On the effects of trampling on montane spiders and other arthropods

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Introduction.

With the growth of leisure and outdoor pursuits in the last few years, has come an increasing interest by ecologists in the effects of trampling on vegetation (Bayfield & Barrow 1985), especially the deterioration of footpaths and damage to plant cover at recreation sites with possible concomitant effects on the invertebrate fauna. In the United Kingdom, the Nature Conservancy Council has been concerned with conservation implications for vegetation, birds and invertebrates of montane habitats. This has included the survey of invertebrate communities of *Racomitrium lanuginosum* heath and 'degraded' related habitats near the summit of Ben Lomond. This mountain, the highest peak in the Loch Lomond area with a summit of 974m, attracts large numbers of hillwalkers. Overgrazing is another cause for concern, with increasing pressure on uplands in Britain for sheep-farming (e.g. Grant et al. 1978, Hudson 1985). This combined with the recreational activities, could induce serious environmental problems.

This paper is concerned with variations in the ground-active invertebrate fauna in relation to vegetation (which has already been influenced by grazing), and trampling, as well as the background influences of season, aspect and altitude. An experimental approach was taken with respect to trampling, with an awareness that changes in the fauna may result even before any obvious physical damage to the plants.

Sample Sites and Methods

Samples of both plants and animals were taken from the western to south-western face of Ben Lomond, at an altitude of between 868m and 914m. Invertebrates were sampled by means of pitfall traps, in spite of their short-comings (e.g. Luff 1975), as they are considered to maximise recorded species richness (Curtis 1980).

Approximately monthly collections were taken from mid-June 1988 through to the beginning of October at eight sampling sites, located near the summit of Ben Lomond in two contiguous transects. Sites 1 to 4 were at equidistant altitudes from 914m down to 868m; sites 4 to 8 were situated about 100m apart along the 868m contour line and so had different aspects, from westerly round to south-westerly. Sampling was discontinued at two sites initially placed at the top of the vertical transect, close to the main footpath along the summit ridge, because of disturbance by vandals.

At each site four sampling stations each had two pitfall traps. Three stations (A, B, C) were set in a triangular configuration about 2m apart and station D was set about 5m downhill from C. All stations were left undisturbed for the first month and subsequently treated experimentally as follows: A - Trampled on visit 1, but thereafter untrampled, B - Trampled on all visits after the initial sample period, C - Untrampled, but close to trampled stations. D - Untrampled. Trampling consisted of 100 footsteps, within the 1m square centred on the trap pair. No obvious physical damage was caused to the vegetation by this treatment.

Invertebrates were classified to family and separated into size categories; Araneida and Opiliones were classified to species. TWINSP (Hill, 1979) was used to classify all the samples (i) in terms of the general invertebrates and (ii) the spiders (and harvest-spiders). Thi was done separately for each month. The plant data samples were also classified using TWINSPAN.

Results.

The most frequently-occurring plant species was *Racomitrium lanuginos* reflecting the derivation of the plants assemblages from degraded Racomitrium heath. Bare earth was also recorded as an obvious ground feature. *Galium saxatile* was the next most frequent plant species, wh other species were *Hypnum jutlandicum, Cladonia uncinalis, Rhytidiadelphus squarrosus, Carex bigelowii, Polytrichum alpinum, Alchemilla glabra, Deschampsia flexuosa, Festuca ovina, Vaccinium myrtillus, Cladonia furcata, Pleurozium schreberi* and *Dicranum scoparium.*

In terms of the occurrence of TWINSPAN-derived classes for the plants the sample sites, there appeared to be a trend down the vertical transect (sites 1 to 4) and then along the horizontal one (sites 4 tc 8), but no statistical support could be obtained for this.

