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ENTOMOLOGICAL INVESTIGATIONS IN ANTARCTICA, 1962-63 SEASON[1]

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Abstract: Two aspects of Bishop Museum work in Victoria Land and Ross I., Antarctica, during the 1962–63 summer season are reported. A survey extended into a biologically unknown area produced new distribution records for 2 collembolan species and 2 mite species. Regular ecological observations at 4 localities in south Victoria Land are recorded. These relate environmental conditions to diurnal and seasonal activities, distribution, and abundance of a collembolan, *Gomphiocephalus hodgsoni* Carp. Relative abundance and food of insects and mites are also considered.

During the 1962–63 Antarctic summer season Bishop Museum field personnel continued investigations in the Ross Sea area. In early October 1962, Wise and Wilkes joined a New Zealand Antarctic Research Programme motor-toboggan party which travelled north along the south Victoria Land coast. Areas of bare ground investigated included Cape Geology in Granite Harbor which is the type locality for the collembolan species *Gomphiocephalus hodgsoni* Carp. In late November Wise and Fearon began ecological studies at Lake Penny, Lake Péwé, Marble Point and Cape Geology, and these were continued for the remainder of the season by Fearon. From late November to January, Wilkes investigated the McMurdo Sound area for spiders and aquatic mites. J. L. Gressitt worked in the McMurdo Sound area for a short period in January 1963, while J. C. L. M. Mather, who was operating aerial nets on ships, spent one day in February ashore at Cape Hallett searching for spiders and collecting moss and soil samples. Part of the results are recorded in the paper preceding this one, but most of the results for 1962–63 are recorded below in two sections:

I. A survey of Collembola and mites conducted during an expedition in south Victoria Land,

II. Aspects of soil arthropod ecology at four localities in south Victoria Land.

A few determinations have already been noted (Gressitt, Leech & Wise 1963; Womersley & Strandtmann 1963).

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1. Partial results of research on the U. S. Antarctic Research Program (National Science Foundation grant G-23720 to Bishop Museum).

tic Research Programme. We particularly acknowledge assistance and advice given by Drs J. L. Gressitt (project supervisor), R. R. Forster, F. Ugolini and M. E. Pryor. The collection of ecological data followed a pattern designed by Prof Heinz Janetschek during the 1961–62 season in Antarctica. The same methods and similar instruments were used in 1962–63. Dr Elizabeth Flint and Mr J. Allen, Canterbury University, Christchurch, N. Z., have examined soil samples for algae and fungi-bacteria respectively. We wish to thank Ron Hewson and Ray Logie, leaders of the New Zealand dog and motor-toboggan parties and other team members for their interest and cooperation. Messrs Cory-Wright & Salmon Ltd., through their Christchurch Branch, kindly made a Speedy Moisture Tester available for trial in Antarctica. E. Bojarski prepared the line drawings for this paper.

I. A SURVEY OF COLLEMBOLA AND MITES MADE ON AN EXPEDITION IN SOUTH VICTORIA LAND.

Following an arrangement made through the United States Antarctic Research Program and the New Zealand Antarctic Research Programme, two Bishop Museum personnel, Wise and Wilkes, joined a New Zealand motor-toboggan field party at Scott Base in early October 1962. This party comprised of two Polaris motor-toboggans and four men, made a two-day preliminary trip to Cape Evans and back on 13–14 October, then joined the New Zealand Southern Party comprised of two dog-teams and four men. This joint party left Scott Base on 18 October, travelled on the sea-ice along the west coast of Ross I. to Cape Royds (fig 1), across McMurdo Sound to C. Bernacchi, and north along the south Victoria Land coast to the north end of Tripp Bay. It then proceeded north over the Oates Piedmont Glacier, crossed the Mawson Glacier, climbed gradually to the Polar Plateau, turned away from the coast, and finally visited several isolated nunataks, in all covering almost 480 km in six weeks.

The motor-toboggan party detoured into Granite Hbr, the type locality for the collembolan *Gomphiocephalus hodgsoni* Carpenter, 1908 (Hypogastruridae), and later, on the Polar Plateau, the parties split up in order to cover more ground. Wise continued with the motor-toboggans on a southward route while Wilkes accompanied the dog-teams north to Mt Joyce on the south side of the David Glacier.

This expedition provided a means of access to the southern portion of a large area, between Granite Hbr and Cape Hallett (72°18′S, 170°18′E) 480 km further north, which had not previously been investigated for insects and mites.

Wherever possible Wise and Wilkes visited rock outcrops and bare soil areas searching for insects and mites and taking soil samples for faunal extractions in the laboratory. Ecological observations were made, including air and soil temperatures with concurrent wind, sun, and cloud observations. A sample of this information, for the sites found positive for insects and/or mites, is given Tab. 1. It should be remembered that the northward travel and the advance of summer are two factors which contributed to a general rise in temperatures during the journey, but that increases in altitude and distance from the coast were two counteracting factors which applied after the party left the sea-ice. At several places air temperatures, ground temperatures, soil humidities and weather were observed over a 24-hour period.

Insects and/or mites were found at only 11 of the 40 spots investigated (Tab. 1), but

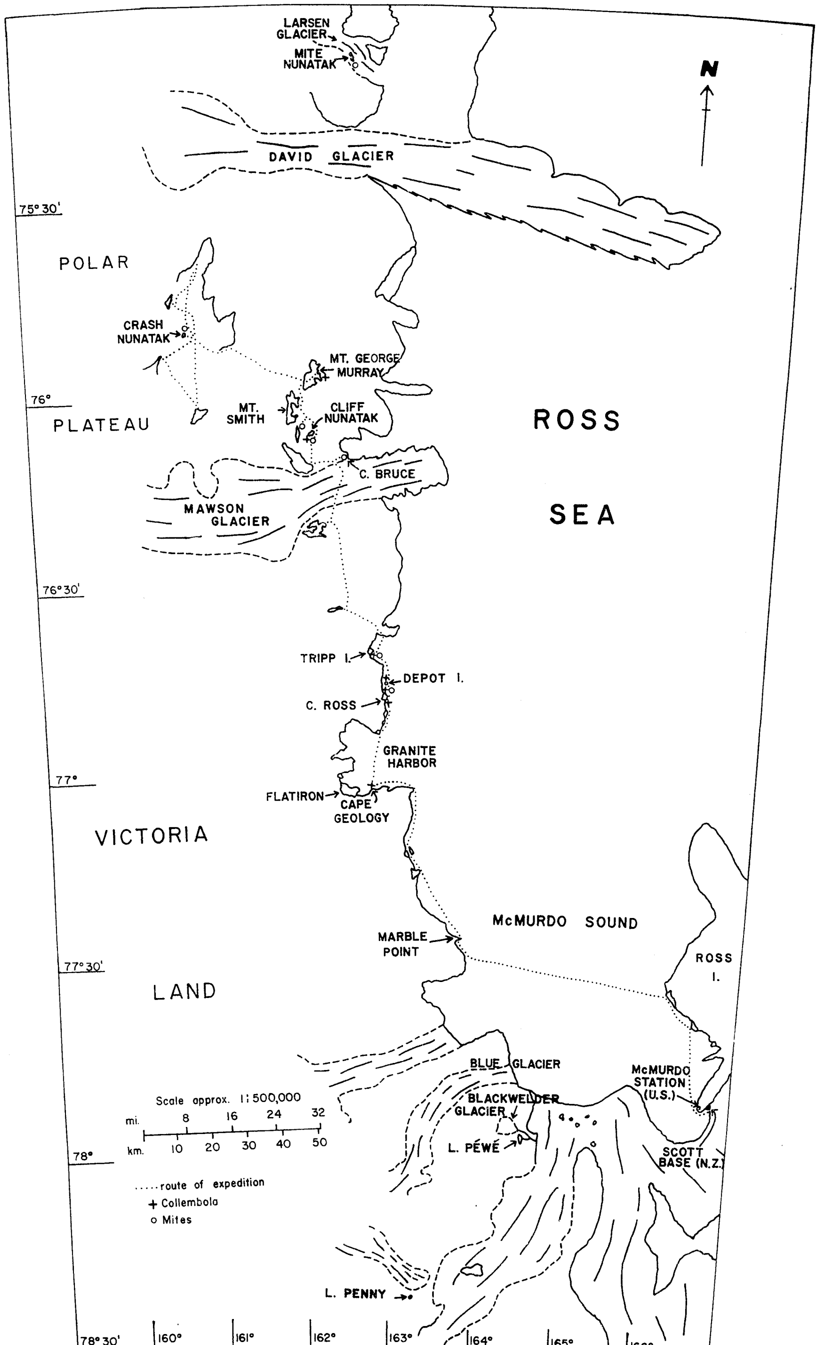


Fig. 1. South Victoria Land Coast and western Ross I. Route of south Victoria Land expedition indicated with collembolan and mite collection sites. Four main observation sites also shown.

Table 1. Results from survey conducted during an expedition in south Victoria Land, Antarctica.

Date	Place	Approx. Alt. (m)	Time (Local)	Cloud Amt./Type	Sun or Shade	Wind Dir. Speed (knots)	Temp. °C. Air	Temp. °C. Soil	Collembola	Mites	Soil Sample Extraction (Berlese fun.)
Oct. 25	Cape Geology	12	1415	——	——	——	-10.5	-8.0	*G. hodgsoni*	Nil	——
27	Cape Ross	21-31	1400	Overcast	Weak sun	N 0-3	-16.5	-16.5	〃	〃	Nil
28	Cape Ross area, North end	46	1030	Cirrus & Stratus	Sun	Variable 0-6	——	-5.5	〃	1 mite	*G. hodgsoni*
28	Depot I.	15	1230	〃	Sun	Nil	——	0.0	〃	Nil	Nil
28	Tripp I.	31	1545	〃	——	S 10	-17.5	-8.5	〃	Nil	mites
Nov. 5	Outcrops nr top C. Bruce	317	2000	Nil	Sun	Nil	-18.5	-14.5	Nil	1 mite	Nil
5	C. Bruce, top	293	2100	〃	Sun	Nil	——	——	〃	mites	〃
8	Cliff nunatak+ (5 km NE of Mt Murray)	180	1230	——	Sun	S 0-1	-8.5	+4.0	〃	1 mite	3 isotomids
9	Ridge SSE of Mt Smith	434	1300	2/10 Cirrus	Sun	——	——	——	〃	1 mite	——
12	Mt George Murray nunatak, E ridge	1161	0835	——	Sun	Nil	-16.5	——	*G. hodgsoni*	Nil	Nil
12	〃 〃	〃	0900	——	Sun	Nil	——	-4.5	〃	〃	——
12	〃 〃	〃	0920	——	Sun	Nil	——	-3.5	Nil	〃	——
12	〃 〃	〃	0935	——	Sun	Nil	——	-2.5	〃	〃	——
12	〃 〃	〃	1030	——	Sun	Nil	-14.5	——	〃	〃	——
12	〃 〃	〃	1730	——	Sun	Nil	-12.5	+6.5	*G. hodgsoni*	Nil	Nil
22	Crash Nunatak⁜ (W of Mt Bowen, 20 km S of Mt Joyce)	1630	1400	——	——	——	ca -16.0	+12.0	Nil	mites	〃

+ Tentative name. Data in field books and specimen labels given in brackets.

