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Comparison of the weevil fauna (Coleoptera: Curculionoidea) in two tussock grassland sites in Otago, New Zealand

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Abstract Invertebrates exhibit exceptional levels of diversity and endemism in New Zealand where, historically, they have received only limited consideration in land management decisions. Many species exist outside the habitats typically set aside for conservation, such as lowland to subalpine *Chionochloa* tussock grasslands. These habitats are under-represented as protected areas due to their modified state and their invertebrate fauna is poorly understood. Compiling inventories has been suggested as one means of facilitating a greater awareness of invertebrate diversity and ecology. This study presents an inventory of Curculionoidea recorded during a single quantitative sampling event in mid summer 2001, from two Otago *Chionochloa* tall-tussock grasslands. Species diversity is compared with that of other southern South Island tussock grassland areas, and notes on weevil ecology and distribution are given. Of the 35 species known from the two sites, only 17 were recorded from samples taken in January 2001, demonstrating the importance of factors such as seasonality and microhabitat to study design. Genera recorded showed affinities with those of grassland studies in neighbouring ecological districts. Almost 50% of the species collected from the two sites were undescribed; this not only limits the capability of land managers to compare areas under consideration for protection or other land uses, but also indicates an abundance of unrecorded and unprotected biological diversity.

Keywords invertebrate inventory; Otago; *Chionochloa* tall-tussock grasslands; Curculionoidea; weevil ecology

INTRODUCTION

New Zealand is classed amongst the top 25 global biodiversity hotspots in terms of endemic species richness (Myers et al. 2000). Invertebrates are the greatest contributors to this diversity (Patrick 1994a) and exhibit particularly high levels of endemism. For example, 90–96% of species and 43% of genera in the order Coleoptera are endemic in New Zealand (Watt 1975; Klimaszewski 1997). Despite this, selection of land for protection has historically been justified mainly by the presence of intact native plant communities or charismatic endangered vertebrates. Many such reserves comprise indigenous alpine or forest ecosystems, while

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botanically modified habitats are often considered of little conservation value and are under-represented in protected areas. A significant proportion of New Zealand's endemic biodiversity, therefore, may potentially be overlooked, as semi-modified and fragmented indigenous vegetation can support considerable indigenous biodiversity, particularly amongst the invertebrate fauna (Barratt et al. 1998; Crisp et al. 1998; Harris & Burns 2000; Derraik et al. 2001).

The general taxonomy and ecology of invertebrates in New Zealand is poorly understood, with recent estimates indicating that only about half of the total fauna is described (Emberson 1998). As a result, knowledge of these species' contribution to overall ecosystem health is limited. A greater understanding of their roles in ecosystem processes such as trophic level interactions, transfer of mass and nutrients, soil aeration and structuring, and maintenance of plant community integrity (Patrick 1994a; Pascarella 1998; Schowalter 2000) is required. Most conservation land managers lack the resources and expertise necessary to adequately survey invertebrates (New 1998), or to determine their functional roles that may be vital to the health of both native and modified ecosystems. Only in recent years have invertebrates been considered during assessments of land for conservation, for example, in the Protected Natural Areas Programme (e.g., Dickinson 1988; Hutcheson 1990), and their conservation values recognised (McGuinness 2001). Despite the contribution of invertebrates to total biodiversity and their value as indicators of environmental quality (New 1998), to date only the Cromwell Chafer Reserve has been established specifically to protect an insect species or community in New Zealand. Constructing biodiversity catalogues has been suggested as the principal step required to expand knowledge of invertebrates in New Zealand and to study them more efficiently (Derraik et al. 2001).

Grasslands cover almost 60% of New Zealand from sea level to the alpine belt (Wardle 1991), and about two-thirds of this area comprises natural and semi-modified indigenous short- and tall-tussock communities. Insect species diversity is considered to be high in Otago tussock grasslands and the region is thought to represent a major centre of invertebrate endemism (Barratt & Patrick 1987; Barratt & Kuschel 1996). Invertebrate herbivory is acknowledged as a key ecosystem process in such habitats with a low density of introduced mammalian herbivores (Schowalter 2000). Despite this, montane tussock grasslands are at risk from agricultural development and are under-represented in Otago reserves (Allen 1978; McIntosh et al. 1983). Few detailed invertebrate studies from below 1000 m a.s.l. have been published from these grasslands (Barratt & Patrick 1987) and knowledge of invertebrate biodiversity and their functional roles are therefore limited.

