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ROLE OF LIFE FORM IN THE FORMATION OF THE WATER REGIME OF MOSSES

Abstract. The role of life forms in the water regime of mosses is described. The results obtained on the basis of material collected on the Putorana Upland, Taymyr Peninsula, show that the life form of mosses helps them to decrease evaporation speed 5.3—46 times depending on site conditions and species, and is thus one of the main formers of their water regime.

Key words: mosses, life forms, water regime.

There are several unsolved questions in the water regime of mosses both on the level of individuals and populations. K. Mägdefrau (1969, 1982) created his classification of the life forms of mosses proceeding from the fact that in the nature mosses exist very rarely as single plants, usually they occur as groups of individuals related to one another in a certain way. The shape and structure of the groups depend on whether they originate from the same protonema and are related to each other with every single plant having its own growth form — stem form and way of branching characteristic of the species. Assemblage of individuals and the growth form, modified by external conditions, provide together the characteristics which can be referred to as the life form.

In the present paper the system worked out by Gimingham and Birse (1957) is used for classifying mosses life forms.

The fact that mosses grow in groups has a great impact on a plant's life, changing the water, light, and temperature regimes in its nearest vicinity. In the present work the relationship between the water regimes and life forms of mosses is described.

The water supply of mosses and vascular plants differs considerably. Vascular plants have a developed root and conducting system enabling them to obtain water from soil where the supply is relatively constant and ample. Mosses get water from the atmosphere. As they do not have a root system, the whole surface of the plant absorbs water and mineral nutrients. Therefore, mosses have a large contact surface with the environment, as a result of which they depend greatly on external conditions.

The relationship between moss sod and water regime has been investigated by many authors. The general conclusion is that evaporation from sod is smaller than from single plants (Библь, 1965; Корчагина, 1956; Смоляницкий, 1971, 1977). A moss sod dries unevenly — the upper part dries more rapidly than the lower one (Skre, Oechel, Miller, 1983; Солдатенкова, 1968). Tagawa (1961), who studied the ability of mosses to actively adjust their water regime, compared the drying of live and dead sods. It was discovered that there were no differences in the drying speed; therefore, evaporation from moss sod is a purely physical process which mosses are not able to adjust.

Data from literature suggest that moss sod has an important role in preserving water and decreasing evaporation, but this is probably only a physical process. Unfortunately, there are no numerical data about

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water regime changes due to the fact that mosses grow in groups. It is also not known what kind of impact these water regime changes have on the metabolic processes of mosses.

The material of the present work comes from nine different site types from the Putorana Upland, Taymyr Peninsula:

1. *Larix sibirica* forest stand with *Alnus fruticosa*, *Vaccinium vitis-idaea*, *Hylocomium splendens*, *Pleurozium schreberi*;
2. *Larix sibirica* forest stand with *Vaccinium uliginosum*, *V. vitis-idaea*, *Pleurozium schreberi*, *Hylocomium splendens*;
3. *Larix sibirica* open woodland with *Alnus fruticosa*, *Vaccinium uliginosum*, and lichens;
4. *Larix sibirica* open woodland with *Betula nana*, *Vaccinium uliginosum*, *Empetrum nigrum*, and lichens;
5. *Alnus fruticosa* bush with *Vaccinium uliginosum* and *Cassiope tetragona* on the tree line;
6. *Betula nana* bush with fragments of lichen-moss layer on the tree line;
7. *Dryas* tundra;
8. feathermoss undershrub sedgegrass tundra;
9. rock stream in the *Larix sibirica* forest.

Water regimes of the sites are shown in Table 1.

Water regime of the sites.

Table 1

Site No.	Average moss moisture content, % dry weight	Potential evaporation E_0 , mm/day	Evaporation E , mm/day
1	113.3	0.94	0.12
2	98.9	1.57	0.15
3	88.1	2.36	0.21
4	78.3	3.36	0.23
5	93.5	2.40	0.23
6	53.8	3.78	0.25
7	58.9	5.06	0.34
8	692.8	4.36	2.90
9	25.6	4.75	0.15

To assess how much the water regime of mosses is stabilized due to their growing in groups, a moss sod and individual plants were dried in certain conditions. For a more exact description of the experiment see an earlier work by the present author (Вильде, 1986). The obtained drying curves were approximated using the following formula:

$$H(t) = H_{\text{MAX}} \cdot e^{-E_0 t / B},$$

where H_{MAX} is maximum water content in moss (% from absolute dry weight); E_0 — potential evaporation (mm/day) at which the experiment was carried out; B — empirical constant characterizing moss drying speed (B_V — drying speed of an individual plant, B_S — drying speed of moss sod); t — time (hours).

The values of constants obtained by approximation are given in Table 2. The correspondence of the empirical row to the theoretical one was checked with the help of F -criterion. The confidence limits for all the experiments were $0.950 < P < 0.990$.

