

MICRO-ARTHROPOD ACTIVITY IN THREE CONTRASTING TERRESTRIAL HABITATS ON SIGNY ISLAND, MARITIME ANTARCTIC

RUDOLF SCHENKER* and WILLIAM BLOCK†

*British Antarctic Survey, Natural Environment Research Council, High Cross,
Madingley Road, Cambridge CB3 0ET, UK*

ABSTRACT. The activity of micro-arthropods was monitored at Signy Island during summer over periods of 48 h by sticky surface traps in three field plots: a fellfield, a *Prasiola-Deschampsia* community and a mossbank. The temperature regime of selected micro-sites within the three 1 m² plots was measured at the same time. Arthropod abundance was determined at the end of the period by extraction from substrate samples. An index of activity, corrected for abundance, was developed. The micro-climates were different for the three plots, which influenced the numbers trapped of the five common species (two Collembola, three Acari). Arthropods (four species) were most abundant in the *Prasiola-Deschampsia* plot, whereas only *Cryptopygus antarcticus* occurred to any extent in the other two sites. Locomotory activity is discussed in terms of habitat structure, micro-climate and temperature as a resource.

INTRODUCTION

The activity of terrestrial ectotherms is largely dependent on the temperature regime in their habitats. In polar terrestrial environments, particular sheltered micro-sites with buffered micro-climates ensure the survival of small arthropods (principally Acari and Collembola in the Antarctic). This is particularly important during winter in the maritime Antarctic, where ground surface minimum temperatures of -21 to -27°C occur under shallow snow cover (Walton, 1982).

Antarctic land arthropods have evolved various strategies to aid their survival (Block, 1980), e.g. increased cold resistance during winter, elevation of metabolism, which allows activity at low temperatures, and adjustment of their breeding and development rates. These result in an extension of life cycles and differing growth rates and energy utilization between some species (Burn, 1984). Therefore, as much of their activity is confined to the summer period, when habitat conditions are optimal, an assessment of their locomotory activity in relation to environmental temperature and other factors is important. Because the frequency of freeze-thaw cycles increases during the austral summer (Walton, 1982), the influence of these physical processes on faunal field activity needs evaluation.

This paper reports the results of field experiments undertaken at Signy Island, South Orkney Islands (60° 43' S, 45° 36' W) in the 1982-83 summer to monitor both the abundance and activity of the micro-arthropod populations in three contrasting sites in relation to their micro-climates. The results allow an ecological interpretation of species field activity under maritime Antarctic conditions and provide a further step in understanding the interactions governing the colonization and occupation of such polar habitats.

* Present address: Universität Basel, Geographisches Institut, Bernoullianum, Klingelbergstrasse 16, CH-4056 BASEL, Switzerland.

† Correspondence and reprints.