This study contributes to an understanding of invertebrate diversity in Otago's indigenous grasslands by providing a baseline inventory of the Curculionoidea fauna for further ecological studies. The Coleoptera are considered to be useful indicators of insect species richness as they include representatives of most trophic levels and functional groups (Hutcheson 1990). The order accounts for about 20% of all named insects worldwide (Vane-Wright 1992) and about 6000 of the estimated 20 000 insect species present in New Zealand (Emberson 1998). The Superfamily Curculionoidea represents a significant proportion of the known species of Coleoptera (Alonso-Zarazaga & Lyal 1999) and a substantial component of the insect diversity in Otago's terrestrial habitats. A good knowledge of the weevil species present at the two study sites and their status as predominantly flightless herbivores suggested Curculionoidea as a particularly appropriate focus group in this study. The objective was to survey and compare the weevil fauna of two semi-modified, indigenous tall-tussock grasslands in Otago, in the context of communities found in similar grassland habitats in the southern South Island of New Zealand.

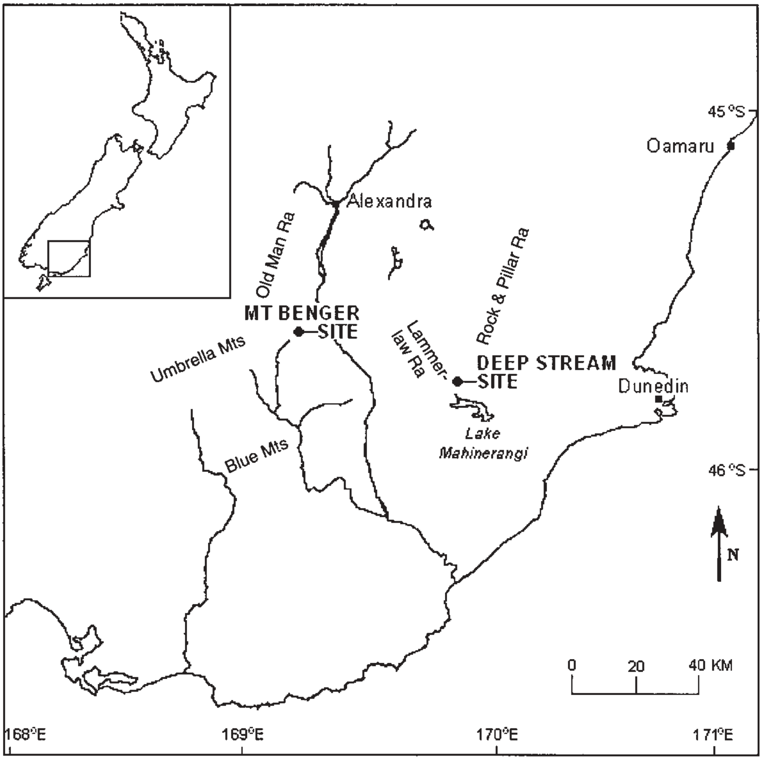

Fig. 1 Locations of the two South Island sites, Mt Benger and Deep Stream, surveyed for Curculionoidea in January 2001.

STUDY AREA

Two sites (Fig. 1) representing semi-modified *Chionochloa rigida* (Poaceae) tall-tussock grasslands with a diverse inter-tussock flora, were sampled for Curculionoidea. Neither site had been burnt for at least 25 years. The Mt Benger site was situated on pastoral lease land (45°35′S, 169°15′E) on the eastern slopes of the Umbrella Range, Central Otago. Annual rainfall in the area averages 500–700 mm at 500 m a.s.l. (Johnstone et al. 1999), but at 1167 m a.s.l. the Mt Benger site is likely to receive a slightly greater rainfall. The area typically experiences moisture deficits for up to 3 months of the year. Sheep grazing at densities of approximately 0.2 stock units ha^{-1} occurs during the warmer months of the year (Ross et al. 1997). Deep Stream (45°2′10″S, 170°15′50″E), a Dunedin City Council water catchment area, is located at 700 m a.s.l., about 10 km north of Lake Mahinerangi. The site receives greater cloud and fog cover, with mean annual rainfall in the nearby Lammerlaw Range exceeding 1000 mm (McIntosh et al. 1983). Stock grazing at the site is minimal (Gitay et al. 1992).

