Lepidoptera of small-leaved divaricating *Olearia* in New Zealand and their conservation priority

SCIENCE FOR CONSERVATION 168

Brian Patrick

Published by
Department of Conservation
P.O. Box 10-420
Wellington, New Zealand

All photographs in this report were taken by Brian Patrick.

Science for Conservation presents the results of investigations by DOC staff, and by contracted science providers outside the Department of Conservation. Publications in this series are internally and externally peer reviewed.
Publication was approved by the Manager, Science & Research Unit, Science Technology and Information Services, Department of Conservation, Wellington.

ISSN 1173–2946
ISBN 0–478–22015–4

Cataloguing-in-Publication data

Patrick, B. H. (Brian H.)
Lepidoptera of small-leaved divaricating Olearia in New Zealand and their conservation priority / Brian Patrick. Wellington, N.Z. : Dept. of Conservation, 2000.
1 v. ; 30 cm. (Science for conservation, 1173-2946 ; 168).
Includes bibliographical references.
ISBN 0478220154
1. Lepidoptera—New Zealand. 2. Olearia. I. Title.
Series: Science for conservation (Wellington, N.Z.) ; 168.

CONTENTS

Lepidoptera of small-leaved divaricating *Olearia* in New Zealand and their conservation priority

Brian Patrick

Otago Museum, PO Box 6202, Dunedin, New Zealand

Abstract

A detailed study of the moths (Lepidoptera) feeding on most species of shrubs and small trees in the genus *Olearia* section *Divaricaster* (Family Asteraceae) revealed a particularly rich fauna including eight new species. Furthermore, the plants were found to be complex ecosystems supporting lichens, mosses and algae, which in turn all support their own moth species. Forty-one species of moth, all endemic to New Zealand, were found to feed naturally on this group of plants. Of these, 20 species were found to be specialists, with 17 species confined to this host group, and the other three species oligophagous within Asteraceae. This *Olearia* moth guild is divided into 30 herbivores and eleven detritivores. New biological, biogeographical, seasonality and conservation information is presented in an annotated list of the 20 specialist moth species. The number of moth species on each *Olearia* species is noted and discussed. The richness of this fauna in different regions is presented. Several of the host plants are threatened with extinction and the conservation of these hosts is supported on entomological grounds.

Keywords: host plants, biology, guilds, detritivores, herbivores, monophagy, distribution, seasonality, new species, *Olearia* section *Divaricaster,* host richness, area richness.

Patrick, B. 2000: Lepidoptera of small-leaved divaricating *Olearia* in New Zealand and their conservation priority. *Science for Conservation 168*. 26 p.

1. Introduction

The small-leaved, divaricating, often deciduous, small trees and shrubs of the plant genus *Olearia* (Asteraceae) are placed in section *Divaricaster* (Heads 1998), and are distributed over North, South and Stewart Islands, New Zealand. This section includes ten species and three sub-species. One species—*Olearia polita*—is not included as no data is available. *Olearia fragrantissima* is included here because its lepidoptera fauna supports the close taxonomic relationship with section *Divaricaster* proposed by Heads (1998).

Dugdale (1975) noted and discussed the high rate of host plant specificity in the New Zealand moth fauna. Furthermore, he noted that this specificity is not evenly distributed across the native flora. Instead, there is a bias for southern, more cold-adapted plant genera to have more species of moth larvae feeding exclusively on them, especially plant genera that are distributed from coastal through to alpine communities. This observation runs counter to the more common situation where biodiversity decreases with increasing latitude and increasing altitude.

Most *Divaricaster* species are southern (Heads 1998). Therefore, following Dugdale (1975), I hypothesize that this section of the genus will be rich in specialist endemic moths, as the section of the genus is both cold-adapted and distributed from coastal through to alpine communities.

Previous authors have recognised the importance of this section of *Olearia* in various plant communities within New Zealand. For example, Dugdale (1975) noted the richness of insects in the frost-hollow vegetation of the North Island and in the shrublands of the South Island, listing *Olearia* species as key plants.

Interim accounts of the present study (Patrick 1994b; 1997a, b; Peat & Patrick 1999) have reported larvae and adults of a significant number of species of native New Zealand Lepidoptera associated with *Olearia* section *Divaricaster*. Patrick (1994b) recorded 16 moth species feeding on, or closely associated with, *Olearia odorata* in the valley floors of Central Otago, and five of these were illustrated as larvae or adults. In addition, five newly discovered moth species that were found associated with *O. odorata,* were listed. I also highlighted the need to conserve this fauna which, like its hosts, show signs of fragmentation and local extinction. Within New Zealand, this number of moth species feeding on just one host or host group is high (Dugdale 1975). This study highlights the number of monophagous (feeding and relying as larvae on one host or closely related group of hosts) native moth species on this group of native shrubs or trees.

There is one erroneous record. Spiller & Wise (1982) list *Olearia divaricata* (= *O. laxiflora*) as a host to the gelechiid moth *Apatetris melanombra*. This is a mistake, being based on a misunderstanding of Watt's (1921) intention when listing *O. nitida*, a synonym of *O. arborescens*.

This paper presents data on the biology, biogeography, area richness and seasonality of these moths. The significance of these results as they pertain to conservation of both the moths and their various host plants is discussed. An additional aim was to see if this information supports the distinctiveness of *Olearia* section *Divaricaster*. The information emphasises the importance of this group of native plants, adding weight to the present efforts to conserve them.

2. Methods

The results were accumulated over 17 years (1983–2000), in a study aimed initially at elucidating the life histories of native New Zealand moths. Once the richness and importance of the *Olearia* group of hosts was recognized, a second study began that focussed more intensely on this group of plants.

In the South Island, moths have been sampled from populations of each plant species throughout its known range as given by Heads (1998). Although sampling has been done in every region of the South Island, there has been a bias towards southern New Zealand, from South Canterbury to Stewart Island. This is also the centre of species richness for the host group (Heads 1998). Moth larvae from a few North Island *Olearia* populations and species have been sampled in several regions and sent to me by colleagues from further regions on an opportunistic basis. A special effort was made by Colin Ogle, Department of Conservation, Wanganui and his colleagues to sample the larvae feeding on the foliage and bark of *O. gardneri* near Taihape, in the central North Island, during 1999–2000.

Sampling was carried out at all times of the year, but especially in spring when new foliage appeared. Soft foliage is favoured over older and tougher leaves by many phytophagous insects. Perhaps, surprisingly, larvae were also found on the bare branches of completely deciduous hosts in winter and in early spring prior to the appearance of the first leaves, so some effort was made to sample this fauna.

Eggs, larvae and pupae of the various moth species were usually obtained by beating the foliage over a flat surface. Searches of feeding damage on the hosts were made by both day and night. Where possible, the bark crevices on branches and trunks were examined for larvae or pupae. Much effort was also put into sampling surrounding vegetation in an identical fashion, to check if the insect species on the *Olearia* species are monophagous or polyphagous. Eggs, caterpillars and pupae were reared, and their transformations documented and photographed.

Adults of other insect orders were also collected, sorted to family, and stored in the dry collections of the Otago Museum, Dunedin.

Larval and adult specimens of all moth species, including undescribed species, are stored in the dry or wet collections of the Otago Museum.

3. Results

A total of 41 species of endemic New Zealand moths in nine families were found feeding on or definitely associated with twelve species and subspecies of *Olearia* section *Divaricaster* and *O. fragrantissima* (Table 1). Twenty of the moths were found to be specialist feeders, with 17 of them (in eight families) restricted to *Olearia* section *Divaricaster*. The three other species are

specialists within the genus *Olearia* (one species), or oligophagous within Asteraceae (two species). Eight of these moth species were first discovered during this study and remain undescribed. An additional eight moth species were first associated with their host(s) during this study.

Within the nine families of moths recorded on this host group the Geometridae (11 species), Tortricidae (ten species), Noctuidae (four species) and Oecophoridae sub-family Stathmopodinae (five species) are best represented. The geometrids include seven species of subfamily Ennominae in genera that have characteristically arboreal larvae.

