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OCCURRENCE OF ARTHROPODS IN MOSSES AT ANVERS ISLAND, ANTARCTIC PENINSULA[1]

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Abstract: Data are presented on the relative occurrence in mosses of the common free-living arthropods at Anvers Island.

In any ecological project involving natural populations of animals in a given habitat, it is essential that an accurate and duplicatable method of determining the populations be devised. Thus if the habitat is manipulated to determine the effect of a factor, such as temperature, it must be sampled in the exact same way at a given temperature, and then again at a modified temperature, if accurate data are to be procured.

In the maritime Antarctic the major arthropod environments involve moss beds, soil, lichens and detritus such as that found around bird nests. The most important factor controlling the abundance of a given species in any of these habitats is the amount of moisture they contain.

The standard method of extracting arthropods from these environments is by Tullgren funnel using a heat source. Several factors have to be taken into consideration, however, when using this method. Most important of these is that mosses of different density in number of stems per given volume will greatly affect the moisture holding capacity of the habitat. Further, it seems evident that the major food sources of many Antarctic arthropods are fungi, and these thrive best in a moist environment.

The density of a moss can vary greatly even within a species. *Drepanocladus*, for example, is a very loose moss when growing in a wet area. However as the environment becomes drier it becomes denser, presumably in order to conserve what moisture it does contain.

As succession progresses and invasion of a given species by another occurs, this will modify density. Fructose lichens, for example, often invade the normally dense *Polytrichum* moss, and in so doing send shoots deep into the beds, thus increasing density. Several crustose lichens may also cover a bed of moss, and while not greatly increasing density it can increase water holding capacity by reducing evaporation.

The parenchymatous alga *Prasiola* often grows in large, loose sheets in very wet areas. However, with increasing dryness a gradation to an entirely lichenized form can be found, and the latter is quite dry.

Thus if a constant amount of heat is applied to any of the above sets of examples, varying results will be produced. In the case of *Drepanocladus* the looser and wetter moss will dry out quicker. In the case of *Polytrichum* the sample without the lichen will dry quicker, and with the *Prasiola*, the samples to dry first will be the looser ones, provided all have the same moisture content.

Density also has another effect on extraction, that of producing resistance to escape. In a loose moss such as *Drepanocladus* it is probable that 100% extraction is possible. But in *Polytrichum*, the animals meet much resistance in the form of hyphae, rhizoids and leaf axils

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as they attempt to escape downward. This, however, can be compensated for to a certain extent by inverting the sample, that is, placing the leaves in the extracting funnel bottom with the rhizoids (the denser area) upward toward the heat source.

Realizing these difficulties, several experiments were conducted in an attempt to find a rapid and accurate method of sampling populations. The rather tedious method of hand sorting was tried first, in an attempt to discover the minimum number of cores which would be needed to get an accurate estimate of population.

CORING AND HAND SORTING

A hollow tube with an inside diameter of 1.3 cm was used to take cores to a depth of 5 cm in a rather uniform bed of the moss *Dicranum*. To prevent movement of the arthropods within the core, it was immediately placed in a vial of alcohol. Twenty cores were extracted and then hand sorted for one species, *Cryptopygus*, an abundant collembolan. The results are shown in Table 1. A randomization test showed that 11 cores would have been sufficient to obtain the percentages indicated for the various cm levels.

Table 1. Numbers of *Cryptopygus antarcticus* found in 20 cores of *Dicranum* moss.

	Level Sorted					
Core No.	First cm from top	2nd cm	3rd cm	4th cm	5th cm	Totals
1	0	0	0	0	0	0
2	0	1	1	0	3	5
3	0	0	5	2	1	8
4	0	2	0	0	5	7
5	0	0	1	0	0	1
6	0	3	2	1	1	7
7	1	0	2	0	1	4
8	0	1	1	6	3	11
9	0	7	0	2	5	14
10	0	0	1	3	0	4
11	0	5	1	6	2	14
12	2	1	0	0	1	4
13	0	0	0	5	1	6
14	0	0	1	1	4	6
15	0	0	0	0	1	1
16	0	0	2	6	4	12
17	0	0	1	1	0	2
18	0	1	3	0	1	5
19	0	1	1	1	0	3
20	0	0	0	1	3	4
Totals	3	22	22	35	36	118
Percent of total	2.5	18.6	18.5	29.7	30.5	

In order to see if any one layer (1 cm deep) of the *Dicranum* bed could be sampled and still get a comparable estimate of the population the following project was tried.