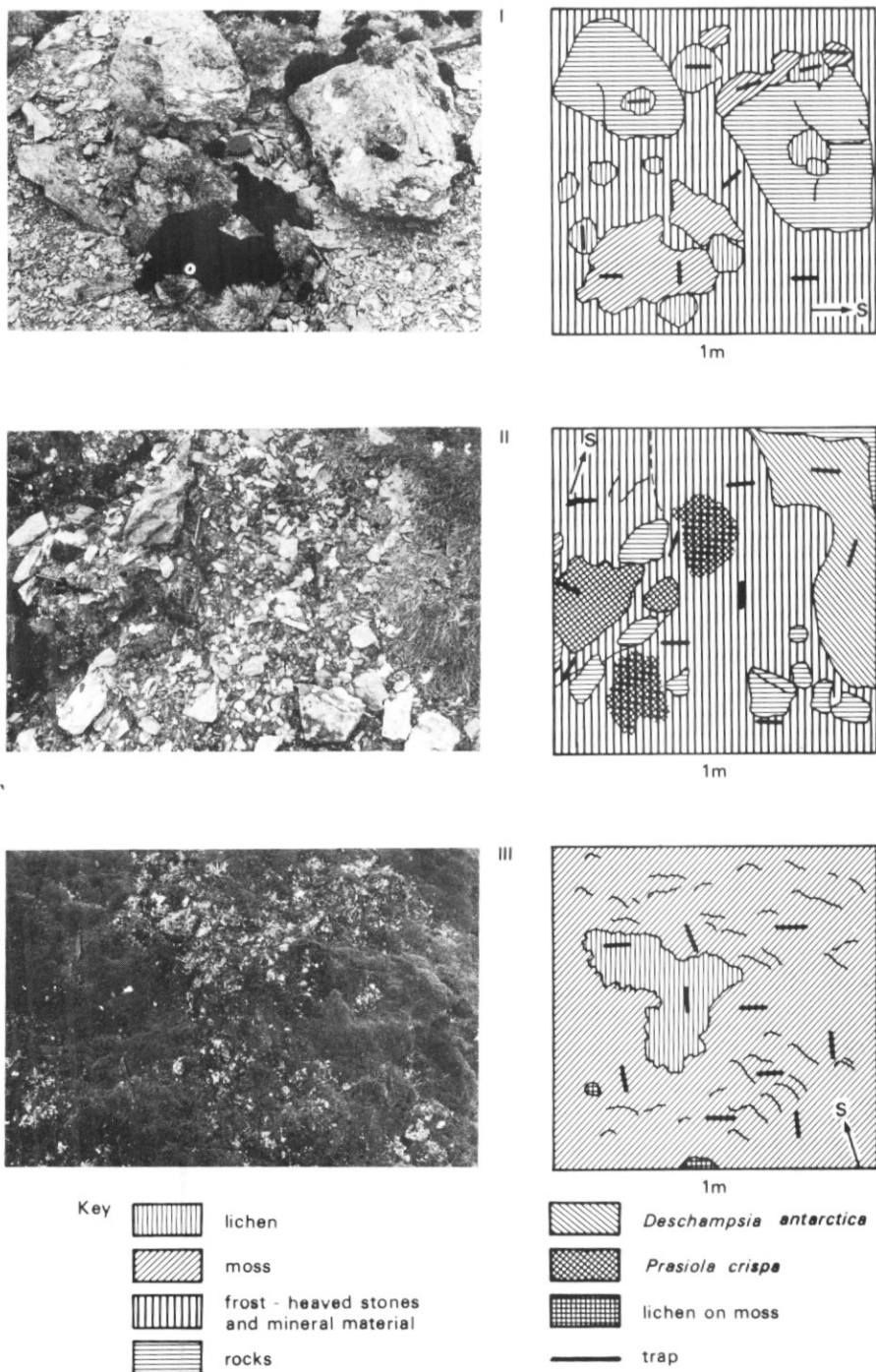


Fig. 1. Photographs of field plots and diagrams showing the distribution of rocks, vegetation and activity traps. I, fellfield site; II, *Prasiola-Deschampsia* site; III, mossbank site.

STUDY SITES

Plots of 1 m² area were staked out in three contrasting habitats: a rocky fellfield, an alga-grass (*Prasiola-Deschampsia*) community and a moss bank, on the eastern side of Signy Island. The fellfield site (I) was situated at the north end of Moraine Valley near Cemetery Bay at 40 m a.s.l. It faced west with a 28% slope. The substrate comprised frost-heaved stones and mineral soil with sparse vegetation consisting of the mosses *Andreaea regularis* and *A. depressinervis*, and the lichens *Usnea fasciata* and *U. antarctica*. The distribution of the rocks and vegetation is shown in Fig. 1. The alga-grass site (II) was beneath Factory Bluffs at 25 m a.s.l. on a north facing slope of 56%. The habitat is diverse and it is fertilized by guano from Cape Pigeons (*Daption capense*) nesting on the cliffs above. A small run of frost-heaved stones on mineral soil covered with the green alga *Prasiola crispa* cuts through the plot. The stone run is bordered by a patch of the grass *Deschampsia antarctica* on one side and mosses (*Polytrichum alpinum*, *Xantheria* sp., *Candelaria* sp. and *Dicranoweisia grimmiceae*) on the other side (Fig. 1). The mossbank (III) was close to Factory Bluffs, being north-facing on a 34% slope at 30 m a.s.l. It is composed of *Polytrichum alpestre* and *P. alpinum*, which in places are overgrown by the lichens *Usnea antarctica*, *Cornicularia oculata* and *Alectoria chalybeiformes* (Fig. 1).

METHODS

Micro-arthropod locomotory activity on the ground surface was monitored at the three sites by using sticky traps. The traps were glass microscope slides (38 × 76 mm) coated on one side with a thin film of insect glue ('Sticktite'). The slides were inserted vertically into the substrate with their long axes parallel to the surface. Using two slides back-to-back animals were trapped on both sides and, after separation, each slide was examined separately at × 50 and the animals identified and counted.

Ten traps of two slides each were inserted in each plot at characteristic and representative micro-sites (Fig. 1). A two-day period was used for each experiment, starting and ending at 1200 h local time (GMT less 3 h), with the traps being changed every four hours. Experiments were conducted at site I from 27 to 29 December 1982, at site II from 28 to 30 January 1983 and at site III from 19 to 21 February 1983.

The trapped animals on the slides were identified and counted for each 4 h trapping period. After each two-day experiment, the substrate (c. 250 cm³ with surface area 100 cm²) around the traps was carefully removed and the arthropods separated from the samples in a portable heat extractor (Usher and Booth, 1984). The arthropod counts were standardized to the number of individuals per 100 cm³ of sample material for comparison.

Micro-arthropod activity is expressed (1) as the number of individuals caught per 4-h interval and (2) as the probability of an individual being trapped during that period. The latter was calculated from a summation of all animals extracted and trapped, and assumed no significant immigration/emigration at the micro-site

$$I_{\text{act}} = \frac{n_1}{n_2 - n_3},$$

where I_{act} = index of activity; n_1 = number of individuals trapped in a given 4-h period; n_2 = total number of individuals trapped over 48 h + total number extracted from 250 cm³ substrate at end of the 48-h trapping period; n_3 = cumulative total of individuals trapped in all previous 4-h periods. This index was used if $(n_1 + n_2 + n_3) > 50$, because rare species, of which only a few individuals were trapped and extracted, inflated the index artificially.

Weather data were used from the Signy Island Meteorological Station (SIMS) to relate to the micro-climate measurements at the study plots. The latter consisted of spot temperature measurements using thermistors at various micro-sites (see Figs. 2a, b and c) and an overall measure of atmospheric relative humidity (RH) by means of wet and dry bulb thermometers. The micro-sites were mostly close to the ground surface of each plot, in plants and soil, under rocks, etc. Relative temperatures for each micro-site were derived from a comparison with those measured at 2 cm depth in moss (sites I and III) and in grass (site II), where the majority of micro-arthropods occur (Tilbrook, 1973; Goddard, 1979). Therefore, they are not presented as absolute temperatures but as the difference between the micro-site and that at 2 cm depth in the substrate.

