Spiders as Surrogate Species in Ecological Monitoring, Habitat Classification and Reserve Selection

A thesis presented in partial fulfilment of the requirements for the degree of

Masters of Science
in
Ecology

at Massey University, Palmerston North,

New Zealand

Gil Michael Ian Coombe

2001

2

ADDITIONS AND CORRECTIONS

Page 12: (Phil Servid, pers comm) dated 2001.

Page 20: (Phil Servid, pers comm) dated 2000.

Page 41: Plant nomenclature follows Allan (1961), Connor & Edgar (1987), and Edgar & Connor (2000).

Page 45: Table 3.1. Replace *Beilschmedia* with *Beilschmiedia*, and *Eleocarpus* with *Elaeocarpus*.

Page 45: PHI sampling was carried out during March 1999, immediately after the spider sampling was completed.

Page 46: Random placement of pitfall traps and beating quadrats was effected by haphazardly throwing an object into the 400 m^2 sampling area.

Page 47, Table 3.2: For leaf dimensions ≥ should replace >

Page 53, Caption to Figure 3.5: Cluster analysis used abundance data

Page 54, Figure 3.4: Eigenvalues for DCA ordinations

Axis	(a)	(b)	(c)
1	0.81	0.63	0.58
2	0.19	0.24	0.22
3	0.11	0.03	0.02

Page 57, Table 3.4: Taxa are ordered according to the range of the successional gradient occupied. Figures are the total number of each taxon recorded at each site over the entire sampling period.

Page 65, para 4, line 1: Replace "individual" with "individuals"

Page 65: References to litter characteristics are based on unstructured personal observations.

Page 72, Table 4.1 caption: Delete reference to plant species richness (this is presented in Table 4.2)

Page 75: Replace "indentification" with "identification".

Page 79, Table 4.2: Black beech (*Nothofagus solandri*) add var. *solandri*. Replace *Sophia* with *Sophora*.

Page 85, Figure 4.5 caption: Replace "complimentarity" with "complementarity".

Additional References

Allan, H.H. 1961. Flora of New Zealand Vol. 1. Department of Science and Industrial Research, Government Printer, Wellington N.Z.

Connor, H.E.; Edgar, E. 1987. Name changes in the indigenous New Zealand Flora, 1960 - 1986 and Nomina Nova IV, 1983 - 1983. *New Zealand Journal of Botany*, 25: 115-170.

Edgar, E.; Connor, H.E. 2000. Flora of New Zealand, Vol V. Manaaki Whenua Press, Lincoln, N.Z.

G.M.I. Coombe, April 2002.

TABLE OF CONTENTS

ABSTRACT

ABSTRACT

The use of invertebrates in the monitoring of terrestrial ecosystems was investigated using spiders as a focal group. In a review of previous literature, spiders were found to meet the majority of criteria required of suitable ecological indicators, including high diversity and abundance, a widespread distribution, easy sampling and sorting, relatively low random fluctuation in population sizes and community composition, a range of dispersal abilities, measurable response to habitat change and representation of other taxa. The main weaknesses of spiders as ecological indicators were the lack of taxonomic expertise and sparse knowledge of baseline biology. However, these disadvantages could be rectified and it was concluded that spiders are suitable for further investigation as ecological indicators, involving field trials and hypothesis testing.

The spider communities in the litter, herb and shrub layer of eight sites representing four habitat types within a forest successional series were sampled in Pouiatoa State Forest in Northern Taranaki. There were no distinct trends in spider richness or abundance across the successional series. However, spider species and family composition both reflected the successional stage from which they were taken. Site classifications using DCA and cluster analysis were similar when using either plant or spider data. Spider communities demonstrated potential for use in habitat classification of terrestrial ecosystems.

Spiders and seven other ground-active invertebrate groups were sampled with pitfall traps from fourteen forest remnants within the Rangitikei Ecological Region to test whether spiders were able to act as indicators of plant and invertebrate diversity. Within-site richness (α-diversity) of spiders was strongly correlated with that of all other invertebrates combined, but spiders were not good predictors of between-site richness (β-diversity) of all other invertebrates. Correlation between the α- and β-diversities of plants and invertebrates were low, indicating that maximising plant diversity in reserve selection might not maximise invertebrate diversity. It is recommended that ground-active invertebrates be included in surveys of potential forest reserves.

Spiders are a useful surrogate group for invertebrate communities and could be more widely used in the assessment, monitoring and management of terrestrial ecosystems.

ACKNOWLEDGMENTS

ACKNOWLEDGMENTS

There are numerous people to thank for direct and indirect assistance in the production of this manuscript. Firstly, I would like to acknowledge my supervisor, Dr. Ian Henderson, for his enthusiasm, encouragement, vast stores of knowledge throughout the thesis, and for writing the Visual Basic programme used in Chapter Four. His help is greatly appreciated.

