

# FEEDING RATES OF THE CRYPTOSTIGMATID MITE *ALASKOZETES ANTARCTICUS* (MICHAEL)

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**ABSTRACT.** Seasonal changes in the feeding activity and diet of *Alaskozetes antarcticus* were investigated at Signy Island during 1979-81, and consumption rates were determined for various instars in the laboratory. Field feeding activity was variable, and declined to negligible levels with the onset of persistent subzero soil temperatures in April. Gut dissections indicated no specialization in food selection, although unicellular algae occurred regularly and were used in laboratory feeding experiments. A radiolabelling and a more direct Coulter-counter method for measuring dry weight consumed gave differing results; reasons for this are discussed. Consumption by *Alaskozetes* ranged from 0.4 to 3.6% of dry body weight per day. An energy budget was derived and, from this, instar durations of greater than one year were predicted. Population energy consumption rates suggested that this species is unlikely to be limited by food availability on Signy Island, even at sites of high population density.

## INTRODUCTION

The role of primary consumers in terrestrial communities in the Antarctic is poorly understood. The contribution of invertebrates, other than Protozoa, to energy flow through moss communities on Signy Island, in the maritime Antarctic, is low relative to their role both in Arctic tundra and in non-tundra communities (Davis, 1981). In Antarctic moss communities, Collembola dominate the group, accounting for 63% of the total metazoan consumption. In other sites on Signy Island, such as communities dominated by algae (*Prasiola*), where the consumption by Collembola may be 7 to 30 times greater than in moss turf (Burn, 1984a), Acari are frequently more abundant, but their role in community energetics is unknown.

*Alaskozetes antarcticus* (Michael) is the largest free-living indigenous arthropod on Signy Island and occurs frequently at high densities, especially in nutrient-enriched sites. It has been described as a detritus-feeding scavenger (Block, 1977), although there are no field studies of its feeding activity and an investigation of its consumption rates (Marsh, 1970) was based on estimates over short periods for adult mites only. In view of the widespread distribution of this species (Goddard, 1979) and its very high densities locally, together with the lack of information on the feeding biology of Antarctic arthropods, especially Acari, the present study was undertaken to assess the contribution of *Alaskozetes* to energy flow in Antarctic terrestrial ecosystems.

Gut content analyses were performed to determine suitable substrates for subsequent long-term constant-temperature feeding experiments and to monitor changes in feeding activity in the field during summer. Consumption rates were measured for three instars, and individual energy budgets were calculated together with estimates of annual population consumption rates in the field.

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## METHODS

Field feeding activity was examined by means of gut dissections of adult *Alaskozetes* collected from two field sites on Signy Island: a dry moss turf community (SIRS I) and a wet moss carpet community (SIRS II), described by Tilbrook (1973). Although neither site provided optimal conditions for *Alaskozetes*, which was found in low numbers at both, these sites were used as part of a wider community energetics study to which the present investigation contributed. Approximately 20–50 individuals of both sexes were collected on 6–9 occasions from each site throughout the summers of 1979–80 and 1980–81. Field feeding activity was measured by the proportion of individuals with food boli present in their guts, whilst food boli from 30 individuals from each site were periodically examined at  $\times 400$  magnification. Identifiable food remains were classified and their frequency of occurrence in the guts determined.

Unicellular algae occurred frequently in the guts of individuals from both sites and so cultures of the widespread unicellular alga, *Monodus subterraneus* (Peterson) (supplied by the NERC Culture Centre of Algae and Protozoa, Cambridge) were used in all subsequent laboratory feeding experiments to determine consumption rates. Rates of faecal pellet production were determined at 5 and 10°C for 15 individuals of all immature instars except larvae, held individually in tubes (40  $\times$  9 mm) half filled with moist plaster of Paris. Each individual was provided with a layer of *M. subterraneus* on a millipore filter disc (Burn, 1984b), which was replaced every 2–3 weeks, when faecal pellets were counted. Observations continued for 16 weeks at 5°C, and for 8 weeks at 10°C.

Two complementary methods – a radiolabelling and a Coulter-counter technique – were used to determine the equivalent dry weight of alga consumed per faecal pellet produced over a 24-h feeding period at 5°C. This was used, together with the rate of faecal pellet production, to derive an estimate of mean daily consumption rate. The radiolabelling technique, using  $^{14}\text{C}$ -labelled *M. subterraneus* presented to individual *Alaskozetes* on millipore filter discs, and the Coulter-counter measurements of algal cell volume removed during a 24-h feeding period, are both described in Burn (1984b). Only a small proportion of individuals produced sufficient faecal pellets over the 24-h experimental period, and successful determinations of feeding rate were made on 3–8 adult males, tritonymphs and deutonymphs using the radiolabelling method, and on 1–12 individual of the same instars using the Coulter-counter method.

