ELEMENT CONTENTS OF THREE ALASKAN-ARCTIC MOSSES[1, 2]

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ABSTRACT

Concentrations of seventeen elements are reported for samples of *Campylium stellatum*, *Polytrichum hyperboreum*, and *Polytrichum commune* var. *jensenii* collected from U.S.-Tundra Biome study sites in the vicinity of Barrow, Alaska. The concentrations of macronutrient elements (P, K, Ca, Mg, N, and S) ranged, on the average, from 0.1% for sulfur to 1.3% for nitrogen. Contents of micronutrient elements (Mn, Fe, B, Cu, Zn, and Mo) ranged, on the average, from 657 ppm for iron to 1.8 ppm for molybdenum. Among the nonessential elements (Na, Si, Al, Sr, and Ba) analyzed, the amounts of silicon and aluminum were especially high.

INTRODUCTION

Bryophytes are major components of many arctic-tundra plant communities, and in some communities the bryophyte synusia exceeds the vascular-plant synusia in standing biomass (Kil'dyushevskii, 1964; Khodachek, 1969; Pavlova, 1969; Clarke *et al.*, 1971). Because mosses and liverworts commonly have major roles in primary production of arctic-tundra communities, one might wonder to what extent these organisms, especially mosses, are involved in mineral-nutrient cycling, if at all. The present study reports the results of an exploratory investigation of this problem. Three taxa of mosses in the arctic tundra near Barrow, Alaska, were selected for elemental analyses. These taxa were selected on the basis of their relatively high abundances in certain habitats, so that limited sampling would not markedly decrease the populations.

MATERIALS AND METHODS

Sample specimens of *Campylium stellatum* (Hedw.) C. Jens., *Polytrichum hyperboreum* R. Br., and *Polytrichum commune* var. *jensenii* (Hag.) Moenk. were collected on August 15, 1972, from International Biological Program (I.B.P.)-U.S.-Tundra Biome study sites in the vicinity of Barrow, Alaska. Samples of *Campylium stellatum* were taken from a relatively pure colony located in a slight depression of a wet-tundra meadow area characterized by weakly defined low-center polygons (I.B.P. site 2). Samples of *Polytrichum hyperboreum* and *Polytrichum commune* var. *jensenii* were collected from swards in an area characterized by high-center polygons (I.B.P. site 1). *Polytrichum hyperboreum* samples were collected from a sward situated at the base of a high-center polygonal ridge near the north bank of Footprint Creek, and samples of *Polytrichum commune* var. *jensenii* came from a nearby sward in an inter-polygonal trough. Voucher specimens of all three species are deposited in the University of Alaska Herbarium.

Procedures used in preparing samples of the moss gametophytes were similar to those used by Shacklette (1965) and by Rastorfer (1972). Field-collected specimens were taken to the Naval Arctic Research Laboratory near Barrow. In the laboratory, the upper 1- to 2-cm portions of the moss shoots were clipped off, air-dried, and then picked clean of brown (apparently dead) shoots and extraneous materials. The remaining green shoots were used for the analyses.

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Each sample was washed for 10 minutes in about one liter of distilled water and subsequently rinsed with a liter of distilled water and then a liter of distilled-deionized water. These samples were then oven-dried for nine hours at 70°C before grinding in a Wiley mill (40-mesh screen). The powdered samples were oven-dried for 24 hours at 70°C and stored in screw-cap vials until the analyses were performed. Nitrogen concentrations were determined with a micro-Kjeldahl autoanalyzer, and sulfur contents were ascertained with a Leco sulfur titritor. The concentrations of the other elements reported here were determined from plant-ash solutions by emission spectroscopy. The plant-ash solutions were prepared from powdered samples ashed in a muffle furnace (500°C, 4 hours) and a buffer solution consisting of Li_2CO_3 and concentrated HNO_3 (further details on the analytical methods may be obtained from Dr. Myron H. Warner, Plant Analysis Laboratory, The Ohio Agricultural Research and Development Center, Wooster, Ohio, 44691). On the other hand, ash weights were determined from powdered samples ashed in a muffle furnace maintained at 550°C for 20 minutes.