⁜ Recent official name approved by New Zealand Geographic Board. Data in field books and specimen labels given in brackets.

the number of occurrences may have been influenced to some extent by the earliness of the season.

Collembola were found in small groups from Cape Geology (Granite Hbr), north to Tripp I, but were presumed to be hibernating as all were inactive with body contracted, slightly curled, with legs and head including antennae tucked underneath. Soil temperatures were below freezing point except at Depot I, where midday temperature was 0.0°C. It was not until Mt George Murray was reached, on 12 November, that active Collembola were found. This was the farthest north occurrence of *G. hodgsoni*, the known range of which is thus extended approximately 112 km farther north.

Collembolan exuviae, which are white and easily seen on the under surfaces of stones, were good indicators of the presence or absence of Collembola. In every case where exuviae were seen, collembolans were found. However, this probably applies only to stone inhabiting species such as *G. hodgsoni.* Although no sign of collembolans was found on a small nunatak north of the Mawson Glacier, three isotomid collembolans were extracted from soil samples. Collembolans were not found on nunataks on the Polar Plateau.

Mites were also found at several places north of Granite Hbr, including one small isolated nunatak on the Polar Plateau. All except one had the appearance of ***Stereotydeus*** species.

Collecting sites are indicated in fig 1 and are discussed below.

Cape Geology, Granite Harbor (77°S, 162°30'E): An observation site (fig 2) was set up on 25 October near a solid rock face on the east side of the Cape, near the spot where Griffith Taylor had collected *Gomphiocephalus hodgsoni*, in November 1911. A few specimens of this species subsequently found on the under-surfaces of stones within 1 m of the rock face, 9–18 m above sea-level appeared to be hibernating. The nearby rock bluff possibly absorbs and retains more heat than the surrounding area. Mites were not found at this time but were collected here later in the season. Mosses are abundant on both Cape Geology and Flatiron in Granite Hbr.

Cape Ross (76°45'S, 162°55'E): Hibernating *G. hodgsoni*, were found under stones in small irregularly placed raised patches of soil amongst boulders on top of the Cape, where there is all around exposure, at 31 m alt.

North end of Cape Ross area (76°44'S, 162°54'E): Bare ground extends from Cape Ross north along the top of the cliffs for about 2 km ending in steep north-facing cliffs. One mite and a few *G. hodgsoni* were collected under stones in soil on the face of these cliffs at a height of 46 m. One springtail was also extracted from a soil sample.

Depot Island (76°43'S, 162°54'E): In a sheltered embayment in the north-facing cliffs (fig 3) several inactive *G. hodgsoni* were found under one stone at 15 m alt. The soil supported growths of moss and algae.

Tripp Island (76°40'S, 162°40'E): Collembola, *G. hodgsoni*, were discovered under stones in soil patches and near soil level in crevices on a low outcrop of solid rock on the top of the southern ridge of Tripp I, alt. 31 m. Mites were collected with the collembolans.

Cape Bruce (76°18'S, 162°25'E): Inactive mites were collected under stones on top of the Cape and on an outcrop overlooking Charcot Bay to the north, the latter site having moss present. Exposure of both sites 180°, height 293 m and 317 m respectively.

'*Cliff Nunatak*' (*5 km NE of Mt Murray*; 76°10′S, 162°E): A small nunatak formed mainly by south-facing rock cliffs in the snow slopes leading down to the north side of the Mawson Glacier (fig 4). There is a narrow strip of bare ground along the top of the cliffs. The western end slopes down with soil and occasional snow patches between boulders. At this point there are mosses growing in soil and much lichen growth on soil and rocks including an abundant large fruticose lichen. At midday, temperatures of the soil (see Tab. 1) and under a stone (+0.8°C.) were above freezing point and the soil in many spots was damp from melt-water (alt. 180 m). One large active mite (*?Coccorhagidia gressitti* Wom. & Str. 1963) was collected but no Collembola or exuviae were seen. However, 3 isotomid collembolans were extracted from soil samples.

Ridge SSE of Mt Smith (76°05′S, 161°52′E): At the foot of this ridge, one inactive mite was collected on an east-facing slope at an altitude of 434 m.

Mt George Murray nunatak (75°55′S, 162°05′E): Several areas of bare ground on this nunatak were investigated. Collembola, *G. hodgsoni*, were found on top of an outcrop situated on one of the eastern ridges. This outcrop, in the form of a pointed knoll, is 35 m high and the top is 1161 m above sea-level. It has a small flat area of soil and stones on top, 6–7 m across, surrounded by boulders so, although having 180° exposure, the soil surface is protected to some degree from winds. Soil temperatures ranged above freezing point, the highest recorded being +6.5°C at 1730 hours. Under one stone, 7×7×4 cm, temperature at 1630 hrs was +4.5°C and at 1800 hrs was +5.0°C. Springtails collected in the morning when temperatures were below freezing point were inactive, but at 1800 hrs a colony of 40 active springtails was found under one stone, 25×15×15 cm in size. No moss was seen on top of the knoll. One snow petrel was discovered sheltering under a boulder, but there was no evidence to suggest that this is a regular roosting or breeding site.

Crash Nunatak (*W of Mt Bowen*; *20 km S of Mt Joyce*; 75°50′S, 160°40′E): This small isolated nunatak, on the edge of the Polar Plateau, is an outcrop of solid rock, 50 m high, 1630 m above sea-level, 64 km from the coast and 10 km distant from other nunataks. It is surrounded by a deep wind-scoop in the snow indicative of strong or continual wind conditions; in fact when the expedition encountered a blizzard in this area, strong southerly winds, funnelling between peaks on the north side of the Mawson Glacier, raised clouds of snow about this nunatak for several hours before blizzard conditions set in over the whole area. When investigated under better conditions, this nunatak was found to have almost vertical walls on the east and west. On the west side a little soil and stones with occasional snow patches were found on narrow ledges (fig 5) and active mites were discovered where soil was damp from snow melt. Mites were also found on the more sloping north end where a 24-hour observation site was set up. Soil temperatures of +12°C. were recorded on two days between 1400 and 1500 hrs.

It is interesting to note that neither mites nor springtails were found on any of the other nunataks and peaks investigated in the same area at the edge of the Polar Plateau. However, the New Zealand Southern Party, which stayed in the field all summer, reported mites on a nunatak (since named Mite Nunatak) at 75°15′S, 162°20′E, on the Larsen Glacier, 96 km NE of Crash Nunatak.

It is suggested that *G. hodgsoni* occurs on any suitable areas of bare ground (bare during the summer) along the south Victoria Land coast between the L. Penny area (fig 6) in the south (see Gressitt, Leech & Wise 1963) and Mt George Murray in the north, from sea-level to 1161 m (on Mt George Murray). The species has previously been recorded on Ross I. (Salmon 1962). *G. hodgsoni* has not been found by Bishop Museum personnel at Cape Hallett or elsewhere in north Victoria Land and M. E. Pryor has kindly confirmed (pers. comm.) that the record of this species at Cape Hallett, in his recent paper (1962), was made in error. One other isotomid collembolan is represented by 3 specimens from Cliff Nunatak.

Mites have not yet been determined but appeared to be all of the same type, *ie* free-living prostigmatic mites, and possibly all of one genus, except for the larger mite taken on Cliff Nunatak, which may represent the southern limit of a northern species (? *Coccorhagidia gressitti* Wom. & Str.). Womersley & Strandtmann (1963) have recorded the free-living prostigmatic mite *Stereotydeus mollis* Wom. & Str. (Penthalodidae) and *Nanorchestes antarcticus* Str. (Pachygnathidae) on Ross I. and in south Victoria Land. Apart from the exception recorded above, mites taken on this expedition were of the obvious red and black kind typical of *S. mollis*.

