6 COLLEMBOLA (springtails)

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Summary

1. The distributions of Collembola on the Warra-Mount Weld Altitudinal Transect were investigated based on samples taken from February–April 2001, November–December 2001 and January–February 2002.
2. The Collembola of the Warra-Mount Weld Altitudinal Transect was species rich with more than 40 species collected; the majority of species recorded have not been described.
3. Most of the species collected are considered endemic to Tasmania and some endemic genera were present.
4. The Malaise traps performed well indicating that a suite of species are arboreal and highly vagile.
5. No exotic (introduced, alien) species were detected in this study indicating that the area sampled has been little disturbed and is of high conservation value.
6. Altitudinal trends were evident with a small number of species only occurring at the high altitudes and others only at low altitudes. Only a few species appeared to occur at all altitudes sampled.
7. Ordination plots showed that Collembola assemblages at lower altitude sites on the Warra transect were more similar to each other than those at the higher altitude sites on Mount Weld which formed three clusters: 1100; 1200 and 1300 m; and 800, 900 and 1000 m.
8. Mount Weld sites 600 and 700 m faunas were most similar to Warra sites so forming a continuum in altitudinal zonation between Warra and Mount Weld.
9. PERMANOVA analysis of monthly pitfall catches in 2001 and 2002 showed differences between months and altitudes on both transects and that the differences between months were more distinct at the lower altitude Warra sites than on the higher altitude Mount Weld sites. This difference was particularly marked for the month of February, which was the only month surveyed in both years.
10. Much of the change in faunal assemblages along the Warra and Mount Weld altitudinal transect seemed to be the result of changes in vegetation cover. The most abrupt faunal transitions took place across the tree line between 1000 and 1100 m and a smaller change from lowland forest to subalpine woodland on the Mount Weld transect.
11. Much material in the pitfalls was in very poor condition because of the long trapping time with unsuitable preservative so could not be identified to species but rough estimates were made of numbers of individuals in each family or genus.

Tasmania's collembolan fauna

The Tasmanian collembolan fauna consists of nearly 85 genera including 17 genera with only introduced species and five genera endemic to Tasmania (Table 6.1) (Greenslade 1987, 2007). In Australia as a whole, there are 144 genera and subgenera of which 23 are endemic. Tasmania therefore has a high proportion (25%) of endemic genera although its land mass is only 1% of the continent. This is probably because of its complex topography, wide range of vegetation types, humid climate and relatively intact native vegetation over nearly half the island. The number of species in Tasmania is around 120, a third of the 361 species currently recorded for the whole of

Australia. A catalogue of Australian Collembola giving distributions of each species is freely available online (Greenslade 2007).

Of the native Tasmanian genera, close to 50% have cosmopolitan distributions and 23% have Gondwanan distributions. The remainder comprise Australian endemics (19%), Tasmanian endemics (7%) and genera from the northern, warmer parts of Australia and south-eastern Asia (Greenslade 1987). The preferred vegetation types and habitats of the endemic genera are varied (Table 6.1).

The vegetation types with highest conservation value, based on the presence of endemic genera are *Nothofagus* rainforest, montane vegetation and buttongrass moorland (*Gymnoschoenus sphaerocephalus)*. Disturbed habitats such as cropping land, improved pastures and horticultural situations tend to be dominated by introduced exotic species and genera, some of which are considered pests. For instance, *Sminthurus viridis*, the clover springtail, is a pest of poppies and cucurbits in northern Tasmania and *Protaphorura fimata* feeds on roots and seedlings and can cause total non-emergence of peas and poppies also in northern Tasmania (Greenslade 2007).

Comments on field methods

Survey methods are provided in Chapter 2 of this compilation of reports. Because Malaise traps and pitfall traps were used to collect Collembola, only the arboreal and more active ground species were caught and not soil-living or humus restricted species. As the active species are those most likely to be affected by environmental change, these methods were appropriate ones to fulfil the overall aims of the study.

The methods used in this survey were not ideal for collecting and preserving soft bodied, minute invertebrates, such as Collembola, so that results may be biased to some extent. The Malaise trap samples were in better condition than the pitfall trap samples. This was because they had been collected directly into 70% ethanol rather than ethylene glycol. This latter preservative is not normally used for Collembola, as it does not preserve them adequately. In addition, the pitfall traps had been left out for four weeks resulting in dilution from surface runoff and some decay and damage to Collembola; one week is normally the maximum for this group. Also, catches were sieved through a 0.9 by 0.3 mm sieve, and the specimens retained on the sieve sorted to Order. This procedure certainly again led to loss and damage of specimens, as many Collembola are less than 0.9 mm in length. In all, 14 sites were sampled at 13 altitudes, six on Warra and eight on Mount Weld with six pitfalls run at each site as described earlier in Chapter 2 (Table 6.2). Two sites, one on the Mount Weld transect and one on Warra transect, were at the same altitude of 600 m.