RESULTS

The concentrations of seventeen elements in samples of the three species of mosses (*Campylium stellatum*, *Polytrichum hyperboreum*, and *Polytrichum commune* var. *jensenii*) are reported in table 1. Among the macroelements, the most striking differences were the higher percentages of calcium and magnesium in

TABLE 1

Element contents and ash weights for three Alaskan arctic mosses (based on dry weight)

Element	*Campylium stellatum*[a]	*Polytrichum hyperboreum*[a]	*Polytrichum commune* var. *jensenii*[a]
Macroelements			
P %	0.23,0.23	0.18,0.17	0.21
K %	0.56,0.54	0.68,0.64	0.88
Ca %	0.97,1.02	0.31,0.28	0.15
Mg %	0.38,0.45	0.18,0.17	0.13
Na[b] %	0.04,0.05	0.11,0.11	0.12
Si[b] %	0.24,0.26	0.57,0.44	0.18
N %	1.45	0.90	1.50
S %	0.097	0.089	0.1045
Microelements			
Mn ppm	310,317	62,57	53
Fe ppm	1056,1042	399,369	537
B ppm	26,27	17,17	10
Cu ppm	36,39	14,14	16
Zn ppm	62,66	55,53	45
Al[b] ppm	387,405	667,628	629
Sr[b] ppm	39,44	27,28	28
Ba[b] ppm	31,34	31,30	38
Mo ppm	1.54,2.24	2.57,2.42	0.97
Ash wts. %	4.86,4.92	2.93,2.93	2.73,2.84

[1]Values separated by commas are the results for paired samples.

[2]These elements are generally considered nonessential for most plants. The macroelements P, K, Ca, Mg, N, and S are considered essential macronutrient (mineral) elements, and the microelements Mn, Fe, B, Cu, Zn, and Mo are considered essential micronutrient elements (Evans and Sorger, 1966; Lewin and Reimann, 1969; Salisbury and Ross, 1969).

Campylium stellatum than in the two species of *Polytrichum*. Phosphorus and sulfur concentrations were essentially the same in all three species, whereas the concentrations of potassium and nitrogen varied somewhat. Appreciable amounts of sodium and silicon occurred in all three species; surprisingly, the silicon contents in the two species of *Polytrichum* differed by nearly a factor of three.

The microelements, manganese, iron, boron, copper, zinc, and strontium, especially manganese and iron, were similar to calcium and magnesium in occurring in higher concentrations in *Campylium stellatum* than in the two species of *Polytrichum*. In contrast, the amounts of aluminum were higher in the two species of *Polytricum* than in *Campylium stellatum*. The concentrations of barium were about the same in *Campylium stellatum* and *Polytrichum hyperboreum*, but were somewhat higher in *Polytrichum commune* var. *jensenii* than in the other two species. The amount of molybdenum varied, the highest amount being found in *Polytrichum hyperboreum* and the lowest amount in *Polytrichum commune* var. *jensenii*.

Ash weights for samples of the three species mentioned above are shown in table 1. Percentages of ash weights are essentially the same for the two *Polytrichum* species, but are appreciably lower than the percentage ash weight for *Campylium stellatum*.

TABLE 2

Macroelement contents for Alaskan arctic and west antarctic mosses (based on dry weight)

Element		Barrow (Alaska)[1]		Argentine Islands (Antarctica)[2]		Signy Island (Antarctica)[3]	
		mean	range	mean	range	mean	range
P	%	0.21	0.17–0.23	0.34	0.13–0.53	0.16	0.07–0.30
K	%	0.70	0.56–0.88	0.67	0.46–1.25	0.46	0.30–0.80
Ca	%	0.48	0.15–1.02	0.22	0.11–0.37	0.64	0.15–1.74
Mg	%	0.24	0.13–0.45	0.11	0.09–0.12	0.41	0.24–0.70
N	%	1.28	0.90–1.50	2.39	1.50–2.95	1.24	0.57–1.66
S	%	0.10	<0.10–0.10+	0.15	0.08–0.20	—	—

[1]For *Campylium stellatum*, *Polytrichum hyperboreum*, and *Polytrichum commune* var. *jensenii* (table 1 and text of this report).

[2]For *Calliergidium austro-stramineum*, *Drepanocladus uncinatus*, *Pohlia nutans*, and a mixed moss-liverwort community, which consisted of *ca.* 95% *Polytrichum strictum*, 5% *Pohlia nutans*, and two leafy liverworts (Rastorfer, 1972).

[3]For *Dicranum aciphyllum*, *Drepanocladus uncinatus*, *Brachythecium* sp., *Andreaea* sp., *Grimmia* sp., *Tortula* sp., and a mixed *Polytrichum-Dicranum* community (Allen *et al.*, 1967).