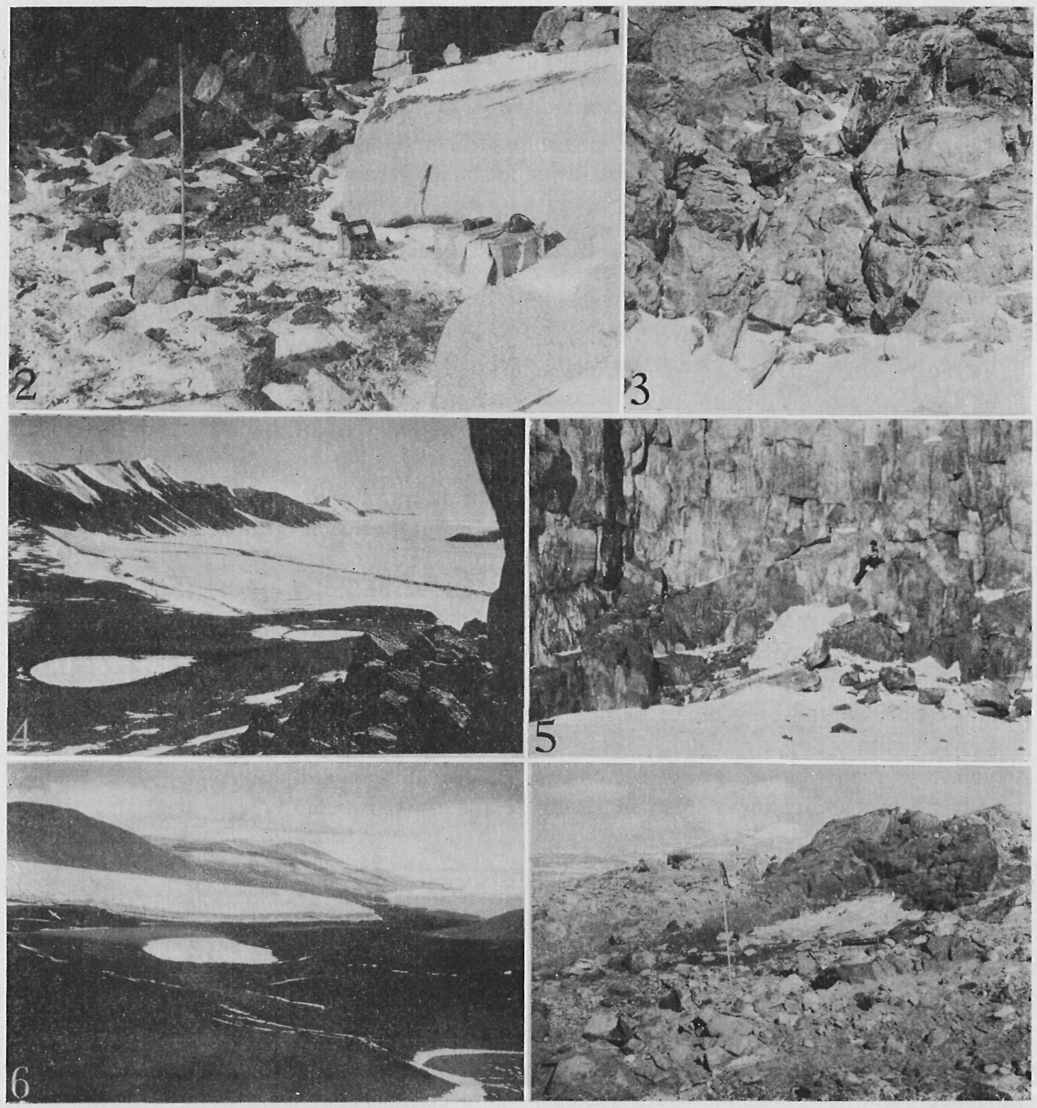
Of particular note was the discontinuous distribution of mites and collembolans. Cliff Nunatak, in the middle of snow-fields, supported a large lichen growth as well as 1 mite species and 1 collembolan species none of which were found elsewhere. Of great contrast was the Mt Murray-Mt Smith range to the west and Cape Bruce on the coast to the east where only a few specimens of a widespread species were seen. Another case was the occurrence of mites on Crash Nunatak while none of the much larger nunataks and peaks north and south of it, at the edge of the Polar Plateau, supported either mites or collembolans. Further, the only report of mites in the area north of Crash Nunatak was again associated with a small nunatak (Mite Nunatak) in the middle of the Larsen Glacier. Although it is realised that further search may change this situation somewhat, it is thought that in all probability these small nunataks do form a particular type of habitat.

II. ASPECTS OF SOIL ARTHROPOD ECOLOGY AT FOUR LOCALITIES IN SOUTH VICTORIA LAND.

In late November 1962 Wise and Fearon chose observation sites and began the regular collection of ecological data which was carried on for the remainder of the season by Fearon, who has also prepared most of the data in this section.

During the 1962–63 summer season an ecological study was made of 4 land arthropod inhabited localities along the south Victoria Land coast. They were each 32–45 km apart and extended from Granite Hbr (77°00′S) to Lake Penny (78°16′S). Longitude of these localities was between 162°30′E and 164°22′E. Microclimatic and meteorological data were recorded hourly for 24 hours at each locality every few weeks. Quadrat and transect work was included in these visits. Soils from each locality were tested for pH, soil moisture, salinity and micro-organisms. Pedological data obtained from other localities during the summer is also presented. Observations and experiments on breeding and feeding of land arthropods were undertaken in the biological laboratory at the U. S. McMurdo Station, McMurdo Sound.

The 4 localities studied are all less than 5.5 km from the McMurdo Sound coastline, and altitude range is 215–594 m. Lakes referred to are permanent ice lakes which melt a



Figs. 2–7. 2, Cape Geology observation site. Foot of rock face in background; 3, Depot I. collecting site (center); 4, Mt Murray-Mt Smith range (foreground and left). 'Cliff Nunatak' in middle distance at right; 5, west wall of Crash Nunatak. Wilkes at collecting site; 6, L. Penny (center) with Walcott Glacier beyond. View from south. Observation site on pale ground area on north side of lake; 7, Marble Pt observation site adjacent to snow patch near top of knoll (Photos by Wise).

little around the edges during summer. The sites are here briefly described:

Lake Penny (400 m; fig 6): The study area is on the north side of the lake, a north-facing slope of 3–5° extending down to the Walcott Glacier 1.6 km to the north. Stones and soil in the area are a mixture of volcanic olivine basalt and undifferentiated moraine.

Lake Péwé (*Lake Rivard*; 594 m): This lake is on a morainic terrace made up of coarse-grained graphite marble, subordinate schist and granite, volcanic and undifferentiated moraine. The site of ecological observations is on the lower eastern side of the lake on a slope, with an inclination of 5° down to the McMurdo coast. This is on the outlet side of the lake, and consequently in terms of drainage corresponds closely to that of the Lake Penny site. The name "Rivard" was misapplied to this lake on a recent geological map and has been used in field notes and specimen labels. The official name is "Péwé." Similarly the adjacent glacier which has previously been recorded as Ricky Glacier is officially named Blackwelder Glacier. Both the lake and the glacier names appear correctly on the New Zealand Dept. of Lands and Survey map NZMS 166 (sheet ST 58–61, 5, 1st Ed. July 1961) (see fig 1).

Marble Point Site (215 m): The study area, a prominent knoll near the base of Marble Point (fig 1), is composed of morainic deposits, gneiss, granodiorite and marble. It lies east of the Wilson Piedmont Glacier face. The observation site was adjacent to a small snow patch near the top of the knoll (fig 7).

Granite Harbor Sites: Observations were made at Cape Geology (3 m) (fig 2) a small rocky outcrop of granodiorite on the south side of the harbor. Later in the season the study area was changed to the Flatiron (182 m). This is a large granodiorite, diorite and granitic moraine covered hill between the New and Mackay glaciers. Both areas project into the harbor, which is covered by sea-ice for most of the year, but was open water in the late summer.

Soil fauna

Only collembolans and mites were studied. The collembolan species was *G. hodgsoni* Carp. The mites *Stereotydeus mollis* Wom. & Str. and *Nanorchestes antarcticus* Str. were discovered at several localities. *S. mollis* occurred at all of the main observation sites and is the species referred to in the following ecological discussions.

Air and soil temperatures and their significance in collembolan ecology

Microhabitat temperatures were recorded every few weeks at each of the 4 localities. Hourly recordings were taken for 24 hours at each visit. The battery-powered telethermometer used for this work had attached to it 6 flexible thermocouple probes, each placed in a different part of the micro-environment. One probe was suspended 1 meter above the ground to record air temperature; 2 were each placed 1 cm deep in the soil some meters apart; 2 were placed under stones and 1 was placed on top of one of these stones to record air temperatures immediately above its surface. Wherever possible, stones bearing collembolans on their under surfaces were used for the measurement of under-stone and above-stone temperatures.

Air temperatures (Tab. 2): Maximum mean values for temperatures recorded 1 m in the air were recorded at all 4 localities during the second week in January. Diurnal maximum values for the season were also recorded during the second week in January, the highest (+10.0 C) being recorded at Lake Penny on 12.I.1963. Lake Penny, the southernmost area of study is also where lowest diurnal minimum temperatures were recorded (–17.9°C). At the same time mean temperatures were also the lowest of all localities

(−13.4°C).

Maximum diurnal air temperatures on calm clear days were generally recorded in the middle of the afternoon, and minimum temperatures usually about one hour before sunrise. Temperatures recorded 1 m in the air showed considerable differences from air temperatures recorded on the same dates at stone surfaces, as may be seen by comparing Table 2 with Table 3. These differences are slight in the case of diurnal minima and means, air

Table 2. Air temperatures at the 4 localities during 24 hour observation periods.

Locality	Date	Maximum	Minimum	Mean
Lake Penny	28.XI.62	−4.0	−8.0	−5.9
	12.I.63	+10.0	−0.5	+2.1
	25.I.63	−5.5	−13.0	−10.5
	20.II.63	−7.0	−17.9	−13.4
Lake Péwé	30.XI.62	−6.0	−11.8	−9.7
	13.I.63	+4.2	−5.0	−0.5
	22.II.63	−6.1	−16.0	−11.5
Marble Point	2.XI.62	−0.8	−8.7	−5.1
	9.I.63	+2.5	−2.0	+0.0
	5.II.63	−0.5	−5.1	−3.3
	23.II.63	−6.0	−13.5	−8.2
Granite Harbor	25.X.62	−9.0	−14.0	−9.7
	7.XII.62	+1.2	−2.7	−0.7
	15.I.63	+0.0	−7.4	+2.6
	2.II.63	+1.0	−9.6	−3.9

Table 3. Air temperatures on surfaces of stones at 4 localities during 24 hour observation periods.

Locality	Date	Maximum	Minimum	Mean
Lake Penny	1.XI.62	−5.0		
	28.XI.62	+1.6	−7.0	−3.2
	12.I.63	+6.7	−0.6	+3.1
	25.I.63	+2.9	−9.9	−5.7
	20.II.63	−2.1	−19.7	−15.0
Lake Péwé	30.XI.62	+0.1	−10.2	−6.7
	13.I.63	+10.5	−3.8	−4.1
	22.II.63	−4.0	−16.9	−10.1
Marble Point	2.XII.62	+5.3	−8.0	−1.0
	9.I.63	+11.0	−1.9	+4.5
	5.II.63	+5.2	−4.0	−0.6
	23.II.63	+1.5	−14.9	−6.4
Granite Harbor	25.X.62	−3.0	−16.7	−10.4
	7.XII.62	+5.0	−1.5	+1.1
	15.I.63	+5.0	−4.1	+0.2
	2.II.63	+6.0	−5.1	+0.7

temperatures at rock surfaces being slightly higher than those 1 m in the air. However diurnal maximum air temperatures at the stone surfaces were, on the average, 5.7° higher than the 1 m air temperatures. In one case this difference reached a maximum of 9.5° (Marble Pt 9.I.1963).