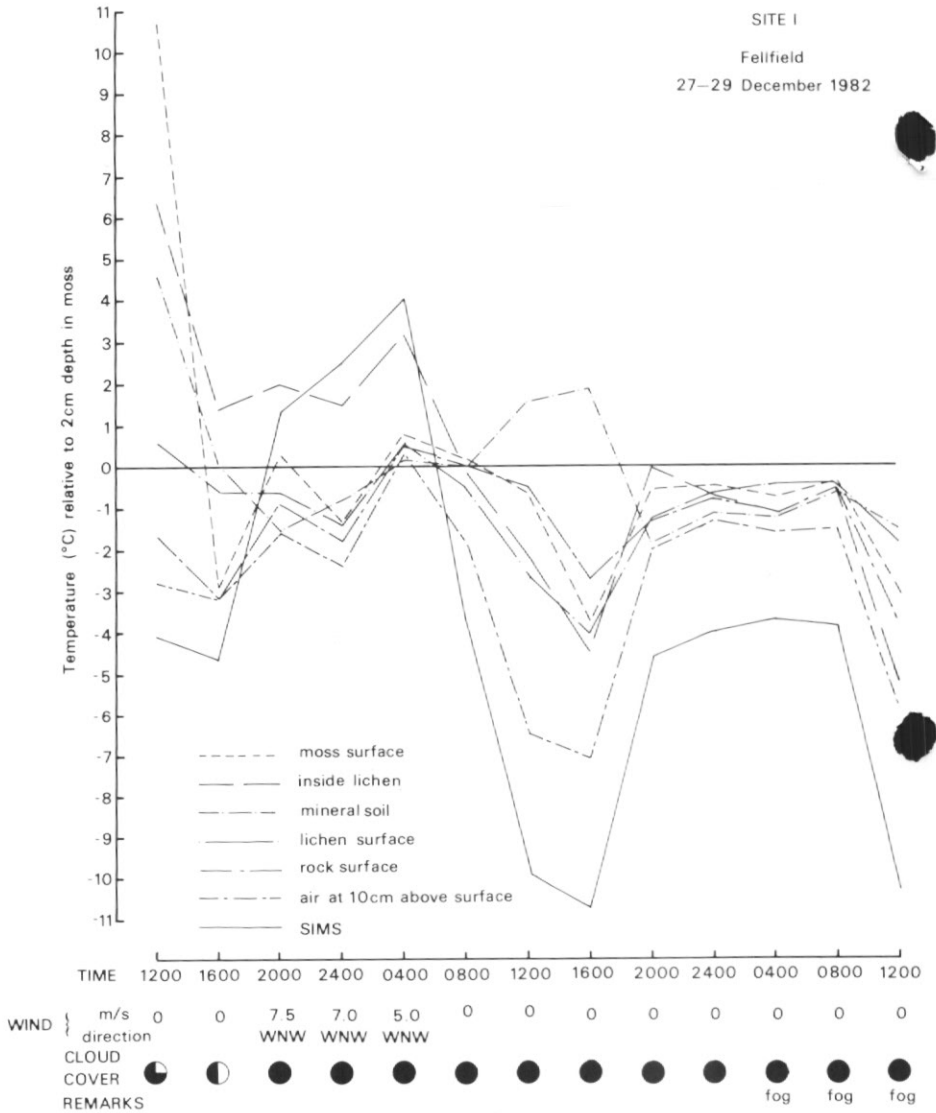


Fig. 2a. Relative temperatures at the fellfield site (site I).