There are other small-leaved, divaricating species of *Olearia* in other sections of the genus, such as *O. capillaris*. This is a species listed as 'sparse' by de Lange et al. (1999) in a list of the threatened and uncommon plants of New Zealand. Although I have not sampled its moth fauna in the wild, I have observed that in cultivation it hosts a moth fauna similar to *Helichrysum lanceolatum* (Patrick 1999).

Other insect orders are also well-represented on *Olearia* section *Divaricaster*, with many Coleoptera (beetles), Diptera (flies) and Hemiptera (bugs) found on the foliage and under the bark. Among the beetles, the families Cerambycidae, Cleridae, Curculionidae, Lucanidae and Tenebrionidae are prominent. The bug family Miridae is well represented with several genera. At least one fly species, with leaf mining larvae, in the family Agromyzidae, was found feeding on *Olearia fragrantissima* and *O. hectorii.*

Table 1 lists all nine families and 41 moth species in taxonomic order, together with the *Olearia* species on which they were found feeding. Detritivores and herbivores, and specialists and generalists are indicated. Table 2 lists the distribution of the 20 specialist species within nine fairly arbitrary geographical regions that are based on availability of data as much as on natural biogeographic boundaries.

The following list of the 20 monophagous and oligophagous moth species is annotated with biological, biogeographical, seasonality and conservation information that resulted from this study, except where indicated.

Gelechiidae

1. *Thiotricha olearíae* Hudson, 1928

Figure 1. Adult of the small-leaved *Olearia* specialist *Thiotricha olearíae*, Dunstan Gorge (wingspan 16 mm).

This small grey moth with darker markings (Fig. 1) was first discovered feeding on *Olearia solandri* at Breaker Bay, Wellington by Stella Hudson, and was subsequently reared and described by her father G.V. Hudson (Hudson 1928). Larvae of this species feed on the foliage of at least eight *Olearia* species (Table 1) from the shelter of a movable case constructed of leaf fragments. Larvae were observed mining and eroding the leaves rather than eating the entire leaf. Adults are nocturnal and emerge between November and March with a peak in February. The species is found from sea level to 900 m a.s.l., and is known from the central North Island southwards to Stewart Island (Table 2). The adult is illustrated by Hudson (1928) and Patrick (1994b), while the former also illustrated the larva in its case.

Oecophoridae: Stenomatinae

2. *Agriophara colligatella* (Walker, 1864)

Hudson (1928) recorded this species feeding on a variety of *Olearia* species including *O. solandri*. It is an *Olearia* specialist, with its larvae known from many large-leaved *Olearia* species in several sections of the genus. During this study it was found on *O. fragrantissima* in eastern Otago and *O. laxiflora* on the West Coast. The slow-moving and fat larvae (Fig. 2) feed between joined leaves, and characteristically eat only the green part of the leaf. The conspicuous, uneaten dry tomentum shrinks and gives away the identity of the herbivore.

Figure 2. Mature larva of *Agriophara colligatella* on *O. fragrantissima* from Dunedin (length 14 mm).

Oecophoridae: Stathmopodinae

3. *Stathmopoda campylocha* Meyrick, 1889

This elegantly patterned species was found to be associated only with *Olearia hectorii* in the Matukituki Valley, western Otago. The moth is a rare species, as is its possible host. The site and method of larval feeding have not been found, but food may include dead leaves, seeds and bark, or the larvae may be predatory on scale insects.

The species was described from Dunedin where the possible hosts might have been *O. fimbriata, O. lineata, O. bullata* or *O. fragrantissima.* The last known individual of *O. fimbriata* growing close to Dunedin died within the last decade, but the plant species still survives in the Taieri Gorge, inland of Dunedin. The moth has not been found in the Dunedin area recently.

4. *Stathmopoda albimaculata* Philpott, 1931

The distinctly marked *Stathmopoda albimaculata* (Fig. 3) was described from a female collected at Woodside, a forest reserve on the Taieri Plain at the foot of Maungatua, west of Dunedin. It has not been recollected in the Dunedin area. During this study it was found in Central and western Otago, the Catlins, Southland and the Waitaki Valley (Table 2), from 50 to 900 m a.s.l. It is a well-patterned species that has been repeatedly beaten from both *Olearia odorata* and *O. hectorii*. Adults have been found between October and February, with a peak emergence in January and February. The wing pattern is sexually dimorphic.

Figure 3. Adult of *Stathmopoda albimaculata* from *O. odorata*, Conroys (wingspan 14 mm).

TABLE 1. LIST OF THE HOST *Olearia* SPECIES OF THE 41 MOTH SPECIES, WITH INDICATIONS TO THE SPECIALISTS/GENERALISTS AND DETRITIVORES/HERBIVORES.

MOTH FAMILIES AND SPECIES		AUTHOR/DATE	*Olearia* TAXA	*odorata*	*bectorii*	*fimbriata*	*bullata*	*lineata*	*laxiflora*	*virgata* spp.*implicita*	*fragrantissima*	*gardneri*	*virgata* spp.*virgata*
Gelechiidae	*Thiotricha olearíae*	Hudson 1928		X	X	X	X	X	X	X		X	X
Oecophoridae	*Izatha peroneanella*	(Walker 1864)			X	X							
	Trachypepla galaxias	Meyrick 1883			X								
	T. anastrella	Meyrick 1883									X		
	Stathmopoda nsp.			X	X	X							
	Stathmopoda albimaculata	Philpott 1931		X	X								
	S. campylocha	Meyrick 1889			X					X			
	S. horticola	Dugdale 1988		X							X		
	S. plumbiflua	Meyrick 1911		X									
	Agriophara colligatella	(Walker 1864)							X		X		
Psychidae	*Liothula omnivora*	Fereday 1878		X	X	X			X		X		
	Rhathamictis perspersa	Meyrick 1924			X								
Cosmopterigidae	*Pyroderces deamatella*	Walker 1864		X									
Nepticulidae	*Stigmella ilsea*	D & W 1989		X	X	X	X	X	X	X	X	X	X
	Stigmella nsp.			X									
Plutellidae	*Protosynaema* nsp.			X	X								
Tortricidae	*Apoctena flavescens*	(Butler 1877)			X								
	Maoritenes nsp.			X	X	X					X		
	Maoritenes modesta	(Philpott 1930)							X				
	Pyrgotis plagiatana	(Walker 1863)									X		
	Pyrgotis nsp.			X		X							
	Harmologa oblongana	(Walker 1863)		X				X	X		X	X	

	H. amplexana	(Zeller 1875)	X									
	Catamacta gavisana	(Walker 1863)		X			X			X	X	
	Ctenopseustis herana	(F & R 1875)	X	X	X					X		
	Planotortrix excessana	(Walker 1863)		X								
Geometridae	*Declana leptomera*	(Walker 1858)		X	X					X	X	
	Declana nsp.		X	X?								
	D. junctilinea	(Walker 1865)	X		X	X						
	D. floccosa	Walker 1858		X		X	X	X		X		X
	Pseudocoremia rudisata	(Walker 1862)	X		X	X				X		
	"P." cineracia	(Howes 1942)	X			X?						
	Pseudocoremia nsp.		X					X				
	Pasiphila cotinaea	(Meyrick 1913)	X	X	X	X		X	X			X
	Pasiphila nsp.		X			X						
	Chloroclystis inductata	(Walker 1862)	X									
	C. testulata	(Guenee 1857)	X									
Noctuidae	*Meterana exquisita*	(Philpott 1903)	X	X	X	X		X	X			X
	M. grandiosa	(Philpott 1903)	X	X	X					X		X
	Graphania tetrachroa	(Meyrick 1931)	X	X	X							
	G. ustistriga	(Walker 1857)		X								
	Total moth species per plant	41	27	23	15	9	5	10	5	14	9	5
	Total specialist species per plant	20	17	12	10	7	2	7	5	5	5	5

TABLE 2. REGIONAL RICHNESS FOR THE TWENTY SPECIALIST MOTH SPECIES.