METHODS

Sampling was conducted at both sites during summer in January 2001. Each site consisted of three replicate 20 × 20 m plots within an approximately 1 km^2 area. From each plot 20 0.1-m^2 turves (32 × 32 cm) were removed to a depth of 5 cm from inter-tussock vegetation, and a further four from beneath tussock (*Chionochloa rigida*) plants which were clipped to facilitate handling. Inter-tussock turves also excluded other large plants such as *Aciphylla hectorii* (Apiaceae) and woody shrubs. Sampling was therefore stratified rather than entirely random.

Turves were individually packed in paper sacks and held in cool storage at 4°C. To extract invertebrates, turves were inverted and placed individually in heat extraction funnels using 150 W light bulbs held 40 cm above the turf as a heat source. Invertebrates were collected into containers of 90% ethanol:10% glycerol over an extraction period of 7 days. Weevils were hand-sorted from other invertebrates and stored in 70% ethanol. Previous tests have

Table 1 Taxonomic inventory of the Curculionoidea of Mt Benger (MB) and Deep Stream (DS). Weevil taxa recorded in January 2001 at each site are indicated in bold. Remaining taxa are those previously recorded at the sites but not during the current study. Non-native species marked *.

Subfamily	Tribe	Taxon	Abbreviation	MB	DS
Apionidae					
Apioninae:	Exapiini	*Exapion ulicis* (Forster)*		–	x
Erirhinidae					
Erirhininae:	Stenopelmini	***Baeosomus amplus* (Broun)**	Bae amp	**x**	**x**
		***Baeosomus rugosus* (Broun)**	Bae rug	**x**	**x**
		***Baeosomus* cf. *angustus* (Broun)**	Bae ang	**x**	**x**
		***Baeosomus* cf. *crassipes* (Broun)**	Bae cra	**x**	**x**
		***Baeosomus* sp.**	Bae sp.	**x**	**x**
		Baeosomus DS sp. 3		–	x
		Baeosomus DS sp. 4		x	x
		Athor arcifera Broun		–	x
Curculionidae					
Curculioninae:	Eugnomini	***Eugnomus durvillei* Schönherr**	Eug dur	**x**	x
		Eugnomus dispar (Broun)		–	x
		Oreocalus sp. 1		x	–
	Tychiini	***Peristoreus insignis* (Broun)**	Per ins	**x**	**x**
		Peristoreus MB sp. 1		x	–
		Peristroreus MB sp. 2		x	–
	Incertae sedis	*Simachus cunepennis* Broun		x	–
Cryptorhynchinae:		**Cryptorhynchinae sp.**	Cry sp.	**x**	**–**
	Cryptorhynchini	***Crisius* sp.**	Cri sp.	**x**	**–**
		Trinodicalles sp. 1		x	–
Cyclominae:	Rhythirrinini	*Gromilus impressus* (Broun)		–	x
		***Gromilus* sp. 1**	Gro sp. 1	**x**	x
		***Gromilus* sp. 2**	Gro sp. 2	**x**	**–**
		Gromilus sp. 5		x	–
		***Nestrius* sp. 1**	Nes sp. 1	**x**	x
		***Nestrius* sp. 2**	Nes sp. 2	**x**	**–**
		Listronotus bonariensis (Kuschel)*		x	x
Entiminae:	Tropiphorini	***Catoptes dispar* Broun**	Cat dis	**x**	**–**
		Catoptes cuspidatus (Broun)		–	x
		Catoptes censorius Pascoe		x	–
		***Catoptes* sp.**	Cat sp.	**x**	**x**
		***Irenimus stolidus* Broun**	Ire sto	**x**	**x**
		***Irenimus curvus* Barratt & Kuschel**	Ire cur	**x**	**x**
		Nicaeana cinerea Broun		–	x
		Nicaeana sp. 4		x	–
	Sitonini	*Sitona discoideus* Gyllenhal*		–	x