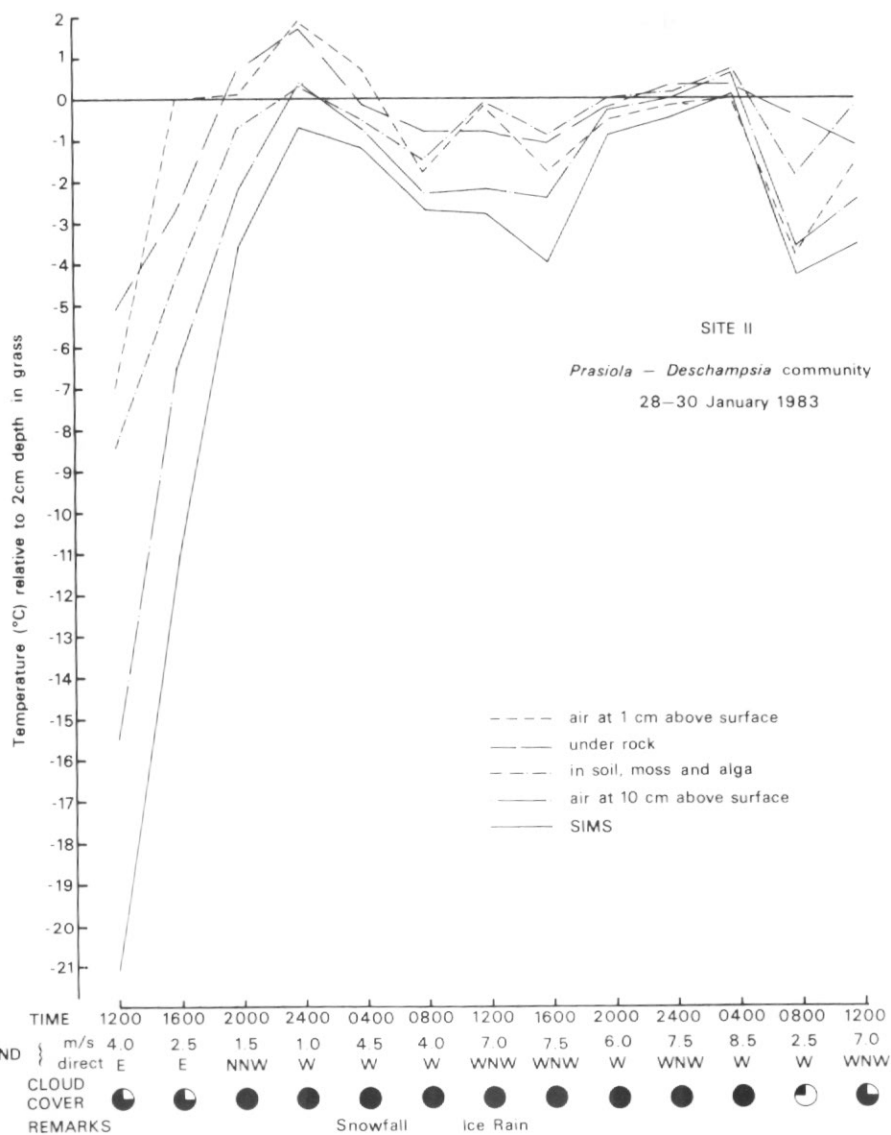


Fig. 2b. Relative temperatures at the *Prasiola-Deschampsia* site (site II).

RESULTS

Habitat micro-climate

There were no large differences between mean (and range) in either air temperature or atmospheric humidity between the study periods (Table I). All the data were typical of a maritime Antarctic summer season. Also, the study sites experienced similar conditions, in general, to those of the Signy Island Meteorological Station which was c. 0.75 km in distance away from them. The dynamics of micro-site temperatures relative to the substrate and to SIMS data are shown in Figs. 2a, b and c. Neither

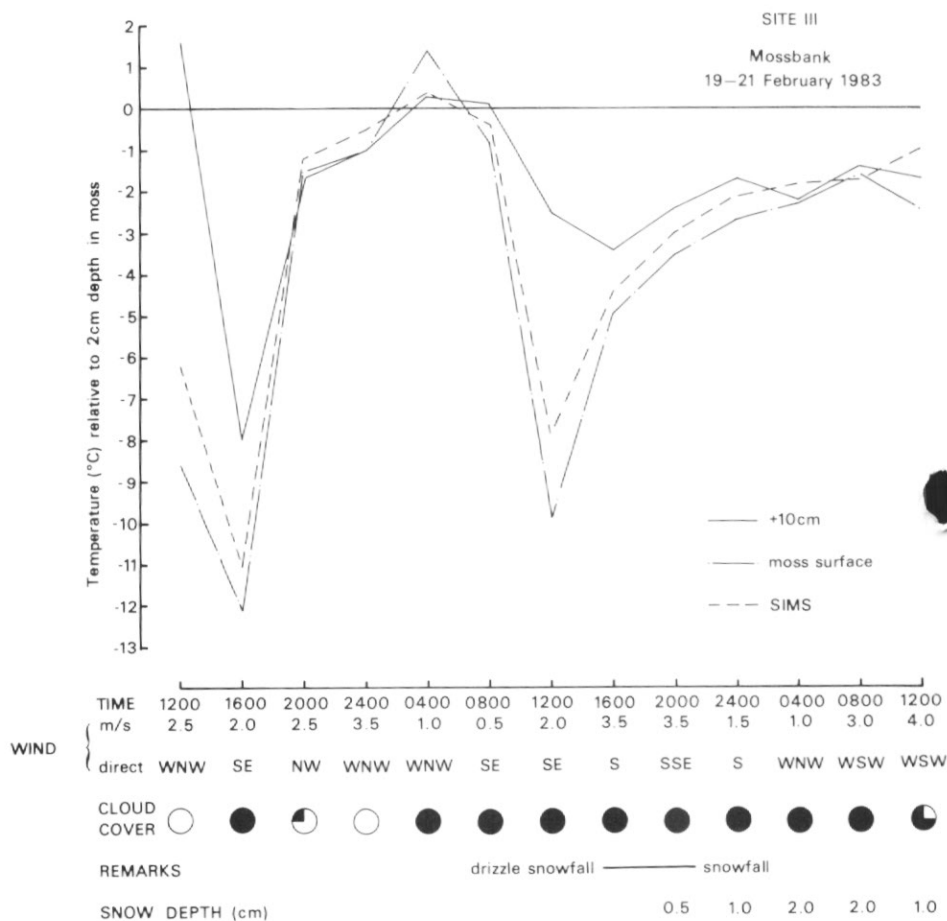


Fig. 2c. Relative temperatures at the mossbank site (site III).

Table I. Comparison of air temperatures and atmospheric humidity for each of the three study sites with SIMS (Signy Island Meteorological Station). All measurements at screen height except air temperatures (at +10 cm above the surface) at the study sites. $n = 13$ in all cases except * where $n = 10$.