The results of the experiments showed that the drying speed was different not only for different moss species, but even for samples of the same species from different sites. It was also discovered that the maximum

Constants of the functions characterizing the drying
 of single plants and sods

Moss species and life forms*	Site No.	B_V	B_S	H_{MAX}	B_S/B_V
<i>Aulacomnium turgidum</i> (Trh)	1	1.85	23.0	1247.1	12.5
<i>Dicranum fuscescens</i>	1	3.13	34.0	935.9	10.9
var. <i>congestum</i> (Te)					
<i>Hylocomium splendens</i> (W)	1	2.27	28.2	738.6	12.4
<i>Pleurozium schreberi</i> (W)	1	2.37	12.6	908.5	5.3
<i>Polytrichum commune</i> (Te)	1	2.15	25.2	325.1	11.7
<i>Ptilidium ciliare</i> (Mr)	1	2.83	25.4	1399.6	9.0
<i>Ptilium crista-castrensis</i> (W)	1	4.01	25.9	1105.8	6.5
<i>Sphagnum squarrosus</i> (Td)	1	2.82	26.46	1521.6	9.4
<i>Dicranum polysetum</i> (Trh)	2	3.80	53.8	1291.4	14.1
<i>Hylocomium splendens</i> (W)	2	1.47	29.7	739.3	20.1
<i>Pleurozium schreberi</i> (W)	2	2.05	20.5	920.2	10.0
<i>Polytrichum strictum</i> (Trh)	2	2.89	27.2	506.0	9.4
<i>Ptilidium ciliare</i> (Mr)	2	2.77	27.7	1398.3	10.0
<i>Dicranum bonjeanii</i> (Te)	3	2.28	35.0	999.3	15.3
<i>Dicranum fuscescens</i>	3	2.52	38.3	970.1	15.2
var. <i>congestum</i> (Te)					
<i>Drepanocladus uncinatus</i> (Mr)	3	2.33	37.4	761.0	16.1
<i>Pleurozium schreberi</i> (W)	3	2.31	30.8	1106.1	13.4
<i>Polytrichum strictum</i> (Trh)	3	2.70	33.6	473.7	12.5
<i>Ptilidium ciliare</i> (Mr)	3	2.40	36.9	1385.7	15.4
<i>Dicranum fuscescens</i>	4	1.92	52.9	989.6	27.6
var. <i>congestum</i> (Te)					
<i>Pleurozium schreberi</i> (W)	4	2.32	38.7	1354.3	16.7
<i>Polytrichum strictum</i> (Trh)	4	2.64	39.7	436.1	15.0
<i>Ptilidium ciliare</i> (Mr)	4	2.03	37.3	1299.2	18.4
<i>Dicranum bonjeanii</i> (Te)	5	2.01	46.2	1029.5	23.0
<i>Drepanocladus uncinatus</i> (Mr)	5	2.15	37.7	1074.5	17.5
<i>Hylocomium splendens</i> (W)	5	1.42	37.4	889.8	26.3
<i>Pleurozium schreberi</i> (W)	5	1.97	22.76	889.8	11.6
<i>Polytrichum alpinum</i> (Te)	5	1.88	27.7	481.0	14.7
<i>Ptilidium ciliare</i> (Mr)	5	2.22	37.6	1279.2	16.9
<i>Dicranum fuscescens</i>	6	1.64	49.6	960.7	30.2
var. <i>congestum</i> (Te)					
<i>Pleurozium schreberi</i> (W)	6	1.78	47.6	1291.4	26.8
<i>Polytrichum piliferum</i> (t)	6	1.78	36.2	332.7	20.4
<i>Ptilidium ciliare</i> (Mr)	6	2.05	40.9	1221.3	19.9
<i>Rhytidium rugosum</i> (W)	6	1.73	41.46	962.3	24.0
<i>Dicranoweisia crispula</i> (t)	7	1.35	62.2	1124.8	46.2
<i>Dicranum angustum</i> (Te)	7	3.53	93.0	1253.2	26.4
<i>Dicranum fuscescens</i>	7	1.57	58.7	889.2	37.4
var. <i>congestum</i> (Te)					
<i>Dicranum spadiceum</i> (Te)	7	1.36	52.1	1030.6	38.2
<i>Drepanocladus uncinatus</i> (Mr)	7	1.77	59.4	1097.9	33.6
<i>Rhacomitrium lanuginosum</i> (Cu)	7	2.30	73.1	667.2	31.8
<i>Loeskygnum badium</i> (Mr)	8	5.54	50.8	1037.9	9.2
<i>Drepanocladus revolvens</i> (Mr)	8	3.15	35.3	1642.3	11.2
<i>Meesia triquetra</i> (Trh)	8	3.29	34.4	1368.9	10.5
<i>Hylocomium splendens</i>	8	2.50	42.13	907.2	16.8
var. <i>obtusifolium</i> (W)					
<i>Meesia triquetra</i> (Trh)	8	3.29	34.4	1368.9	10.5
<i>Rhizomnium andrewsianum</i> (Trh)	8	2.50	35.3	1639.9	14.1
<i>Polytrichum strictum</i> (Trh)	8	1.72	39.7	440.1	16.1
<i>Ptilidium ciliare</i> (Mr)	8	1.99	45.5	1256.6	22.9
<i>Tomenthypnum nitens</i> (W)	8	2.21	39.5	899.6	17.8
<i>Chandonanthus setiformis</i> (Te)	9	1.96	43.4	1045.8	22.1
<i>Ptilidium ciliare</i> (Mr)	9	1.95	45.99	1201.1	23.6
<i>Rhacomitrium lanuginosum</i> (Cu)	9	2.37	67.0	656.1	28.3
<i>Schistidium apocarpum</i> (cu)	9	2.15	69.2	1163.2	32.2