Identification

As only about 20% of the Australian Collembola fauna is described, not all species could be identified below genus. However the different species could be distinguished and were therefore considered morphospecies and so numbered rather than named.

Analysis

Differences in species composition between sites were assessed using non-metric multidimensional scaling (MDS) based on a Bray-Curtis distance/similarity matrix. This ordination arranges sites in a reduced set of dimensions based on the rank order of similarities so that similar objects are near each other and dissimilar objects are farther away. We have used square-root transformed data for all analyses, taking the option for a dummy variable in the Bray-Curtis calculation because there are a few site/altitude/month combinations with sparse data. The goodness of the fit of the ordination plot is indicated by a stress value < 0.20 (Clarke 1993).

Only pitfall data were analysed as the Malaise trap collections were more limited in altitude and species collected. Because not all six pitfalls were retrieved from each site due to disturbance (e.g. from lyrebirds), mean numbers per pitfall were used in the analysis.

To investigate the effect of month and altitude on Collembola assemblages we used a two-way crossed design with no replication using PERMANOVA. Each transect was analysed separately. Note that sites are confounded with altitude because all sites on the Warra transect range from 100 to 600 m altitude and all Weld sites range from 600 to 1300 m altitude.

Primer 6© (Primer-E, Ltd, Lutton U.K) was used for multivariate analyses.

Results

Over 40 species and morphospecies were collected. No exotic (introduced) species were collected and it is likely that most if not all species, based on current knowledge, were endemic to Tasmania and some even local endemics.

Description of fauna and changes with altitude and habitat

Malaise traps

Sixteen species/morphospecies were collected (Table 6.3) altogether on both transects, which is relatively high for an arboreal collection. Abundance also was high with nearly 2500 specimens counted. Altitude changes in abundance were evident with relatively low numbers at 100 m, 600 m and 1000 m. The highest numbers of Collembola were at 200–400 m. There was a distinct change in family composition with altitude with the elongate Entomobryidae being more abundant up to 400 m and the globular Katiannidae and Bourletiellidae more abundant at higher altitudes. Exceptions to this family pattern were the elongate Paronellidae species which responded differently with sp. 1 and sp. 2 more common below 600 m and sp. 3, sp. 4 and sp. 5 more common above 600 m, although numbers of some species were low (≤10). This change is certainly related to changes in vegetation, in particular, the loss of tree cover and an increase in low, heathy vegetation although species restricted to higher altitudes were only in low numbers. One other globular family, the Dicyrtomidae, appeared restricted to lower altitudes in the malaise traps but few individuals were collected. This family is highly dependent on moist conditions so is normally restricted to ground habitats and would not be expected to be trapped above ground. The genus *Cassagnella* was rare and is normally a leaf litter inhabitant.

Pitfalls

A total of 6488 specimens were identified belonging to over 40 species (Table 6.4) from both transects and so provided a more complete inventory of the species present in the transects than did the Malaise traps. Collembola abundance in pitfall traps was overall greater at the higher altitude sites on the Mount Weld transect than at the lower altitude sites on the Warra transect (Table 6.2). Considering the Warra transect data alone, abundance was similar from 100 to 400 m and then dropped at 500 and 600 m. There was no apparent trend in species richness on this transect although species richness was highest at 400 m. On the Mount Weld transect abundance generally increased with altitude to 1100 m and then dropped at 1200 and 1300 m. Species richness on this transect tended to decrease with altitude with the lowest number of species recorded at 1200 and 1300 m.

More individuals were caught in 2002 compared to 2001 (mean numbers per trap in Feb. 2001 = 2, Mar. 2001 = 12, Apr. 2001 = 7, Nov. 2001 = 7, Dec. 2001 = 11, Jan. 2002 = 16, Feb. 2002 = 23). In particular, the February 2002 samples had many more specimens than the February 2001 samples. The most abundant taxa were *Acanthomurus* sp., *Isotoma* sp. 1, *Lepidophorella* sp., cf. *Pseudachorutella* sp., immature Symphypleona, Odontellidae, Dicyrtomidae, immature *Poduromorpha*, Paronellidae sp. 5, in that order (Table 6.4).