Cumulative averages for each individual cm level were taken in the order sorted for test one. Thus all cores were averaged from the top cm, then the second, on so on to the fifth:

In the 1 cm level, 8 cores level off at about 0.1, while the arithmetic average for that layer is 0.2

In the 2 cm level, 15 cores level off at about 1.2, while the arithmetic average is 1.1
In the 3 cm level, 11 cores average off at about 1.1, while the arithmetic average is 1.1
In the 4 cm level, 11 cores level off at about 1.8, while the arithmetic average is 1.8
In the 5 cm level, 10 cores level off at about 1.8, while the arithmetic average is 1.8

This would indicate that rather than sorting all five cm levels of the cores, comparable ideas of the population could be attained by sorting only the 3, 4 or 5 cm level. These have the highest correlation between total average in that layer and cumulative average for 20 cores. Since the above cores were taken in a frozen state, with the insects inactive, it could be argued that it would not be accurate to sample only the 3, 4 or 5 cm level when the moss is not frozen, as is the case in the summer. Perhaps the animals become more concentrated in different areas in response to solar radiation and wind desiccation of the upper layers of the moss. To test this, the following project was tried.

EFFECT OF TEMPERATURE ON THE DISTRIBUTION OF *CRYPTOPYGUS ANTARCTICUS* IN *DICRANUM*

Two plastic vials were filled with a core of *Dicranum* from a bed which has a normally low population of *Cryptopygus*. Each vial was then cut of at the top off the moss to eliminate any possibility of an air pocket forming. Into these vials, at the top of the moss core several *Cryptopygus* were released and allowed 24 hours to work their way down into the core. One vial was then submerged in a bed of moss so that the top was level with that of the moss bed. After 24 hrs in the moss bed the core was saturated with alcohol to kill the animals in place. The second vial was placed in a building where the temperature of the core would be uniform and near that of the ambient outside. However, it would not receive any solar radiation and would not be affected by any wind movement. After 24 hrs this core was also saturated with alcohol. Both cores were then hand sorted, with the results shown in Table 2.

Since the previous study seems to indicate that there is a definite movement downward in

Table 2. Percent of *Cryptopygus* in each level of two cores of *Dicranum*. (Inside core kept in a building where temperature and wind could not affect it).

Cm level	% in inside core	% in outside core
0–1	5.8	11.3
1–2	15.3	1.9
2–3	34.1	18.9
3–4	24.7	17.0
4–5	20.0	50.9

Table 3. Temperatures (°F) in a study involving daily movements of *Cryptopygus* in response to temperature and desiccation. (Readings taken at time each core pulled for sorting).

	Time				
Depth in cm	0630	1230	1830	0030	Range
Surface	36.5	45.5	43.5	37.0	9.0
1	36.5	46.5	43.0	36.0	10.5
2	36.5	47.5	43.0	36.0	11.5
3	37.0	47.5	42.5	35.5	12.0
4	38.5	46.5	41.0	33.5	13.0
5	40.0	46.0	39.5	33.0	13.0
Range	3.5	2.0	4.5	4.0	

Table 4. Location of *Cryptopygus* at various times of day (in %) (Movement probably in response to solar radiation and wind desiccation).

Cm level	Time			
	0630	1230	1830	0030
0–1	0.0	0.8	4.8	1.6
1–2	8.7	0.0	3.6	3.1
2–3	13.0	23.4	24.2	10.9
3–4	21.7	34.4	19.3	73.5
4–5	56.6	39.9	48.4	10.9

the core which was kept outside, the following experiment was devised to find out if there is any noticeable daily movement.