REGION		EASTERN SOUTHLAND	FIORDLAND	WESTERN OTAGO	CENTRAL OTAGO	EASTERN OTAGO	WEST COAST	MACKENZIE COUNTRY	CANTERBURY	NORTH ISLAND
MOTH SPECIES	LARVAL STRATEGY*									
Thiotricha olearíae	S	X		X	X	X		X	X	X
Stathmopoda nsp.	S			X	X			X		
Stathmopoda albimaculata	S	X		X	X	X		X		
Stathmopoda campylocha	S			X		X				
Agriophara colligatella	OS		X			X	X			X
Stigmella ilsea	S	X	X	X	X	X	X	X	X	X
Stigmella nsp.	S			X						
Protosynaema nsp.	S	X		X	X					
Maoritenes modesta	AS						X			
Maoritenes nsp.	S	X		X	X	X				
Pyrgotis nsp.	S			X	X					
Declana nsp.	S	X?		X						X?
Pseudocoremia rudisata	AS	X	X	X	X	X	X	X	X	X
Pseudocoremia nsp.	S		X	X	X		X	X	X	
"*Psuedocoremia*" *cineracia*	S		X?	X				X		
Pasiphila cotinaea	S	X	X	X	X		X		X	X
Pasiphila nsp.	S			X	X	X		X		
Meterana exquisita	S	X	X	X	X		X	X	X	X
Meterana grandiosa	S	X		X	X	X				X
Graphania tetrachroa	S	X		X	X					X
Total Species per area		11	7	18	14	9	7	9	6	9

* S = specialist on *Divaricaster*; OS = specialist on *Olearia*; AS = specialist on arboreal Asteraceae.

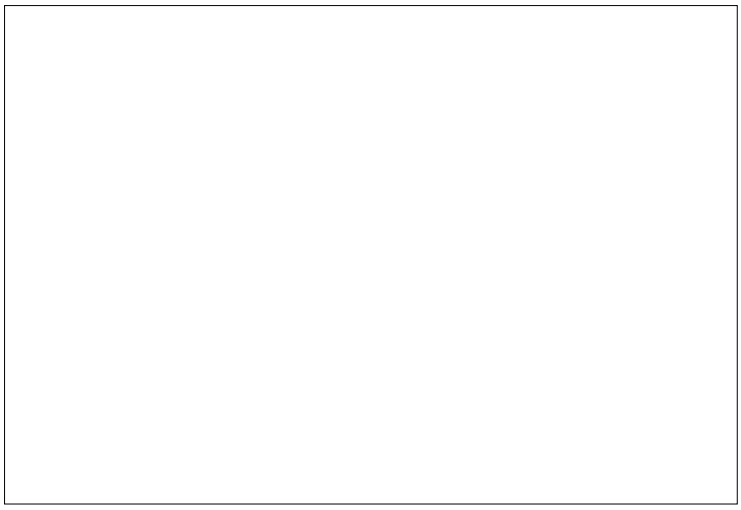

Figure 4. Adult of *Stathmopoda* new species off *O. odorata*, Kawarau Gorge (wingspan 15 mm).

Like *S. campylocha* and *Stathmopoda* new species, the larvae of this species is probably a detritivore. They are joined on *Olearia* section *Divaricaster* by two species of generalist detritivores: *S. horticola* and *S. plumbiflua* (Table 1).

5. *Stathmopoda* new species

This undescribed species of *Stathmopoda* was discovered during the survey (Patrick 1994b & 1997b), and is exclusively associated with various small-leaved *Olearia* species, including *Olearia odorata,* on which it was found. It is a plain white species (Fig. 4), and has been found in Central and western Otago and the Mackenzie Country, from 150 to 600 m a.s.l. (Table 2). Adults have been found in consistent numbers between November and February and either beaten from the three *Olearia* hosts or observed at night on them (Table 1).

Nepticulidae

6. *Stigmella ilsea* Donner & Wilkinson, 1989

This tiny pinhead-sized species is known to have larvae that mine eleven taxa of small-leaved *Olearia* (Table 1). Each larva feeds on only one small leaf and pupates in the litter at the base of the host. There is only one generation per year. Adults are diurnal, and can at times can be extremely abundant, fluttering around the host. The adult is illustrated in Donner & Wilkinson (1989). Adults fly between October and February and are known from sea level to 900 m a.s.l., ranging from Stewart Island to western Taupo in the North Island (Table 2). Five other species of *Stigmella* are confined to other sections of *Olearia*.

7. *Stigmella* new species

This undescribed species (C. van den Berg pers. comm. 2000) is significantly larger than *S. ilsea*, and has been found associated with *O. odorata* only in the Skippers Valley, western Otago, in late December (Patrick 1997b). The diurnal adults are plain white with distinctive black marks in the wing centre and the base of the costal margin.

Plutellidae

8. *Protosynaema* new species

Grey-green wriggly larvae of this distinctive undescribed species (Fig. 5), discovered during the survey, have been found on *O. odorata* and *O. hectorii* in western Otago, Central Otago (Patrick, 1994b) and in the Catlins, Southland (Table 1 & 2). Larvae are most often found on older leaves of the host. The species has been found from 50 to 800 m a.s.l. with adults emerging from late December to January. Adults (Fig. 6) are nocturnal and have rarely been seen in the wild. Patrick (1994b) illustrated the adult. This species is unusual, as all other species of *Protosynaema*—a New Zealand endemic genus—feed exclusively on flowerheads of monocotyledonous plants.

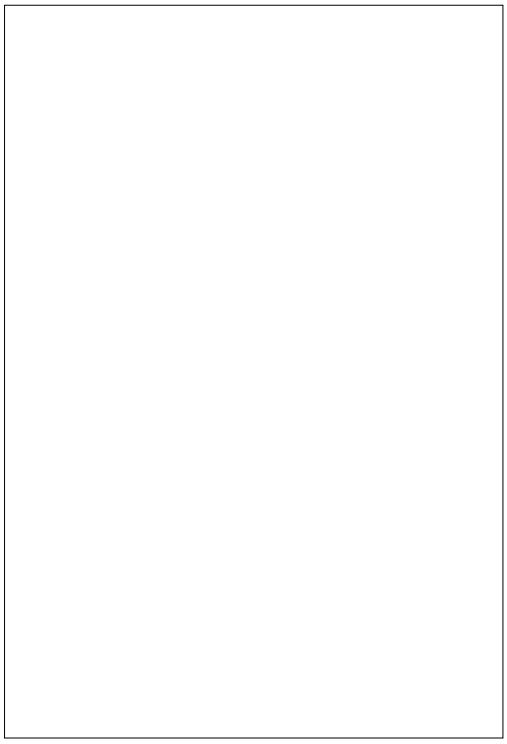

Figure 5. Larvae of *Protosynaema* new species on *O. odorata*, Skippers (length 10 mm).

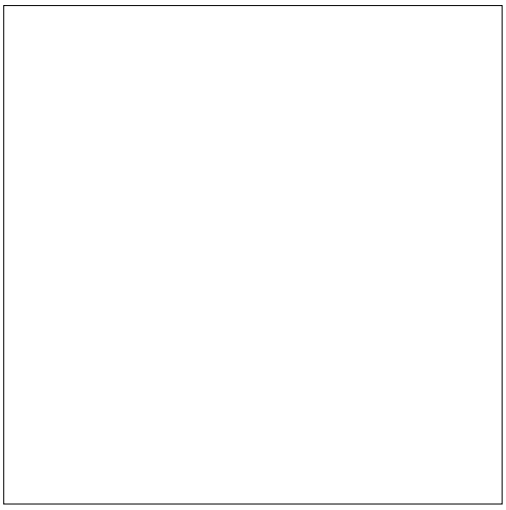

Figure 6. Adult of *Protosynaema* new species reared from *O. odorata*, Kawarau Gorge (wingspan 12 mm).

Tortricidae: Tortricinae: Schoenotenini

9. *Maoritenes* new species

This very distinctive, undescribed white-banded grey species was discovered during the study. When viewed under some lights the undersides of the wings and body have a purple flush. The larvae feed from within a shelter between developing leaves of at least four *Olearia* species (Table 1). The fat grey-green larvae feed rapidly then spend only about two weeks as pupae. It is generally a rare species in eastern Southland and eastern Otago, but can be locally abundant in parts of Central (Patrick 1994b) and western Otago (Table 2). Adults are diurnal and emerge between December and February. Although found from sea level to 800 m a.s.l., it is encountered most commonly between 600 and 800 m a.s.l.