## RESULTS

A wide range of food items was identified from gut contents (Fig. 1) and no obvious feeding specialization was apparent, in agreement with the generalist feeding behaviour attributed to this species (Block, 1977). Unicellular algae were present in the guts of individuals from both sites and occurred frequently in those from the moss carpet site, confirming that these algae were suitable for subsequent laboratory feeding experiments.

The proportion of individuals with food present in their guts varied greatly during the summer, from 20 to 80% for both sexes (Fig. 2a and b). Feeding rates declined sharply towards the end of summer, and the number of individual containing food remains in their guts had declined to negligible levels at the onset of persistent subzero soil temperatures in April.

Rates of faecal pellet production in the laboratory were low (Table I) and, in common with the Antarctic collembolan *Cryptopygus antarcticus* Willem feeding on the same material (Burn, 1984b), rates were similar for instars of different ages. As

		moss turf site (SIRS I)		moss carpet (SIRS II)	}
		17 Jan	14 Feb	14 Feb	
FUNGI	melanised hyphae		██████████		50%
	hyaline hyphae		██████████		
	septate spores		██████████		
	aseptate spores		██████████		
	yeast				
ALGAE	diatoms	██████████			
	thallose algae	██████████	██████████		
	filamentous algae		██████████		
	unicellular algae	██████████	██████████	██████████	
	blue-green algae	██████████			
MOSS	living moss		██████████		
	dead moss	██████████	██████████	██████████	
OTHER	microarthropod remains	██████████	██████████		
	mineral particles	██████████	██████████	██████████	
	other identifiable material				

Fig. 1. Trophic spectrum for *Alaskozetes antarcticus* at two sites on Signy Island. The frequency of occurrence of identifiable components in the gut is given (range 0–50% for each food type).

Table I. Mean daily faecal pellet production for *Alaskozetes antarcticus* feeding on the alga *Monodus subterraneus*.

	Mean ( $\pm$ SE) number of faecal pellets produced per day	
	5°C	10°C
Tritonymph	0.40 $\pm$ 0.06	0.36 $\pm$ 0.08
Deutonymph	0.27 $\pm$ 0.025	0.54 $\pm$ 0.09
Protonymph	0.25 $\pm$ 0.05	0.48 $\pm$ 0.24