Stone-surface temperatures (Tab. 3): Highest mean rock surface temperatures were calculated from Lake Penny, Lake Péwé, Marble Point data recorded during the second week of January. However at Cape Geology, the highest mean rock-surface temperature during the summer was calculated from readings taken on 7.XII.1962. At this time collembolans were seen actively moving on stone-surfaces. The total period they were seen on top of stones was 6 hours, made up of a continuous 4-hour period, and 2 separate 1-hour periods, out of the total 24 hours observations. The total daily number of hours that stone-surface temperatures were above 0°C at the time was 16, the highest number at that locality for the season. The hours that collembolans were observed on top of stones were also the hours during which stone temperatures were above 0°C. Collembolans disappeared from the top of an observation stone when its surface temperature dropped from 1.9°C to just above freezing point (+0.1°C).

Similar conditions existed at Marble Pt when collembolans were observed actively moving on the upper sides of stones there. This occurred at a time when top-of-stone temperatures were recorded above 0°C for 17 hours out of 24 hours, the greatest proportionate number of hours for the whole season at Marble Point.

Maximum population densities for the season coincided with top-of-stone collembolan activities at both Granite Harbor and Marble Point in early December. It is possible that, with temperatures at which normal activity and feeding took place (above 0°C) the high population density and resultant competition for food and space forced some individuals from the undersides of rocks to their upper sides.

Under-stone temperatures (fig 3): As with air temperatures, maximum under-stone temperatures were recorded during the second week of January at the 4 localities, minimum temperatures being recorded toward the end of February. Collembolans were active under stones when under-stone temperatures exceeded 0°C and inactive at lower temperatures. Hibernation (presumed when collembolans in inactive aggregations) or disappearance (death?) occurred when the maximum diurnal under-stone temperatures did not exceed 0°C. Collembolan hibernation or disappearance could also be correlated with a low soil water content, which will be discussed later.

Soil temperatures: A comparison of Table 4 with Table 5 shows that soil temperatures differed greatly from under-stone temperatures in the following respects:

a) Diurnal maximum temperatures were higher.

b) Diurnal minimum temperatures were lower.

c) Diurnal fluctuations were greater.

These differences in temperature were probably due to the greater volume to surface area ratio of stones than that of soil particles. Soil particles heated more quickly with higher environmental temperatures than did stones, and lost heat more rapidly with lower temperatures. Such temperature differences probably explain in part the extremely infrequent occurrence of collembolans in bare soil and their great abundance under stones. (These collembolan frequencies were found from field observations, and by comparing numbers of

Table 4. Under-stone temperatures.

Locality	Date	Diurnal Maximum temp.	Diurnal Minimum temp.	Mean Diurnal temp.	Hours out of 24 that temps. exceeded 0°C.	Presence of collembolans
Lake Penny	28.XI.62	+4.3	−5.2	−1.6	7	Present
	12.I.63	+7.8	−1.1	+2.9	24	Present
	25.I.63	+2.0	−6.8	−2.6	5	Present
	20.II.63	−7.0	−16.1	−13.1	0	Absent
Lake Péwé	30.XI.62	+1.9	−7.8	−4.2	2	Present
	13.I.63	+11.0	−2.9	+4.1	19	Present
	22.II.63	−6.3	−16.0	−11.3	0	Absent
Marble Point	2.XII.62	+4.7	−4.3	+0.8	18	Present
	9.I.63	+9.9	+1.0	+5.7	24	Present
	5.II.63	+6.8	−1.4	+0.7	15	Present
	23.II.63	−1.0	−12.2	−6.9	0	Hibernating
Granite Harbor	25.X.62	−0.5	−20.3	−11.5	0	Hibernating
	7.XII.62	+9.0	−1.3	+0.3	22	Present
	15.I.63	+7.7	−1.1	+2.8	17	Present
	2.II.63	+7.3	−1.9	+1.8	17	Present

Table 5. Soil temperatures at four localities.

Locality	Date	Diurnal Maximum temp.	Diurnal Minimum temp.	Diurnal Mean temp.
Lake Penny	28.XI.62	+7.1	−6.9	−2.1
	12.I.63	+8.0	−1.2	+3.7
	25.I.63	+4.9	−6.8	−2.6
	20.II.63	−7.0	−17.1	−12.8
Lake Péwé	30.XI.62	+3.5	−8.2	−4.1
	13.I.63	+10.0	−1.6	+3.1
	22.II.63	−3.0	−17.2	−10.5
Marble Point	2.XII.62	+7.2	−5.0	+0.5
	9.I.63	+11.0	−2.2	+5.4
	5.II.63	+7.4	−2.2	+1.1
	23.II.63	+6.0	−15.0	−6.0
Granite Harbor	25.X.62	−2.5	−19.4	−13.3
	7.XII.62	+10.0	−0.5	+2.1
	15.I.63	+8.1	−2.2	+2.7
	2.II.63	+8.2	−3.3	+2.0

collembolans obtained from Berlese funnel processing of soil samples with numbers of collembolans under stones.)

Humidity and soil water

Relative humidity of air in soil: The relative humidity of the soil air was measured by placing a hygrometer 1 cm into the soil. An analysis of the RH values obtained from the fifteen 24-hour observation periods at the 4 localities did not reveal any correlation between the occurrence or non-occurrence of arthropods under adjacent stones and soil RH (Tab. 6). During some 24-hour periods the range of RH values obtained was almost as wide as that obtained at the same locality through the summer.

Table 6. Relative humidity values from 4 localities through the summer.

Locality	Date	Diurnal Maximum RH	Diurnal Minimum RH	Diurnal Mean RH	Collembolans
Lake Penny	28.XI.62	97	57	77.6	Present
	12.I.63	100	25	67.8	Present
	25.I.63	100	31	82.7	Present
	20.II.63	58	31	59.7	Absent
Lake Péwé	30.XI.62	92	54	71.9	Present
	13.I.63	34	24	30.8	Present
	22.II.63	62	19	39.6	Absent
Marble Point	2.XII.62	92	79	87.3	Present
	9.I.63	89	51	70.0	Present
	5.II.63	95.5	78	89.8	Present
	23.II.63	69	40	58.5	Hibernating
Granite Harbor	25.X.62	58.5	47	42.2	Hibernating
	7.XII.62	64	37	51.6	Present
	15.I.63	90	57	90.1	Present
	2.II.63	89	56	86.0	Present

Relative humidity and wind: Throughout the summer, wind velocities during the 24-hour periods of study at each of the 4 localities were recorded on an anemometer 1 m above the ground surface. From these measurements, maximum mean velocity was calculated for each locality (Tab. 7).

Table 7. Maximum mean wind velocities at 4 localities. (XI.1962–II.1963).

Locality	Maximum mean velocity in knots
Lake Penny	17.0
Lake Péwé	15.0
Marble Point	4.5
Granite Harbor	4.5

Table 8. Total wind hours and percentage frequency of wind at 4 localities (XI.1962–II.1963).

Locality	Total Observation Hours	Total Wind Hours	Percentage frequency
Lake Penny	96	64	66.7
Lake Péwé	72	61	85
Marble Point	96	60	62.5
Granite Harbor	96	44	46

The number of hours that winds were recorded and percentage frequency of winds is shown in Tab. 8.

Local topography plays an important role in influencing wind direction recorded at any locality. Wind directions and frequencies are given in Table 9 and it can be seen that, although all sites are on an east-facing coast, the wind direction frequencies vary from place to place.

Table 9. Wind direction and frequency at 4 localities (XI.1962–II.1963.)

Locality	Direction	Frequency (in hours)
Lake Penny	NE	36
	S	21
	N	7
Lake Péwé	S	29
	NE	27
	N	3
	NW	1
	W	1
Marble Point	E	23
	N	22
	NE	13
	S	2
Granite Harbor	NE	20
	N	11
	SW	11
	NW	2

Wind, as illustrated and discussed by Pryor (1962) affects the heatwater balance of the soil and air; relative humidity is decreased and evaporation rate is increased by an increase in wind velocity. However Pryor also recorded great decreases in microclimatic wind velocities between 1 m and 10 cm above ground level; often the wind velocity of the former being as much as three times as great as that of the latter. Consequently it would be of no great value to attempt to express any relationship between the recorded wind at 1 m and relative humidity of the soil air except that a general inverse relationship existed between the two. This inverse relationship no doubt influenced local distribution of arthropods.

From field observations it was found that soil arthropods were absent from areas of constant exposure to wind, *eg* the tops of ridges and mounds. These areas also had low soil moisture content, showing a more obvious relationship to occurrence or non-occurrence of collembolans and mites.

Soil water: There was some evidence of a direct correlation between the presence or absence of soil arthropods and the amount of moisture the top-soil contained. The amount of moisture in the soil was measured by 2 methods:

a) Direct measurement in the field using a patented "speedy" portable moisture tester. A certain quantity of soil was shaken up in a sealed cylinder with calcium carbide, and the resultant pressure of acetylene gas operated a needle on a gauge calibrated in percentage water content.

b) The weighing of 100 grams of wet soil in the laboratory and then reweighing the sample after drying in an oven at 193°C (380°F) for 24 hours.

For soils containing 5% water or more, the results obtained from both methods were comparable, but for percentage values of less than 5% only the results from the second method were used.