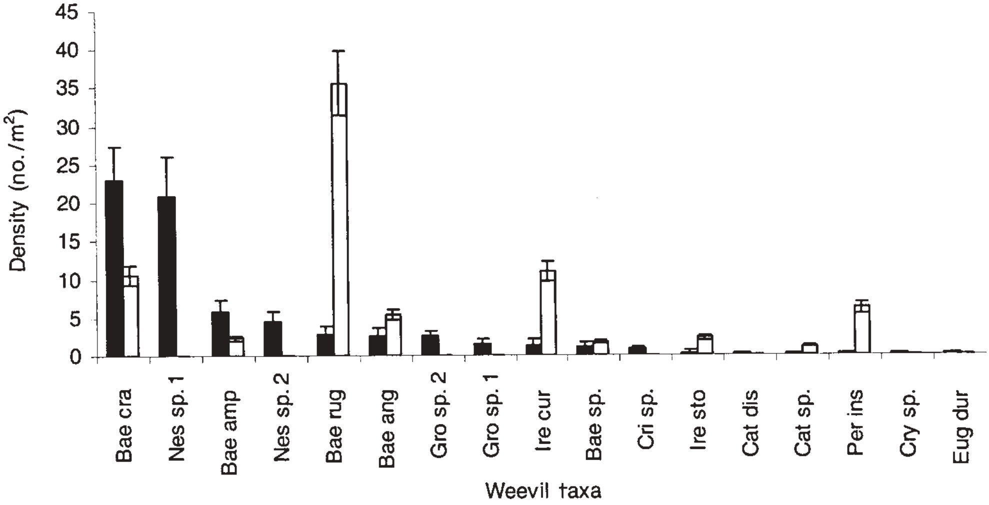

Fig. 2 Weevil density (± SEM) per m^2 calculated for Mt Benger (solid bars) and Deep Stream (open bars) in January 2001 (see Table 1 for full species names). Species are shown in order of abundance at Mt Benger.

indicated that the recovery rate for weevils using this method is between 97 and 100%, and that the transport and cool storage methods applied have no appreciable effect on this yield (Bremner 1988). Weevils were identified to species where possible under a low-power stereo-binocular microscope following the nomenclature of Alonso-Zarazaga & Lyal (1999) and the abundance of each species was recorded per turf.

RESULTS

A total of 490 and 349 individual Curculionoidea were collected and identified from Mt Benger and Deep Stream, respectively, representing 17 New Zealand endemic taxa from 9 genera and 5 subfamilies (Table 1). A further 18 taxa (Table 1), of which three are exotic, have been recorded from these two sites using the same sampling methods during previous years (Ferguson et al. 2003). Species richness was higher in January at Mt Benger where all 17 taxa occurred, compared with 9 species at Deep Stream, none of which was exclusive to the site. To date a total of 27 (13 exclusive) and 22 (8 exclusive) weevil species are known from Mt Benger and Deep Stream, respectively. Species composition and abundance also varied within sites in January, especially at Mt Benger where plots contained 16, 7, and 9 species, even though they were located within 500 m of each other. Of these species only five were recorded from all three plots. Species richness was more consistent at Deep Stream with 6, 7, and 8 species per plot, however, relative species abundance varied considerably (Murray 2001; Murray et al. unpubl. data)

At both sites more than half of the species present each occurred in < 10% of individual turf samples and several (*Catoptes dispar* Broun, *Eugnomus durvillei* Schönherr, Cryptorhynchinae sp., and *Catoptes* sp.) were represented by only one or two specimens. Both sites were numerically dominated by the genus *Baeosomus*, accounting for 52 and 72% of all weevils collected from Mt Benger and Deep Stream, respectively, followed by *Nestrius* at Mt Benger and *Irenimus* at Deep Stream (Fig. 2). Those taxa with relatively low densities at Mt Benger tended to be absent or uncommon at Deep Stream (Fig. 2), with the exception