Five cores of *Dicranum* were again placed in plastic vials, the vials were cut off level with the top of the moss and then imbedded outside in a bed of moss. These were left in place for three days, after several *Cryptopygus* had been introduced into them. In one of the vials of moss, a thermocouple arrangement was placed and temperature readings at one cm intervals were taken. After three days, the cores were pulled one at a time at 6 hr intervals, saturated with alcohol and hand sorted. The weather throughout this period was fairly calm and cloudy. Table 3 gives the results of the thermocouple readings and Table 4 the results of the hand sorting.

In the early morning, most of the *Cryptopygus* are in the warmer, deeper levels. By midday, they began to move down from the top, presumably in response to the sun's warming and wind desiccation, and up from the bottom. Maximum temperatures at this time are in the center of the core. In the early evening the majority are in the upper layers. As the surface began to cool, they again move deeper, where by early morning the temperatures should be warmest.

From the above, it seems quite evident that *Cryptopygus* do move vertically in moss in response to temperature fluctuation and probably also wind desiccation. Here again, however, as in the previous experiments, the greater part of the population is in the lower levels, that is, the 3, 4 and 5 cm levels.

Since both of these experiments show that highest populations do occur in the lower levels at all times, it is probable that just these could be sampled at any time of day and get good results by the arithmetic averaging method.

TULLGREN SAMPLING

The moss *Polytrichum* grows in both large and small beds as much as 45 cm deep and is very compact due to binding by fungi and rhizoids. A bed of this moss, and its associates, approximately 30 cm deep and covering about 2 sq. m, was sampled using Tullgren funnels to extract the arthropods. It was located on a north facing slope subjected to winds from all directions except the south. As is typical most of the bed is covered by a white crustose lichen, but several other species of lichen are also present. In some beds, but not this one, the lichens can be so thick as to prevent any photosynthesis from occurring in the mosses. Patches of brown or gray dead *Polytrichum* can be seen dispersed throughout the bed, often covering 30 cm^2. Around the edges of the *Polytrichum* growing on the rock or on the edges of the moss itself, another looser moss, *Drepanocladus*, is found. This moss is also found in depressions which are created by the hummocky growth form of *Polytrichum*. *Drepanocladus* can have most any other moss and even grass growing on it.

Samples in each habitat within this bed were extracted in a Tullgren funnel. The moss was placed top down in the funnel to facilitate escape of the arthropods. A small piece of the moss was frozen, and then immersed in water to determine volume. This was then expanded for the sample being extracted. The samples were weighed before and after drying in order to determine water content. Samples were taken as follows. The numbers preceding each are used in Table 5.

1. Very dry *Drepanocladus* from around the edges of the *Polytrichum* bed. The base of the moss is on rock, with only a very few stems in the *Polytrichum.* It is less than 3 cm deep, with the bottom layers tightly bound by grass roots. No grass is growing on the sample itself.

2. *Dicranum-Deschampsia* growing on humus on the rock around the edges of the *Polytrichum* bed. Except for the top cm it is rather tight due to binding by grass roots.

3. Dry *Dicranum* on the edge of the *Polytrichum* bed where it is blending into the latter. Its depth is about 5 cm. The top 4 cm are moderately tight and the last is very tight.

4. Crustose lichens growing on *Polytrichum.* The sample was taken to a depth of 6 cm. A few *Cladonia*-like lichens are also present.

5. *Deschampsia* grass growing on humus to a depth of 5 cm. This sample is rather tight due to binding by grass roots.

6. An unknown loose moss, plus *Dicranum* and *Deschampsia* mixed together. Sampled to a depth of about 4 cm. It is based on rock and is moderately loose. It is about 50% *Dicranum* and 45% of the unknown species.

7. Pure *Polytrichum* sampled to a depth of 7 cm. Very tight except for the top cm.

8. Fructose lichen-*Polytrichum* mixture. The lichen grows on the moss. This habitat was sampled to a depth of 5 cm. It is very loose for the top 4 cm and very tight in the last.

