recorded that 98% of beetle species recorded in indigenous vegetation were indigenous, yet in adjacent exotic pasture only 9% of the beetles were indigenous species. We examined a recovering coastal forest where exotic pasture has been replanted with indigenous shrubs and trees in an effort to restore the previous biota. Matiu-Somes Island, in Wellington Harbour, where the study was done, provides a unique opportunity to examine the role of replanted indigenous vegetation for restoring indigenous faunal diversity after degradation to exotic pasture. Due to a time sequence of replantings, a series of vegetation communities at different successional stages were available. The 25 ha island has been a pastoral agricultural quarantine station for 110 years, its only indigenous vegetation being that which survived on the steep rocky coastal cliffs and shoreline (Grehan 1990). A small patch of native trees were planted for shelter in approximately 1900. Since 1981, a replanting programme conducted by the Lower Hutt Branch of the Royal Forest and Bird Protection Society, has been revegetating the island, section by section. As succession proceeds in these replanted sections, the introduced pasture grasses are being replaced by indigenous trees and shrubs. This study examined the relative contribution of indigenous and alien beetle species richness at four sites; one a relatively undisturbed cliff-top, the other three at different successional stages resulting from the revegetation programme replanted 5, 17, and 100 years before present.

Methods

Study sites

Three of the sites chosen for study on the island were typical of different stages of plant communities developing as the result of the revegetation of the island. The fourth site, '*Muehlenbeckia*', typified the vegetation near the coastal cliffs on the island. The following is a descriptive summary of the vegetation in each study site:

Muehlenbeckia. The dominant plant species in this study site was *Muehlenbeckia complexa*[1] . Eight other indigenous species were also present, comprising mostly of *Haloragis erecta*, *Parsonsia heterophylla* and *Coprosma repens*. The only introduced plant was red fescue (*Festuca rubra*). The vegetation height was approximately 30 cm.

5-year scrubland. The ground cover at this site was dominated by sweet vernal (*Anthoxanthum odoratum*), an introduced grass. Predominant indigenous species were *Ozothamnus leptophyllus, Pittosporum crassifolium, Olearia solandri, Myoporum laetum* and *Haloragis erecta,* planted in 1993. These formed a broken canopy of 1.1 m height.

17-year shrubland. This site had a diverse range of indigenous species planted in 1981. The dominant species were *Coprosma repens, Hebe stricta*, *Melicytus ramiflorus*, *Corynocarpus laevigatus* and *M. laetum*. Five introduced plant species were present but contributed a minor component of the community. The closed canopy had a height of approximately 4 m.

100-year forest. The canopy trees at this study site were planted in 1900 (approximately). The canopy (height – 14 m) was composed entirely of four species; *Metrosideros excelsa, Vitex lucens*, *C. laevigatus* and *M. laetum*. The understorey was extremely sparse and consisted mostly of *C. laevigatus* seedlings and *C. repens*. All plants were indigenous, but *M. excelsa* and *V. lucens* do not naturally occur in the Wellington region.

[1]Plant nomenclature follows Allan (1961), Moore and Edgar (1970), Connor and Edgar (1987), Webb *et al*. (1988), Breitwieser and Ward (1997) and Lambrechtsen (1992).

Beetle collection and identification

Beetles were sampled using pitfall traps consisting of a 170 mm length of 75mm (inner diameter) PVC pipe sunk vertically in the ground so that the rim was flush with the surface. A 90 mm deep plastic cup with a diameter of 70 mm containing 75 ml of Gault's solution (Walker and Crosby 1988) was fitted inside the pipe. A metal lid was secured a few centimetres above the trap to minimise debris entering the trap. Ten pitfall traps were located randomly within a 20 m x 4 m grid in each of the four study sites and had a minimum distance between traps of 1.75 m. The traps were continuously set from May 1997 - April 1998 and were cleared at the end of every month.