Soil samples were taken from 1 m² areas at each locality through the season, and also from other areas at the same locality. All samples were collected during the hours of maximum soil temperatures (1400 hrs ±1 hr). From an increase in percentage moisture content at Marble Point between December and January, there was a sharp decline towards the end of the summer to less than 3%, when the collembolans were aggregated into immobile clusters under the stones (fig 8). This January-February decline also occurred at the 3 other localities reaching values below 2% in late February. No collembolans or mites were

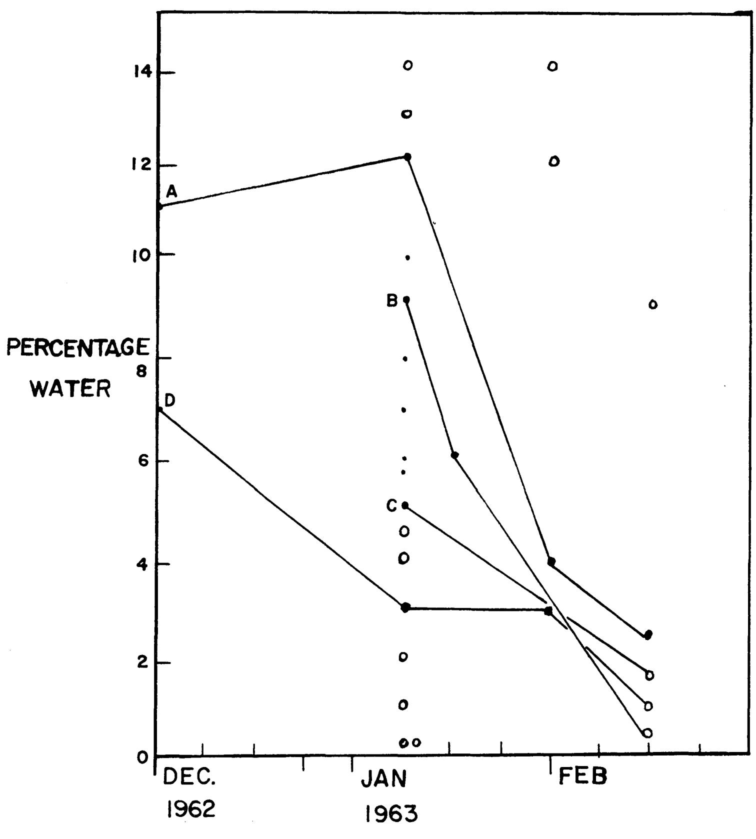


Fig. 8. Graph showing percentage soil moisture content from four localities through 1962/63 season.
A—Marble Point B—Lake Penny C—Lake Péwé
D—Granite Harbor ○—Collembolans absent ●—Collembolans present
(Other points on graph represent results from other microhabitats at each locality).

found at these localities at this time. Likewise when percentage soil moisture values in early December and the second week of January in different areas at each locality were 2% or less, again no arthropods could be found.

Percentage soil moisture values of about 12% appeared to be the upper limit of soil-moisture tolerance for collembolans and mites. The absence of arthropods from areas at localities at times where soil moisture percentages were within the optimum range (4% and 4.5%) is probably due to other factors such as absence of food organisms or high or low salinity, which will be discussed later. Percentage soil moisture results obtained from other localities visited during the summer are presented in Table 10 to further validate the conclusions reached from the 4 intensively studied localities.

Table 10. Percentage soil water at localities in vicinity of McMurdo sound.

Locality	Date	% water	Collembolans present	Mites present
Buddha Lake	22.XII.62	0.0	–	–
Stranded Moraine	11.XII.62	0.0	–	–
Cape Evans	14.XII.62	0.0	–	–
〃 〃	〃	0.0	–	–
〃 〃	〃	0.0	–	–
Buddha Lake	22.XII.62	0.5	–	–
〃 〃	〃	1.0	–	–
Blue Glacier	12.II.63	1.0	–	–
Buddha Lake	22.XII.62	1.1	–	–
Mt Discovery	15.II.63	1.5	–	–
Cape Royds	9.II.63	2.0	–	–
Mt Discovery	15.II.63	3.2	–	–
〃 〃	〃	3.9	–	–
Buddha Lake	22.XII.62	5.25	present	–
〃 〃	〃	5.5	present	–
Cape Royds	9.II.63	5.8	–	present
Cape Evans	30.I.63	6.0	–	present
Blue Glacier	12.II.63	6.0	present	–
Minna Bluff	12.II.63	6.5	–	–
〃 〃	12.II.63	7.7	–	–
Cape Royds	9.II.63	7.9	–	present
Blue Glacier	12.II.63	8.4	present	–
Observation Hill	29.I.63	9.0	–	present
〃 〃	〃	10.0	–	present
Cape Evans	30.I.63	11.0	–	–
Stranded Moraine	11.XII.62	11.6	present	–
〃 〃	〃	12.1	present	–
Observation Hill	29.I.63	12.2	–	–
Stranded Moraine	11.XII.62	13.0	–	–

The presence of water in their microhabitats is a most important environmental requirement of collembolans, whose respiration is cutaneous. Thus the bodies of the animals must have a film of water about them for gaseous exchange to take place. Possibly a soil-water content of less than about 3% is not sufficient for the animals to actively respire, slightly less than 3% contributing towards an inactive state (as at Marble Point), and less than 2% contributing towards death, [at L. Péwé, Flatiron (Granite Hbr) and L. Penny]. Similarly habitats with a soil water content much more than 12% might be unfavorable by inducing death by drowning. This is in contrast to Pryor's (1962) observations of *Isotoma klovstadi* when he frequently found adult and immature collembolans on the surface of stones submerged in water. Experimentally he found that adults of this species after being kept under water for 5 days were quite active when brought to the surface. Possibly this species, living at a lower latitude than the southern Victoria Land collembolans, is more able to withstand periods of immersion.

It was mentioned in a previous section that low under-stone temperatures could be correlated with the disappearance of collembolans from some localities, and their hibernation at others. This would serve to emphasize the complex relationship between living organisms

Table 11. Values for pH obtained from south Victoria Land soils.

Locality	Date	pH	Collembolans present	Mites present
Granite Hbr	2.II.63	6.85	present	–
〃 〃	2.II.63	7.14	–	–
Marble Pt	9.I.63	7.25	present	–
Granite Hbr	2.II.63	7.40	–	–
〃 〃	24.II.63	7.40	present	–
Marble Pt	23.II.63	7.50	present	–
〃 〃	23.II.63	7.70	present	–
Lake Penny	20.II.63	7.80	–	–
Granite Hbr	24.II.63	7.80	–	–
Lake Penny	25.I.63	7.85	–	–
Lake Péwé	22.II.63	7.90	–	eggs
Lake Penny	25.I.63	7.91	present	–
〃 〃	20.II.63	8.00	–	–
Lake Péwé	22.II.63	8.00	–	eggs
Granite Hbr	24.II.63	8.10	–	–
〃 〃	2.II.63	9.60	present	–
Mt Discovery	15.II.63	7.20	–	–
Observation Hill	29.I.63	7.24	–	present
〃 〃	29.I.63	7.30	–	present
Mt Discovery	15.II.63	7.50	–	–
〃 〃	15.II.63	7.50	–	–
Observation Hill	29.I.63	7.58	–	–
Cape Evans	30.I.63	7.86	–	present
Blue Glacier	12.II.63	7.90	present	–
Cape Evans	30.I.63	8.14	–	–
Minna Bluff	12.II.63	8.15	–	–
Blue Glacier	12.II.63	8.20	present	–
Cape Royds	9.II.63	8.40	–	present
Blue Glacier	12.II.63	8.53	–	–
Cape Royds	9.II.63	8.75	–	present
Minna Bluff	12.II.63	8.90	–	–
Cape Royds	9.II.63	9.05	–	–

and their physical environment, obscuring even in a simple community the single effect of any one physical factor upon the organisms present. It is likely then that low soil water content either on its own or in combination with low under-stone temperatures could induce hibernation or death. Under-stone low temperatures combined with very low soil water content (less than 2.5%) at the Flatiron (Granite Hbr), Lake Péwé and Lake Penny could have contributed to the absence of collembolans at these localities late in the summer.

Soils

Soil acidity-alkalinity: Soil samples from each of the 4 localities were tested in the

Table 12. Soil salinity values at south Victoria Land localities.

Locality	Date	% Salinity	Collembolans present	Mites present
Lake Penny	20.II.63	.035	–	–
〃 〃	20.II.63	.06	–	–
〃 〃	25.I.63	.12	present	–
Marble Pt	23.II.63	.15	present	–
Lake Penny	25.I.63	.16	–	–
Lake Péwé	22.II.63	.17	–	eggs
Granite Hbr	2.II.63	.20	present	–
Marble Pt	9.I.63	.42	present	–
〃 〃	9.I.63	.44	present	–
Granite Hbr	2.II.63	.48	present	–
〃 〃	24.II.63	.60	–	–
Marble Pt	1.I.63	.66	present	–
〃 〃	9.I.63	.69	present	–
Granite Hbr	24.II.63	.70	–	–
〃 〃	24.II.63	1.00	–	–
〃 〃	2.II.63	1.50	present	–
〃 〃	2.II.63	1.80	present	–
Marble Pt	23.II.63	2.00	–	–
Cape Royds	9.II.63	.14	–	present
Observation Hill	29.I.63	.16	–	–
Blue Glacier	12.II.63	.17	present	present
Observation Hill	29.I.63	.18	–	present
Mt Discovery	15.II.63	.19	–	–
〃 〃	15.II.63	.24	–	–
Cape Evans	30.I.63	.28	–	present
Blue Glacier	12.II.63	.30	–	–
Observation Hill	29.I.63	.35	–	present
Mt Discovery	15.II.63	.36	–	–
Cape Royds	9.II.63	4.37	–	present
Blue Glacier	12.II.63	.68	present	–
〃 〃	12.II.63	1.30	present	–
Cape Royds	9.II.63	3.50	–	–
Minna Bluff	12.II.63	5.40	–	–
Cape Evans	30.I.63	8.00	–	–
Minna Bluff	12.II.63	19.00	–	–

laboratory for acidity-alkalinity, using a pH meter. The results presented in Table 11 indicate a moderately wide range of pH values obtained from soils in which collembolans and mites were living. The values, except for one instance, were on the alkaline side of neutrality. The range of pH values obtained from soils in which no arthropods were found was well within the extreme pH limits of arthropod-bearing soil. This would indicate that factors other than pH were responsible for the non-occurrence of arthropods at such localities. Data from other localities visited during the Antarctic summer 1962–63 are also presented.

Soil salinity: Soil samples from each of the 4 localities were tested in the laboratory using a salinity-conductance meter with standard procedures. (Prior to testing, samples were dried in an electric oven at 193°C for 24 hours. Then 30 gm of the dried soil was mixed with 30 ml of distilled water and allowed to stand for a further 24 hours. The supernatent solution was then filtered and tested.) All salinity measurements in Tab. 12 are expressed as percentage salinity of the soil solutions.