9. Dead *Polytrichum* sampled to a depth of 7 cm. It is very firm except for the top cm which is quite loose.

10. *Drepanocladus* taken from a depression in the *Polytrichum.* The depression is filled with humus, but little of this was taken in the sample. The purely *Drepanocladus* part taken is 4 cm deep.

From Table 5, the following results can be deduced: *Cryptopygus* is most abundant in dry moss with 18.5% moisture. It is probable that they were concentrated in the lower centimeter of this shallow bed, where grass roots bind the moss tightly together, thus retaining the majority of the moisture. Since these animals tend to desiccate rather quickly when exposed to dry atmospheres, it would have been expected that they would be more abundant in a wetter habitat. However,

Table 5. Number of arthropods per cm^3 in a *Polytrichum* Association.

Sample Number	1	2	3	4	5	6	7	8	9	10
Species										
Cryptopygus	31.4	2.6	3.8	0.3	1.5	0.1	0.1	0.4	0.2	1.3
Parisotoma	0.0	0.5	0.0	0.1	0.1	0.0	0.0	0.2	0.0	0.2
Friesea	0.0	0.3	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.4
Halozetes	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Nanorchestes	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0
Tydeus	0.4	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.1
Stereotydeus	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2
Cyrtolaelaps	0.0	0.0	0.0	0.0	0.1	0.0	0.3	0.0	0.0	0.0
Percent water	18.5	74.0	29.7	73.6	62.5	81.2	74.0	37.7	37.9	66.3

only about 3% are the dark black type, the rest being almost white or bluish white. Collections from other areas indicate that these lighter types can withstand drier habitats. It further seems doubtful that all of these paler animals are immatures, since many of them are adult size. Perhaps these are teneral adults.

Parisotoma is most abundant in *Dicranum-Deschampsia* mixture which is growing on humus. This has a moisture content of 74.0%. It is also found in significant numbers in a very loose *Drepanocladus* and a loose fructose lichen growing on a shallow *Polytrichum*. These have moisture contents of 66.3 and 37.7% respectively. This is to be expected as these collembolans are the only arthropods commonly seen exposed to surface conditions such as the upper sides of rocks. Thus they can withstand a wide range of humidity. Their occurrence however seems to be governed by some factor other than moisture. Similiar beds of moss side by side may have entirely different populations, and often the animal may be present in one, but not another. They are quite rare in the winter, indicating that they overwinter in the egg, and perhaps it is survival of this stage which makes the difference.

Friesea was found most abundantly in *Drepanocladus* in a depression in the *Polytrichum* bed. Moisture content was 66.3%. High numbers were also found in *Dicranum-Deschampsia* on humus and a crustose-lichen encrusted *Polytrichum*. These had a moisture content of 74.0 and 73.6%, a rather narrow range as compared with the other two species of Collembola.

Halozetes, a small brown mite, was found only in the *Dicranum-Deschampsia* bed and the crustose lichen on *Polytrichum* bed. Like *Parisotoma* this species is often absent from areas where it would be expected.

Tydeus was most abundant in the same dry *Drepanocladus* as was the pale colored *Cryptopygus*. It is found only in beds with at least 1.3 *Cryptopygus* per cc, while it is often absent from others with a higher population. However, since the highest number were associated with the highest population of *Cryptopygus*, perhaps it is predatory on the eggs or young stages.

Nanorchestes was found only in pure *Polytrichum* and in a mixture of an unknown moss, *Dicranum* and *Deschampsia*. Of all the species extracted in this study, this is the one most likely to be misrepresented. While it is small like *Tydeus*, it does not have the rapid mobility of the latter and probably the majority desiccate rather than escape the extracting apparatus.

Cyrtolaelaps, a predatory species, was most abundant in a deep, pure *Polytrichum* bed. This species seems to be more abundant under rocks, particularly those that have fallen on moss, rather than in the moss itself.

None of the mites collected in this study seem to be particularly sensitive to short term low humidity as are some of the collembolans.