10. *Maoritenes modesta* (Philpott, 1930)

Maoritenes modesta was described from the Waiho Gorge, West Coast. Adults (a mating pair) resembling those from the type locality in wing shape and palpi, were beaten from *Olearia laxiflora* at The Windbag, near Lake Paringa, West Coast. The wings from these adults contain distinctive orange scales on a pale brownish-white ground colour. The species is oligophagous on *Olearia* section *Divaricaster* and on *Brachyglottis* species (J.S. Dugdale, pers. comm.).

Figure 7. Adult female of *Pyrgotis* new species reared from *O. odorata*, Kawarau Gorge (wingspan 16 mm).

11. *Pyrgotis* new species

This distinctive species was discovered during this survey (Dickinson 1988). It is possibly widespread in western Otago, but was rarely encountered in Central Otago, except in the Pomahaka Valley, Umbrella Mountains (Table 2). In all, it is known from just eight localities. Adults emerge between December and March, with a peak in January. The species is both nocturnal and diurnal, and is found from 150 to 800 m a.s.l., but is more common from 500 to 800 m a.s.l. Pale green-grey larvae feed on the leaves of at least two *Olearia* species (Table 1), which they characteristically tie together and consume from within. Larvae appear to favour the foliage of juvenile plants or the sheltered fresh foliage sometimes found in the interior of the hosts. Adult females have two distinctive colour forms (Fig. 7), but the darker males are consistently grey (Fig. 8). The adult is illustrated in Patrick (1994b) and Peat & Patrick (1999).

Figure 8. Adult male of *Pyrgotis* new species reared from *O. odorata*, Knobby Range (wingspan 15 mm).

Geometridae: Larentiinae

12. *Pasiphila cotinaea* (Meyrick, 1913)

This nocturnal geometrid species (Fig. 9) has a wide distribution from Southland to the middle of the North Island (Table 2). It was found abundantly in the western South Island on both sides of the Southern Alps. It is not known from eastern Otago. Adults have been found between November and April with a peak emergence in April. There may be two generations in a season. Altitudinally, the species is found from sea level to 700 m a.s.l., but is most common between 500 and 600 m a.s.l. Elegant green-, red- and white-lined larvae (Fig. 10) scour the foliage of at least eight small-leaved *Olearia* species (Table 1). Most records are from *O. odorata, O. bullata, O. laxiflora* and *O. fimbriata*, but I have one record from Dunsdale, Hokonui Hills, Southland on *O. hectorii*. The species is illustrated in Hudson (1939).

Figure 9. Adult of *Pasiphila cotinaea* reared from *O. bullata*, Fiordland (wingspan 24 mm).

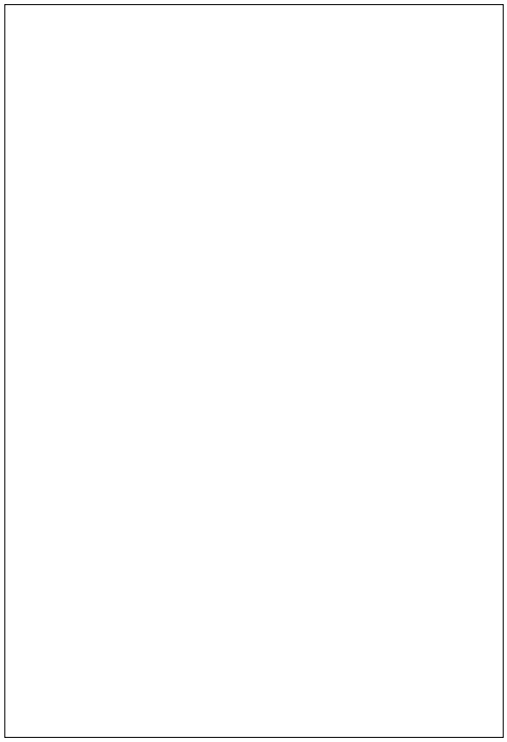

Figure 10. Fully grown larva of *Pasiphila cotinaea* on *O. bullata*, eastern Takitimu Mountains (length 16 mm).

13. *Pasiphila* new species

This nocturnal species, first discovered during the study (Patrick 1994b), is smaller, has a more compact distribution and was found to be locally more common than *P. cotinaea.* It was only found in western and eastern Otago, including the Waitaki Valley, from 100 to 750 m a.s.l. (Table 2). Although adults (Fig. 11) have been recorded from September to March, it is most common in January. The greenish-white larvae (Fig. 12) are illustrated in Patrick (1994b) and feed on the foliage of at least two *Olearia* species—*O. bullata* and *O. odorata* (Table 1).

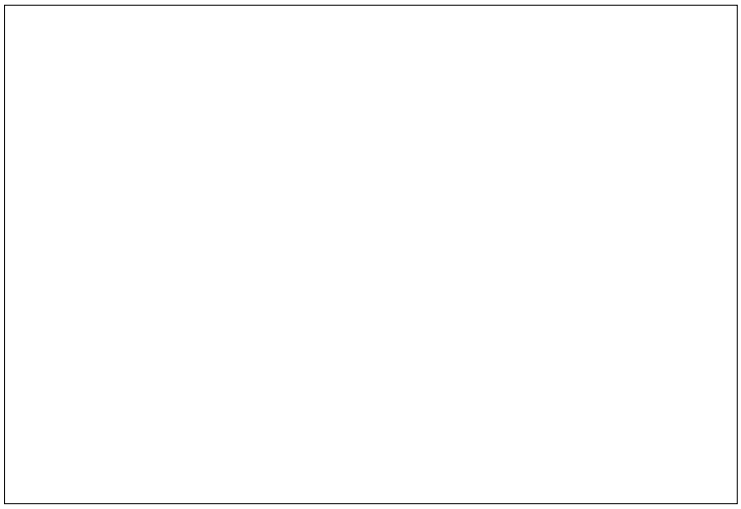

Figure 11. Adult of *Pasiphila* new species reared from *O. Odorata*, Skippers (wingspan 18 mm).

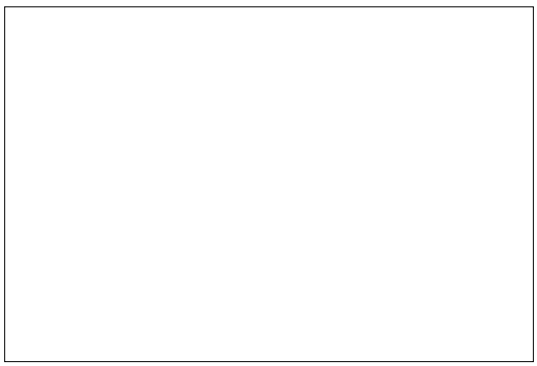

Figure 12. Larva of *Pasiphila* new species on *O. odorata*, Conroys, Central Otago (length 16 mm).

Geometridae: Ennominae

14. *Declana* new species

This distinctive new species was discovered during this study, and was found at only two sites—Kawarau Gorge (Patrick 1994b) and Skippers Valley in western Otago. Possible larvae were found on *O. hectorii* in the Hokonui Hills. An adult found in the Waitakere Ranges, Auckland may be the same species, the only small-leaved *Olearia* there is *O. solandri* (J.S. Dugdale pers. comm.). The brown-grey larvae (Fig. 13) have been found on, and reared from, *Olearia odorata*. There appears to be just one generation per year. Adults are nocturnal and consistently grey-patterned. They emerge from late August till October and are found between 150 and 500 m a.s.l.

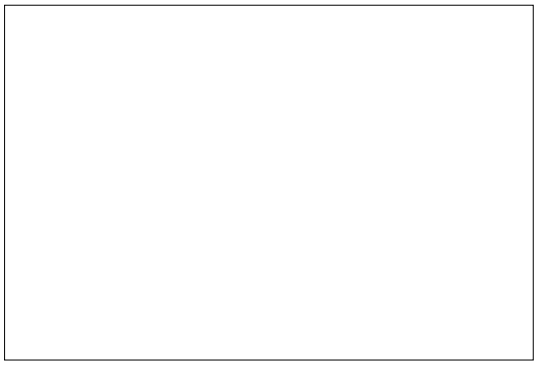

Figure 13. Larva of *Declana* new species on *O. odorata*, Skippers (length 24 mm).