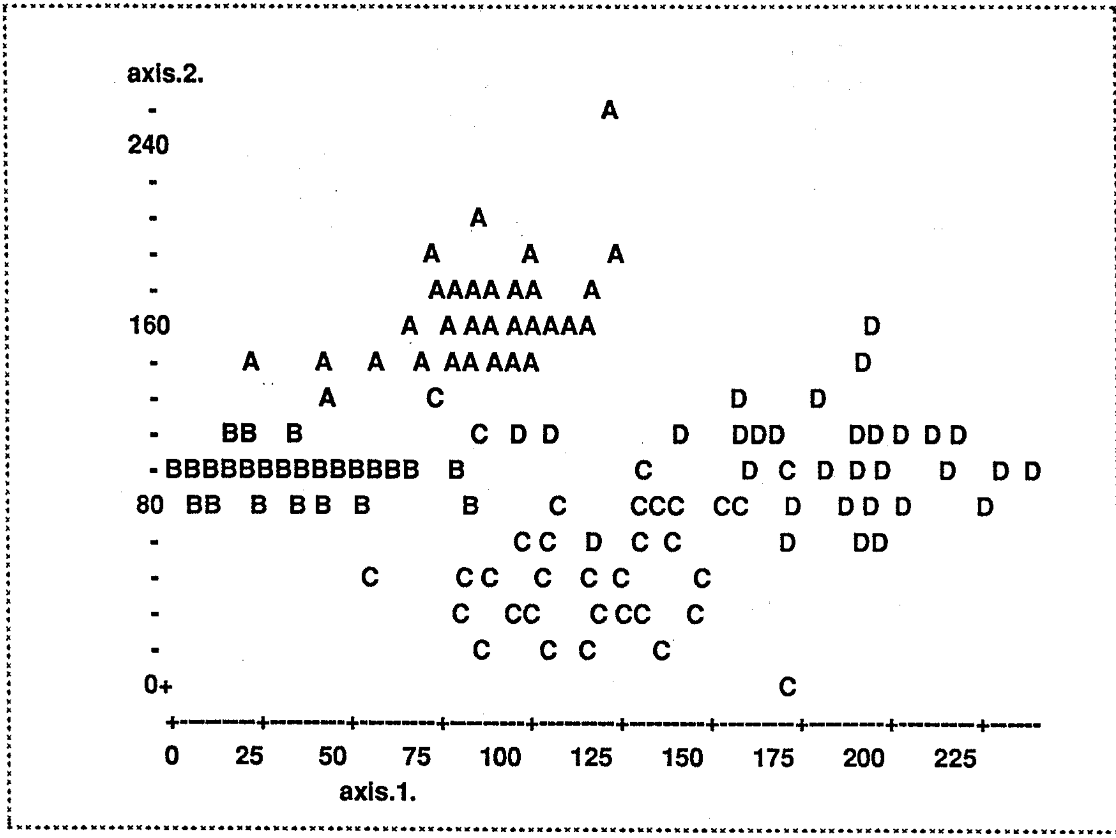
For the data on general invertebrates, a pooled data set, containing of the individual samples over the four months, was subjected to ordination by means of reciprocal averaging. The scores for the sampl against the first two axes of this ordination are plotted in Fig. 1(a in which the points are labelled to indicate the month of sampling. A seasonal trend is evident in this plot, supported by analysis of variance tests, which is also reported in Fig. 1. The other potential influencing factors, site, station, aspect and altitude, did not emer clearly in this analysis.

The most frequently-occurring invertebrate group in July was the Carabidae family, in a size category of 8-9mm in length, with a total 146, followed by Linyphiidae in size category of 2mm with a total of 82. In August, most frequent were Coleoptera larvae in size category <4mm, with a total of 40, followed by Opiliones in a 6mm size categor The most frequently-occurring invertebrate group in September was Staphylinidae in 4-5mm size category with a total 50, followed by Coleoptera larvae in size category of 8-9mm, with a total of 38. In October, Coleoptera larvae in size category of 12-13mm were most frequent, with an abundance of 60 counts.

The first two ordination axes for the spider samples are shown in Fig 1(b). Although, in comparison to the plot for invertebrates data set, the relative positions of the months are slightly different, especial July and August, a seasonal trend is again evident and supported by analysis of variance. The other potential influencing factors, site, station, aspect and altitude, again did not emerge clearly in this analysis.

Figure 1. Ordination plot based on reciprocal averaging for (a) general invertebrates data and (b) spiders (Araneida and Opiliones). Samples a labelled A, B, C and D to correspond with the month of collection: A - July, B - August, C - September, D - October. Clear separation of the four monthly samples is evident and verified by the results from analysis of variance.

Ordination plot for invertebrates data



Analysis of variance for differences between months: axis.1 F = 223.94 p < 0.0001