Table 2 Comparison of the weevil fauna (see Table 1 for full genus names) recorded in January 2001 to studies in nearby ecological districts (McEwen 1987) which focused on or included tussock grassland sites. The total number of species recorded, the number of species of each genus recorded in the present study, and particular species recorded in common with the present study are shown; a, *Baeosomus amplus*; r, *B. rugosus*; c, *Irenimus curvus*; s, *I. stolidus*; d, *Eugnomus durvillei*. Location, altitude at which weevils were recorded, and the main vegetation type sampled is also indicated. ED, ecological district; TG, tussock grassland.

			Weevil genera										
Location	Altitude (m)	Main vegetation sampled	Total	Bae	Ire	Nes	Gro	Cri	Cat	Per	Cry	Eug	Reference
Mt Benger	1167	*Chionochloa rigida* TG	17	5	2	2	2	1	2	1	1	1	Present study
Deep Stream	500	*C. rigida* TG	9	5	2				1	1			Present study
East Otago Plateau	850–1000	*C. rigida* TG	32	4[a,r]	3	2	2	1	2	4		2[d]	Barratt & Patrick 1987
Old Man Ra.	1450–1700	TG/cushion-herbfield	12		1								Brumley et al. 1986
Umbrella ED	850–1500	TG/shrubland	32	5[a]	4		2		2	3	1	1	Dickinson et al. 1998
Nokomai ED	110–1500	TG/shrubland	47	6[a]	5	2			2	4	2	6	Dickinson et al. 1998
Garvie Mts	1200–1850	TG/bog/herbfield	23	2[a]	7	1			2			1	Otago Branch, Ent. Soc. of New Zealand 1985
Eyre ED	1200–1860	TG/herbfield	13		2					1		1[d]	Mark et al. 1989
Dansey ED	760–1500	TG/fellfield/herbfield	4										Patrick 1991
Hawkdun ED	1500–1850	TG/fellfield/upland-wetlands	9		2					1			Patrick 1994b
Lammermoor Ra.	1100	TG	8		3[c]				2				Barratt & Kuschel 1996*
Logan Burn	850–1000	TG	8		4[c,s]								Barratt & Kuschel 1996
Rock & Pillar Ra.	110–1400	TG/fellfield/herbfield	12		6[c,s]				2				Barratt & Kuschel 1996
Macraes ED	580–600	TG/remnant shrubland	2						1				Patrick 1997
Blue Mts	850–1020	TG/shrubland/cushion-bog	26	5[a,r]					2	2	1	1	Patrick et al. 1985
Rastus Burn Basin	850–1900	TG/shrubland/wetland/herbfield	16	3[a]	2	1							Patrick et al. 1992
Waipori ED	500–1200	TG/cushion-herbfield/wetlands	31	5[a,r]	5	1	1		3	2	1	2[d]	Patrick et al. 1993
Dart Valley	900–1830	TG/cushionfield/beech forest	5	2[a]	1			1		1			Watt 1980

*Listed Entiminae: Tropiphorini only.

of *Peristoreus insignis* (Broun) and *Irenimus curvus* Barratt & Kuschel. Although only obtained from Mt Benger in this study, *Gromilus* sp. 1, *Nestrius* sp. 1, and *E. durvillei* have been recorded from Deep Stream on previous sampling occasions (B. I. P. Barratt unpubl. data).

Weevil species have been recorded during several other insect surveys in Otago which have focused on or included tussock grassland sites; the number of species in genera shared by these and the current survey are shown in Table 2. As in the current survey, *Baeosomus*, especially *B. amplus*, were numerically prominent in nearby ecological districts (McEwan 1987). *Irenimus*, *Catoptes*, and *Peristorius* were also consistently represented in the majority of surveys, however, most records of these, and *Baeosomus*, were of undescribed species making direct comparisons of species level biodiversity to the current survey impossible.