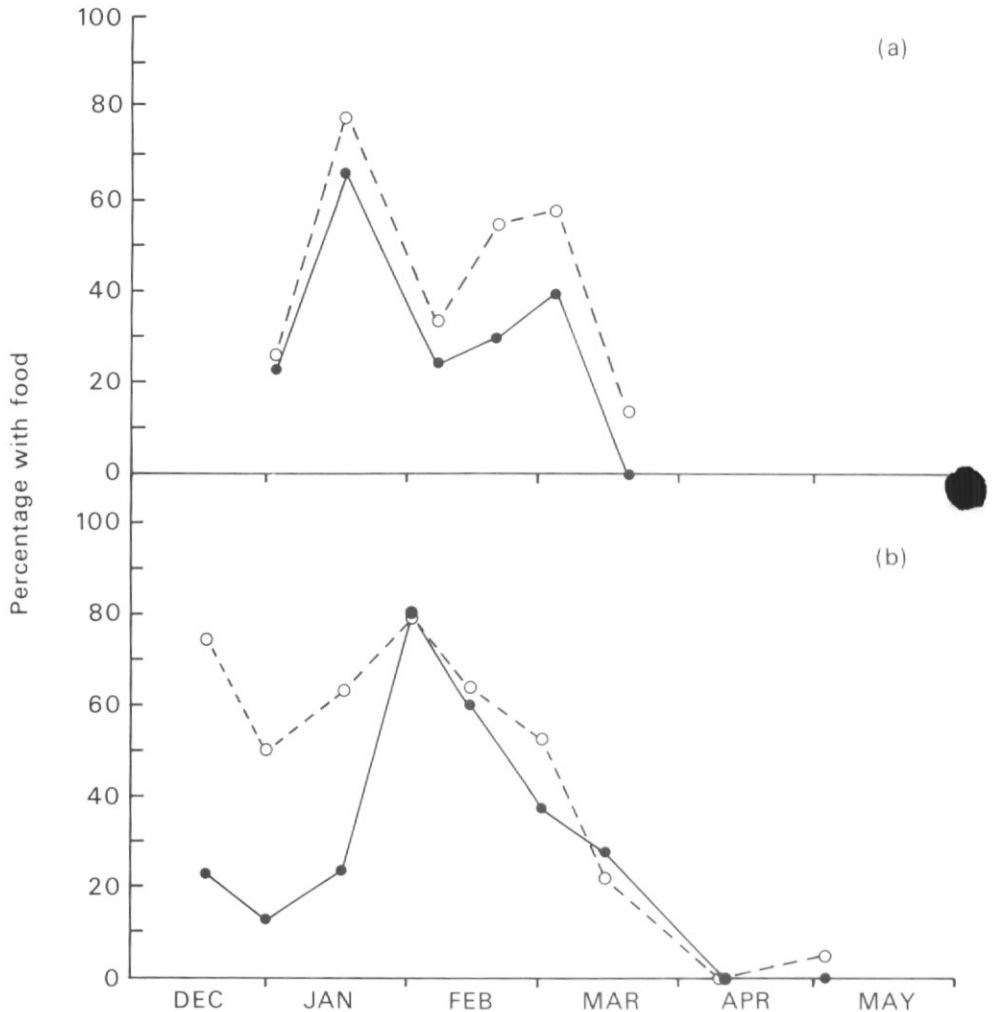


Fig. 2. Changes in percentage of adult *Alaskozetes antarcticus* with food in their guts during (a) the 1979-80 and (b) the 1980-81 austral summers at Signy Island. ○, Female; ●, male.

for *Cryptopygus*, faecal production was not significantly faster at 10 than at 5°C, suggesting also a low optimum temperature for feeding activity by *Alaskozetes*. Therefore, in calculations of daily consumption rate at field temperatures during summer, the mean faecal pellet production at both temperatures was used. No individual underwent a complete moult interval during the entire period of study (approximately 560 day degrees above a threshold of 0°C at both temperatures), so that the variation in faecal pellet production during an intermoult period was not observed. This may have led to an overestimate of faecal pellet production if this species fasts for a period prior to and after moulting.

The results of the two independent methods for determining the dry weight of food consumed per faecal pellet produced are presented in Table II. The radiolabelling method yielded a consumption rate from two to eight times lower than that measured

Table II. Mean dry weight of food consumed per faecal pellet produced for *Alaskozetes antarcticus* feeding on the alga *Monodus subterraneus*.

	Mean ( $\pm$ SE) dry weight ( $\mu$ g) consumed per faecal pellet	
	Radiolabel method	Coulter-counter method
Adult	1.42 $\pm$ 0.27 (n = 8)	3.27 (n = 1)
Tritonymph	0.37 $\pm$ 0.044 (n = 8)	2.66 $\pm$ 0.32 (n = 12)
Deutonymph	0.18 $\pm$ 0.012 (n = 3)	1.46 $\pm$ 0.34 (n = 3)

using the Coulter-counter. Whole body radioactivity counts may have been underestimated due to incomplete maceration and solubilization in scintillation fluid of the heavily sclerotized bodies of *Alaskozetes*. The greater variability of results obtained using the Coulter-counter may have resulted from the larger number of steps involved in this procedure; moreover, the dimensions of faecal pellets appeared more variable in this species than in Antarctic Collembola, for which a similar technique has been used and in which similar values for consumption were obtained from both methods (Burn, 1984b).

#### DISCUSSION

The ingestion rates of temperate oribatid mites, expressed as the percentage of body dry weight consumed per day, range from 1 to 25% (Luxton, 1980). The corresponding values measured for *Alaskozetes* ranged between 0.4 and 1.0% per day (radiolabelling method) and between 2.2 and 3.6% per day (Coulter-counter method), and so consumption by this species is at the lower end of the range determined for temperate oribatids. The dry weight of food consumed per faecal pellet produced for a similarly sized adult temperate oribatid (*Hermannia gibba* (C. L. Koch)), determined using gravimetric techniques, was 1.9–3.92  $\mu$ g (calculated from data in Thomas, 1979), close to that for adult *Alaskozetes*. However, rates of faecal pellet production by *H. gibba* ranged from 0.5 to 2.2 faecal pellets per day over the temperature range 4–15°C, and therefore the low consumption rate by *Alaskozetes* measured in the present study may arise from its slow rate of faecal pellet production. Previous studies of temperate oribatids have usually measured feeding rates on leaf litter or fungal mycelia (Luxton, 1981), whereas in a previous study on an Antarctic microarthropod feeding rates were shown to be 2–7 times faster when feeding was on detritus rather than on an alga (Burn 1984b).

