ACTIVITY PATTERNS IN AN ANTARCTIC ARTHROPOD COMMUNITY

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ABSTRACT. The activity patterns of terrestrial arthropods were investigated in a maritime Antarctic community over a 9-day period during March 1980. Only two species were trapped in sufficient numbers to show diurnal patterns of activity, the predatory mite *Gamasellus racovitzai* and the collembolan *Cryptopygus antarcticus*. Whereas *C. antarcticus* showed a peak in activity during the day, and a positive relationship between activity and temperature, *G. racovitzai* had maximum activity around midnight and a negative correlation with temperature over the period of study. Activity of another collembolan, *Parisotoma octooculata*, showed no clear circadian pattern. These observations on field activity are discussed in relation to previous laboratory studies on the effects of temperature on these species. It is suggested that despite overlaps in food selection by the two Collembola, there is unlikely to be temporal separation of activity on the basis of resource partitioning in such Antarctic terrestrial ecosystems. *G. racovitzai*, by being active at night, may exploit the low activity of its principal prey species then and thereby improve its capture efficiency.

INTRODUCTION

Resource partitioning within a community may occur through, for example, different feeding preferences or habitat selection, and also through the temporal separation of activities (e.g. Dennison and Hodkinson, 1983). It has been suggested (Park, 1941) that in a highly evolved community, activity patterns of different species would be regularly distributed over 24 h, whereas an asymmetric distribution of activity periods would be characteristic of a less-evolved community, since competition would not yet have resulted in the maximum partitioning of resources. Terrestrial Antarctic ecosystems are characterized by having a few arthropod species, chiefly Acari and Collembola, often with overlapping spatial distributions and feeding preferences (Burn, 1984*a*, 1986; Usher and Booth, 1984). However, on the basis of food availability, competition for food among primary consumers seems unlikely, although there may be local depletion of resources (Burn, 1984*b*).

In the present study, only one arthropod predator was present (the mesostigmatid mite *Gamasellus racovitzai*), which feeds chiefly on the two dominant Collembola (*Parisotoma octooculata* and *Cryptopygus antarcticus*) approximately in proportion to their relative abundance (Lister, 1984). Separation of the activity periods for Collembola and Acari has been demonstrated in a temperate woodland ecosystem (McClay, 1977), and a knowledge of field activity patterns is clearly an important component in understanding the interactions between arthropods in such systems.

The present study was carried out to determine activity patterns in the field for the most abundant terrestrial arthropods in an ornithogenic site in the maritime Antarctic, and to provide information on the organization of such simple communities as part of a wider study of the feeding interactions between arthropods in a low temperature environment.

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Methods

The study was carried out within a 200-m^2 area in a moss and lichen dominated site ('Factory Bluffs') at Signy Island, South Orkney Islands. The site was enriched by run-off from seabird colonies and had very high densities of both Collembola and Acari (Lister, 1984).

Glass microscope slides, 75 × 22 mm, coated on one side with a polybutene-based sticky material (obtained from Biological Control Systems Ltd, UK), were inserted vertically into slits in the substrate, to a depth of 15–20 mm (maximum densities of most species of Collembola and Acari occurred over that range; Usher and Booth, 1984). Twenty slides were used on each sampling occasion; these were recovered, assessed, and fresh slides were replaced at 4-h intervals over a 216-h period from 17 to 23 March 1980. Local depletion was avoided by using a stratified random technique for positioning the slides: twenty 1-m transects were marked out on the site, one slide was inserted at each transect on each sampling occasion, its position being determined randomly but with no locus being used twice in succession and a minimum of 10 cm between successive loci. The mean number of individuals caught per slide was taken as an index of locomotory activity throughout the 4-h period.

Soil temperatures were recorded at the end of each 4-h period using four thermocouples placed at the soil surface and at 1-cm depth. The mean of these temperatures was used in calculations of activity–temperature relationships.

Results

Three species of Acari and two species of Collembola were trapped during the study. However, the only species trapped in sufficient numbers for analysis of their activity patterns were the collembola *C. antarcticus* and, less frequently, *P. octooculata*, and their predator *G. racovitzai*. Both *C. antarcticus* and *G. racovitzai* showed clear circadian activity patterns during the study, although this was less apparent during a period of snow cover (Fig. 1). The mean daily activity per 4-h