Few species were distributed evenly over the Mount Weld transect compared to Warra (Table 6.4), and many showed distinct altitudinal preferences as indicated by the number caught in traps. Species that were also collected in Malaise traps showed the same altitude preferences as shown by the pitfall catches except perhaps for the Dicyrtomidae. This apparent restriction of Dicyrtomidae to low altitudes in Malaise samples but presence in pitfalls at higher altitudes reflects the biology of this family with regards to movement above the ground in different microclimatic conditions. The pitfall fauna was dominated by different species compared to the Malaise traps and was richer in species. Several species in the same genera showed different altitudinal distributions notably *Isotoma* sp. 1 and 2, Paronellidae sp. 2, and sp. 4, 5 and 6, and *Lepidocyrtus* sp. 1 and 2 and possibly Paronellidae sp. 3.

Possible indicator species

Based on the Malaise trap catches, two *Katianna* species, *Rastriopes* sp. 1 and *Paronellides* sp. 5 appear to show a preference for the higher altitudes while *Lepidocyrtoides* sp. 1 is abundant in traps at mid to low altitudes at Warra (200–400 m). The pitfalls caught *Paronellides* sp. 4, *Paronellides* sp. 5, several Katiannidae species, *Lepidocyrtus* sp. 2 and *Isotoma* sp. 2 in highest numbers at high altitudes.

On the other hand *Isotoma* sp. 1, Odontellidae and Neanuridae and other Poduromorpha seemed to be absent or nearly absent at the higher altitudes (1000 m and above). This is probably due to a loss of habitat such as leaf litter which is less developed in montane heath compared to woodlands and forest

Table 6.1 Distributions and habitats of Tasmanian endemic Collembola genera.

Genus	Family	Distribution	Vegetation type	Habitat
*Megalanura**	Neanuridae: Pseudachorutinae	Throughout Tasmania	Tall wet forest, temperate rainforest	Under and in well-rotted logs
Tasmanura	Neanuridae: Anuridinae	Sporadic, at and above 1000 m, ca. 6 sites known	*Nothofagus gunnii*, montane vegetation	In leaf litter, humus
Tasphorura	Tullbergiidae	Only in NE Tasmania, one location 20 km S Scottsdale	Temperate rainforest	In moss
Azeritoma	Isotomidae	Only on Macquarie Island	Tundra, cushion plants	*Azorella* plants and soil
*Lasofinius**	Tomoceridae	SW Tasmania World Heritage Area	Buttongrass moorland *Gymnoschoenus sphaerocephalus*	In leaf litter, humus

*Genera found at Warra-Mount Weld.

Table 6.2 Collembola abundance and number of species/morphospecies recorded in pitfall traps on the Warra and Mount Weld transects.

Site /Altitude (m)	Transect	Abundance	Number of species/morphospecies
100	Warra	329	17
200	Warra	299	10
300	Warra	277	12
400	Warra	302	20
500	Warra	148	16
600	Warra	121	13
600*	Mount Weld	40	10
700	Mount Weld	300	16
800	Mount Weld	721	17
900	Mount Weld	999	20
1000	Mount Weld	378	16
1100	Mount Weld	1522	15
1200	Mount Weld	532	11
1300	Mount Weld	520	11

*Several pitfall traps were lost at this site due to lyrebird disturbance.

Table 6.3 Collembola captured in Malaise traps on the Warra (100–600 m) and Mount Weld (600–1300 m) altitudinal transects.

Taxa	Warra			Mount Weld			Total
	100	200	400	600	800	1000	
Brachystomellidae							
cf. *Cassagnella* sp. 1	0	0	0	0	1	0	1
Isotomidae							
Acanthomurus sp. 1	1	4	5	0	6	3	19
Acanthomurus sp. 2	0	0	1	0	0	0	1
Entomobryidae							
cf. *Drepanura* sp. 1	0	0	1	0	0	0	1
Lepidocyrtoides sp. 1	0	326	650	33	0	1	1010
immature & damaged indeterminate	0	300	0	12	0	0	312
Paronellidae							
Paronellides cf. *mjobergi* sp. 1	11	156	293	0	2	19	481
Paronellides sp. 2	3	3	15	0	0	0	21
Paronellides sp. 3	0	0	2	1	0	7	10
Paronellides sp. 4	0	0	1	0	12	20	33
Paronellides sp. 5	0	0	0	0	1	3	4
immature	0	0	0	0	19	34	53
Bourletiellidae							
Rastriopes sp. 1	0	0	0	0	0	93	93
Katiannidae							
cf. *Katianna* sp. 2	0	0	0	0	38	0	38
?*Katianna* sp.	0	0	0	0	170	0	170
cf. *Polykatianna* gen & sp. Indeterminate sp. 1	0	0	1	0	0	0	1
cf. *Pseudokatianna* sp. 1	10	0	1	1	0	0	12
Symphypleona							
immature & damaged indeterminate sp. 2	0	0	0	0	190	5	195