Study period	Site	Air temperatures (°C)		Relative humidity (%)	
		mean \pm SD	range	mean \pm SD	range
27-29 December 1982	Fellfield (I)	2.4 \pm 2.9	-2.5 to 6.0	83.1 \pm 9.5	69-95
	SIMS	1.3 \pm 1.7	-1.2 to 4.0	85.3 \pm 7.6	74-94
28-30 January 1983	Prasiola- Deschampsia (II)	2.5 \pm 2.1	-0.5 to 6.4	88.2 \pm 16.6	43-100
	SIMS	1.1 \pm 1.9	-1.0 to 5.3	74.8 \pm 5.2	64-80
19-21 February 1983	Mossbank (III)	0.9 \pm 1.5	-0.7 to 3.6	94.2 \pm 10.8*	66-100
	SIMS	0.3 \pm 1.2	-1.3 to 2.0	84.5 \pm 10.3	66-95

temperature nor RH measured at SIMS showed regular fluctuations during any of the trapping periods. However, the relative temperatures at various micro-sites changed diurnally and the amplitude of individual curves varied. Air temperatures at the fellfield (site I) were between 1.3 and 4.3 deg (10 cm above the ground) and between 3.7 and 10.7 deg (surface) higher than the SIMS data (meteorological screen at 150 cm above ground) (Table I). Wind was associated with a sharp decrease in most surface temperatures (except the rock surfaces as a result of the stored thermal energy). In the fellfield, over the two-day period, most of the micro-sites experienced lower temperatures than in the moss, especially during the second day of recording. Such temperature deficits approached 4 deg inside lichens and 6 deg in mineral soil. Direct radiation induced a strong temperature rise at site II, whereas cloud cover moderated diurnal fluctuations. SIMS data differed greatly from micro-site temperatures when radiation was high and easterly winds occurred (Fig. 2a). Temperature fluctuations in the *Prasiola-Deschampsia* community were fewer and not so pronounced compared with the fellfield (Fig. 2b). The maximum deficit (8 deg) between plant material and 2 cm grass temperature occurred early in the first day of the experiment. Thereafter, micro-site temperatures remained within 1 deg of the substrate temperature. At site II, temperatures followed each other closely but diverged when a thin (2 cm deep) snow cover formed. As above ground and surface temperatures declined, moss temperatures, moderated by snow cover, increased slightly with direct radiation (Fig. 2c). Large fluctuations were observed in mossbank surface temperatures relative to 2 cm depth, which produced large relative temperature deficits.

The micro-climate characteristics of the three sites during the study periods may be summarized as follows: at site I there were large temperature fluctuations and rapid changes, which differed significantly from the general climatic conditions, whereas, at the other two sites, temperature fluctuations were closely related to the general weather, and the rate of thermal change in these habitats was slow compared to the fellfield. In particular, wind affected the thermal characteristics of the fellfield site more than the other two sites. Atmospheric RH showed no diurnal patterns or regular changes at any of the study sites but was strongly influenced by both wind speed and cloud cover. A range of 66–100% RH was recorded.

Species composition and abundance

Six micro-arthropod species occurred on the traps and were also extracted from the habitat samples in sufficient numbers for analysis. Other species, namely small prostigmatid mites, were extracted but did not occur on the traps. This may be due to their deeper distribution in the substrate and their low level of surface activity. Therefore, only the abundant species are discussed further.

Micro-arthropod abundance (estimated from substrate sampling) was highest at site II (*Prasiola-Deschampsia*) and lowest at site I (fellfield) (Fig. 3). In the fellfield material, no arthropods were found from extraction of the four *Usnea fasciata* samples but they occurred in all the *Andreaea* spp. samples. The soil and stone samples also contained micro-arthropods. Four species were found (in order of abundance) in the fellfield materials: *Parisetoma octooculata*, *Cryptopygus antarcticus* (Collembola), *Stereotydeus villosus* and *Gamasellus racovitzi* (Acari). More than 90% of the Collembola were adults, only a few immature individuals being found.

These four species were extracted also from site II samples, but only a single individual of *S. villosus* was recorded. In addition, *Alaskozetes antarcticus* and small numbers of *Halozetes belgicae* (4), *Friesea woyciechowski* (3) and prostigmatid mites (3) occurred. Here, *Cryptopygus* was most abundant, followed by *Parisetoma*,