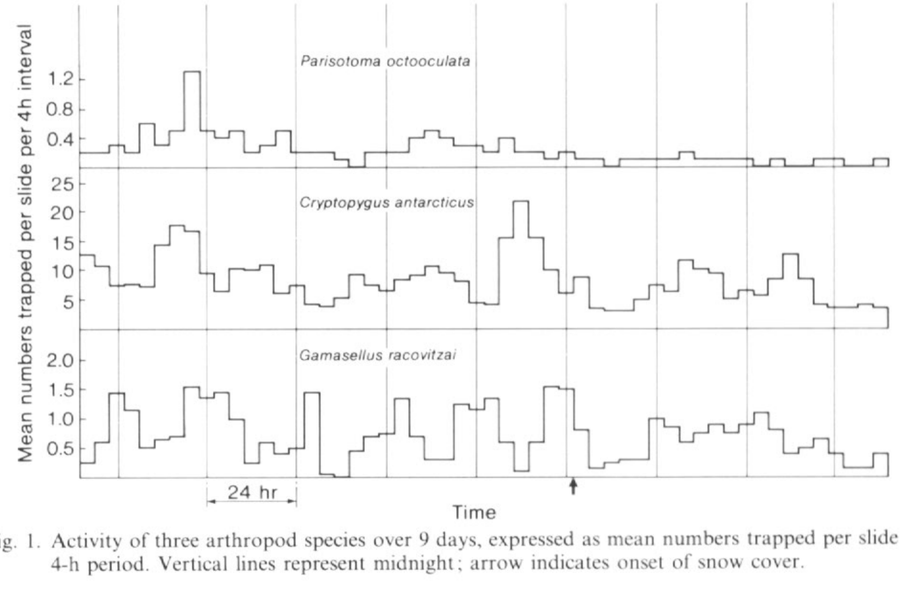

Fig. 1. Activity of three arthropod species over 9 days, expressed as mean numbers trapped per slide per 4-h period. Vertical lines represent midnight; arrow indicates onset of snow cover.

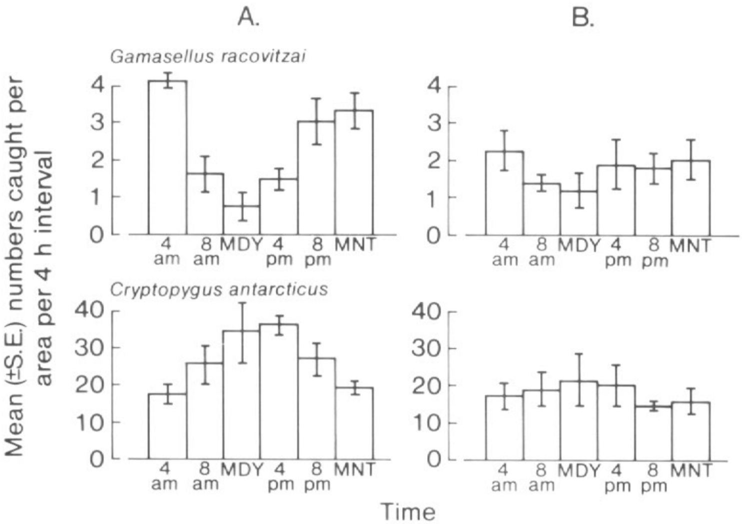

Fig. 2. Overall mean numbers of *G. racovitzai* and *C. antarcticus* trapped per slide per 4-h trapping period (±SE). (A) trapping periods 1–33 (pre-snow cover); (B) trapping periods 34–54 (post-snow cover); MDY, mid-day; MNT, mid-night.

period prior to the snow cover, shows that these species have entirely different circadian patterns, with peak activity of *C. antarcticus* occurring during the day, whereas *G. racovitzai* showed most activity around midnight (Fig. 2).

P. octooculata was not caught in sufficient numbers for clear circadian patterns to be discerned, but its activity appeared to change little throughout a 24-h period. A slight decline in activity was apparent after snow fall (Fig. 1).

The relationship between activity and field temperature during the snow-free period was positive for *C. antarcticus* (regression coefficient ± SE $= 0.93 \pm 0.17$, $t_{31} = 5.42$, $P < 0.001$, $r^2 = 0.49$), whilst *G. racovitzai* showed a weak negative relationship (-0.07 ± 0.025, $t_{31} = -2.79$, $P < 0.01$, $r^2 = 0.20$). Inclusion of data for the period during which the site was under snow cover and at nearly constant 1.5 °C, decreased the regression coefficient for *G. racovitzai* (-0.04 ± 0.02, $t_{51} = -1.91$, NS), but not for *C. antarcticus* (1.01 ± 0.16, $t_{51} = 6.47$, $P < 0.001$), suggesting that periodic activity by *G. racovitzai* was less strongly affected by temperature.

Discussion

During the snow-free period of the study, mean peak diurnal soil surface temperatures ranged between 2.0 and 14.5 °C, and minimum nocturnal temperatures were between 0.4 and 2.5 °C. These values are typical for Signy Island in summer, and although temperatures and therefore activity patterns during autumn and spring are likely to diverge from the pattern shown, the activity shown in this study is probably characteristic for much of the summer period.

