A NOTE ON THE DISTRIBUTION AND ABUNDANCE OF THE ENDEMIC COLLEMBOLAN *GOMPHIOCEPHALUS HODGSONI* CARPENTER 1908 AT CAPE BIRD, ANTARCTICA

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ABSTRACT

In December, 1976, the springtail, *Gomphiocephalus hodgsoni*, was found at densities of up to 4 752 m^{-2} in summer snow-free scoria at Cape Bird, Antarctica. Springtails preferred damp, but not sodden conditions, at or just below the air-soil interface on large semi-buried stones.

INTRODUCTION

During the annual census of Adéle penguin and McCormick skua nests at Cape Bird, Ross Island, Antarctica (77°13'S, 166°26'E), a few days were available in December, 1976, for the author to study the distribution and abundance of the collembolan, *Gomphiocephalus hodgsoni*. This species is found under stones and in patches of moss (*Bryum* sp.) in summer snow-free localities in South Victoria Land and off-shore islands in McMurdo Sound (Janetschek 1967, Wise 1967, Wise 1971).

The aim of this study was to investigate the relationship between the density of the animals and some environmental factors, especially free water. Both Wise *et al.* (1964) and Spain (1971) have emphasized the importance of free water in determining springtail distribution.

Previous workers have disagreed about the number of instars in the life cycle, and the frequency and date of occurrence of the various life stages (egg, juvenile, adult) have also been the subject of disagreement (Janetschek 1967, Smith 1970, Peterson 1971).

The influence of some environmental factors on distribution and activity was investigated by Wise *et al.* (1964), Wise and Shoup (1967) and Wise and Spain (1967) who all used floatation and Berlese funnel extraction, and Peterson (1971) who used hand sorting in his study of the population of *G. hodgsoni* at Cape Bird. Peterson reported much higher densities than did Wise and Spain, and he attributed these to the relatively milder climate at Cape Bird. He questioned the validity of the results presented by Wise *et al.* (1964) and Wise and Spain (1967) on the grounds that the age structure in the samples was far too biased towards the larger individuals to be representative of the population, and that the decline in numbers with time which occurred in their study was the opposite of what he observed, since his study population increased in density throughout the summer as recruitment took place.

METHODS

Preliminary work showed that the animals could be extracted from soil samples by floatation in either fresh or salt water alone since, unlike most other soils, there was very little organic matter present. The animals floated on top of the meniscus where they were quite visible and easily removed using a fine sieve.

A transect was laid out along the floor and up one wall of a small, 2 ha drainage basin, 100 m due east of the Cape Bird hut, at an elevation of about 100 m above sea level, and at right angles to a small melt stream which flowed down the basin from some melting snow at the head of the basin.

The soil along the transect consisted of volcanic scoria with stones and particles ranging in size from approximately 1 m in diameter to dust or mud. Most of the stones, however, had a greatest linear dimension of between 30 mm and 250 mm.

At eight intervals along the transect (for positions see Table 1), a 250 x 250 mm quadrat was laid down and the soil carefully removed using a hand trowel from each of the three depth layers: 0 to 25 mm, 25 to 50 mm and 50 to 150 mm. Then the animals were removed from each layer-sample using melt water. Only a few environmental factors were measured because very little equipment was available. Soil temperature at 15 mm, 35 mm and 100 mm depths in each quadrat was measured with a mercury thermometer. Some indication of the size composition of the stones in each sample was gained by measuring the greatest linear dimension of each of the 10 largest stones in each soil layer of each quadrat sampled. The water content of the soil was measured on samples taken immediately adjacent and uphill to the quadrat; these soil samples were weighed to the nearest 30 g with a spring balance before and after drying (to constant weight) at 20°C in the extremely dry atmosphere of the laboratory.

TABLE 1. THE DENSITY OF *GOMPHIOCEPHALUS HODGSONI* AND VALUES OF SOME ENVIRONMENTAL FACTORS MEASURED IN QUADRATS ALONG A TRANSECT ACROSS A DRAINAGE BASIN AT CAPE BIRD, ANTARCTICA.

Date	Distance from end of transect (m)	Height above reference point (mm)	Mean largest diameter of 10 largest stones (mm) Layer*			Temperature (°C) Layer*			% weight lost on drying Layer*			Air temp. (°C)	Animal Nos. per quadrat (0.0625 m^2) Layer*			Total No. animals (per m^2)
			Upper	Mid	Lower	Upper	Mid	Lower	Upper	Mid	Lower		Upper	Mid	Lower	
15.12.76	11	1517	70	50	62	6.3	4.9	3.5	0	0	0	+0.6	0	0	0	0
14.12.76	6	241	55	42	44	14.3	9.0	4.0	0	4	2	-0.2	1	0	4	80
14.12.76	5	214	51	54	33	12.4	9.0	5.1	1	2	6	-0.2	10	4	3	272
14.12.76	4	77	59	40	73	11.3	9.0	3.8	2	0	7	-0.2	39	8	9	896
14.12.76	3	0	52	49	38	14.0	6.7	4.5	4	5	13	-0.2	149	27	5	2896
15.12.76	2	-17	51	42	45	5.6	8.0	6.1	0	7	8	+0.6	137	13	5	2480
15.12.76	1	+41	60	40	47	3.2	2.0	1.1	8	5	8	+0.6	267	23	7	4752
15.12.76	0	+65	61	46	43	5.9	4.2	3.1		Very wet+		+0.6	82	8	8	1568
Mean			57.2	45.3	48.1	9.13	6.6	3.9	2.14	3.14	6.29		85.63	10.38	5.13	