Using the present data on consumption rates and available data on respiration rates at 5°C (Young, 1980), an energy budget for immature stages of *Alaskozetes* can be derived (Table III). Dry weights of algae were converted to energy equivalents using a conversion factor of 16.1 J mg<sup>-1</sup> dry weight for Chlorophyceae (Cummins and Wuychek, 1971), and 0.02 J  $\mu$ l<sup>-1</sup> oxygen consumed in respiration (Block and Tilbrook, 1975). Since no data were available for growth rates of this species, the daily production term (*P*) was derived assuming an assimilation efficiency of 70% (the maximum measured for temperate oribatids feeding on detritus (Luxton, 1980)); the production per moult (*p*) was derived using dry weight data for *Alaskozetes* nymphs (Block, 1977), an estimate for the energy required for oribatid cuticle production (Webb and Elmes, 1972) and a conversion factor of 21.4 J mg<sup>-1</sup> dry body weight for Cryptostigmata (Luxton, 1980).

Table III. An energy budget for the immature stages of *Alaskozetes antarcticus*, assuming assimilation efficiency = 70% and using the Coulter-counter measurement of consumption rate to derive assimilation rate.

	Consumption ( $\mu\text{g d}^{-1}$ )	Consumption $J \text{ d}^{-1} \times 10^{-3}$ (C)	Respiration $J \text{ d}^{-1} \times 10^{-3}$ (R)	Assimilation $J \text{ d}^{-1} \times 10^{-3}$ (A)	Production $J \text{ per moults}$ (p)	Daily Production $J \text{ d}^{-1} \times 10^{-3}$ (P = A - R)	p/P (days)
Tritonymph	0.15-1.03	2.4-16.5	9.6	12.0	0.50	2.4	208
Deutonymph	0.08-0.59	1.3-9.5	4.4	6.7	0.44	2.3	191

Respiration, as a proportion of daily consumption, appears very high -  $R/C = 0.46$  for deutonymphs and 0.58 for tritonymphs, using the Coulter-counter measure of consumption - and exceeds energy consumed determined by radiolabelling. This ratio is much lower for temperate Cryptostigmata (0.14-0.19; Thomas, 1979), and for the Antarctic collembolan *Cryptopygus antarcticus*,  $R/C = 0.04-0.09$  when feeding on detritus and 0.16-0.32 when feeding on algae (Burn, 1984b). This high value for *Alaskozetes* relative to temperate species may be a function of the food chosen for the study.

Assuming maximum values for assimilation rate and for consumption rate, a minimum intermoult duration of 208 days (tritonymph to adult) and 191 days (deutonymph to tritonymph) may be proposed (Table III). At a mean temperature of 5°C, such a development time would require a temperature accumulation of 955-1040 day degrees above a threshold of 0°C. Taking a mean summer soil temperature accumulation of 550 day degrees above a threshold of 0°C on Signy Island (Walton, 1982), these two nymphal instars alone would require 1.7-1.9 years to complete development. Block (1980) has proposed that *Alaskozetes* may complete its life cycle within a minimum of 1.5 years, and the only field data on the life cycle of an Antarctic mite (the mesostigmatid *Gamasellus racovitzae*) (Trouessart) suggests a development time of one year for older instars on Signy Island (Lister, 1984). Further field data are required to confirm whether *Alaskozetes* also has prolonged instar durations as suggested by this energetics study.

Populations of *Alaskozetes* at the moss turf and moss carpet sites were low. However, at fellfield sites on Signy Island populations ranged from 300 to 5000  $\text{m}^{-2}$  and at nutrient-enriched sites may reach 55000  $\text{m}^{-2}$  (Lister, 1984). The proportion of animals in each size class varied annually and from site to site, but a mean of 10 samples from four different fellfield sites gave ratios of adult:tritonymph:deutonymph:protonymph of 0.42:0.27:0.21:0.10 (Lister, 1984). These density and size class data were used, together with the consumption rates (including a single Coulter-counter estimate for protonymph consumption) to calculate the mean annual population consumption rate. Over a summer activity period of 120 days at 5°C with a mean of 50% feeding activity by the population during summer (Fig. 2) the mean annual population consumption rate at fellfield sites was 0.04 (min)-0.59  $\text{g m}^{-2} \text{y}^{-1}$  (max). This is 10-100 times lower than consumption by Collembola at such sites (Burn, 1984b). A maximum estimate for the consumption rate by *Alaskozetes* at locally high population densities in *Prasiola*-dominated sites of 1.86-6.5  $\text{g m}^{-2} \text{y}^{-1}$  was derived, but with an algal standing crop of 100-300  $\text{g m}^{-2}$  at such sites it appears unlikely that *Alaskozetes* populations are limited by food availability there.

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