Beetles were sorted on the basis of external morphology to morphospecies or recognised taxonomic units (RTUs) using keys. Where species-level identification was possible, beetles were scored as 'probably indigenous' or 'probably introduced' using Hudson (1934), Kuschel (1990), Klimaszewski and Watt (1997) and the Museum of New Zealand invertebrate collection and with the assistance of an experienced coleopterist. Beetle species that could not be identified to a level sufficient to determine their indigenous/introduced status, were categorised as 'uncertain', and were not used in the calculations.

Vegetation sampling

Vegetation was sampled from a 24 m x 8 m (192 m^2) plot at each study site. Percentage cover was estimated for each plant species in six strata. The six strata heights were; <0.1 m., 0.1-0.5 m, 0.5-1.5 m, 1.5-3.0 m, 3.0-5.0 m, and >5 m. Percentage cover was measured using seven classes of <1%, 1-5%, 6-10%, 11-25%, 26-50%, 51-75% and 76-100%. Plant species were identified as indigenous or introduced using Allan (1961), Moore and Edgar (1970), Connor and Edgar (1987), Webb *et al*. (1988) and Lambrechtsen (1992).

Data analysis

A Kruskal-Wallis one way analysis of variance and *Bonferroni* analysis (using SigmaStat version 2.03) was used to determine if there was any significant difference in the percentages of indigenous beetle species between the study sites. Reported differences were significant at $P = 0.01$, unless reported otherwise. The test was conducted on the percentages of indigenous beetle species caught in ten pitfall traps (replicates) per study site. Although the traps were replicated, the sites were not, so any statistical comparison is only relevant with regard to comparing sites rather than comparing vegetation stages.

Table 1. Number of beetle and plant species recorded in each of three 'nativeness' categories (indigenous, introduced and uncertain) for each study site on Matiu-Somes Island.

Taxa:	Study site:	Number of: Indigenous species	Introduced Species	Uncertain nativeness state	Total:	Percent of Indigenous species[1]
Beetles	*Muehlenbeckia*	27	4	0	31	87 [a]
	5-year plantings	20	4	1	25	83 [b]
	17-year plantings	37	5	1	43	88 [a]
	100-year forest	48	4	3	55	92 [a]
Plants	*Muehlenbeckia*	9	1	-	10	90 [a]
	5-year plantings	17	5	-	22	77 [b]
	17-year plantings	27	5	-	32	84 [c]
	100-year forest	10	0	-	10	100 [d]

[1]Percent indigenous beetle species sharing the same letter do not significantly differ (ANOVA and *Bonferroni* analysis).

Results

During 12 months of pitfall trapping: 67 indigenous (86%), 7 introduced (9%) and 4 uncertain (5%) beetle species were trapped on Matiu-Somes Island. These taxa are listed in Appendix 1. Samples from the 100-year forest contained the highest percentage of indigenous species (92%), while the 5-year scrubland contained the least (83%) (Table 1). The percentages of indigenous beetle species varied significantly between study site.

The 5-year scrubland had a lower percentage of indigenous beetle species than the *Muehlenbeckia*, 17-year shrubland and 100-year forest. There was no detectable difference in the percentages of indigenous beetle species present in the *Muehlenbeckia,* 17-year shrubland and 100-year forest. The number of introduced beetle species recorded at the four sites were remarkably constant (4-5 species).

From the four study sites a total of forty-six plant species were identified. The 5-year and 17-year replanted study sites had the lowest percentage of indigenous plant species (Table 1). In the 100-year forest, no introduced plant species were recorded. The indigenous plant species recorded were significantly different between the four study sites.

The study sites with higher percentages of indigenous plant species, i.e. 100-year forest and *Muehlenbeckia*, had higher percentages of indigenous beetle species present (Table 1). A similar trend was shown in indigenous beetle abundances (data not presented). The 5-year scrubland, with the most introduced plant species (23%), had the fewest indigenous beetle species (83%) and indigenous beetle abundance (82%) of all sites.