Dicyrtomidae							
gen & sp. indeterminate sp. 1	0	1	2	0	0	0	3
Total	25	790	972	47	439	185	2458

Table 6.4 Collembola captured in pitfall traps on the Warra (100–600m) and Mount Weld (600–1300m) altitudinal transects.

Taxa	Warra						Mount Weld								Total
	100	200	300	400	500	600	600	700	800	900	1000	1100	1200	1300	
Neanuridae															
cf. *Pseudachorutella* sp. 1	0	17	0	7	16	14	3	66	124	59	35	0	0	3	344
Megalanura tasmaniae	0	0	0	1	0	0	0	2	1	1	0	0	0	0	5
Australonura cf. *wellingtonia* sp. 1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	2
cf. *Pseudachorutes* sp. 1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
gen & sp. indeterminate	30	38	13	23	6	7	4	3	5	5	0	3	0	0	137
Acanthanura sp.	6	7	3	2	2	1	0	3	1	0	0	0	0	0	25
Brachystomellidae															
cf. *Cassagnella* sp. 1	0	1	0	15	0	0	1	0	1	0	1	0	0	0	19
n.gen. sp. 1	0	1	3	3	2	0	0	1	2	0	0	1	0	0	13
gen. & sp. indet.	0	1	0	35	8	2	0	0	0	0	0	0	0	0	45
Poduromorpha															
immature & damaged indeterminate	8	17	23	9	12	11	0	19	57	47	11	5	0	0	219
Isotomidae															
Acanthomurus sp. 1	50	27	34	23	20	38	15	66	129	97	69	1259	236	302	2365
Acanthomurus sp. 2	0	0	0	0	0	0	1	0	1	1	2	1	0	10	16

Acanthomurus sp. 3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Isotoma sp. 1	0	0	0	0	0	0	0	5	20	559	82	8	0	0	674
Isotoma sp. 2	0	0	0	0	0	0	0	0	0	0	0	13	1	0	14
Cryptopygus antarcticus group	1	0	0	0	0	0	0	0	0	1	0	1	0	0	3
immature & damaged indeterminate	0	0	0	0	0	0	0	0	0	0	0	41	0	14	55
Entomobryidae															
Australotomurus cf. *echidnus* sp. 1	0	0	0	0	2	0	0	0	5	17	0	0	0	0	24
cf. *Entomobrya* sp. 1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Entomobrya cf. *virgata* sp. 1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Lepidocyrtus sp. 1	8	5	9	7	3	2	0	1	14	5	5	1	0	0	60
Lepidocyrtus sp. 2	0	0	0	0	0	0	0	0	0	0	0	13	1	10	24
cf. *Drepanura* sp. 1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Lepidocyrtoides sp. 1	7	5	3	9	4	2	2	11	0	0	0	0	0	0	43
immature & damaged indeterminate	6	2	19	19	14	4	0	14	25	6	19	0	0	0	128
Odontellidae															
gen & sp. indeterminate	2	0	1	14	0	1	1	1	134	54	0	0	18	56	282
Paronellidae															
Paronellides cf. *mjobergi* sp. 1	12	9	7	3	5	0	1	10	1	1	0	0	2	18	69
Paronellides sp. 2	0	2	19	17	4	0	0	0	0	0	0	0	0	0	42
Paronellides sp. 3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Paronellides sp. 4	0	0	0	0	0	0	0	0	0	0	0	1	21	20	43
Paronellides sp. 5	1	0	0	0	0	0	0	0	1	1	29	11	103	63	209
Paronellides sp. 6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
immature & damaged indeterminate	8	0	11	14	2	5	0	2	2	10	17	4	4	7	87
Tomoceridae															
Novacerus cf. *tasmanicus* sp. 1	2	2	3	25	8	11	0	11	4	17	10	2	2	0	97