The salinity of soils in which collembolans and mites were living ranged from 0.12% to 1.8%. No arthropods were found in soils obtained from these localities where salinities were lower or higher than the above values respectively. From the values obtained it would seem that mites are less tolerant of lower and higher salinities. Soil salinities from other localities visited during the summer are also presented.

Populations

Summer fluctuations in collembolan numbers: A 3 m × 3 m square ground area of homogeneous chalikosystem (Janetschek 1963) was measured at each of the 4 localities at the beginning of the summer. Within each area a 1 m quadrat was measured in each corner. All the collembolans living in one quadrat were collected during each of the 4 monthly visits. Each 1 m quadrat was thus surrounded by undisturbed ground. This method sought to prevent errors in sampling due to collembolans moving from a quadrat not yet examined to a quadrat from which all the collembolans had been removed. A 3 m×3 m square was generally the largest homogeneous area that could be found at each locality—homogeneous as far as drainage, aspect, and stone color and size composition were concerned.

Due to distortion of many of the collembolans upon fixing in alcohol, it was difficult to measure their exact lengths, so more arbitrary units were used—collembolans more than 0.7 mm in length were classed as "large" and those less than 0.7 mm in length were classed as "small."

The bar graphs (figs 9 & 10) of total numbers of collembolans taken from the quadrats at each of the 4 study areas indicate that a maximum population density occurred during late November–early December. This period was also one for maximum number of "small" collembolans. The "small" collembolans group diminished in frequency in the quadrats taken about a month later.

The greater number of collembolans that Marble Pt and Granite Hbr soils could support, when compared with those obtained from Lake Péwé and Lake Penny, was probably indicative of more favorable physical and/or biotic environments at the former localities *eg* higher maximum and mean micro-temperatures would seem more favorable for reproduction and growth. (A quantitative analysis of bacterial and fungal content of soils from all 4

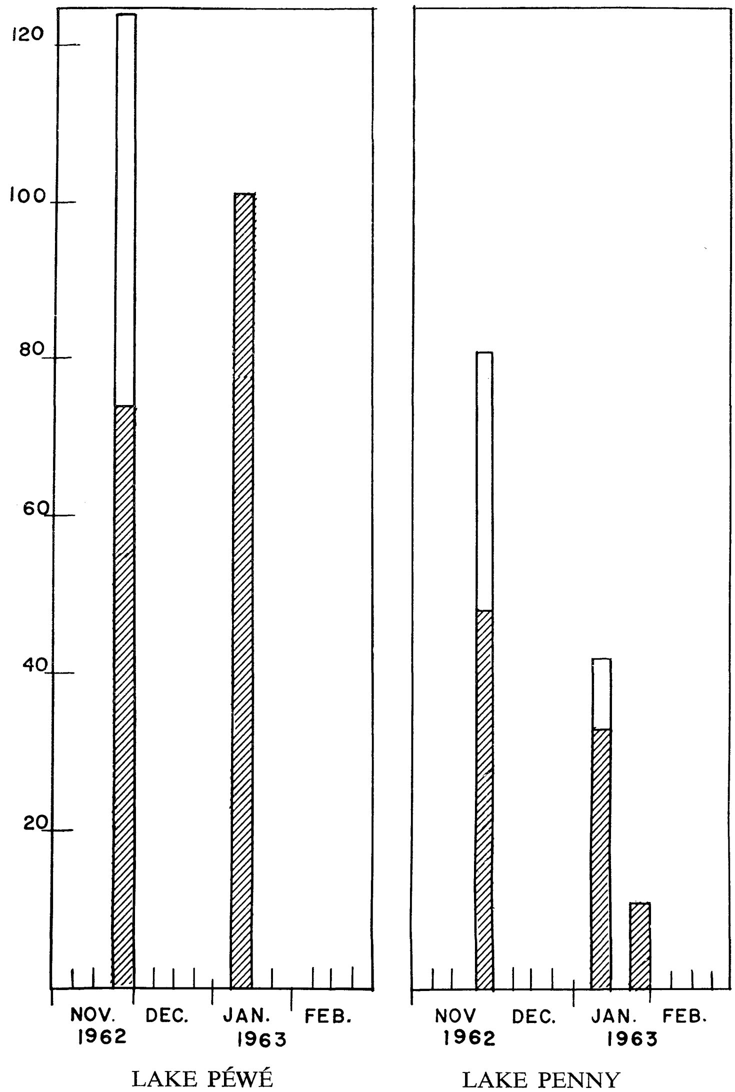


Fig. 9. Bar graphs showing fluctuations in collembolan numbers at L. Péwé & L. Penny. [ ] Small collembolans (up to .7 mm in length). ////// Large collembolans (more than .7 mm in length).

localities is being conducted).

The peak population density at each locality was recorded more than one month before the period of maximum and maximum mean microclimatic temperature records at each locality. This may be related to the large surface area to volume ratio of collembolans which also have no organs of water conservation (malpighian tubules). Thus a decrease in population density at the time of high temperatures could have been due to death through desiccation. The relative greater surface area to volume ratio in "small" collembolans would increase risk of desiccation and might have contributed to their very sharp decline at this period of high temperatures. Except at L. Péwé this decline was not compensated for by an increase in numbers of "large" collembolans which might otherwise have indicated that "small" ones had grown.

The apparently sudden outbreak and disappearance of collembolans at the beginning and end of summer, particularly as illustrated at the 2 southern sites, L. Penny and L. Péwé, may arise to some extent from the hatching of young in early summer and the death of adults after egg-laying at the end of summer, but the high proportion of "large" collembolans throughout the summer suggests that outbreak and disappearance result from mass movement of adults which overwinter deeper in the soil or in specific niches.

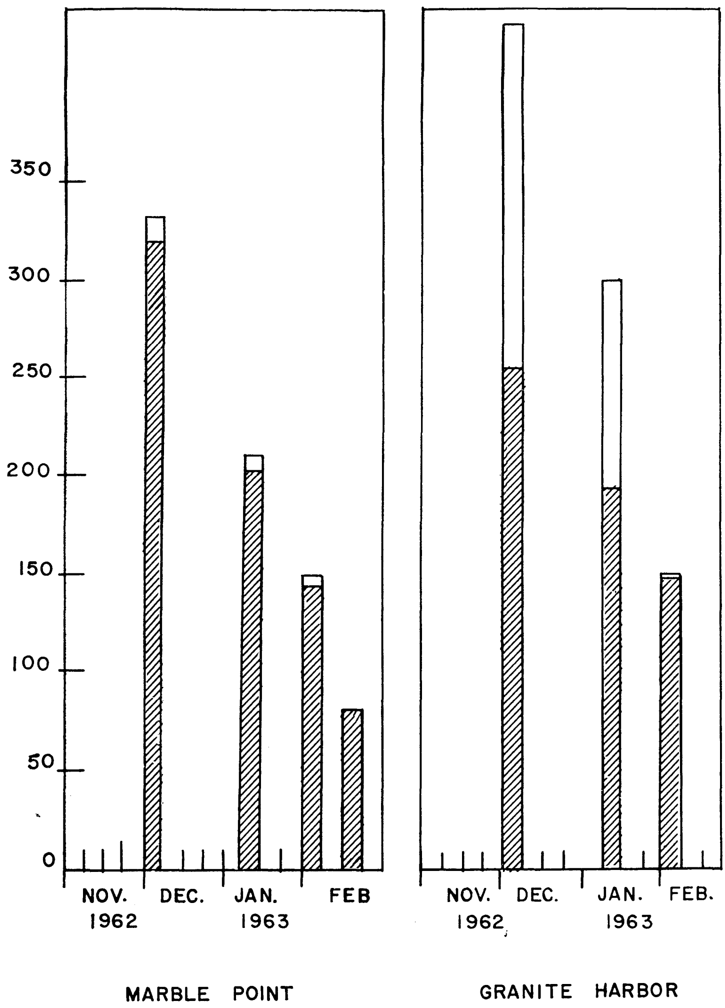


Fig. 10. Bar graphs showing fluctuations in collembolan numbers at Marble Pt and Granite Hbr. [open bar] Small collembolans (up to .7 mm in length). [hatched bar] Large collembolans (more than .7 mm in length).

The very low numbers of "small" collembolans found at Marble Point throughout the summer could have been due to low numbers of eggs hatching from the previous season. Alternatively it could have been due to death through over-crowding and unsuccessful competition by the smaller ones with larger ones which had previously overwintered.

The general conclusions which may be drawn from the quadrat work are:

1. Where conditions are favorable, "Chalikosystem" ground may support up to about 300 collembolans per m^2.
2. There is a fall-off in numbers towards the middle of the summer, when maximum soil temperatures are reached.
3. Collembolans probably overwinter both as adults and eggs, there being mass movements of adults from and to overwintering sites deeper in the soil, or in specific niches, which would account for the sudden outbreak and disappearance of collembolans, at beginning and end of summer respectively.

Cape Geology had maximum, minimum and mean temperatures closely corresponding to those at Marble Point during the first week of December. However the Flatiron site, 2 km distant from Cape Geology was in a higher and much more exposed position. Environmental temperatures recorded there were much lower than at Marble Point, and were more comparable to those at Lake Penny and Lake Péwé. These facts may help explain the presence of hibernating collembolans in the early summer at Cape Geology and their absence from the Flatiron in late summer.

Relative abundance of collembolans under stones of different colors: Information from transect work undertaken at Lake Penny, Lake Péwé and Marble Pt determined the correlation between stones of different colors and the abundance of collembolans under them. The different amounts of solar radiation absorbed by stones of different colors were measured. Line transects at each of the 3 above localities were made at times of maximum population density. At Lake Penny the transect was spread over 300 m between the lake and the Walcott Glacier to the north of the lake. Over this distance 83 stones were examined. Stone color and the number of collembolans and mites adhering to their undersides were noted. At Lake Péwé the transect covered a distance of 400 m from the lake in an eastward direction towards the Ross Ice Shelf. 178 stones were examined. At Marble Point 135 stones were examined over 650 m from a promontory near the camp site eastwards towards the sea.

In each case where small areas containing high densities of collembolans were crossed, the distance apart of examination points was reduced. Where areas of low densities were encountered the distance apart of examination points was increased.