The lowest beetle species richness (25) were recorded from samples in the 5-year scrubland (Table 1). Samples from the *Muehlenbeckia* and 100-year forest had 10 plant species each, and 31 and 55 beetle species respectively. Plant species richness was higher in the 5-year and 17-year plantings, however this was not reflected in the number of beetle species (Table 1). The ratio of beetle species richness to plant species richness was much higher in the *Muehlenbeckia* (3:1) and 100-year forest (5:2) than in the 5-year plantings (1:1) and 17-year plantings (1:3).

Discussion

Our expectation that the exotic pasture of a quarantine island would have lost its indigenous beetle fauna, with the result that restoration to forest vegetation would lead to a dominance of introduced beetles, seems unfounded. For a small island with a long history of quarantine and pastoral farming, the ratio of indigenous to introduced beetle species on Matiu-Somes Island was surprisingly high (86%). Our samples indicate that restoration of indigenous vegetation is associated with an increase in species richness and abundance of indigenous beetles, even in this predominantly exotic landscape. The number of indigenous beetle species in the 100-year forest on Matiu-Somes Island was twice that of the 5-year scrubland which were still dominated by pasture species. This demonstrates that, in highly degraded habitats, restoration of indigenous vegetation will be accompanied by increases in indigenous beetle species richness and abundance over time.

This study has demonstrated that there is a weak relationship between the ratio of indigenous to introduced plants at a site and the ratio of indigenous to introduced beetle species. Type rather than number of plant species seems to be most important. The rank grass site (5-year scrubland) with the lowest proportion of indigenous plant species had a significantly lower percentage of indigenous beetles than the sites with more dominant indigenous vegetation. The cliff-top site with its "refuge" of original indigenous vegetation ("*Muehlenbeckia*") was intermediate and supported very few individuals of the introduced beetles. This result confirms a recent study by Crisp *et al*. (1998) in similar ecosystems on the nearby Wellington south coast; they also found that the lowest proportion of native plant and beetle species occurred in rank grassland, with the maximum in remnant mature forest. The difference between these two studies was that Crisp *et al*. (1998) investigated a series of degraded ecosystems as indigenous forest plants were being lost. The sites in the present study had degraded beyond that stage (possibly 100+ years ago) before revegetation had commenced. Although the ratios of indigenous to introduced beetles were very similar for the two studies, Crisp *et al*. (1998) trapped approximately twice the number of beetle species (150 species) that we did. The reduced beetle species richness on Matiu-Somes Island is undoubtedly a combined result of its small area (low diversity of habitats) and its degraded state. In his Auckland study, Kuschel (1990) found that only 9% of indigenous beetle species were found in exotic grassland outside indigenous forest. The number of introduced beetle species caught in the present study was low [7 (9%)] compared to the number of introduced ground-living beetle species [179 out of 596 (30%)] found by Kuschel (1990) but similar to that to found by Crisp *et al*. (1998) [13 out of 127 (10%)]. The higher number of introduced beetle species established in Auckland could be attributed to its role as a major population centre and New Zealand's main international port, as well as its subtropical climate (Cumber 1961; Kuschel 1990). To our knowledge there are no other comparable New Zealand studies indicating indigenous beetle recovery in restored indigenous plant communities.

There is potential on Matiu-Somes Island for research on the interactions between indigenous and introduced beetle species. These interactions have not been studied in New Zealand (Cumber 1961; Klimaszewski and Watt 1997). As Matiu-Somes Island is revegetated there are opportunities for future research into the changes in the balance of indigenous and introduced beetle species associated with successional development of plant communities.

Revegetation programmes are almost always viewed from a positive perspective – re-creating native habitats (Majer 1990). However, revegetating degraded ecosystems can create a physical disturbance (Hobbs 1993), and the timespan involved for a species rich beetle fauna to establish is unknown. In support of the present findings, Kuschel (1990) found that beetle species which were common in remnant native ecosystems were never collected from the same native plant species in suburban gardens. However, restored patches of indigenous vegetation, such as those in the present survey, are still considered important areas for indigenous insects. The results we found suggest that revegetation promotes the re-establishment of indigenous beetle species although it can take a long time.

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Appendix. List of beetle species collected from pitfall traps on Matiu-Somes Island from May 1997- April 1998.