Lepidophorella sp. 1	86	64	0	13	4	4	2	79	146	23	12	4	21	0	458
Lasofinius sp. 1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
Bourletiellidae															
Rastriopes sp. 1	0	0	0	0	0	0	0	0	3	3	9	13	0	0	28
Katiannidae															
cf. *Pseudokatianna* sp. 1	6	2	0	3	7	10	2	4	0	3	0	0	42	0	79
cf. *Polykatianna* gen & sp. indeterminate sp. 1	0	0	0	8	5	0	0	0	0	0	5	0	0	16	34
?K*atianna* sp. 1	6	0	0	1	0	0	0	0	0	2	1	0	0	0	10
cf. *Katianna* sp. 2	0	0	1	43	0	9	0	0	0	6	0	0	16	0	75
cf. *Katianna* sp. 3	1	0	0	0	0	0	0	0	0	0	0	2	0	0	3
Symphypleona															
immature & damaged indeterminate sp. 1	14	3	5	8	3	0	2	0	5	9	43	17	54	0	163
immature & damaged indeterminate sp. 2	35	1	5	0	19	0	0	0	40	65	18	120	11	0	329
Dicyrtomidae															
gen & sp. indeterminate sp. 1	37	78	118	0	0	0	6	0	0	1	4	1	0	0	245
gen. & sp. indeterminate sp. 2	0	0	0	0	0	0	0	0	0	6	5	0	0	0	11
Total	329	284	277	302	148	121	40	300	721	999	378	1522	532	520	6473

Multivariate comparison of Collembola assemblages in pitfall traps

Faunal assemblages from the lower altitude sites at Warra were more similar to each other than were the higher altitude Mount Weld sites (Fig. 6.1). Mount Weld sites fell into three clusters, with the two highest altitudes isolated together as did the 800, 900 and 1000 m sites, while the position of the 1100 m site indicates it is least like any other site. The Mount Weld sites at 600 m and 700 m were in intermediate positions between Mount Weld and Warra indicating to some extent the validity of the altitudinal continuum. Eight species distributions seem to be responsible for the position of these sites' positions close to the Warra sites. *Acanthanura* sp. and *Lepidocyrtoides* sp. were only found at or below 700 m, while *Paronellides* sp. 4, 5 and 6 and *Rastriopes* sp. are only found above 700 m (Table 6.4).