Samples of the different colored rocks from each locality were brought back to the laboratory and the amount of heat/light absorbed by the upper surface of each rock was measured with an albedometer. The results showed consistent relationship with rock colors.

Bar graphs showing both percentage frequency of different stone colors and percentage of the total number of Collembola found under stones of each color are presented (fig 11). The graphs indicate that the greatest percentage of collembolans were found under stones of the color which occurred most frequently at any particular habitat: at Marble Point pale gray stones made up the greatest percentage of the substrate, and also carried the highest percentage of collembolans. Similarly for the second greatest color frequency at each

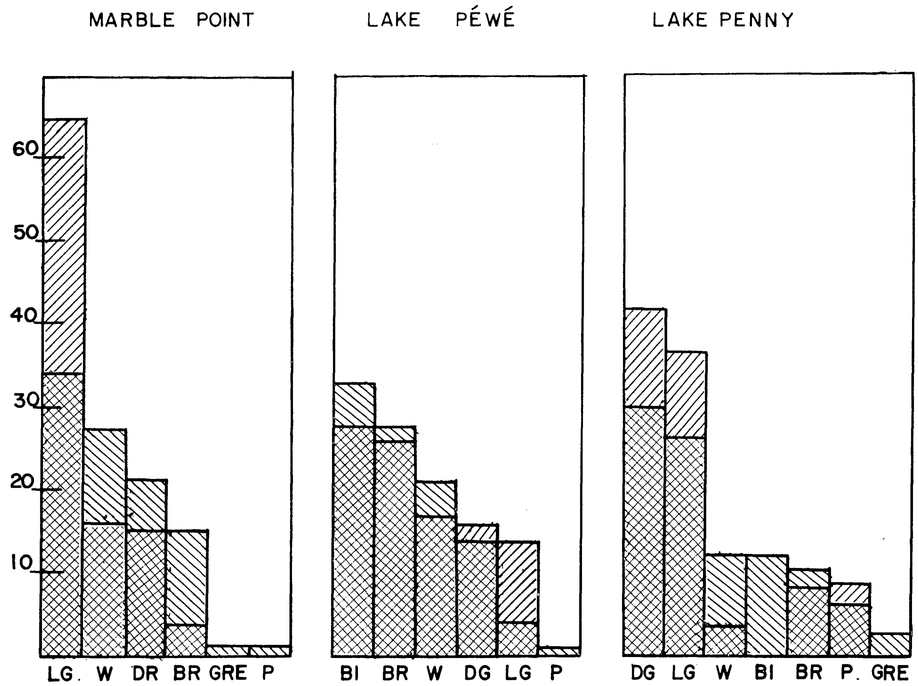


Fig. 11. Bar graphs showing the percentage of total number of collembolans found under stones of different colors. Stone colors also indicated as percentages of the total number of stones. LG—light grey stones W—white DG—dark grey Br—brown Gre—green P—pink Bl—black. ////// Percentage collembolans. \\\\\\ Percentage color stones.

locality. This relationship remains valid for the rest of the stone colors at Marble Point and Lake Péwé. At Lake Penny it is not valid for the stone colors occurring less frequently, but this may be due to errors arising from the shorter transect distance covered there. It may be concluded that although stones of different colors have different heat absorbing properties, this is not a significant factor in influencing the choice of habitat by collembolans.

Relative abundance of collembolans and mites: At L. Penny, L. Péwé, and Marble Pt a 1 m wide transect of the ground was examined to determine the distribution of collembolans and mites. All stones at 1 m intervals were examined near the beginning of each transect but the distance was lengthened to 5 and 10 m intervals as more uniform ground and conditions were reached. The state of the ground and presence or absence of algae and moss were noted.

At L. Penny (29. XI. 1962) the transect lay from the northern shore north towards the Walcott Glacier, the ground rising slightly for a distance then sloping down (fig 12). Numbers of collembolans and mites under individual stones were counted and a summary of results is given in Tab. 13. There was sub-surface seepage near the lake but the ground was drier beyond the rise except near an occasional snow-patch. Collembolans occurred along the length of the transect except in the wet zone near the lake edge. Mites were few but those recorded were concentrated on the rise near the lake and were predominant adjacent to the wet zone. Moss was not recorded but an algal mat covered the surface of the wet zone and green algae occurred on stones in the area where mites were most abundant.

At L. Péwé (1. XII. 1962) the transect again lay from the lake outwards but here there is a definite seepage stream flowing eastwards but curving northwards to run almost parallel to the lake edge at one point. The transect was chosen so that it lay from the lake edge eastward and crossed the seepage stream (fig 13). Results summarised in Tab. 14 clearly show that mites occurred adjacent to wet zones near the lake and on each side of the seepage stream. Algal mats covered the surface in wet zones and green algae were found at a few places along the transect. Collembolans occurred most frequently in the drier zones. One other occurrence of 3 mites and 1 collembolan in the sector to 411 m was on the only stone in the sector recorded with algae and may have been adjacent to a snow patch. No moss was found.

At Marble Pt (3. XII. 1962) the transect examined was from the top of a knoll down the slopes and across a bare plain sloping to the sea (fig 14). In this case the beginning of the transect was dry, towards the bottom of the knoll lay snow patches with a wet zone below and the plain was an area lying below a glacier front from which it received surface and sub-surface seepage. The summarised results in Tab. 15 indicate that collembolans predominated on the higher and drier slopes of the knoll and mites on the plain but the situation in the very wet intermediary zone at the foot of the knoll is confused.

Table 13. Numbers of collembolans and mites in a transect at L. Penny (29.XI.1962)

Zones	Wet	Damp										
Sectors*	6	8	12	30	39	48	58	67	140	149	231	311
Collembolans	0	3	73	64	42	1	3	1	40	36	124	36
Mites	0	7	1	0	1	0	0	1	0	1	0	0

* Distance in m, outer extent of each sector is given.

Table 14. Numbers of collembolans and mites in a transect at L. Péwé (1.XII.1962)

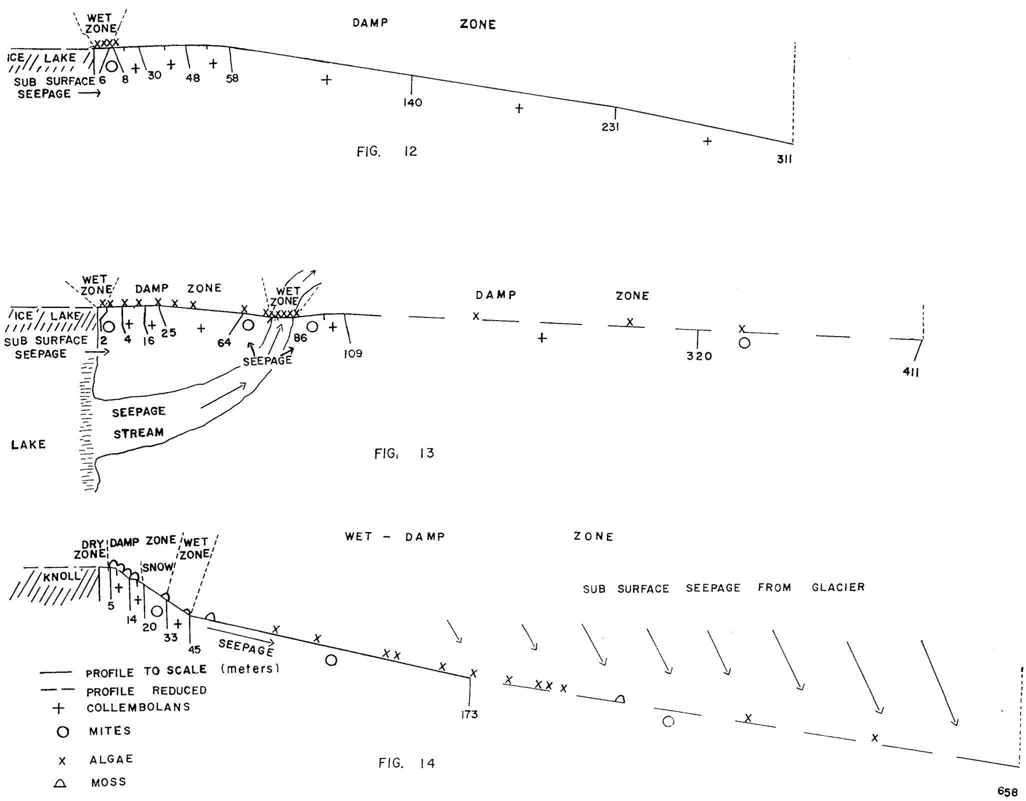
Zones	Wet	Damp								Wet	Damp			
Sectors*	2	4	11	16	21	25	27	64	77	86	100	109	320	411
Collembolans	0	9	5	19	7	47	20	0	1	0	0	1	31	1
Mites	0	20	3	1	0	0	0	0	10	0	7	0	0	3

* Distance in m, outer extent of each sector is given.

Table 15. Numbers of collembolans and mites in transect at Marble Pt (3.XII.1962)

Zones	Dry	Damp					Wet	Damp	
Sectors*	1	7	14	18	20	33	45	173	658
Collembolans	0	22	968	149	9	0	587	129	0
Mites	0	2	44	8	5	3	63	289	53

* Distance in m, outer extent of each sector is given.



Figs. 12–14. Profiles of transects at L. Penny (fig. 12), L. Péwé (fig. 13), Marble Pt (fig. 14), showing collembolan, mite, alga, moss, distributions. Figs. 13, 14, plan view of stream and glacier seepage superimposed.

However this may be explained by the fact that most of the collembolans were on only a few of the stones (225 collembolans on 4 stones which only carried 4 mites) which must have been dry enough to support them. Similarly in the sector to 173 m, 107 collembolans were under 1 stone, 22 under another and none on any others. Mosses were found on the knoll, where collembolans predominated, and algae occurred on the wetter plain area as did mites.

The assessment of wetness and dryness in the above discussions was based on conditions during the day when soil temperatures were above freezing point and melt-water was available, 3 major zones are recognized: wet, damp and dry. The situation at that time of season was reasonably clear but later in the season when there is more melt it is more confused as dry, damp, and wet niches are intermingled. However, mites were always more abundant in the wetter spots and about meltwater streams and pools. There appears to be a distinct alga-mite association adjacent to wet areas and, where moss occurs, a moss-collembolan association in drier sites, however the moss itself was not examined.