C. antarcticus and *G. racovitzai* both show marked periodic activity in the field. *C. antarcticus* is chiefly diurnally active, and such activity is apparently strongly temperature-dependent, in agreement with results for this species over a shorter period from a range of habitats (Schenker and Block, 1986). The field evidence for diurnal activity in *P. octooculata* is less clear. Both *C. antarcticus* and *P. octooculata*

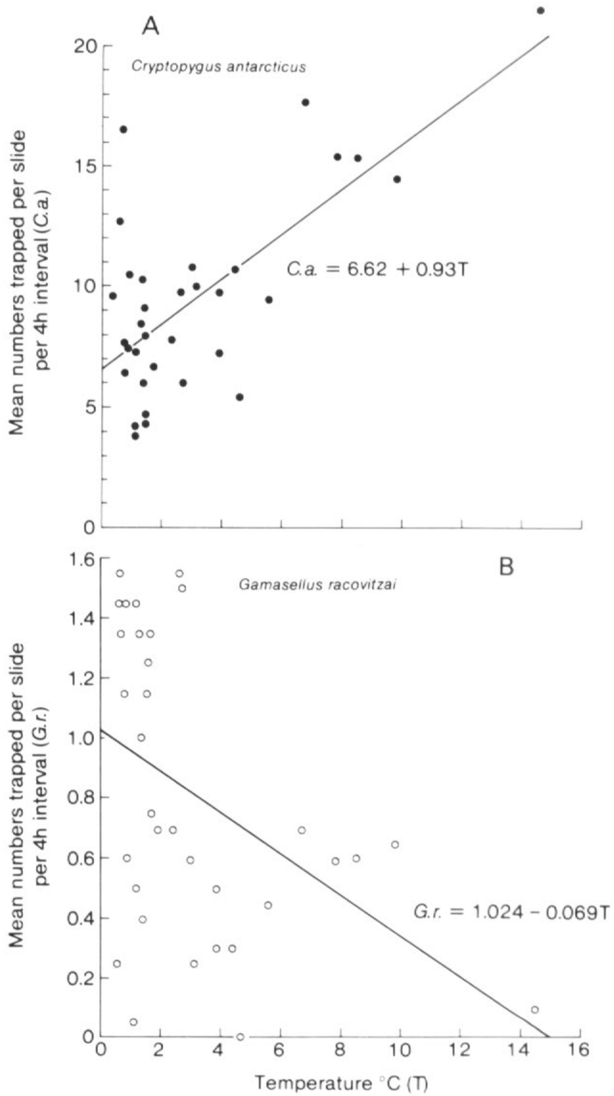

Fig. 3. Relationship between activity and field temperature per 4-h period for (A) *C. antarcticus*, and (B) *G. racovitzai*, both for pre-snowfall observations.

show positive temperature-related activity in the laboratory (Burn, 1984*a*) with lower activity thresholds of −8.3 and −4.8 °C respectively, both lower than the lowest temperatures experienced during the present study. Although these springtails have similar feeding preferences, they probably do not compete for food at this site (Burn, 1984*a*) and therefore partitioning of activity time would not be expected on this basis. The temperature-mediated diurnal activity shown by *C. antarcticus* may allow it to take advantage of higher temperatures and greater radiant energy in an environment with a limited heat budget; absorption of radiant energy may be more important in a dark-pigmented species such as *C. antarcticus* than in the more lightly pigmented *P. octooculata*.

In contrast, *G. racovitzai* shows high levels of activity around midnight, and a negative activity–temperature relationship at field temperatures experienced during this study. Although its lower threshold for activity is similar to that for the two Collembola, in a laboratory study, nocturnal feeding activity at 2–3 °C was greater than diurnal activity at 6–7 °C (Lister, 1984), in agreement with the evidence from this field study. During a period of continuous snow cover and relatively constant temperature (Fig. 1), activity levels remained at a more constant level throughout the 24 h for both *G. racovitzai* and *C. antarcticus* (Fig. 2), suggesting an overriding role of temperature and possibly humidity in maintaining circadian activity. However, the inverse temperature relationship for *G. racovitzai* shown in this study is probably a function of its nocturnal activity, rather than a response to temperature *per se*, as suggested by the poorer fit for the regression including the period under snow cover. Clearly, data on nocturnal activity at higher temperatures are necessary to demonstrate the true upper temperature limits for activity in this species.

The difference in activity patterns between *C. antarcticus* and *G. racovitzai* is similar to that shown for temperate Collembola and Acari in woodland (McClay, 1977). In general, most terrestrial arthropods other than insects are nocturnally active, which is usually attributed to their more permeable cuticle. The differences shown in the present study are probably not related to relative susceptibilities to water loss, however, since *G. racovitzai* is considerably more resistant to desiccation than either *P. octooculata* or *C. antarcticus* at the temperatures normally experienced in summer in the maritime Antarctic (Worland and Block, 1986). Circadian activity peaks of arthropod predators and prey often coincide (e.g. Dondale and others, 1972; McClay, 1977), and where increased prey activity makes it more available to the predator, it is advantageous for the predator to synchronize its activity with that of the prey. The nocturnal activity peak of *G. racovitzai* might imply restrictions on its predatory potential, both by causing asynchronous activity with its prey, and especially when night-time temperatures may be below its activity threshold. However, laboratory observations of *G. racovitzai* feeding behaviour suggest that its capture efficiency is low, even at high prey densities, due to the ease of escape by the Collembola (by 'springing'), and the relatively slow rate of movement of *G. racovitzai* at low ambient temperatures (Lister, 1984; Usher and Bowring, 1984). In fact, nocturnal, low-temperature activity of *G. racovitzai* may assist the capture of the then less-active or mobile springtails and so outweigh the penalty of operating at a lower ambient temperature.

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