My grateful thanks go to those who graciously agreed to identify various invertebrates during the course of the study: Mike Fitzgerald, Grace Hall (Landcare), Phil Sirvid (Te Papa) and Cor Vink (Lincoln University) for the Araneae; Ian Townsend for the Carabidae; Stephen Thorpe (Auckland Museum) for the rest of the Coleoptera; Ian Andrew (Massey University) for the Diptera and Hymenoptera; and Marie-Claude Lariviere (Landcare) for the Hemiptera. My thanks also to Jill Rapson and Pete van Essen for much needed help with the identification of ferns and small-leaved shrubs.

I would like to thank the tireless technicians, Cathy Lake and Tracey Harris, for hunting up all the right gear and gallons of 70% ethanol. Special thanks also to Barbara, Erica and Jodie for immense (and undervalued) logistical support, and to Dawn for the crash course in ArcView. Also thanks to The Department of Conservation, Forest and Bird and Stu Langridge for access to sites, and to Alex for helping with the fun job of laying pitfalls. And another big thank you to Phil Sirvid for his helpful comments on early drafts of Chapter 2.

I would especially like to pay tribute to my flatmates during the course of my thesis, Ange S., Debbie, Dom, Liz K., Liz R., Renske and Taku, for keeping me sane and for just being fun to be around. And to all the guys at 'Rangiland', who reminded me that there was more to life than Massey (...like horses, golf and the Sportsman). Cheers to everyone in the Community Lab during the tricky writing up period who tried their hardest not to roll their eyes every time I claimed "Not long to go now", and other general constructive support: Ange M., Dawn, Erna, Mark, Nathan, Pepe, Renske, Scott, Sheinach, Sjaan and Tanya. (A special mention has to go to Nathan ('Boycott') and Reece ('Rangatunga') for the in-lab cricket, without which I may have finished this thesis months earlier). And to everyone else in the Ecology Department, a great bunch of people who have made this experience an enjoyable one.

And last but not least, a great big thank you to my family, whose support and general enthusiasm over the years has been greatly appreciated, and which has probably not been acknowledged nearly often enough.

CHAPTER ONE

General Introduction

GENERAL INTRODUCTION

Invertebrates and Ecological Monitoring

Biodiversity is recognized as having enormous economic value, both directly as a resource for human use (Kunin and Lawton 1996) and indirectly as a vital component of ecosystem functioning and sustainability (Lawton 1994, Tilman *et al* 1996, Nijs and Roy 2000). There are also aesthetic and ethical aspects inherent in the maintenance of undisturbed natural systems and high levels of habitat, taxonomic and genetic diversity. However, human-induced habitat change and degradation of both environmental and biotic systems has lead to drastic declines in species numbers world-wide (Stork 1997). Arresting this decline requires knowledge of ecosystem function and how ecosystems respond to disturbance. This enables measures to be implemented minimising deleterious impacts on native communities, and allow for sustainable landscape development incorporating both economic and conservation interests. Extensive surveys and monitoring of the flora and fauna within endangered ecosystems is required to achieve this purpose.

Invertebrates represent the greatest proportion of terrestrial biodiversity (Stork 1997) and are vital components in many ecosystem processes (Kajak 1997, Schowalter 2000, Whitford 2000). However, general information about biology, ecology, distribution and taxonomy is scarce for many species (Oliver and Beattie 1996a, New 1999, Hooper *et al* 2000). The combination of high species numbers, small body size, complex interactions within communities, and poor biological and taxonomic knowledge mean that the ecological monitoring of invertebrates is often difficult. There is generally too little time, money and expertise available to enable all species to be catalogued, even on small regional scales (Disney 1986). Consequently, invertebrates have been underrepresented in conservation programmes and disturbance impact studies, especially in comparison to less diverse groups more amenable to sampling or with greater public appeal, such as large vertebrates or plants (e.g. Hilty and Merenlender 2000).

Surrogate Species

A surrogate is a single species or a group of species used as a proxy measure of ecosystem conditions that cannot be measured directly due to time and cost restraints, or lack of suitable methods, expertise or knowledge (Landres *et al* 1988, McGeoch 1998, Caro and O'Doherty 1999, Hilty and Merenlender 2000). These ecosystem conditions could be the biotic and abiotic components, such as species richness, species composition, soil quality and microclimate; functioning and processes, including nutrient turnover and energy dynamics; or conservation value, including complementarity, naturalness and presence of target taxa. There are three main uses for surrogate species: detection and monitoring of disturbance in ecosystems; providing information on ecological processes; and addressing conservation questions, including the selection of areas for protection, and monitoring of conservation techniques.