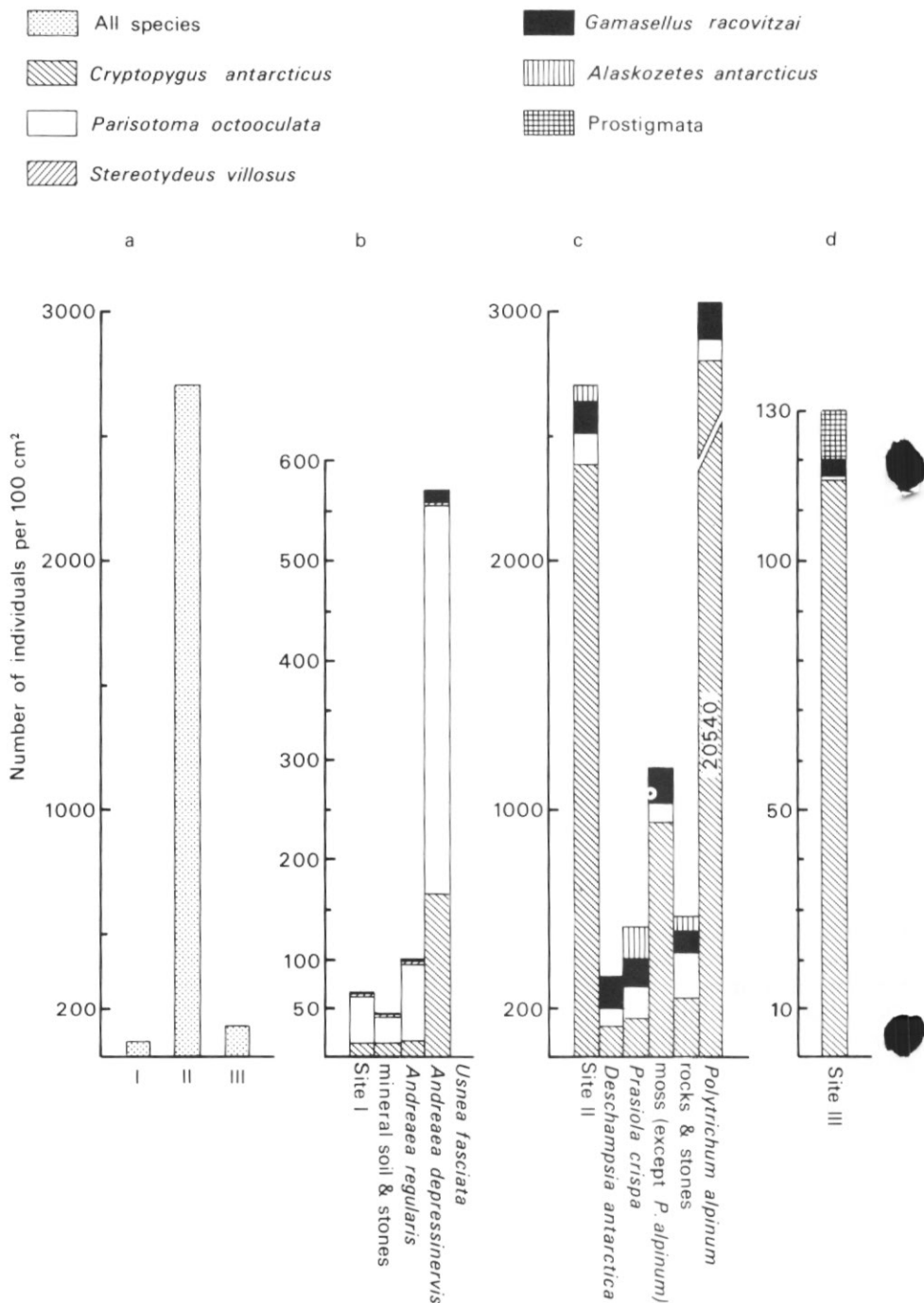


Fig. 3. Micro-arthropod abundance estimated from substrate samples at the three activity study sites: (a) total numbers of individuals of all species per 100 cm² substrate at each site (b, c, d) abundance of individual species at sites I(b), II(c) and III(d) according to micro-sites within each. It should be noted that although the vertical scales are different, the data are standardized to 100 cm² of substrate.

Gamasellus and *Alaskozetes*. The Collembola and *Gamasellus* were distributed abundantly over the whole site, but *Alaskozetes* occurred almost exclusively in *Prasiola* on the frost-heaved stones and on the undersides of rocks. Immature stages of the four most abundant species occurred in greater numbers than adults. Of the total of 47 600 *Cryptopygus* extracted, only c. 4% were adults on the basis of size (Block and Tilbrook, 1975). This was caused by a large aggregation of immature individuals in the *P. alpestre* sample, which accounted for 96% of all immatures at this site. Excluding these, adults made up 31% of the total for this species. The proportion of adult *Parisotoma* was estimated at 27%, 31% for *Alaskozetes* and 7% for *Gamasellus*.

At the comparatively homogeneous mossbank (site III), 89% of all extracted arthropods were *Cryptopygus* (of these 16% were adults). Here prostigmatid mites occurred in the greatest numbers (206 individuals) for the three sites, followed by *Gamasellus* (10 adult, 47 immature), *Parisotoma* (3 adult, 12 immature), *Stereotydeus* (4), *Halozetes* (1), *Friesea* (1) and one *Alaskozetes* larva.

Activity

Total activity i.e. individuals trapped on each plot during each 4-h trapping period, is compared in Fig. 4. As the activity expressed in this way is related to species' abundance, an index (I_{act}), which is corrected for abundance, was used (Fig. 5). The data of the four abundant species for each site are presented using the measure of total activity obtained and the calculated activity index.

Except for single individuals of *Stereotydeus* and *Parisotoma* only *Cryptopygus* was trapped in the fellfield (site I). Activity increased after midnight reaching a peak between 0400 and 0800 h in the morning, and decreased again to a minimum towards midnight (Figs. 4 and 5). Most animals were caught on traps in the frost-heaved stones on mineral soil and in the *Andreaea* spp. mosses. However, although no animals were extracted from *Usnea*, some *Cryptopygus* were found on the traps in this lichen (Fig. 4).

Total activity at site II (*Prasiola-Deschampsia*) differed for the various species. For the Collembola (*Cryptopygus* and *Parisotoma*), it was relatively even over time with a peak, however, in *Polytrichum* where the large aggregation of *Cryptopygus* was found. The main characteristics of the activity pattern of *Cryptopygus* and *Parisotoma* were the divergent activity index curves (Fig. 5). Throughout the observation period *Parisotoma* showed high activity when *Cryptopygus* showed low activity, but a regression of their activity indices on each other was not significant. *Halozetes* and *Stereotydeus* were only active during daytime. *Gamasellus* was least active in *Polytrichum*, whereas *Alaskozetes* was active mainly in *Prasiola* on frost-heaved stones and under rocks.