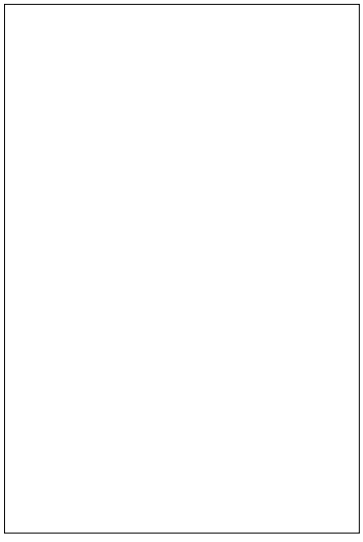

Figure 14. Adult female of "*Pseudocoremia*" *cineracia* reared from larva on *O. odorata*, Mackenzie Country (wingspan 30 mm).

15. *"Pseudocoremia" cineracia* Howes, 1942

Adults and larvae of this species are distinct within the genus and, on the basis of both larval and adult morphology, may belong to an as yet undescribed genus (B. Patrick & R. Craw unpubl. data). At rest, the wings are folded in a distinctive fashion (Fig. 14). They are particularly cryptic resting on the bark of the larval host, *O. odorata* (Table 1). Despite the wide distribution of its host in eastern areas, this moth appears to be confined to western Otago and the Mackenzie Country, although larvae may have been found on *O. bullata* in Fiordland (Table 2). The nocturnal adults are locally common in the Kawarau Gorge, where they have been trapped from August to early June, with a peak emergence in September. In Otago the species is known from only five sites, all between 150 and 850 m a.s.l. The grey larvae (Fig. 15) feed on the foliage of the host. Howes (1942), Hudson (1951) and Peat & Patrick (1999) all illustrated the adult.

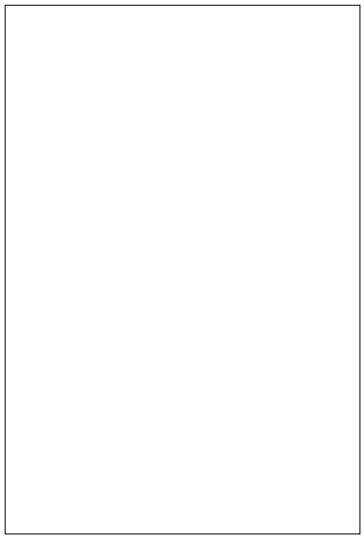

Figure 15. Probable larva of "*Pseudocoremia*" *cineracia* on *O. bullata*, Fiordland (wingspan 26 mm).

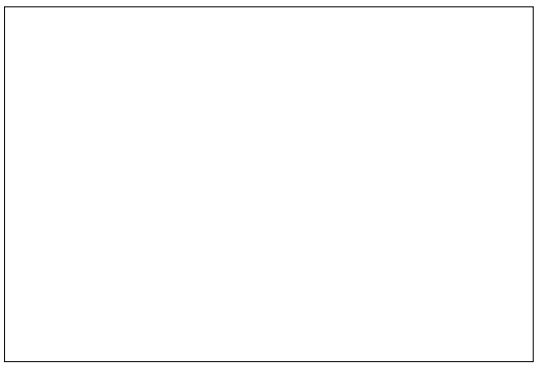

Figure 16. Brachypterous female of *Pseudocoremia* new species, Knobby Range (length 10 mm).

16. *Pseudocoremia* new species

This undescribed species is known from Fiordland, western Otago, Central Otago, Canterbury and the West Coast. Few adults have been collected and the association of the nearly apterous females (Fig. 16) with the large speckled males is tentative. In fact, the known adults may represent a species complex. The distinctive larvae of this species (Fig. 17) have been found only twice—in October at 400 m a.s.l. on *O. odorata* on the Knobby Range near Alexandra, Central Otago (Patrick 1997b), and in early January on *O. laxiflora* on the West Coast—both records made during this study. Both adults reared from these larvae were brachypterous females with 10 mm long bodies and 1 mm long wings (Fig. 16) (Patrick 1997b, Peat & Patrick 1999). The distinctive red-brown-lined larvae (Fig. 17) feed on the foliage of their host. Repeated light trapping in these locations attracted one male that may belong to the same species. More collection and rearing of larvae are required to confirm the association of this undescribed male with the brachypterous female. Adults of this undescribed species have a superficial resemblence to *P. colpogramma,* whose larvae feed on *Ozothamnus*. The rarity of this species is understandable considering the lack of mobility of the female, and the fragmentation of its host's communities over the past 150 years. It must be impossible for this species to recolonise sites from which it has been eliminated. Peat & Patrick (1999) illustrate the elegant larva.

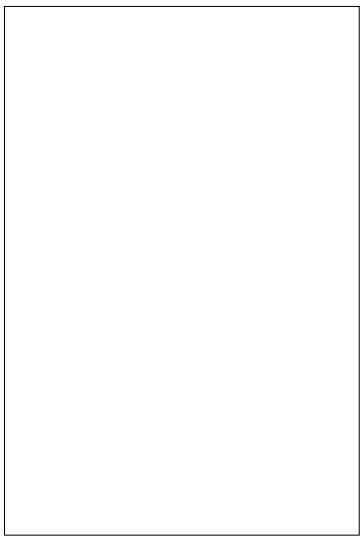

Figure 17. Fully grown larva of *Pseudocoremia* new species on *O. odorata*, Knobby Range (length 23 mm).

17. *Pseudocoremia rudisata* (Walker, 1862)

This species contains two allopatric subspecies (*rudisata; ampla* Hudson, 1923) that are both widespread and common. Larvae (Fig. 18) are oligophagous within Asteraceae on *Olearia* generally, *Ozothamnus, Brachyglottis* and *Helichrysum lanceolatum.* In this study they were found to be feeding on five species within *Olearia* section *Divaricaster* (Table 1).

Figure 18. Fully grown larva of the *Olearia* specialist *Pseudocoremia rudisata* on *O. bullata*, Fiordland (length 27 mm).

Noctuidae

Figure 19. Fully grown larva of *Meterana exquisita* on *O. bullata*, Hokonui Hills (length 30 mm).

18. *Meterana exquisita* (Philpott, 1903)

This appropriately named species was first found close to Invercargill, where its hosts are now extinct (Patrick 1994a). This study resulted in the discovery of the distinctly angular larvae (Fig. 19) and its host plants, and much additional information on the distribution and seasonality of the moth. It feeds on at least nine different *Olearia* species (Table 1), but most records are from *O. odorata* and *O. hectorii*. The fat green larvae feed on the foliage of the host and are well camouflaged there. Only one generation is passed each year despite the moth spending just one month as a fast-feeding larva. This species has (or had) a wide distribution from the south of the South Island to Auckland (Hudson 1928), including Pureora, Lake Taupo, Manawatu (McGregor et al. 1987) and Hawkes Bay (Davies 1986) in the North Island; and it has been found at a large number of sites within only one region in Central Otago (Table 2). The species has not been found in eastern Otago. Green cryptic adults (Fig. 20) emerge and fly from August to December (with one May record), with a peak from mid-September to mid-October and are known from sea level to 680 m a.s.l. Both Philpott (1903) and Hudson (1928) illustrated the elegant adult, while Patrick (1994b) illustrated both the adult and larva.