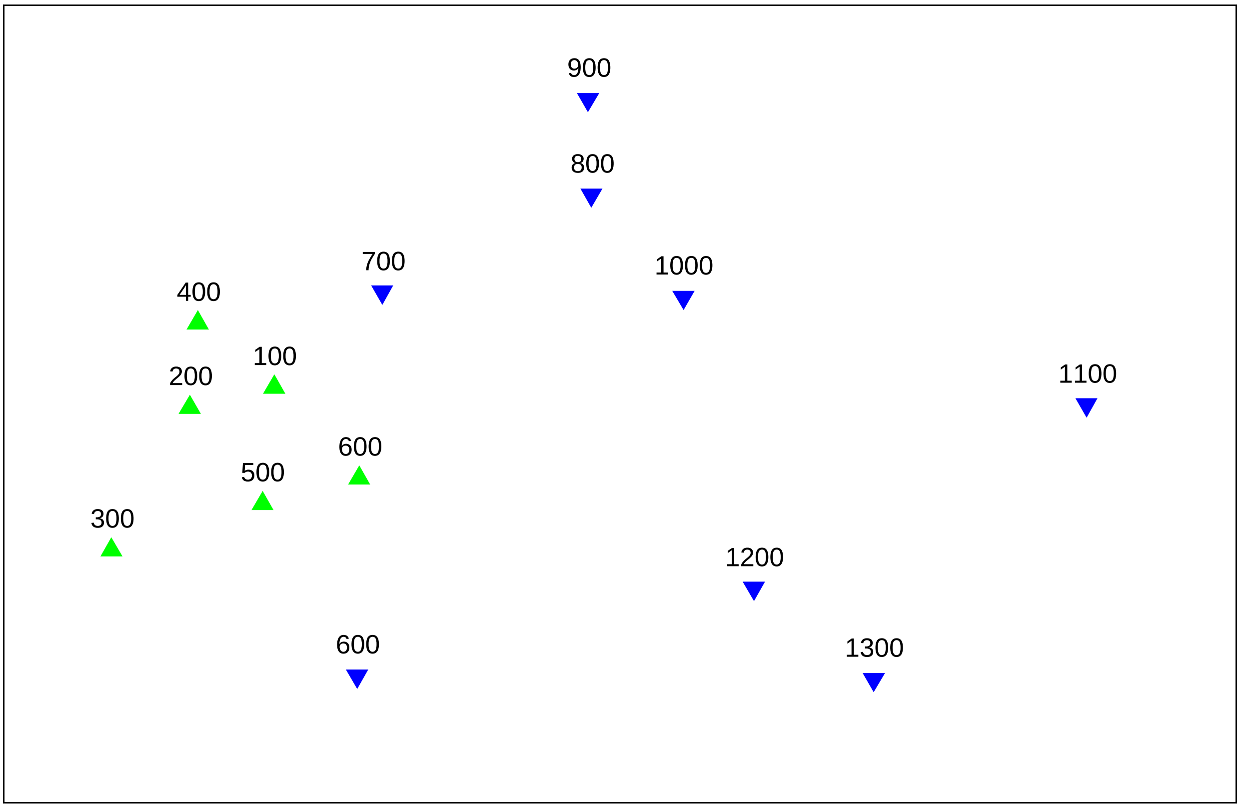


Fig. 6.1 MDS ordination of Collembola assemblages at each altitude on the Warra (▲) and Mount Weld (▼) transects for pitfall trap samples. Data has been averaged across sampling months. Stress value = 0.1

The influence of vegetation is paramount here in determining faunal assemblages. For instance the tree line was just above 1000 m on Mount Weld and sites on this transect at 1100, 1200 and 1300 m all carried alpine heath while sites 800, 900 and 1000m all carried subalpine *Eucalyptus coccifera* woodland. Sites up to 700 m carried a mix of *Eucalyptus delegatensis* and *E. obliqua* (Doran *et al.* 2003). The different vegetation types seem to reflect the positions of the sites in Fig. 6.1. The isolated position of Mount Weld at 1100 m is due to very large numbers of *Acanthomurus* sp. 1 and this may be an artefact of pitfall sampling

PERMANOVA analysis showed a significant effect of both month and altitude on Collembola assemblages on both the Warra and Mount Weld transects (Tables 6.5 and 6.6). Fig. 6.2 indicates that on the Warra sites there was also an effect of season with the early summer months November 2001–February 2002, tending to the left of the graph, while the late summer months February 2001–April 2001 tending to the right. There was also a difference between years with February 2001 and 2002 assemblages well separated with the February 2001 assemblage grouping with the later summer months and the February 2002 grouping with the early summer months. By contrast, on Mount Weld, there was less demarcation between assemblages in early summer months and late summer and between February 2001 and 2002 (Fig. 6.2).

Table 6.5 PERMANOVA test of month and altitude on Collembola pitfall assemblages for Warra

F**actors**	Df	SS	MS	Pseudo-F	P
Month	6	19887	3314.5	2.9417	0.0001
Altitude	5	17367	3433.4	3.0828	0.0001
Residuals	30	33801	1126.7		
Total	41	71055			

Table 6.6 PERMANOVA test of month and altitude on Collembola pitfall assemblages for Mount Weld.

F**actors**	Df	SS	MS	Pseudo-F	P
Month	6	26925	4487.4	2.6986	0.0001
Altitude	5	55409	7915.5	4.7602	0.0001
Residuals	42	69840	1662.9		
Total	55	15217			