There are four main types of surrogate species: environmental indicators, ecological indicators, biodiversity indicators and umbrella species (McGeoch 1998, Caro and O'Doherty 1999). *Environmental indicators* are species that are used to detect the presence, or gauge the degree, of disturbance in an ecosystem. They are used as proxy instruments for measuring environmental conditions, particularly in relation to human-produced pollution (McGeoch 1998). The most common examples of this type are species that accumulate toxins in their tissues, but it also includes species whose presence or absence from a site indicates the presence of a particular pollutant, or those that show a measurable change in their biology or morphology in response to disturbance. *Ecological indicators* are selected to demonstrate the impact on the remaining flora and fauna within the community, and therefore act more as a surrogate for that community rather than for the disturbance itself (McGeoch 1998). Ecological indicators can play an important role in understanding the impacts of disturbance of biota, and thus aid in management and conservation of disturbed systems (e.g. Rodríguez *et al* 1998). *Biodiversity indicators* are a group of species whose diversity correlates with the diversity of other higher taxa in a habitat or a group of habitats. They can be used to identify sites of high species richness (α-diversity) or a set of sites that when combined maximizes the species diversity across a landscape (β-diversity), and therefore can play an important role in the selection of sites for conservation. As an α-diversity indicator, the hotspots for the taxa selected (those sites where their richness is highest) should coincide with the hotspots of other taxa. For the β-diversity indicators, the selection of sites that maximizes their richness across the landscape should also maximise the richness of other taxa. There has been a great volume of literature devoted to testing and discussing the utility of biodiversity indicators involving many faunal and floral groups, with mixed results and conclusions (Vane-Wright *et al* 1991, Prendergast *et al* 1993, Sætersdal *et al* 1993, Gaston 1996, Gaston and Williams 1996, Howard *et al* 1998, Kerr *et al* 2000). *Umbrella species* are those whose habitat is specifically managed to maintain viable populations of the umbrella, and in doing so simultaneously conserves a large part of the habitat for other, sympatric species (Caro and O'Doherty 1999). The most obvious examples of this type of surrogate in New Zealand are the various kiwi species (*Apteryx* spp.), which are the focus of intensive conservation involving the protection of large stretches of native forest and removal of introduced predators. Both of these measures will simultaneously benefit other native species present within the same habitat. Umbrella species are usually the specific targets for conservation in this way, and as such hold intrinsic value in themselves. Environmental, ecological and biodiversity indicators, on the other hand, do not necessarily have to be conservation targets, though it has been suggested that they should be of some economic importance (Hilty and Merenlender 2000).

The surrogate species concept provides a method by which invertebrates can be viably incorporated into ecological monitoring programmes. With debate about the degree to which invertebrate communities are represented by plant or vertebrate surrogates still ongoing (e.g. Oliver *et al* 1998, Panzer and Schwartz 1998), various terrestrial invertebrate groups are now recognised as potentially useful surrogate species including ants (Majer and Beeston 1996, Oliver *et al* 2000), beetles (Hutcheson *et al* 1999), braconid wasps (Lewis and Whitfield 1999), butterflies (Kerr *et al* 2000), and tiger beetles (Rodríguez *et al* 1998). In New Zealand, the use of invertebrate surrogates has been restricted mainly to detection of pollution in aquatic environments (e.g. Boothroyd and Stark 2000, Scarsbrook *et al* 2000). In contrast, there has been relatively little attention given to the utility of terrestrial invertebrate surrogates in ecological monitoring and reserve selection, or to whether current conservation strategies are adept at protecting invertebrate diversity (but see Hutcheson *et al* 1999).

Introduction to Spiders

Spiders comprise the order Araneae in the class Arachnida, a class that also includes scorpions, mites, harvestmen and seven other orders. They are characterized by having two main body parts, the cephalothorax, to which are attached eight walking legs, eyes, pedipalps and chelicerae, and the abdomen, the posterior of which are attached the silk-producing spinnerets. Spider species exhibit a wide variety of life histories and morphologies, though all feed on other animals, with the great majority being generalist predators utilising a diverse range of prey types (Moulder and Reichle 1972, Turnbull 1973, Eberhard 1990, Nyffeler *et al* 1994). The devotion to a single feeding strategy makes spiders unique among other diverse invertebrates orders, such as the Diptera and

Coleoptera, which exhibit a range of trophic habits (Coddington and Levi 1991), and makes them one of the most important predator guilds in a wide variety of habitats. Spiders have been shown to influence many ecosystem functions, such as energy dynamics (Moulder and Reichle 1972), litter decomposition (Kajak 1997) and plant productivity (Carter and Rypstra 1995). They have also been investigated as biocontrol agents in agroecosystems, with accumulating evidence that despite being generalist predators, spiders can be effective at reducing invertebrate pest numbers and thus reducing crop damage (see Riechert and Lockley 1984 for a review; see also Riechert and Bishop 1990, Carter and Rypstra 1995 for additional experimental evidence). There has been little work on using spiders as environmental or ecological indicators, outside a few agriculture and grassland studies (e.g. Pristavko and Zhukovets 1988, Marc *et al* 1999) and those involving detection and monitoring of industrial pollutants (Clausen 1986, Maelfait 1996, Cárcamo *et al* 1998), though New (1999) discusses the potential for spiders as a focal group in general invertebrate conservation.

Thesis structure

Chapter 2 analyses how spiders conform to *a priori* criteria for suitable ecological indicators based on previously published literature. Chapter 3 establishes whether spider communities can be used to distinguish between habitat types along a successional gradient, and thus be useful in habitat classification in New Zealand. Chapter 4 investigates how well spider and other ground-active invertebrate diversity is correlated with plant diversity, determines whether any particular invertebrate group sampled shows potential as biodiversity indicators for all other invertebrates, and discusses the findings in the light of current reserve selection procedure in New Zealand. Chapter 5 reviews the findings of the previous chapters with respect to ecological monitoring in New Zealand.