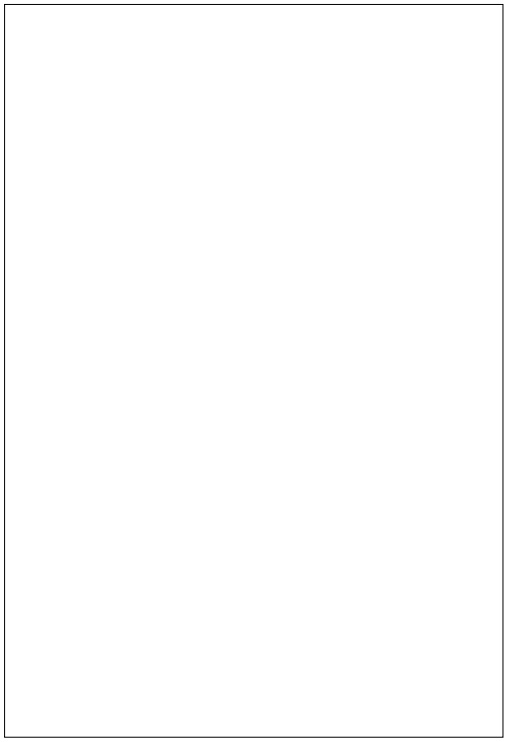

Figure 20. Cryptically marked adult of *Meterana exquisita* from Central Otago (wingspan 30 mm).

19. *Meterana grandiosa* (Philpott, 1903)

In terms of size and colour pattern this is one of the finest noctuid species in New Zealand (Fig. 21). It is another species discovered and named from specimens found close to Invercargill, where its possible hosts are now extinct (Patrick 1994a). During this study the larvae (Fig. 22) were found and reared for the first time, and found to feed on at least six *Olearia* species (Table 1). In captivity the early instar larvae fed on flowers of lawn daisy (*Bellis*) so the larvae may at first feed on the flowers of early-flowering species such as *Olearia hectorii*, whose flowers often emerge prior to the foliage in spring. Later instars are green with a broad lateral white stripe, and are well camouflaged amongst the foliage of the host. When larger, the larvae are fat and pinkish, growing to 33 mm in length. They hide under the bark of the host, most probably because they are not the colour of the foliage, as are the green larvae of *M. exquisita,* and may be better protected from predators hidden under the bark. This may necessitate the larvae travelling many metres each day to and from the foliage. Larvae pupate between late November and late December each year. Adults emerge late in the season from mid-April to early June and have been found from sea level to 1130 m a.s.l. The species has, or had, a wide distribution in the south of the South Island and, according to records, is disjunct to at least the lower half of the North Island (Table 2). McGregor et al. (1987) found it in large

Figure 21. Adult of *Meterana grandiosa* from Central Otago (wingspan 42 mm).

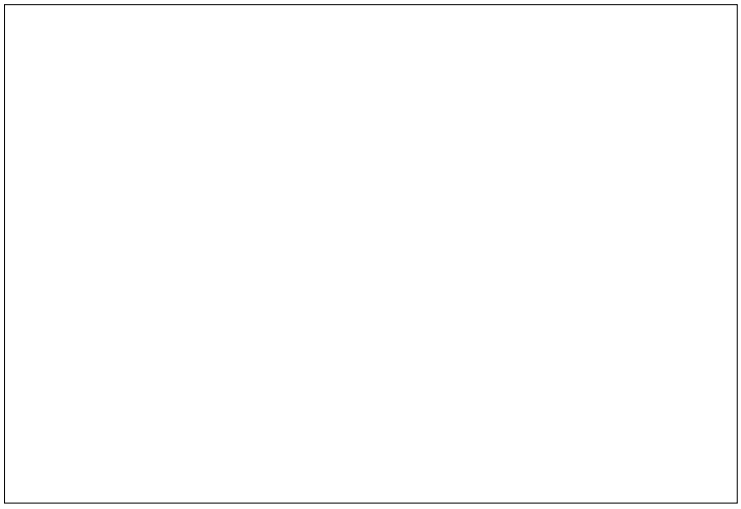

Figure 22. Fat, mature larva of *M. grandiosa* on *O. hectorii*, Catlins (length 33 mm).

numbers on the eastern flanks of Wharite Peak near Woodville in the Manawatu region; this is its only record I know of in the North Island. Generally it is a rarely captured species, but can be locally abundant. Its late emergence as an adult may account for its apparent rarity. Both Philpott (1903) and Hudson (1928) illustrate the adult.

20. *Graphania tetrachroa* (Meyrick, 1931)

This rarely captured species is known from Pureora and National Park (its type locality) in the centre of the North Island, to Southland. It was reared for the first time during this study from two distinctive larvae found on *Olearia fimbriata* at 600 m at Jordan River, in the Pomahaka Valley, Central Otago. The brown-orange larvae (Fig. 23) have black or grey mottling and feed on the foliage, pupating by February. The green, nocturnal adults emerge in mid-summer and have been found to be abundant in western Otago, where it is assumed larvae feed on *O. odorata*.

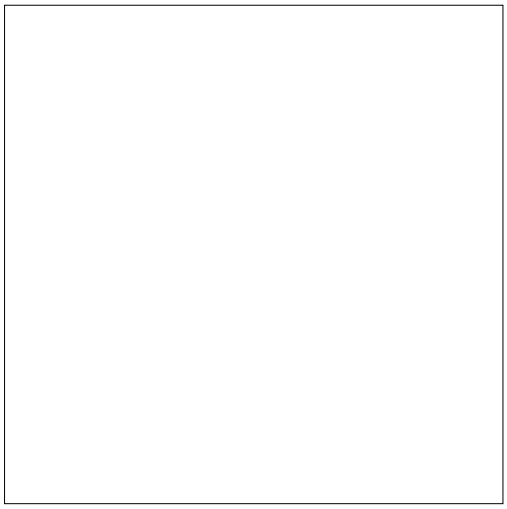

Figure 23. Larva of *Graphania tetrachroa* on *Olearia fimbriata*, Pomahaka Valley (length 31 mm).

4. Discussion

4.1 FEEDING STRATEGIES

This moth 'guild' can be divided into two functional groups with 30 herbivore and 11 detritivore species. Of the herbivores, 13 species are polyphagous and 17 species are either monophagous within *Olearia* section *Divaricaster* plus *O. fragrantissima* (14), monophagous within *Olearia* generally (1) or oligophagous (2) within fruticose (shrubby) Asteraceae. Typical of the two oligophagous species is the ennomid *Pseudocoremia rudisata*, whose larvae feed on many composites including *Ozothamnus* spp., *Brachyglottis* spp., *Helichrysum lanceolatum* and other sections of *Olearia*. For two specialists, the North Island *Olearia* hosts are not known. A genus-monophagous species—*Agriophara colligatella*—has larvae that feed on several sections of *Olearia.* The ten detritivores can be divided into seven generalists and three specialist monophagous species.

Where larvae have been found, they feed on the host in specific ways and the various ways they feed are highly synchronized to specific times of year. A variety of feeding strategies are employed that include leaf mining (three species, one of which utilizes a movable case from which to feed), feeding on the flowers (*Chloroclystis testulata),* feeding on the dead bark, scavenging on dead insects and passive live prey from within a moveable case (*Rhathamictis perspersa*) and feeding on the live foliage. While fresh foliage is the most popular part of the host consumed by herbivorous larvae, such as those of *Pyrgotis* new species; the larvae of the plutellid *Protosynaema* new species prefer older foliage and those of the tortricid *Harmologa amplexana* overwinter, feeding on perched dead leaves. In contrast, the distinctively patterned larvae of *Harmologa oblongana* (Fig. 24) feed from between silk-joined leaves on fresh foliage. Beating of the branches of *Olearia odorata* in winter and early spring, prior to the appearance of fresh leaves, yielded surprising results. Larvae of the leaf-rolling generalist detritus feeder *Harmologa amplexana* overwinter as late instar larvae amongst dead leaves that they have attached to a stem. They feed slowly over the winter on these perched dead leaves, pupating in spring in situ. By early spring (September), with the new leaves still not evident, newly hatched larvae of another generalist, *Declana junctilinea* (Fig. 25), are found patrolling the branches searching for fresh foliage.

Figure 24. larva of *Harmologa oblongana* on *O. odorata*, Skippers (length 15 mm).

