COLD TOLERANCE OF A CRYPTOSTIGMATID MITE AT SIGNY ISLAND, MARITIME ANTARCTIC

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ABSTRACT. A variety of cold tolerance parameters were examined for a small, relatively scarce cryptostigmatid mite, *Halozetes belgicae*, from summer to winter (1983) at Signy Island. The species exhibited extensive supercooling potential (down to −38°C), in field-fresh and laboratory-acclimated samples. Low-temperature survival, chill-coma and reactivation temperatures were also investigated. Glycerol was the most abundant polyol (to *c.* 9% of fresh weight). The ability to survive climatic extremes at Signy Island is not considered to be the factor limiting the abundance of this species.

INTRODUCTION AND METHODS

Halozetes belgicae (Michael) is a small (adult body length < 700 μm), free-living mite, which is relatively uncommon on Signy Island (60° 43′ S, 45° 38′ W), but can be found grazing on crustose lichens, often close to the splash zone (Goddard, 1977). It usually occurs in association with the larger (adult body length *c.* 1 mm), and more abundant cryptostigmatid mite, *Alaskozetes antarcticus* (Michael), but does not form the aggregations that are characteristic of the latter. The aims of this short study were to determine the cold resistance and supercooling capacity of *Halozetes*.

In 1983, regular collections of large numbers of *Alaskozetes* provided a sufficient number of adult *Halozetes* for cold-tolerance studies. Samples of mites were collected from beneath rocks and stones (quartz mica-schist) near a moss-dominated site close to a penguin rookery, located on Gourlay Peninsula. On five occasions, ranging from summer to winter, samples were obtained for supercooling point determinations (carried out within 24 h of field collection). Supercooling points were measured using the method of Block and Sømme (1982) with a cooling rate of *c.* 1 deg min^{-1}. To investigate *Halozetes* survival at a constant sub-zero temperature, a standard regime (14 d at −15°C) was used. Mites were divided into five batches each of 50 individuals, and these were assessed for mortality after 24 h recovery at 5°C. Samples for polyhydric alcohol/sugar assays were extracted in 70% ethanol, and transported to BAS Headquarters at Cambridge at −20°C, where they were analysed by gas–liquid chromatography (Block and Sømme, 1982). Each of these samples comprised *c.* 40 mites (*c.* 1.5 mg), which were kept at 5°C for 24 h after collection or acclimation, prior to extraction. Chill-coma and reactivation temperatures were determined by the method of Schenker (1984).

The results from this study enable a comparison with *Alaskozetes* (Young and Block, 1980), which is the only other terrestrial cryptostigmatid mite on Signy Island, and with other micro-arthropod species.

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Results and Discussion

Supercooling

The supercooling points for *Halozetes* collected during the austral summer (19 January 1983) (Fig. 1) are bimodally distributed, but this situation gradually changes, such that by mid-winter (13 July 1983), only a single low modal group remains. The terms 'low group' (LG) and 'high group' (HG) in Fig. 1, refer to separate modal groups in the two portions of the supercooling point continuum, divided at −20°C (i.e. LG ⩽ −20°C < HG) (for details see Young and Block, 1980). It is thought that the decay of the high group in *Alaskozetes* is caused mainly by cessation of feeding (Block and others, 1978), whilst the downward shift of the low group is correlated with the accumulation of glycerol (Young and Block, 1980). Thus *Halozetes* may employ a similar bipartite acclimatization strategy. However, the supercooling potential of *Halozetes* adults is slightly greater than that of *Alaskozetes*, the latter achieving a winter minimum low group mean (±SD) supercooling point of −30.2±2.4°C (on 15 August 1983), compared to an equivalent −33.5±2.4°C for *Halozetes* (on 13 July 1983). This *c.* 3 deg difference may be a consequence of a smaller body volume in *Halozetes*, although other studies on this phenomenon show that it does not occur within a species (Cannon, 1983). Between species there are 'innumberable differences in physical and chemical composition', which can complicate comparisons (Salt, 1966).