Mount Weld

Warra

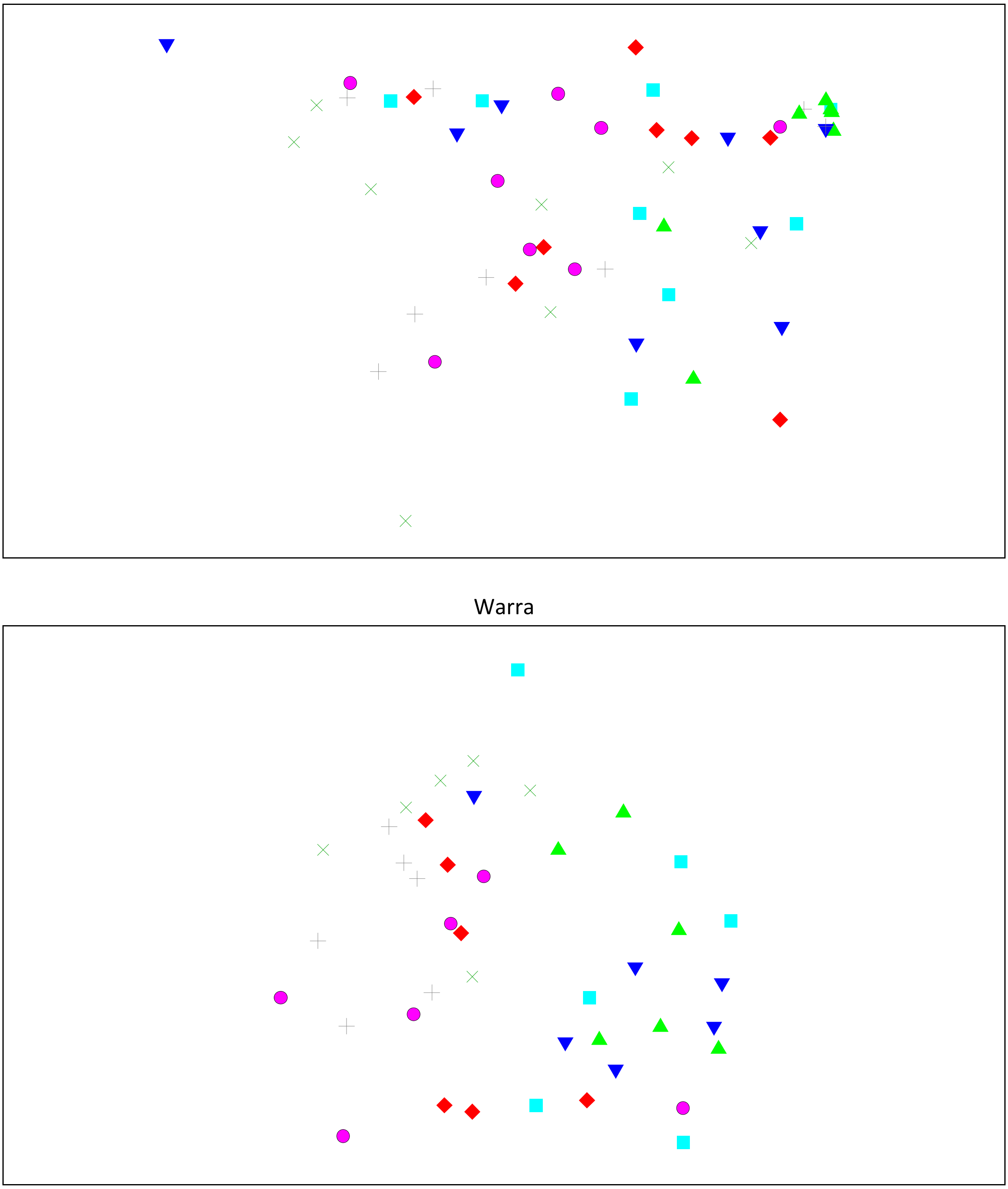


Fig. 6.2 MDS ordination of Collembola assemblages for each site and month sampled using pitfall traps on the Mount Weld (top, stress value = 0.13) and Warra (bottom, stress value = 0.23) transects. Triangle = Feb. 2001, inverted triangle = Mar. 2001, square = Apr. 2001, diamond = Nov. 2001, circle = Dec. 2001, plus sign = Jan. 2002, and cross = Feb. 2002.

Discussion

The results from the Warra-Mount Weld Altitudinal Transect in Tasmania can be compared to a similar altitudinal survey, using pitfall traps only, in subtropical and cool temperate rainforest on Mount Lamington, south-eastern Queensland (Kitching *et al.* 2013). Sites there ranged from 300 to 1100 m, a similar range to the survey in Tasmania, but at Lamington *Nothofagus* rainforest was only present at 1100 m. Similarities between the two data sets were that Collembola abundance generally increased with altitude but with a decline in abundance at the highest altitudes. Species richness increased on Mount Lamington between 300 and 900 m with a small decline at 1100 m. Similarly there was a decline in species richness with altitude on the Mount Weld transect between 700 and 1300 m. In both studies, broad altitudinal changes in Collembola abundance and taxon richness were associated with changes in vegetation type. On Mount Lamington the decrease in abundance and taxon richness between 900 and 1100 m was associated with a change from subtropical rainforest to cool temperate rainforest. The increase in abundance of Collembola on Warra-Mount Weld is associated with a change from lowland E*. obliqua*/*E. delegatensis* forest to subalpine woodland and alpine heathland.