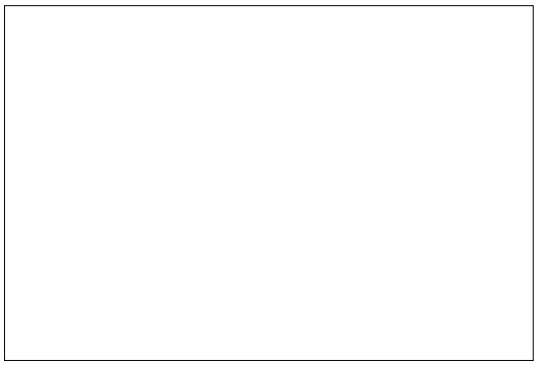

Figure 25. Larva of *Declana junctilinea* on *O. fimbriata*, Pomahaka Valley (length 40 mm).

4.2 PLANTS AS ECOSYSTEMS

Tree daisies of *Olearia* section *Divaricaster* often grow in pure stands, forming a distinctive community over hundreds of square metres. Individually the shrubs or trees are themselves ecosystems, with their covering of algae, lichens and mosses on trunks and branches. None of these epiphytes is confined to *Olearia*. Each of these life forms has a separate moth fauna feeding on them. In this study *O. hectorii, O. bullata, O. fimbriata* and *O. laxiflora* were all found to have lichens on their bark which larvae of the oecophorid *Phaeosaces apocrypta* feed on. Algae on the bark of *O. hectorii* and *O. fimbriata* supported two species of undescribed casemoths (Psychidae) in the genus *Reductoderces*. Meanwhile, the moss specialist *Eudonia minualis* (Crambidae) ate mosses on the bark of *O. bullata* and *O. hectorii*. *Olearia gardneri* trunks also have an extensive covering of mosses, lichens and algae, which can be expected to be fed on by a variety of moth species. The further study of the moth communities of the epiphytes of *O. gardneri* and many other *Olearia* species is needed.

4.3 SEASONALITY

Within the specialist moth species on *Olearia* section *Divaricaster*, there is a wide range of adult emergence patterns. The large noctuid *Meterana grandiosa* emerges consistently in the late autumn to early winter period, no matter whether its host is fully deciduous or not. It is joined in this emergence pattern by the geometrids *Pasiphila cotinaea* and *Pseudocoremia* new species, although the former species is on the wing from November (although it is uncommon before April). Conversely, another noctuid *M. exquisita,* an ennomine *Declana* new species*, Stathmopoda albimaculata* and a geometrid *Pasiphila* new species emerge from early spring to early summer to coincide with the appearance of first fresh leaves. Another ennomine, "*Pseudocoremia*" *cineracia,* is found in almost every month but with a distinct peak of emergence in spring. The other specialists are generally found as adults in the summer months for a short period of time in any one locality. *Pyrgotis* new species emerges between summer and autumn. These emergence patterns are consistent throughout the range of each species independent of altitude, degree of deciduousness of host and latitude. A possible explanation for the number of species emerging in spring and autumn is that by this strategy they avoid having young larvae feeding on the host foliage during mid to late summer when it is probably least palatable (Yela & Herrera 1993). Interestingly, in cases of both autumn and spring adult emergence, the larvae emerge together in spring and feed quickly during spring and early summer when the foliage is soft and fresh. Yela & Herrera (1993) report this for noctuid moths in the Mediterranean region.

4.4 HOST RICHNESS

Amongst the *Olearia* species, the shrub *Olearia odorata* was found to be host to the largest number of moth species with 27 (Table 1). Additionally, of the seventeen moth species that feed exclusively on *Olearia* section *Divaricaster,* three are so far only confirmed from *O. odorata*. The richness of this single host may reflect the greater abundance of this species in the pre-human landscape of Otago and Canterbury. The small trees *O. hectorii* (23 moths, 12 specialists), *O. fimbriata* (15 moths, ten specialists), *O. fragrantissima* (14 moths, five specialists) and *O. laxiflora* (ten moths, seven specialists), along with *O. gardneri* and *O. bullata* were also found to be rich in specialist moth species that use them as a larval host.

4.5 CONSERVATION

The future of the diverse and endemic specialist moth fauna on *Olearia* section *Divaricaster* is intricately bound up with the fate of its hosts. According to the results of a detailed study by Nieminen (1996), moth species that feed exclusively on deciduous hosts are significantly more likely to suffer local extinction than those feeding on evergreen hosts. Further, he found that the risk of extinction of herbivorous moths is significantly affected by the host plant characteristics rather than by the characteristics of the moths themselves. These hosts are distinctive in being pioneer species of disturbed habitats, including outwash terraces and fertile floodplains. Consequently, over the 160 years of intensive European settlement of New Zealand, they have suffered disproportionately, as they occupied favoured sites for settlement and farming. Currently there is conservation concern for five of the host species in this section of *Olearia* (Cameron et al. 1995; de Lange et al. 1999). Peat & Patrick (1995) pictured and commented on the rarity of *O. fimbriata* in Dunedin City. Rogers (1996) assessed the status of *O. hectorii* and *O. gardneri* in detail, and documented the scale of decline for these small trees. Both species now exist in highly fragmented populations with most of these lacking juveniles. Rogers et al. (1998) note the former importance of *O. hectorii* in southern New Zealand non-forest communities and report on 17 recent discoveries of individuals and populations there. Additionally, *O. fragrantissima,* in a closely related section of the genus, has suffered range reduction and is now local in distribution, with most known populations lacking juveniles. In de Lange et al. (1999) it is regarded as declining.

Patrick (1994a) highlighted the local extinction of two splendid noctuid species—*Meterana exquisita* and *M. grandiosa*—from their type locality at West Plains, Invercargill, as a result of the elimination of their host plants. The current rarity of *O. hectorii, O. fimbriata* and *O. fragrantissima* puts at least seven species of specialist moth at risk of extinction, of which four of these—*Stathmopoda campylocha, Protosynaema* new species, *Pyrgotis* new species and *Graphania tetrachroa*—are already present as fragmented small populations. The undescribed species of *Pseudocoremia* is rare, despite the fact that one of its host plants—*O. odorata*—is still relatively common. This is probably because of the moth has a flightless and relatively immobile female,

and its host now has an unnaturally fragmented population. It requires a habitat with a reasonable density of the host to make passage of the female between plants possible. If fragmentation of its habitat has resulted in many local extinctions, there is little or no chance of recolonisation. It is a high priority to protect the remaining habitat of *Pseudocoremia* new species and ensure that this habitat is of sufficient quality to maintain a species with specialist needs.

4.6 BIOGEOGRAPHY

An interesting observation from this study is that the natural distributions of the various moth species do not necessarily coincide with that of the host. Ofteb they occupy only part of the host's range. For example, "*Pseudocoremia*" *cineracia* is only known to feed as larvae on *Olearia odorata* (one possible record on *O. bullata* in Fiordland) but occupies only a fraction of its host's range, being apparently absent from Central and eastern Otago (Table 2). Similarly, the undescribed *Stigmella* species, which has been found once only, was associated with *O. odorata* in the Skippers area of western Otago. Ten of the other monophages have distributions that are centred on Otago, but in many cases encompass Southland to the south and the Mackenzie Country/ Waitaki Valley to the north.

Whereas the small geometrid *Pasiphila cotinaea* is widespread from the Volcanic Plateau to Southland, it is most often encountered in the wetter western zone and is apparently absent from eastern Otago. The undescribed *Pasiphila* replaces it in the latter area (Kakanui Mountains and Macraes), and is also found across western and Central Otago and in the Waitaki Valley.

No *Olearia* moth is endemic to the North Island.

4.7 AREA RICHNESS

Within southern New Zealand there are sufficient data available for a valid comparison of species richness per area for the specialist feeders (Table 2). Western Otago, with 18 of the specialist moth species, is the richest area, followed by Central Otago with 14. There is a lower diversity in eastern Southland, with 11 species, and eastern Otago, with nine species, followed by the wetter western areas, such as Fiordland (seven) and the West Coast (seven). From Canterbury northwards to the North Island the species numbers appear to match the lower totals of eastern Otago. Although more sampling north of the Rangitata River is needed, it is clear that there are more moth species known to be feeding on *Olearia* section *Divaricaster* species and *O. fragrantissima* in southern New Zealand than elsewhere (Table 2). Heads (1998) mapped this section of the plant genus and found that the group has its highest diversity in Southland, Central and, especially, western Otago, south-western Canterbury, north Canterbury and Marlborough.