Halozetes mites collected in summer (25 January 1983) and starved for 10 d at 0°C (Fig. 1), showed a smaller high group than that for a field-fresh sample collected six days previously. This suggests that starvation led to a loss of gut nucleators, as in *Alaskozetes* (Block and others, 1978). In a second acclimation experiment, mites collected in late summer (27 April 1983) were exposed to −15°C for 14 d. The supercooling point distribution that resulted (Fig. 1) was very similar to that of field-fresh mites collected at mid-winter (on 13 July 1983). The single HG supercooling point (at −13.6°C) in this distribution, i.e. above the acclimation temperature, probably resulted from the 24 h recovery period at 5°C. Thus, cold hardening can be induced fairly rapidly by acclimation in the laboratory.

Survival

Field-fresh mites collected on 19 April 1983 and placed directly in a −15°C cabinet had a mean (±SD) survival value of 96.4±4.3% after 14 d. This result, which is slightly better than that predicted from the supercooling point distribution for this sample (Fig. 1), shows that low-group animals are not affected by prolonged exposure to this temperature. A second sample (collected on 27 April 1983), which had a 10 d (pre-treatment) starvation period at 0°C, survived slightly less well: 84.8±4.6%. This may have been due to the pre-treatment causing a loss of cold hardiness relative to the field situation, where sub-zero temperatures would be expected to exert greater cold-hardening effects, even at this time of the year.

Chill-coma and reactivation

The mean (±SD) chill-coma (or immobilisation) temperature for field-fresh *Halozetes* mites was −5.2±0.9°C ($n = 25$), whilst the mean (±SD) reactivation temperature for the same batch was −3.2±1.0°C. When mites were first starved for 20 d at 0°C, the mean chill-coma and reactivation temperatures were −5.1±1.2 and