At site III (mossbank), the activity index of *Cryptopygus* declined steadily throughout the two day period (Fig. 5) in conjunction with a decline in the numbers trapped (Fig. 4). Few other species occurred on traps at this site.

DISCUSSION

The three study sites had different micro-climate characteristics, although they experienced similar climatic conditions during the three separate study periods (Table I). Of the three sites the fellfield habitat experienced the greatest variability and the widest extremes of temperature. Here, micro-arthropods were not abundant and their activity (mainly *Cryptopygus*) was confined to a few micro-sites within the community. The *Prasiola-Deschampsia* site experienced more moderate temperatures during the

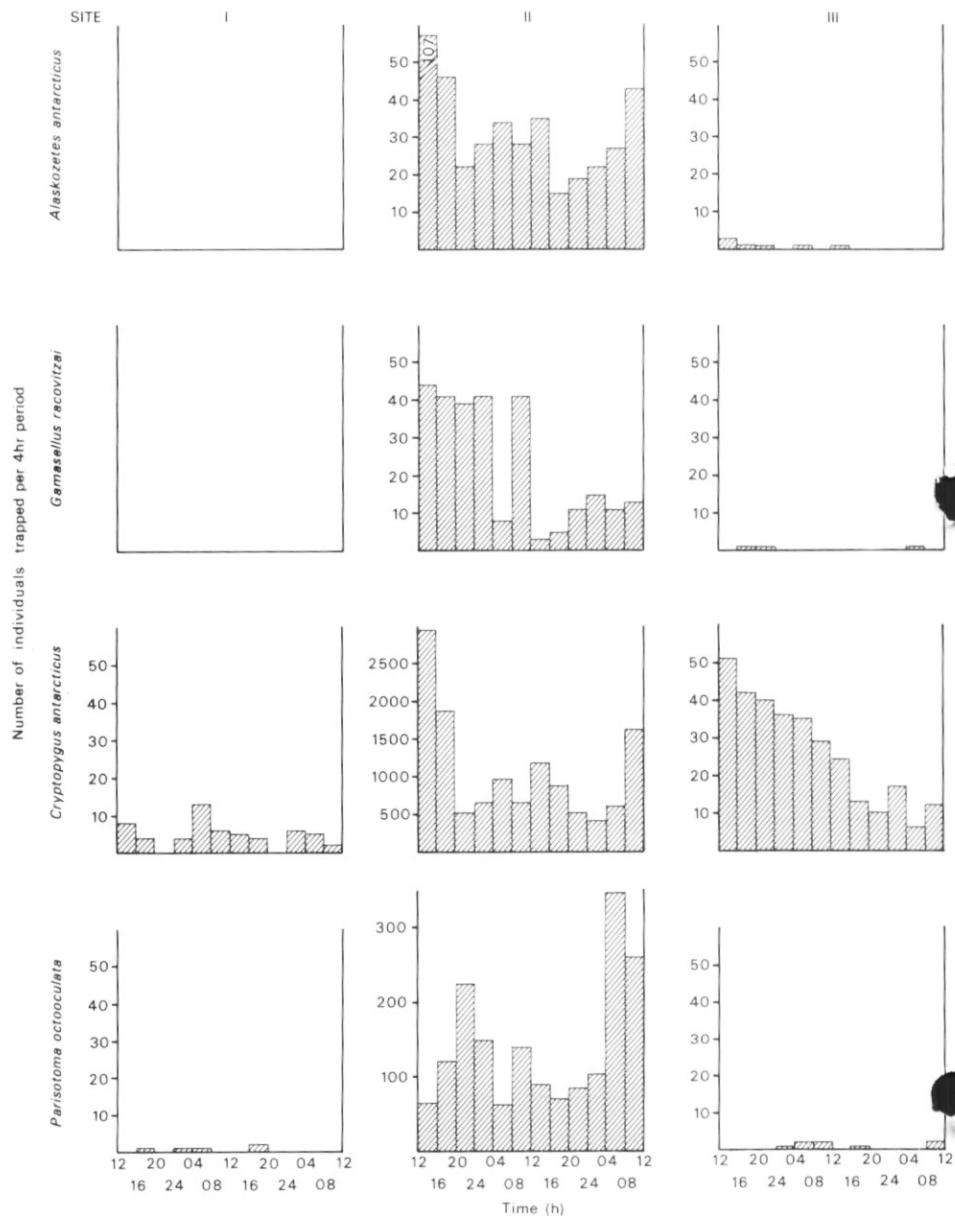


Fig. 4. Activity of six micro-arthropod species at the three sites in terms of numbers of individuals trapped per 4-h periods. The scales for the two species of Collembola at site II are different from the remainder.

study, and its habitat structure was substantially diverse. This resulted in high arthropod abundance (the highest of the three sites), increased species diversity and a high level of surface activity when environmental conditions allowed. At the mossbank site, only *Cryptopygus* was abundant and showed declining numbers trapped (and hence reduced activity) during the two-day study. This may have