DISCUSSION

At the present time there appear to be no readily available data on macroelement (mineral) content of mosses from arctic-tundra localities other than the present one. Data are available for some west antarctic moss taxa (Allen *et al.*, 1967; Rastorfer, 1972), however, in which the concentrations of several macroelements are remarkably similar to those reported in the present study (table 2). The most noticeable differences among the values shown in table 2 are the lower average amounts of calcium and magnesium for the moss taxa of the Argentine Islands (Rastorfer, 1972).

Silicon concentrations reported in the present study range from 0.18% to 0.57% (table 1). In contrast, concentrations of silicon in four west antarctic moss taxa were much lower, and ranged from less than 0.01% to 0.02% (Rastorfer, 1972).

The higher amounts of silicon found in the moss taxa of the present study might indicate sample contamination, though this seems unlikely because the ash weights ranged from only 2.7% to 4.9% (table 1). Similarly, the ash weights of four west antarctic moss taxa ranged from 1.5% for *Polytrichum strictum* to 5.3% for *Calliergidium austro-stramineum* (Rastorfer, 1972). Shacklette (1965) has suggested that ash weights of less than 10% for bryophytes are indicative of little or no contamination.

Comparisons of the average concentrations of several microelements in the moss taxa of the present study and in four west antarctic moss taxa are given in table 3. Particularly noticeable are the higher average amounts of manganese and copper for the moss taxa of the present study, as compared to values for these metals in the west antarctic moss taxa (Rastorfer, 1972). Three Russian-tundra moss taxa (*Polytrichum commune*, *Polytrichum strictum*, and *Pleurozium schreberi*), occurring in northeast Komi, Russia, had average concentrations of manganese, iron, and copper of 372 ppm, 805 ppm, and 5.5 ppm, respectively (Paribok *et al.*, 1967).

TABLE 3

Microelement contents for Alaskan arctic and west antarctic mosses (based on dry weight)

Element		Barrow (Alaska)[1]		Argentine Islands (Antarctica)[2]	
		mean	range	mean	range
Mn	ppm	142	53–317	15	<10–23
Fe	ppm	657	369–1056	1349	78–4000+
B	ppm	18	10–27	14	6–32
Cu	ppm	23	14–39	6	5–9
Zn	ppm	54	45–66	32	21–41
Mo	ppm	1.79	0.97–2.57	1.02	0.97–1.09

[1]For *Campylium stellatum*, *Polytrichum hyperboreum*, and *Polytrichum commune* var. *jensenii* (table 1 and text of this report).

[2]For *Calliergidium austro-stramineum*, *Drepanocladus uncinatus*, *Pohlia nutans*, and a mixed moss-liverwort community, which consisted of *ca.* 95% *Polytrichum strictum*, 5% *Pohlia nutans*, and two leafy liverworts (Rastorfer, 1972).

The amounts of aluminum, strontium, and barium in the moss taxa of the present study appear to be quite large (table 1), especially the amounts of aluminum in the species of *Polytrichum*. However, similar amounts of aluminum and strontium were found in four west antarctic moss taxa, amounts which averaged approximately 789 ppm and 31 ppm, respectively, whereas the amount of barium averaged only about 4 ppm (Rastorfer, 1972). In contrast, three Russian-tundra moss taxa contained averages of 8.3 ppm for strontium and 16 ppm for barium (Paribok *et al.*, 1967).

The concentrations of specific elements in tissues of bryophytes are difficult to assess, because the minimal amounts required for normal growth and reproduction have not been established. Nevertheless, the number and the amounts of certain mineral elements, especially microelements, in gametophytic shoots of bryophytes tend to exceed those found in shoots of vascular plants of the same locality (Shacklette, 1965). Thus bryophytes apparently have a capacity to accumulate some mineral elements. Whether or not this applies to bryophytes of arctic-tundra communities is still uncertain. However, shoots of three vascular plants occurring in the same community from which the specimens of *Campylium stellatum* were taken for the present study had much lower amounts of iron (Dr. Larry Tieszen, personal communication) than the amount of iron found in *Campylium stellatum* (table 1).

If bryophytes, especially mosses, should have the capacity to accumulate mineral elements in arctic-tundra communities, they may provide reservoirs for some elements which might otherwise be lost from biotic communities, during spring run-off for example. With respect to mineral-nutrient cycling in arctic-tundra communities, elements retained in bryophytes might be released to vascular plants via microbial decomposition, whereas herbivorous animals (*e.g.*, lemmings, which do eat mosses—Dr. George Batzli, personal communication)might obtain them directly. Of course this is conjecture, but it does suggest one of the many possible roles of bryophytes in the function of arctic-tundra ecosystems, in which they are major components of the vegetation.

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