Food of collembolans and mites

Experiments investigating the feeding habits of soil inhabiting arthropods were undertaken to determine their diets. The experiments were of 4 main types, to find:

1. The different micro-organisms present in soils containing arthropods, which might have been used for food by the arthropods.
2. The presence of micro-organisms inside the bodies of the arthropods.
3. If there was evidence of moss thalli having been eaten.
4. Whether there was preference given to any particular type of food organism.

Micro-organisms found in south Victoria Land soils: Soils macroscopically barren (Chalikosystem soil, Janetschek 1963), but supporting life for collembolans and mites at Lake Penny, Lake Péwé, Marble Pt, Granite Hbr, and also Cape Royds were collected in sterile bags and transported to the biology laboratory. There under sterile conditions a few particles of each soil were sprinkled onto Sabouraud dextrose agar plates and sealed. From cultures on each plate, sub-cultures were made of each colony type, using carrot agar for fungi and malt agar for bacteria. After examination cultures still not identified were further sub-cultured to malt agar for fungi, and nutrient agar for bacteria. Soils from the above localities were also cultured to determine the presence of algae. Results are shown in Tab. 16.

Blue-green algae were the most common, with green algae next in abundance, while diatoms and yellow green algae were much less common. In the case of the Cape Royds soil samples, mites were found in the first 2 soils (containing ***Penicillium*** sp.) but not in the third sample which had neither mites, fungi nor bacteria in it. This soil was absolutely dry which might explain the absence of plant and animal life.

Table 16. Organisms present in soil containing arthropods.

Location	Algae	Fungi	Bacteria
Lake Penny	1. Filamentous	1. *Penicillium* sp.	1. Unidentified
	2. Unicellular	2. Unidentified	2. 〃
			3. 〃
Lake Péwé	Filamentous	1. Unidentified	1. 〃
		2. *Penicillium* sp.	2. 〃
			3. 〃
Marble Point	1. Filamentous	1. *Penicillium* sp.	1. 〃
	2. Unicellular	2. Unidentified	–
		1. 〃	–
Granite Harbor	1. Filamentous	1. *Penicillium* sp.	–
	2. Unicellular	2. Unidentified	–
		3. Unidentified	–
		1. Unidentified	–
		2. Unidentified	–
Cape Royds	1. Unidentified	1. *Penicillium* sp.	–
	1. Unidentified	1. *Penicillium* sp.	–
		1. –	–

Culture plate smears of whole arthropods: Collembolans from Marble Pt and Granite Hbr moss and Chalikosystem soil and mites from Cape Royds Chalikosystem were collected into sterile tubes containing absolute alcohol. To prevent contamination of the nutrient plates by organisms adhering to the bodies of the animals, they were shaken vigorously with fresh alcohol, left for 24 hours, and then reshaken with fresh alcohol. Individuals were then smeared across petri dishes containing Sabouraud dextrose agar. Control collembolans and mites were placed upon the nutrient medium without smearing, to determine the validity of the above method of removal of possible bacterial and fungal spores from their external surfaces. Dishes containing control collembolans yielded no fungal or bacterial growths. All plates containing collembolan and mite smears yielded growths of a *Penicillium* species in great quantity. No bacteria were found in these cultures. It may be concluded that, whether moss is present or not in a micro-habitat, *Penicillium* sp. occurs in the gut contents of collembolans and mites.

Moss as an article of the collembolan diet: Six groups each of 5 collembolans were placed in the center of covered petri dishes, each of which contained a single moss thallus and a piece of moist filter paper. These dishes were placed in an outside opening steel cupboard on the north side of the biological storehouse at McMurdo Sound. The dishes were then examined after 15 hours. Maximum-minimum temperatures at the beginning and end of the 15 hour period of observation were:

	Maximum	Minimum
Beginning	+6.7°C	−0.4°C
End	+5.2°C	−1.4°C

All the collembolans placed in the middle of the dish had within 15 hours made their way to the moss thalli. There was evidence, from the observed feeding behavior of the collembolans, and from the chewed appearance of moss thalli, that moss had been consumed.

Selection of diet by collembolans: Three groups each of 25 collembolans taken from a moss mat at Marble Point were placed in the centers of 3 large covered petri dishes with moist filter paper stuck to their upper lids. Placed equidistant around the sides of each petri dish were 5 different soil plants.

1. Moss Thallus (Marble Pt)
2. Blue Green alga (Granite Hbr)
3. Red lichen (Granite Hbr)
4. Fungal hyphae (*Penicillium* sp.) from a Granite Hbr soil culture.
5. Green filamentous alga (Marble Pt).

Each dish was examined once daily for 4 days. Those collembolans upon or immediately around each plant were counted, at daily intervals, and those between plants or towards the middle of the dish were recorded as undecided (Category U). Those which did not respond to pricking with a blunt glass seeker were recorded as dead (D). Results are shown in Tab. 17.

The results indicate that preference was shown by the collembolans to moss in the first place, and *Penicillium* sp. in the second. This may have been due to some instinctive preference for moss by the previously moss inhabiting (Marble Pt) collembolans, or it could have been due to some or all of the following factors.

1. The collembolans taken from a moss habitat for the experiment had acquired a

Table 17. Results of food preference experiments using collembolans.
1, Moss thallus; 2, Blue green algae; 3, Red lichen; 4, Fungal hyphae (*Penicillium* sp.); 5, Green algae.

Date	Time	Sample	1	2	3	4	5	U	D
8.II	1900	1	8	0	0	4	2	11	0
		2	9	0	0	3	2	12	0
		3	8	1	0	6	2	8	0
9.II	1700	1	7	0	0	7	2	9	0
		2	7	1	0	4	1	11	1
		3	5	0	1	4	1	14	1
10.II	1900	1	8	0	0	9	5	3	0
		2	7	0	0	7	4	6	1
		3	8	0	0	5	2	8	2
11.II	1900	1	6	0	1	6	2	9	1
		2	6	2	0	6	2	7	2
		3	10	1	0	7	4	2	2

"liking" for moss during their growth. Unfortunately the experiment was not repeated using animals taken from a fungi-bacteria soil.

2. The moss appeared and felt damper than the other plants. Thus some hydrophilic behavior may have attracted the collembolans to it.

3. The collembolans clustered on the undersides of the moss thalli, as well as to the underside of each small stone bearing the filamentous green algae. This negative phototactic behavior may have contributed to their choice of food organism.

4. Those collembolans found amongst the fungal hyphae appeared to have had some difficulty in extricating themselves from it. This may have also influenced choice of food in that those which escaped from the hyphal mass probably did not return to it. In nature fungal hyphae would probably not grow in as dense clusters as in the nutrient medium, or alternatively the collembolans may only feed on fungal spores in the field.

The large number of collembolans which had not chosen any plant-food even after 32 hours may have been due to the different nutritional states of individuals at the beginning of the experiment. This could be compensated for in future experiments by food deprivation of the collembolans for some days before starting the experiments.

The general conclusions that may be drawn from the feeding experiments are:

a) Collembolans and mites feed upon *Penicillium* sp.
b) There is definite evidence that moss forms at least part of the collembolan diet.
c) Tentative results from food preference experiments indicate that there is some preference for moss and *Penicillium* sp. rather than other plants.

Summary

1. Maximum air temperatures (at 1 m) were recorded in January the highest being +10°C. Maximum air temperatures on stones also recorded in January, 11°C.
2. Times when collembolans were seen moving upon upper rock surfaces at 2 localities coincided with upper rock surface temperatures above 0°C. These observations were

made during peak population densities.

3. Collembolans were active under stones when under-stone temperatures were above 0°C and inactive at lower temperatures. Low temperatures recorded under stones could be correlated with collembolan hibernation (disappearance) when under-stone temperatures did not rise above 0°C in 24 hours.
4. Soil temperatures differed from under-stone temperatures in reaching higher diurnal maximum temperatures, lower diurnal minimum temperatures, and in greater diurnal fluctuations. These differences probably explained at least in part the extremely infrequent occurrence of collembolans in bare soil and their great abundance under stones.
5. There was no correlation between soil/air relative humidities and the occurrence of collembolans. Some diurnal RH ranges were almost as wide as seasonal ranges.
6. A general inverse relationship between wind and soil/air relative humidity may influence the occurrence of soil arthropods which were absent from areas of constant exposure to wind.
7. Collembolans were found hibernating at localities where soil water-content values were less than 3%, and were absent from localities where soil water-content values were less than 2%. They were also absent from localities where soil water values exceeded 12%. It is likely then that low soil water content either on its own or in combination with low under-stone temperatures induced hibernation or death of collembolans.
8. pH values obtained from soils containing collembolans indicated a moderately wide range of tolerance (6.85–9.6). All but one value were on the alkaline side of neutrality.
9. No soil arthropods were found in soils with salinity above 1.8% or below 0.12%. Mites did not occur at localities where salinities were nearing the upper and lower limits of collembolan salinity tolerance.
10. Quadrats taken through the season indicated that where conditions are favorable, chalikosystem soils may support up to 300 collembolans per m^2. Maximum population densities occurred during late November–early December. There was a fall-off in numbers towards the time when maximum soil temperatures were reached. Sudden appearance and disappearance of collembolans at beginning and end of summer and the high proportion of "large" collembolans at these times suggests that both adults and eggs overwinter, there being mass movements of the former from and to deeper or specific overwintering niches.
11. Results from transect work indicate that the greatest percentage of collembolans occurred under stones of the color which occurred most frequently at any particular habitat: although stones of different colors had different heat absorbing properties, this was not a significant factor in influencing the choice of habitat.
12. Results from 3 transects indicate that collembolans predominate in drier areas and mites in wetter areas where algae also occur. At Marble Pt moss and collembolans were both found on drier slopes.
13. Chalikosystem soil contained various algae, fungi and bacteria. Smears of collembolans and mites upon culture media revealed growths of *Penicillium* sp. only. Observed feeding behavior and the chewed appearance of moss thalli yielded evidence that moss was a part of the collembolan diet. Selection of food experiments using collembolans indicated preference for moss and *Penicillium* sp.

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