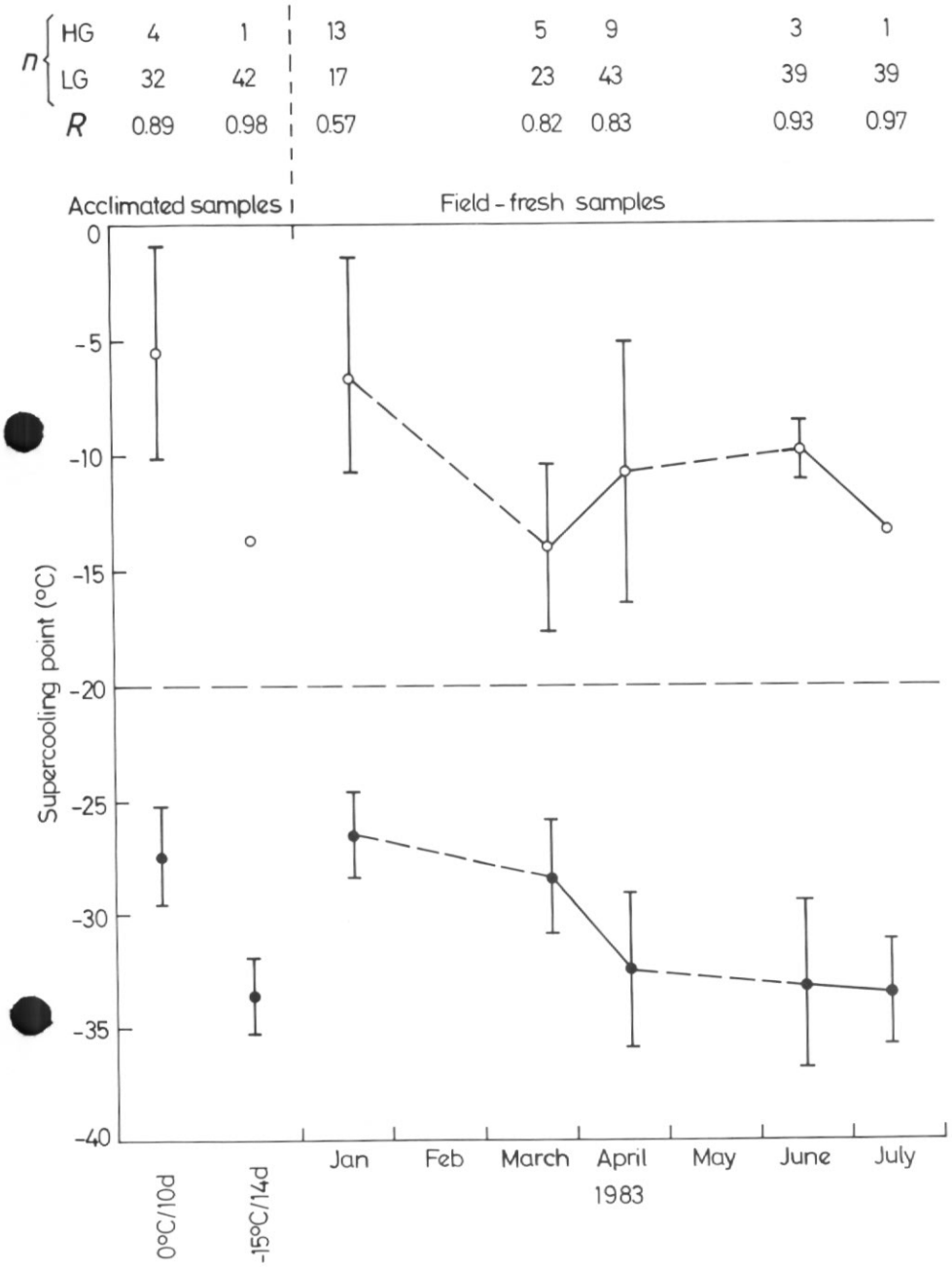

Figure 1. High group (HG, ○) and low group (LG, ●) Mean (±SD) supercooling points of adult *Halozetes belgicae* acclimated at 0 and −15°C (collected on 25 January and 27 April 1983 respectively), compared with data from field specimens collected from January to July 1983. *n*: number of specimens in the HG and LG, R: LG/(HG+LG) ratio.

0.5 ± 2.6°C ($n = 15$), respectively. A third sample was acclimated for 10 d at 5°C and then 10 d at 0°C, resulting in mean chill-coma and reactivation temperatures of -4.7 ± 1.3 and -1.0 ± 3.1°C ($n = 12$), respectively.

The chill-coma temperatures for field-fresh *Halozetes* were generally lower than those for adult *Alaskozetes*, which have chill-coma temperatures of −4.6°C (Block and Sømme, 1982) and −2.8°C (Schenker, 1984). However, environmental conditions in the field prior to collection may affect these temperatures. The difference between chill-coma and reactivation temperatures (hysteresis) for *Halozetes* appears to be slightly greater than that for *Alaskozetes*, for which Schenker (1984) found an average 1.1 deg hysteresis.

Cryoprotectants

For *Halozetes*, the small size and relative paucity of adults in the field restricted the number of samples taken for polyol and sugar analysis to eight. Nevertheless, these were sufficient to show that glycerol is the most abundant polyol in this species, and that substantial concentrations can be built up under both natural and laboratory acclimation conditions (Table I). As in *Alaskozetes* (Block and Sømme, 1982), ribitol was the second most abundant polyol in these samples, although overall it occurred in lower concentrations in *Halozetes*.

Table I. Concentrations of sugars and polyols in samples of adult *Halozetes belgicae* acclimated to various temperatures, and for field animals at Signy Island during February to July 1983. Single samples except for * when $n = 2$.

	Mean (±SD) concentrations (μg mg⁻¹ fresh weight)		
	Glucose	*Ribitol*	*Glycerol*
Field			
5 February*	1.7	1.8	14.7
28 and 30 March	0.3	1.5	30.5
27 April	—	1.0	43.9
13 July	—	1.1	28.9
Acclimation			
0°C/20 d	0.4	1.4	22.8
5°C/10 d, 0°C/10 d	0.6	—	11.3
−5°C/10 d	3.3	4.3	91.9

Only low concentrations of sugars were detected. Glucose was present in most samples, but not in the April and July 1983 field samples (Table I). Small amounts of xylose and fructose, together with traces of sucrose and trehalose, were detected in some samples.

Conclusions

Halozetes is well adapted to survive both the low temperatures and the large annual range (*c.* 62 deg; Block, 1984) likely to be experienced in terrestrial habitats on Signy Island. It is slightly more cold-hardy than *Alaskozetes* (at least during 1983), and the synthesis of relatively large amounts of glycerol (up to *c.* 9% of fresh weight) is probably responsible. It is suggested that factors other than an ability to survive low temperatures may be involved in determining its low abundance relative to *Alaskozetes* at Signy Island.

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