4.8 FURTHER WORK REQUIRED

- Much more survey work is required in many areas of New Zealand, including the North Island, Canterbury and Marlborough, for both adults and larvae of this group of *Olearia*-feeding moths. Also, one *Olearia* species—*O. polita*—not covered here requires surveying.
- As eight of these *Olearia*-feeding moths were first detected and an additional eight were first reared during this study, further surveys are likely to discover new species of moth and provide additional host records.
- A study of the herbivorous Diptera, Hemiptera and Coleoptera associated with this plant group would be useful.
- The deciduous nature of many of the hosts has evidently not hindered these predominantly foliage-feeding moths, but must have a major influence on moth seasonality. The diversity of monophagous moth species feeding on this sometimes deciduous host group, and the similar richness of other deciduous hosts in New Zealand such as *Muehlenbeckia* (Polygonaceae) and *Sophora* (Fabaceae) (B. Patrick unpubl. data) are perhaps surprising in light of the findings of Nieminen (1996). He found that the risk of extinction for monophagous moth species on non-deciduous hosts was significantly lower than those on deciduous hosts, because the former provided a more stable and predictable resource. The role of other aspects of plant morphology and architecture has not been examined in this study, but would warrant attention as evidenced by the novel adaptation to loose bark on *Olearia hectorii* and *O. fimbriata* by the larvae of *Meterana grandiosa*.

5. Conclusion

In the New Zealand context, *Olearia* section *Divaricaster* has a particularly rich fauna of endemic moths associated with it and nearly half the members of this rich moth fauna are specialists. This is in line with the results of Basset (1996) who found that New Guinea trees supporting the richest insect fauna also supported the highest proportion of specialists.

An additional four endemic moth species feed on algae, lichens and mosses growing on the bark of these shrubs and small trees. In a sense the individual *Olearia* plants are ecosystems supporting a complex array of invertebrates that include many endemic moth species.

The geographic location of the main diversity of specialist moths is the same as the location of maximum diversity in this section of *Olearia* in western Otago.

This study highlights that, within the New Zealand flora, this section of *Olearia* supports a rich moth fauna, including a high percentage of specialists. These results underline the richness of insect-plant relationships in temperate regions as highlighted by Morrone et al. (1996) who used a cladistic approach to show that for some groups of insects and plants, temperate regions had species that are more important in terms of biodiversity conservation than tropical areas.

This suite of tree daisies deserves more conservation attention than it has attracted to date, not only because some of the plants are endangered but also because at least five of the specialist moth species are endangered as a consequence of their host's population fragmentation and rarity. Management action across a variety of altitudes and biogeographic regions is required urgently. Consideration of the tree daisies in the Tenure Review Programme and other conservation initiatives in Otago are encouraging examples of such action.

6. Acknowledgements

I am grateful for the assistance of the following persons during the course of this work: Graeme Anderson and family from the Hokonui Hills, John Barkla, Robin Craw, John Douglas, Eric Edwards, Peter Edgerton, Pat Enright, the Adams family, Michael Heads, Mr McNab from near Owaka, Colin Ogle, Hamish Patrick, Brian Rance, Geoff Rogers and many landowners. Two referees and Lynette Clelland, Editor, Science Publications, greatly improved the manuscript.

7. References

Basset, Y. 1996: Local communities of arboreal herbivores in Papua New Guinea: predictors of insect variables. *Ecology 77(6)*: 1906–1919.

Cameron, E.K.; de Lange, P.J.; Given, D.R.;Johnson, P.N.; Ogle, C.C. 1995: New Zealand Botanical Society threatened and local plant lists. *New Zealand Botanical Society Newsletter 39*: 15–28.

Davies, T.H. 1986: A checklist of the Arthropoda from Hawkes Bay, New Zealand. A Royal Forest & Bird Protection Society, Hawkes Bay Branch 1986 Community Service Project.

Dickinson, K.J.M. 1988: Umbrella Ecological District. Survey report for the New Zealand Protected Natural Area Programme No. 7. Department of Conservation. Wellington.

Donner, H.; Wilkinson, C. 1989: Nepticulidae (Insecta: Lepidoptera*). Fauna of New Zealand 16.* Landcare Research NZ Ltd. Lincoln.

Dugdale, J. S. 1975: The insects in relation to plants. In Biogeography and ecology in New Zealand, edited by G. Kuschel. Dr. W. Junk. The Hague.

Heads, M. 1998: Biodiversity in the New Zealand divaricating tree daisies: *Olearia* sect. nov. (Compositae). *Botanical Journal of the Linnean Society 127*: 239–285.

Howes, G. 1942: New Lepidoptera. *Transactions and proceedings of the Royal Society of New Zealand 71*: 277–278.

Hudson, G.V. 1928: The butterflies and moths of New Zealand. Ferguson & Osborn Ltd. Wellington.

Hudson, G.V. 1939: A supplement to the butterflies and moths of New Zealand. Ferguson & Osborn Ltd. Wellington.

Hudson, G.V. 1951: Fragments of New Zealand entomology. Ferguson & Osborn Ltd. Wellington.

De Lange, P.J.; Heenan, P.B.; Given, D.R.; Norton, D.A.; Ogle, C.C.; Johnson, P.N.; Cameron, E.K. 1999: Threatened and uncommon plants of New Zealand. *New Zealand Journal of Botany 37*: 603–628.

McGregor, P.G.; Watts, P.J.; Esson, M.J. 1987: Light trap records from southern North Island hill country. *New Zealand Entomologist 10*: 104–121.

Morrone, J.J.; Katinas, L.; Crisci, J.V. 1996: On temperate areas, basal clades and biodiversity conservation. *Oryx 30(3)*: 187–194.

Nieminen, M. 1996: Risk of population extinction in moths: effect of host plant characteristics. *Oikos 76*: 475–484.

Patrick, B.H. 1994a: Lepidoptera of the southern plains and coast of New Zealand. Department of Conservation. *Otago Conservancy Miscellaneous Series 17*. Dunedin.

Patrick, B.H. 1994b: Valley floor Lepidoptera of Central Otago. Department of Conservation. *Otago Conservancy Miscellaneous Series 19*. Dunedin.

Patrick, B.H. 1997a: Invertebrates of Macraes Ecological District. Department of Conservation. *Otago Conservancy Miscellaneous Series 30*. Dunedin.

Patrick, B.H. 1997b: An Entomologist's Summer. *Rare Bits No 26*: 44–46. Department of Conservation, Wellington.

Patrick, B.H. 1999: Are moths and their caterpillars good botanists? *New Zealand Botanical Society Newsleter 58*: 13.

Peat, N; Patrick, B. 1995: Wild Dunedin. University of Otago Press. Dunedin. 144 p.

Peat, N; Patrick, B. 1999: Wild Central. University of Otago Press. Dunedin. 144 p.

Philpott, A. 1903: On some new species of Lepidoptera (moths) from Southland. *Transactions and Proceedings of the New Zealand Institute. 35*: 246–249.

Rogers, G.M. 1996: Aspects of the ecology and conservation of the threatened tree *Olearia hectorii* in New Zealand. *New Zealand Journal of Botany 34*: 227–240.

Rogers, G.; Barkla, J.; Rance, B.; Simpson, N. 1998: Recent discoveries of small-leaved shrubs and trees from Otago and Southland. *New Zealand Botanical Society Newsletter. 54*: 8–13.

Spiller, D.M.; Wise, K.A.J. 1982: New Zealand insects and their host plants. *DSIR Bulletin 231*. Wellington.

Watt, M.N. 1921: The leaf-mining insects of New Zealand Part 2. *Transactions and Proceedings of the New Zealand Institute 52*: 197–219.

Yela, J.L.; Herrera, C.M. 1993: Seasonality and life cycles of woody plant-feeding noctuid moths (Lepidoptera:Noctuidae) in Mediterranean habitats. *Ecological Entomology 18*: 259–269.