As emphasized earlier, any attempt to correlate populations or associations of species using Tullgren apparatus is subject to some error. In this case an attempt was made to keep the temperature of the light bulb used as a heat source as constant as possible. Unless the sample being extracted and its container can be placed on a balance it is impossible to know when it is thoroughly dry. In this case it was assumed to be dry when the plants would crumble between ones fingers. Thus the data is somewhat subjective.

It would be interesting to extract a moss such as *Dicranum* in a Tullgren funnel and also simultaneously hand core the same bed to see if comparable results could be obtained. As in the case of any sampling other than hand sorting, this would have to be done for all densities of moss.

ARTHROPODS IN A BED OF POLYTRICHUM AND ITS ASSOCIATES

In another study *Cryptopygus antarcticus* was found to be most abundant in dry *Drepanocladus* growing around the edges of the *Polytrichum*, and having a moisture content of 31.4% (weight of moss as collected minus dry weight). *Friesea grisea* was found to be most abundant in *Drepanocladus* taken from a depression in the bed of *Drepanocladus* itself. This had a moisture content of 65.7%. *Friesea* was also common in *Dicranum-Deschampsia* and crustose lichen-encrusted *Polytrichum*, with 75.1 and 73,6% moisture content. *Parisotoma octooculata* was most abundant in *Dicranum* with *Deschampsia* growing on it, and this had a moisture content of 75%.

For each species of Collembola, the five highest populations and the corresponding % water in the habitat in which they were living are shown in the following:

Cryptopygus		Friesea		Parisotoma	
No./cc	% Water	No./cc	% Water	No./cc	% Water
31.4	26.5	0.35	65.7	0.51	75.1
3.83	29.7	0.27	75.1	0.236	65.7
2.61	75.1	0.27	73.6	0.19	37.5
1.47	62.5	0.08	62.5	0.14	62.5
1.27	65.7	0.02	29.7	0.07	73.6

Averaging the above five values for percent water shows the five highest populations of *Cryptopygus* to be in 51.9% moisture, *Parisotoma* in 62.9% and *Friesea* in 61.3%. This is probably close to an optimum figure for moisture preference throughout (at least on a given exposure which in this case was facing west).

The following is a list of the habitats in which the collembolans were found with the first as the most densely populated and the last the least.

Cryptopygus antarcticus

Sample 1 Dry *Drepanocladus* along edges of *Polytrichum*
3 Dry *Dicranum* along edge of *Polytrichum* bed
5 Grass on humus in a depression
2 *Deschampsia* growing on *Dicranum*
10 *Drepanocladus* on humus in a depression

Friesea grisea

Sample 10 *Drepanocladus* growing on humus in depression
2 *Deschampsia* growing on *Dicranum*
4 Crustose lichen on *Polytrichum*
5 Grass on humus in a depression
3 Dry *Dicranum* along edge of *Polytrichum*

Parisotoma octooculata

Sample 2 *Deschampsia* growing on *Dicranum*
10 *Drepanocladus* growing on humus in a depression
8 Lichen growing on *Polytrichum*
5 Grass on humus in depression
4 Crustose lichen on *Polytrichum*

The following is a listing of the % water and the number of collembolans per cc for each of the 10 samples taken from this association. Note that every microhabitat type was sampled.

% Water	Cryptopygus	Friesea	Parisotoma
26.5	31.40	0.10	0.00
29.7	3.83	0.02	0.01
37.5	0.36	0.01	0.19
43.4	0.15	0.02	0.04
62.5	1.47	0.08	0.14
65.7	1.27	0.35	0.24
73.6	0.31	0.27	0.07
75.1	2.61	0.27	0.51
78.5	0.12	0.02	0.03
81.2	0.12	0.00	0.23

Cryptopygus thus occurs in mosses from very dry to very wet, but with higher concentration in drier. *Friesea* occurs in higher concentration in the wetter habitats, though they can be found over a wide moisture range. *Parisotoma* is most abundant in intermediate moisture conditions.