DISCUSSION

The shortcomings of basing biodiversity studies on single sampling events are highlighted here in that only 17 of 35 weevil species known from these sites were recorded on this occasion. This was almost certainly influenced by seasonality as sampling occurred only during summer, potentially missing species that were between adult generations. In particular, rare or highly specialised species may have been missed or underestimated in their abundance due to the restrictions of sampling design, including the exclusion of certain plant forms and therefore microhabitats, and the limited number of samples taken. Derraik (2001) calculated on the basis of extrapolation, that to obtain an exhaustive invertebrate inventory for a lowland Otago shrubland would require sampling of over 700 shrubs. The need to minimise sampling time and cost in ecological studies, however, has led to the application of rapid inventory techniques, which often assume that native invertebrate diversity reflects native plant diversity (Crisp et al. 1998). Although such correlations have been reported (Crisp et al. 1998; Harris & Burns 2000), causation has not been clearly determined. In this study, weevil diversity varied considerably between sites and plots while the numbers of native plant species present (Murray 2001) remained more consistent, cautioning against the credibility of such assumptions and reiterating the influence of microhabitat heterogeneity on species diversity.

As few detailed invertebrate inventories from grassland systems have been published in New Zealand it is difficult to assess whether the Mt Benger or Deep Stream weevil communities are particularly unique or diverse. All but three of the species recorded from these sites, however, are New Zealand endemics, thus supporting the argument that the preservation of semi-modified plant communities may be essential to the continued survival of a significant proportion of New Zealand's endemic invertebrate diversity. The weevil genera present in the current study have also been recorded from tussock grassland surveys in most neighbouring ecological districts (McEwen 1987; Table 2). The number of weevil species recorded during these surveys, primarily between November and March, has generally ranged from 5 to 30, indicating similar weevil diversity to the current investigation. It must be emphasised that these surveys were not consistent in the amount of time spent sampling specifically for weevils at each site and most occurred over greater spatial and time scales. Notably absent from Mt Benger and Deep Stream were species of *Anagotus* (Curculionidae: Cyclominae), *Nicaeana* (Curculionidae: Entiminae), *Lyperobius* (Curculionidae: Molytinae), and *Liparogetus* (Curculionidae: Cyclominae), all of which have been recorded from other tussock grassland sites in the southern South Island (Brumley et al. 1986; Barratt & Patrick 1987; Dickinson 1988; Mark et al. 1989; Patrick 1991, 1994b; Patrick et al. 1992, 1993; Otago Branch, Entomological Society of New Zealand 1985). This may be explained partly by the exclusion of *Aciphylla* and woody shrubs from the January study, as other invertebrate surveys in tussock grasslands frequently included weevils collected from shrubs within the area (e.g., Mark et al. 1989; Patrick et al. 1992; Dickinson et al. 1998). Shrubs, however, were not abundant in the current study sites and no additional weevil species have been recorded from those that were present. Phenology may explain the absence of genera such as *Nicaeana*, which has been collected during other studies at Deep Stream but may have been present mainly as larval stages in January. *Lyperobius* may be absent from the sites as it is usually associated with *Aciphylla* at higher altitudes. *Anagotus* and *Liparogetus*, however, might have been expected to occur at these study sites, although neither has been recorded during this or other studies.

The genus *Baeosomus*, especially *B. amplus* (Broun) and several undescribed species, is particularly prevalent in the Otago grasslands (Table 2) and often recorded in higher abundance than other genera. Barratt & Patrick (1987) noted that the genera *Irenimus* and *Nicaeana* form a large numerical component of the weevil fauna of mid-altitudinal tussock grasslands of East Otago, and species in these genera can reach high densities in more modified pasture environments (Barratt et al. 1998). Several *Irenimus* species have been recorded during most grassland surveys in these and neighbouring districts. In addition, one or two species of *Peristoreus*, *Eugnomus*, *Nestrius*, *Catoptes*, *Crisus*, and genera of Cryptorhinchinae have also been recorded during these surveys. Many species are undescribed, however, e.g., Dickinson et al. (1998), making comparisons between studies particularly difficult without viewing the material collected by others.