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* = mean (within 95% confidence limits)
Month              MEAN      STDEV   ---------+---------+---------+-------
July (A)           97.03     25.85                  (*-)
August (B)         20.26     17.40    (*-)
September(C)      131.81     27.84                       (-*-)
October (D)       190.00     32.67                                 (-*)
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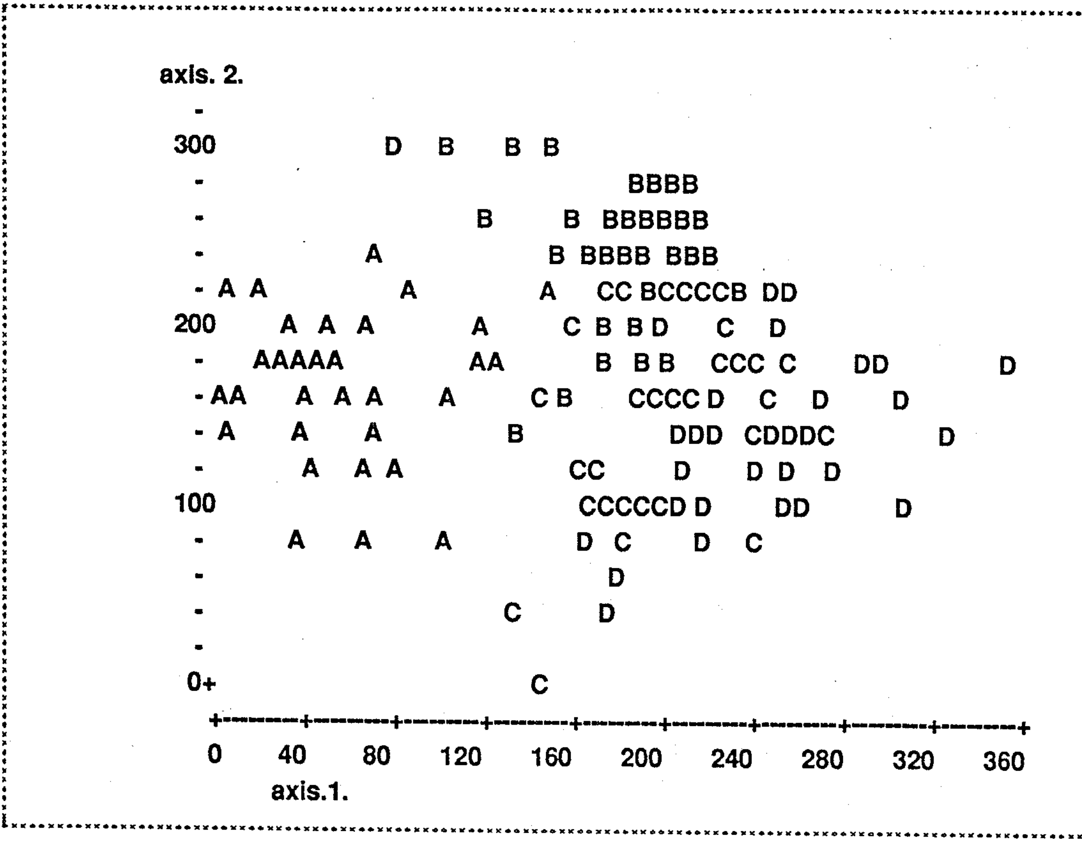
Ordination plot for spider data.



Analysis of variance between months: axis.1 F = 140.57 p 0.001

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* = mean (within 95% confidence limits)
Month              MEAN      STDEV   ---+---------+---------+---------+---
July (A)           59.58     42.14    (-*-)
August (B)        197.29     29.42                        (-*-)
September(C)      218.72     31.39                          (-*--)
October (D)       244.78     49.39                              (-*-)
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A classification of the 32 sample stations, based on a combined data obtained by simple summation of samples over the four months, provid summary of the main spider species recorded and their associations. profile of these classes is listed in Table 1. These classes tend to correspond to different sample sites, with intriguing suggestions of trends, but with no firm statistical support, in contrast to the separate monthly data.

Table 1. More abundant spiders listed in relation to groupings produced by TWINSPAN classification; average captures per trap-pair.

Species	Classes A	B	C	D	E	F	G
Meioneta gulosa	35	5	21	8	3	5	2
Mitopus morio	33	10	27	16	16	9	10
immature Linyphiidae	9	5	5	5	2	3	3
Haplodrassus signifer	7	2	1	1	0	1	1
Robertus lividus	4	2	2	0	0	0	0
Centromerus prudens	4	4	4	3	3	2	0
Centromerita concinna	4	10	3	5	8	2	0
Alopecosa pulverulenta	1	14	4	2	3	4	0
Lepthyphantes zimmermanni	3	6	12	17	3	1	0
immature *Lepthyphantes*	0	4	0	0	0	0	0
immature Oligolophinae	0	0	2	3	0	2	0
Erigone dentipalpis	0	0	0	0	2	4	3
Lepthyphantes mengei	0	1	0	0	0	0	2

The most frequently-occurring species were *Mitopus morio* (with a total of 121) and *Meioneta gulosa* (79). The most frequently-occurring species in the month of July was *Meioneta gulosa* (48), whereas in August it was *Mitopus morio* (43) and again in September (16). In October, the most frequently-occurring species was *Centromerita concinna* (27).