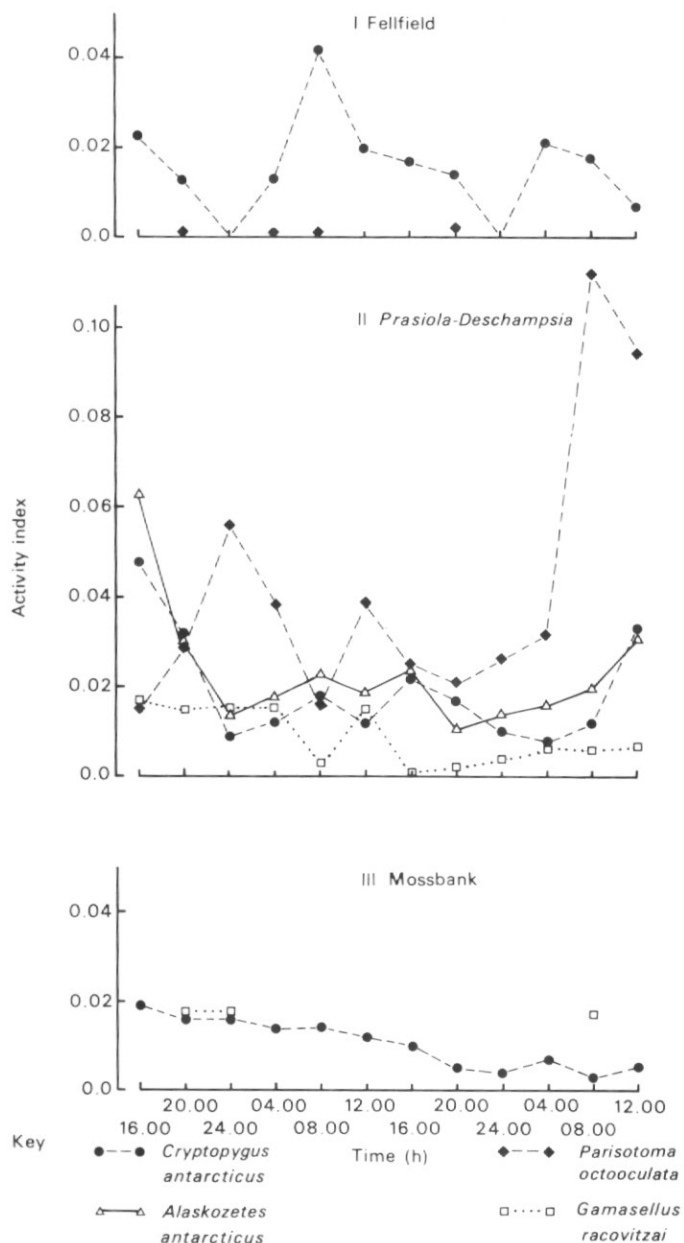


Fig. 5. Activity indices of the four abundant micro-arthropods at the three study sites over two days. See text for details.

reflected the technique of removal trapping. The single-species dominance at this site probably reflects the homogeneous nature of the habitat compared to the other two sites.

Notwithstanding the short sampling period (two days for each site) used in this study, the results make it possible to suggest a relationship between arthropod activity

and air temperature at the ground surface in the habitats studied. In terms of total numbers of arthropods trapped per 4 h, only the mossbank (site III) showed a significant ($P < 0.05$) regression on temperature: y (arthropod number) = $23.2 + 6.6x$ (mean air temperature). For the most abundant species, *Cryptopygus antarcticus*, a between-site comparison shows an increasing dependence of its activity index on mean temperature with the sites ranked as follows: fellfield (N.S.), *Prasiola-Deschampsia* ($P < 0.05$), mossbank ($P < 0.01$). A similar ranking is obtained when the number of *Cryptopygus* trapped per 4 h is analysed with respect to temperature. These relationships suggest that temperature is more limiting to arthropods inhabiting a mossbank (in terms of influencing their surface activity) than those of a fellfield habitat. In the mixed habitat of site II (*Prasiola-Deschampsia*), the numbers of individuals trapped per 4 h and the derived indices of activity of both *Cryptopygus* and *Alaskozetes* were significantly related to surface temperature ($P < 0.05$ in all cases). Clearly, such temperature-dependent activity will affect species differently according to their physiological and ecological requirements.

The data reported here suggest that, in addition to large-scale weather and climatic conditions, the structure of Antarctic terrestrial habitats influences micro-arthropod activity by providing a variety of micro-sites in which the micro-climate is buffered to a greater or lesser degree. Therefore, a habitat comprising a series of micro-sites with contrasting properties will afford a greater potential for both individual and species survival than a more homogeneous one with fewer micro-sites. The present data are for summer conditions and in winter the observed differences in temperature, especially between the fellfield and the other two sites, may disappear with the establishment of a snow cover. Temperature fluctuations will be reduced even under a shallow snow layer (Walton, 1982), and the micro-climate considerably moderated. It would appear that winter activity of micro-arthropods would be possible under Signy Island conditions, as their chill-coma temperatures (Schenker, 1984) are lower than soil temperatures over that period (Walton, 1977).

Temperature may be viewed as an ecological resource (Magnuson and others, 1979) in the same way as food. Thus, in polar habitats, heat (or higher temperatures) will be exploited by both invertebrates and plants. Activity of terrestrial micro-arthropods may be classed as thermoregulatory behaviour just as locomotion is used in the search for food. The lower lethal temperatures have been defined for some species (Block and Sømme, 1982; Sømme and Block, 1982), and locomotion ceases at temperatures in the range -4.5 to -8.9°C . Therefore adaptation of locomotory activity to persistently low environmental temperatures is of increasing survival value for such small ectotherms in relation to the demands of their life style. Ecological and physiological differences between predators such as *Gamasellus* and omnivores like *Alaskozetes* are already apparent. In these instances, the resources of temperature (i.e. heat) and food may be of similar survival value.

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