*Refers to soil depths of 0 to 25 mm (Upper); 25 to 50 mm (Mid); 50 to 150 mm (Lower)

+ These samples were taken in the middle of a small melt stream.

RESULTS AND DISCUSSION

Springtails were extremely abundant in the lower part of the transect (Table 1). The maximum density recorded was 4 752 m^{-2}. They occur in damp, but not saturated, soil. They did not appear to live in dry places, although individuals were found often in very dry situations as a result of wind displacement. For the same reason, a few individuals were found on sea ice and on the ice cap. Springtails were also found in melt streams, having been washed out of the soil by running water. Obviously, they are easily transported, and this probably explains their wide distribution on the shores of the Ross Sea.

The preferred microhabitat is the surface layer (0-25 mm) of the soil (Table 1). During the study period this layer had a much higher temperature than the air or deep soil layer because solar radiation warmed the surface. On a sunny day, the soil temperature at a depth of 15 mm was 15°C higher than the air temperature (Table 2). On a cloudy day, the difference was much less, but even so, the temperatures experienced by springtails must have been much higher than the ambient air temperature. A similar effect has been recorded on Signy Island by Tilbrook (1967).

TABLE 2. AVERAGE OF FOUR SOIL TEMPERATURES (°C) AT EACH OF THREE DEPTHS ON TWO SUCCESSIVE DAYS AT CAPE BIRD, ANTARCTICA.

Depth (mm)	Sunny day (14.12.1976)	Cloudy, overcast day (15.12.1976)
15	13.0	5.3
35	8.4	4.8
100	4.3	3.5
air temperature	-2.0	-0.2

The largest stones were on the surface (Table 1), presumably because the small surface material had been blown away leaving a wind-swept pavement of rocks, some of which were anchored in the soil while others were lying loose on the surface as described by Spain (1971). Most springtails occurred on or under fixed rocks. Only a few were found under loose rocks.

The water content of the soil samples decreased with increasing height above datum, but increased with soil depth (Table 1). Springtail density also decreased with height above datum, but decreased with increasing soil depth. In drier situations however, a higher proportion of the animals were found at the greater depths where soil water content was higher.

Many springtails were found trapped in frozen soil, and when some of this frozen soil (temperature = -5.2°C) was melted by immersion in water the springtails became active within seconds.

TABLE 3. DENSITY OF *G. HODGSONI* UNDER DIFFERENT TYPES OF SUBSTRATE AT CAPE BIRD, ANTARCTICA, DECEMBER, 1976

	Numbers of Collembola per m^2			Total
	Under large stones	In other surface material	Subsurface	
Quadrat 1	2304	1536	352	4192
Quadrat 2	1264	320	160	1744
Quadrat 3	1488	160	272	1920
Mean	1685.33	672.00	261.33	2618.67

To investigate whether or not *G. hodgsoni* had a preference for living under large stones, three quadrats were sampled in the following manner. First, the surface stones (i.e., those with a dry surface or a maximum linear dimension greater than 10 mm) were sampled and the animals floated off; then the other surface material was sampled and the animals resident in this material floated off; finally, the subsurface material down to a depth of 150 mm was processed. Sixty-four percent of the springtails were found under the large surface stones, but a significant proportion (10%) were found well below the surface (Table 3). Direct observation showed that the most densely occupied sites were under large stones, and on large, anchored stones at the soil-air surface or just below this where the animals could be seen clustering in cracks or depressions. By occupying cracks and depressions, the springtails were protected against crushing and abrasion. During the melt, the steeper slopes may slip and flow like a slurry if they become saturated with water, and even where this does not occur frost-heave and winds may cause soil movement and abrasion. The cracks and depressions may also provide areas of higher humidities than occur in the larger soil-air spaces. On fine, warm days, springtails were seen moving over the surface of stones, indicating that cracks and crevices represent refugia and are not occupied continuously.

Gomphiocephalus hodgsoni is unusually flexible for such a heavily sclerotized insect, probably because the unsclerotized sutures are much more extensive than in temperate or tropical springtails. This flexibility appears to enable the animals to squeeze through very narrow cracks and to occupy narrow crevices. In addition, it may increase resistance to freezing damage by enabling the body to conform elastically to the volume changes induced by freezing.

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