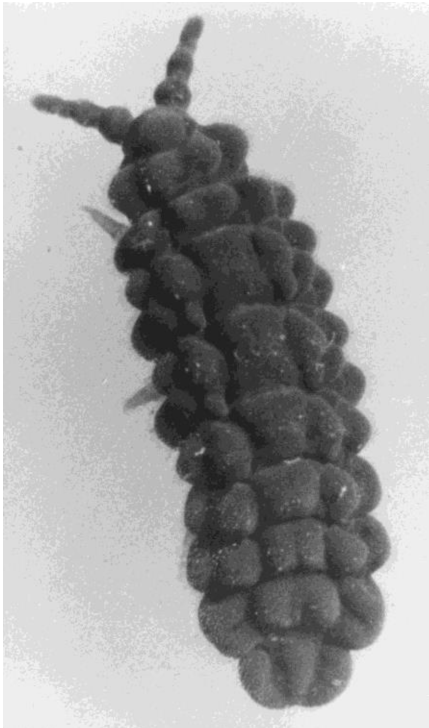
There was no congruence in species between the two State locations and the only generic similarity was that species of *Rastriopes*. In Tasmania a single species of this genus was restricted to the highest altitude while on the Lamington transect, one species was found only at low altitudes and another at the highest altitude. Major differences were that on Mount Lamington, species in the genus *Acanthanura* were found at and below 900 m on the transect in but only at the highest altitude of 1100 m on Mount Lamington*.* Also, on Mount Lamington, all species of Paronellidae were restricted to low altitudes while Poduromorpha were most abundant at the highest altitude. One genus on Mount Lamington, *Isotopenola*, was not collected on the Tasmanian transect, this genus tends to be found at lower altitudes, in drier, more open habitats while the related genus, *Cryptopygus*, present at high altitudes at Lamington and in low numbers in Tasmanian transects, is found in moister vegetation types and further south, even occurring on the Antarctic Continent. Greenslade and Kitching (2011) suggested that under a climate warming scenario, the Tasmanian fauna may develop some of the characteristics of the Lamington fauna. What is significance here is that species of *Rastriopes*, some Paronellidae and Isotomidae species are selective as to their habitat and environmental requirements.

Greenslade and Kitching (2011) selected several taxa that appeared, on this limited sampling effort, to be restricted to particular altitudes. None of the five 'sentinel' species (represented by multiple specimens collected from only a single elevation), that were considered promising candidates for future monitoring of climate change belonged to the same genera as the altitudinally restricted taxa in Tasmania.

More recently, Maunsell *et al.* (2013), using only Isotomidae, Symphypleona and Neelipleona from sieved leaf litter samples at the three highest altitudes on Mount Lamington, also found changes in species composition with altitude. As well as elevation, these authors found that collembolan changes with altitude correlated with a number of abiotic factors, such as organic matter, ammonia, calcium, potassium, sodium, soil moisture, tree base area and various temperature measures.

Conclusion

Collembola were collected in adequate numbers of individuals and species in the pitfalls for the total fauna to be amenable to statistical analysis**.** We found a statistically significant effect of altitude on both Weld and Warra transects and the ordination revealed that the pattern of change and separation differs between the two transects being greater on Mount Weld than at Warra, that there were slight indications of a continuum of altitudinal effects from Warra to Mount Weld and that vegetation strongly influenced faunas as did season and year, the latter being more marked at lower altitudes than on Mount Weld. There were a number of species that were restricted as to the altitude at which they were found.



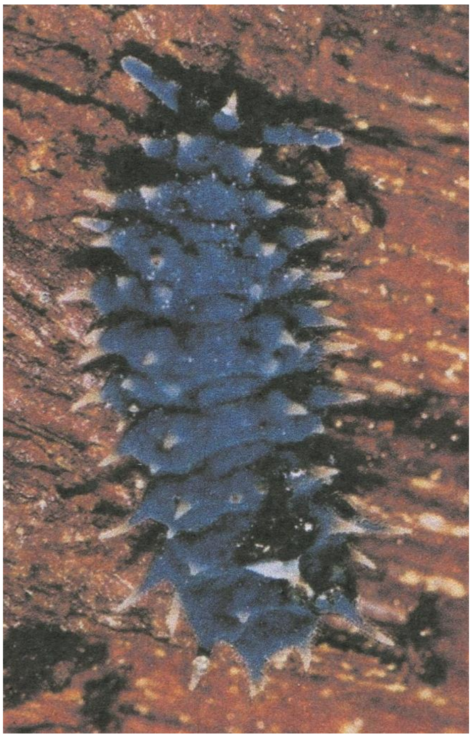


Fig. 6.3 Images of *Megalanura tasmaniae* (left) by J. E. Ireson and *Acanthanura dendyi* (right) by S. Grove.

Fig. 6.4 Images of *Acanthomurus* sp. (top left), *Paronellides* sp. cf. *tasmaniae* (top right), *Lepidocyrtoides* sp. (middle left), Katiannidae gen. & sp. indet. (middle right), *Novacerus* sp. (bottom left), Dicyrtomidae gen & sp. indet. (bottom right) from water colour paintings by G. Davis.