Family and Species:	Status[1]	Family and Species:	Status[1]
Carabidae		Corticariidae	
Holcaspis vagepunctata White	N	*Lithostygnus sinuosus* (Belon, 1884)	N
Mecodema sulcatum (Sharp 1886)	N	*Lithostygnus* sp. 1	N
Mecyclothorax rotundicollis (White 1846)	N	*Cortinicara* sp. 1	I
Lecanomerus vestigialis (Erichson 1842)	I	*Aridius nodifer* (Westwood 1839)	I
Demetrida nasuta White 1846	N	*Melanophthalma* sp. 1	N
Histeridae		Languriidae	
Parepierus sp. 1	N	*Loberus nitens* (Sharp 1876)	N
Parepierus sp. 2	N	Melandryidae	
Ptiliidae		*Hylobia velox* (Broun 1880)	N
Notoptenidium lawsoni Matthews 1893	N	Colydiidae	
Ptilinae sp. 1	N	*Enarsus bakewelli* Pascoe 1886	N
Ptilinae sp. 2	N	*Pristoderus* sp. 1	N
Leiodidae		Colydiinae sp. 1	N
Colon hirtale (Broun 1880)	N	Colydiinae sp. 2	N
Mesocolon alacre (Broun 1880)	N	Colydiinae sp. 3	N
Staphylinidae		*Pycnomerus* sp. 1	N
Aleocharinae sp. 1	?	Tenebrionidae	
Anotylus brunniepennis (Macleay)	I	*Mimopeus opaculus* Bates 1873	N
Anotylus sp. 1	I	*Pheloneis amaroides* Lacordaire 1859	N
Euaesthetinae sp. 1	N	*Lorelus tarsalis* Broun 1910	N
Ocalea fuscicornis (Broun 1880)	N	Cerambycidae	
Ocalea sp. 1	N	*Ptinosoma* sp. 1	N
Omaliinae sp. 1	N	*Ptinosoma* sp.2	N
Oxytelinae sp. 1	N	*Ptinosoma ptinoides* (Bates 1874)	N
Oxytelinae sp. 2	N	*Somatidia antarctica* (White 1846)	N
Oxytelinae sp. 3	N	Chrysomelidae	
Phloeocharinae sp. 1	?	*Eucolaspis brunnea* (Fabricius 1792)	N
Staphylininae sp. 1	N	Anthribidae	
Tachyporini sp. 1	N	*Dysnocryptus pallidus* Broun 1893	N
Lucanidae		Curculionidae	
Ceratognathus irroratus (Parry 1845)	N	Bracholus sp. 1	N
Scarabaeidae		Brachycerinae sp. 2	N
Odontria smithii (Broun 1893)	N	Cryptorhynchini sp. 1	N
Odontria rufescens (Given 1952)	N	Cryptorhynchini sp. 2	N
Melyridae		Cryptorhynchini sp. 4	N
"*Dasytes*" sp. 1	N	Curculioninae sp. 1	N
Nitidulidae		Curculioninae sp. 2	N
Platipidia asperella (Broun 1893)	N	Curculioninae sp. 3	?
Epuraea antarctica (White 1846)	N	Curculioninae sp. 4	?
Epuraea sp. 1	N	Entiminae sp. 1	N
Cryptophagidae		*Irenimus* sp. 1	N
Micrambina sp. 1	N	*Microcryptorhynchus* sp. 1	N
Cerylonidae		*Pentarthrum zealandicum* (Wollaston 1873)	N
Hypodacnella rubripes (Reitter 1880)	N	*Peristoreus* sp. 2	N
Corylophidae		*Phrynixus* sp. 1	N
Anisomeristes sp.1	I	*Phrynixus* sp. 2	N
Anisomeristes sp. 2	I	*Phrynixus* sp. 3	N
Coccinellidae		*Whitiacalles ignotus* (Broun 1914)	N
Stethorus sp 1	N		
Rhyzobius suffusus (Broun 1880)	N		

[1]Beetle species status: N- probably indigenous; I – probably introduced; ? – status unknown.