Weevil ecology and distribution

The ecology of the main taxonomic groups of the weevil fauna collected is discussed below, including known host-plant associations. The distribution of species is given, with particular reference to southern South Island localities. Abbreviations of these localities are: CO (Central Otago), SL (Southland), DN (Dunedin), OL (Otago Lakes) (Crosby et al. 1976).

Erirhinidae: *Erirhininae*

Outside New Zealand, larvae of Erirhininae live underwater in the tissues of aquatic plants and the adults trap air under their convex elytra (Watt 1975). The New Zealand representatives, however, are terrestrial as adults, at least, and thought to be host-specific to particular moss species (Kuschel 1964). The numerical dominance of *Baeosomus* cf. *crassipes* (Broun) and *B. rugosus* (Broun) at Mt Benger and Deep Stream is not surprising as the prevalence of *Baeosomus* spp. has been noted previously in these and neighbouring ecological districts (see above). Both *B. amplus* and *B. rugosus* have been associated with *Polytrichum juniperinum* (Polytrichaceae) (Barratt & Patrick 1987; G. Kuschel pers. comm. 2001). *B. rugosus* has been extracted from samples predominantly containing *Anthoxanthum odoratum* (Poaceae), *Raoulia subsericea* (Asteraceae), *Leucopogon fraseri* (Epacridaceae), *Pentachondra pumila* (Epacridaceae), and *Oreobolus pectinatus* (Cyperaceae) (Barratt & Patrick 1987), all of which occurred in a high proportion of turf samples in this study (Murray 2001).

Known distribution

B. rugosus: Slopedown (SL); Catlins (SL); Lammermoor Ra. (CO); Blue Mts (SL); Swampy Summit (DN); Mt Maungatua (DN); Rough Ridge (CO); Dart Vly (OL); Remarkables (OL). *B. amplus*: Throughout New Zealand.

Curculionidae: *Curculioninae*

Curculioninae are often host specific or oligophagous at the generic level (May 1993) and may therefore be restricted to areas where native plants still predominate (Barratt et al. 1998). *Peristoreus* spp. are often restricted to *Dracophyllum* (Epacridaceae) and other shrubs (Barratt et al. 1998) and have been found in samples containing *Usnea* sp. (Parmeliaceae), *Polytrichum juniperinum*, *Oreobolus pectinatus*, and *Olearia bullata* (Asteraceae) (Barratt & Patrick 1987; Derraik et al. 2001). *Peristoreus insignis* (Broun) feeds on plants in the family Asteraceae (G. Kuschel pers. comm.). *Eugnomus durvillei*, represented here by a single specimen, has been found in association with *Anthoxanthum odoratum* but feeds more commonly on *Aciphylla* inflorescences (Barratt & Patrick 1987). This suggests an aggregated distribution, and the exclusion of mature *Aciphylla* plants from the current survey may have underestimated the abundance of *E. durvillei*.

Known distribution

E. durvillei and *P. insignis*: both known from many Otago tussock grassland sites.

Curculionidae: *Cryptorhynchinae*

Cryptorhynchine larvae are known to feed on dead wood, although it is unclear whether they consume the wood itself or the associated fungi and bacteria (May 1977; Lyal 1993). The adult diet has yet to be ascertained although live foliage is likely to be consumed by the majority of species (Lyal 1993). The concealment afforded by the habitat of Cryptorhynchinae is thought to predominate over its food potential in terms of the plant species on which these taxa are found (Lyal 1993). Due to its undescribed status, a comparison of the cryptorhinchine species collected here with other records cannot be made, and its distribution has not been determined.

Curculionidae: *Cyclominae*

Gromilus and *Nestrius* are primarily phanerognathous (root-feeding) as larvae, occurring amongst the roots of various native plants, and they are uncommon in areas of cultivation (May 1977). These factors may imply a reliance on intact native vegetation and undisturbed soils. Dicotyledon remains have been found in the guts of adults from both genera (Kuschel 1964). *Nestrius* species have reduced eyes and are thought to inhabit the litter layer at the soil surface and to be reasonably immobile (Barratt & Patrick 1987), explaining the restricted distribution of most species (Kuschel 1964).