Factors affecting the invertebrate communities.

Chi-squared was used to test for contingency of TWINSPAN-derived class, separately against (a) site, (b) station, (c) aspect and (d) altitude within each monthly data set (Table 2). The overall environmental effects of aspect and altitude are apparent. These will have contributed to the effect of site, which is generally strong, but additional factors are likely to be involved. There were clear seasonal trends for both the invertebrates and spider data sets. The classifications derived for each month, generally were site-related. The effects of aspect and altitude were different from month to month, aspect being important in July and August and altitude in September and October. This could be related to downward migrations of the animals with onset of winter weather conditions.

Three community parameters were calculated for each sample: species richness (number of species recorded), abundance (number of individuals captured) and species diversity (expressed as Simpson's Inverse Index). Analysis of variance indicated differences between the classes obtained from TWINSPAN, for the general invertebrates in terms of species diversity ($F = 2.73$, d.f. 7,24, $p = 0.031$) and the spiders in terms of species richness ($F = 4.16$, d.f. 7,23, $p = 0.004$). Differences were also apparent for species diversity in relation to aspect for the invertebrates ($F = 2.77$, d.f. 4,27, $p = 0.048$). Spider abundance also varied significantly between the classes ($F = 5.39$, d.f. 7,23, $p = 0.001$).

Table 2. Chi-square values for contingency between classifications.

	Invertebrate classes			Spider classes		
	chi-sq.	(d.f.)	p	chi-sq.	(d.f.)	p
July:						
station/trampling	19.51	(24)	n.s.	21.53	(24)	n.s.
site	79.91	(56)	<.05	75.20	(56)	<.05
aspect	45.04	(32)	<.05	48.52	(32)	<.05
altitude	27.46	(24)	n.s.	24.61	(24)	n.s.
August:						
station/trampling	22.88	(24)	n.s.	25.05	(24)	n.s.
site	65.33	(56)	n.s.	81.71	(56)	<.05
aspect	52.58	(32)	<.05	49.02	(32)	<.05
altitude	19.00	(24)	n.s.	33.11	(24)	n.s.
September:						
station/trampling	14.22	(21)	n.s.	12.89	(12)	n.s.
site	74.22	(49)	<.05	32.00	(28)	n.s.
aspect	40.00	(28)	n.s.	18.67	(16)	n.s.
altitude	41.42	(21)	<.05	16.60	(12)	n.s.
October:						
station/trampling	17.31	(18)	n.s.	9.52	(12)	n.s.
site	77.98	(42)	<.05	43.39	(28)	<.05
aspect	57.06	(24)	<.05	23.45	(16)	n.s.
altitude	30.83	(18)	<.05	24.96	(12)	<.02

Possible influence of grazing.

The sites differ in terms of invertebrates and spiders and although no contingency could be proven between the faunistic classes and classes based on plant species, the general vegetal characteristics of the sit may go some way to explaining the faunistic differences between them. sites vary in terms of the percentage cover values of overall mosses grasses and this is reflected in the ratios of moss/grass; over all te sample sites, these moss/grass ratios vary significantly ($F = 6.36$, p <0.001).

One of the expected impacts of sheep grazing is a reduction in the extent of *Racomitrium* heath (Thompson et al., 1987). Heavily damaged areas were characterised by the sedge, *Carex bigelowii*, along with muc bare earth. *Racomitrium lanuginosum* also featured prominently in the apparently less-damaged areas, supporting the view that these habitats represent degraded *Racomitrium* heath. Sheep were observed to be grazin over the sample area at various times and the tips of plants had been nibbled, providing a clear indication of grazing. As a convenient and rapid measure of grazing, the number of pellets of sheep faeces were counted at each of the stations over the sites. A significant negative correlation ($r = - 0.370$, $p < 0.02$) was found between the moss/grass ratio and the number of sheep pellets. This is in keeping with expectations based on the information of Thompson et al. (1987). This may well support the hypothesis that grazing has affected these systems.

The effect of trampling.

Most interestingly, there was a significant difference in spider species diversity between stations ($F = 3.38$, d.f. 3,27, $p = 0.033$). Stations A and B, which had been trampled, had lower species diversity than C and D, untrampled. This may be taken as an indication of some effect by trampling on the spider community. Thus, the spider communities might be affected by trampling pressures even before vegetation damage is evident.

The experimental trampling at stations A and B appeared to have no effect on the invertebrate community as a whole. However, species diversity for spiders over the whole sampling period showed significantly lower values for the trampled stations. This could relate to the dependence of the spiders on vegetation structure, although there was no visually noticeable damage.

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