Known distribution

Gromilus sp. 1: Lammermoor Ra. (CO); Rock & Pillar Ra. (CO).
Gromilis sp. 2: Slopedown (SL).
Nestrius sp. 1: Crown Ra. (OL); Remarkables (OL); Nokomai Ra. (CO); Mt Tennyson (CO); Garvie Mts (CO) (probably widespread on CO block mountains).
Nestrius sp. 2: Nokomai Ra. (CO).

Curculionidae: *Entiminae*

Irenimus stolidus Broun, *I. curvus, Catoptes dispar*, and *Catoptes* sp. are representatives of the "broad-nosed" weevils in the tribe Tropiphorini. The group shows little host plant specificity (Barratt et al. 1998) with adults feeding on seedling and mature plant foliage (Bremner 1988) and possibly pollen (Barratt & Kuschel 1996). The adult stage of an unidentified *Catoptes* species was recently collected from *Olearia bullata* in a remnant shrubland near exotic grassland (Derraik et al. 2001) and the larvae of several species have been associated with Gramineae, including *Chionochloa rubra*, *Festuca novae-zelandiae*, and *Poa* spp. (May 1993) which were all abundant in the current survey sites. Gramineae have also been recorded as food plants of *Irenimus* species (May 1977; Bremner 1988). Both *I. stolidus* and *I. curvus* are widely distributed (see below) at least within Otago grasslands (Barratt & Kuschel 1996). *I. stolidus* has a wide host range and has been implicated in the damage of oversown white clover seedlings (Barratt et al. 1992). Larvae feed on plant roots, and the foliage-feeding adults have been extracted from a range of plants including *Gaultheria depressa* (Ericaceae), *G. macrostigma*, *Lycopodium fastigiatum* (Lycopodiaceae), and *Coprosma propinqua* (Rubiaceae) (Barratt & Patrick 1987; Bremner 1988; Barratt & Kuschel 1996; Derraik et al. 2001). *I. curvus* has also been recovered from an array of native plant species including *Leucopogon fraseri*, *G. depressa*, and *Pentachondra pumila* (Barratt & Patrick 1987) and is included in Bremner's (1988) "*Irenimus* sp.3" which he observed feeding on several native grassland species, adventive weeds, and oversown pasture species.

Known distribution

I. stolidus: Rock & Pillar Ra. (CO); Taieri (DN); Strath-Taieri (DN); Lammermoor Ra. (CO); Maniototo (CO).
I. curvus: Mt Maungatua (DN); Rough Ridge (CO); Rock & Pillar Ra. (CO); Lammermoor Ra. (CO).

CONCLUSION

A total of only 17 of 35 weevil species known from Mt Benger and Deep Stream were collected and identified during this survey, highlighting the importance of sampling throughout the year to accurately determine invertebrate diversity in tussock grassland ecosystems. The weevil taxa recorded in January 2001, including high abundances of *Baeosomus* spp., are comparable to those found in adjacent districts and mountain ranges where other surveys have been conducted. Mt Benger is the more species-rich of the two sites yet diversity varied considerably between plots over distances as short as a few hundred metres, emphasising the complexity of the grassland habitat despite its botanically uniform appearance and semi-modified state. The importance, therefore, of conducting surveys in as many localities as possible and using sufficiently large sample units to fully ascertain faunal composition in this habitat type, is highlighted.

About half of the species of weevils collected during this study and a high proportion of those recorded in the other studies reviewed, are undescribed. Thus, a significant pool of unrecorded invertebrate biodiversity may be represented in these modified habitats which currently have no formal conservation protection. Without detailed species-level information the accuracy with which invertebrate diversity can be compared between sites is severely restricted. This in turn limits the degree to which invertebrate diversity is considered by land managers when making decisions on the allocation of land for conservation or other land uses. Detailed species inventories may aid these decisions; however, to be useful for such purposes, inventories must be based on well-designed sampling methods which take into account spatial and seasonal factors.

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