* The life forms of mosses: Cu — large cushions; cu — small cushions; Te — tall turfs, divergent branches erect; (Trh) — tall turfs, divergent branches erect with dense felt of rhizoids along the greater part of the stem; Td — tall turfs, divergent branches of limited growth; t — short turfs; Mr — rough mats; W — wefts.

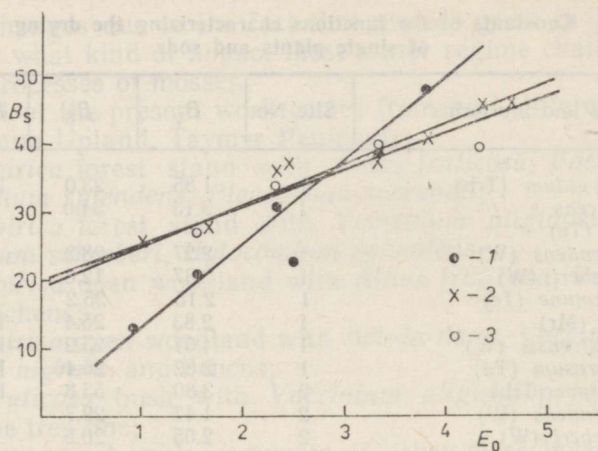


Fig. 1. Dependence of the empirical coefficient characterizing the drying speed of sods (B_S) on the site's average potential evaporation (E_0).

1 — *Pleurozium schreberi*, 2 — *Ptilidium ciliare*, 3 — *Polytrichum strictum*.

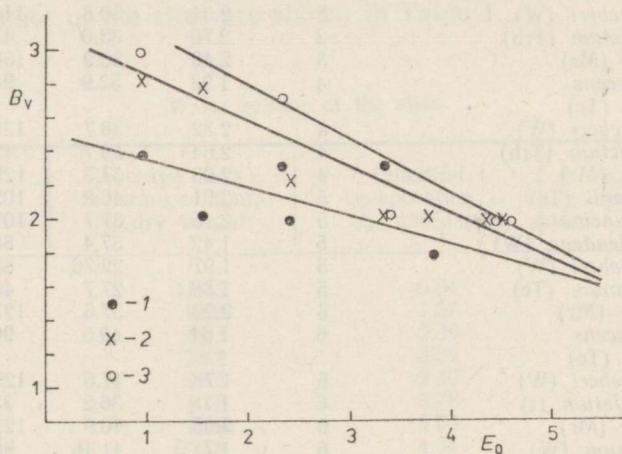


Fig. 2. Dependence of the empirical coefficient characterizing the drying speed of single plants (B_V) on the site's average potential evaporation (E_0).

1 — *Pleurozium schreberi*, 2 — *Ptilidium ciliare*, 3 — *Polytrichum strictum*.

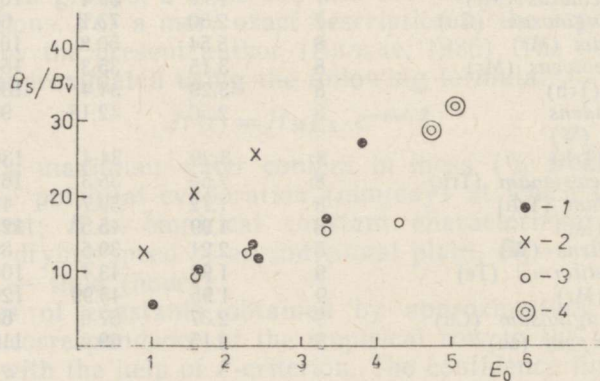


Fig. 3. Dependence of the ratios B_S/B_V on the site's average potential evaporation (E_0).

1 — *Pleurozium schreberi*, 2 — *Hylocomium splendens*, 3 — *Polytrichum strictum*, 4 — *Rhacomitrium lanuginosum*.

water content in single shoots and sods was quite similar and therefore a common constant, H_{MAX} , showing the maximum water content was found for them. Consequently, moss sod (life form) cannot be regarded as a water reservoir.

The drying speed of moss sod is characterized by a constant B_S . The greatest values of B_S (the slowest drying speed) belong to mosses from the *Dryas* tundra and the rock stream in the *Larix sibirica* forest. Table 1 shows that potential evaporation also has maximum values on these sites.

If we compare representatives of one species (which have the same life form) from different sites, we can observe that the constant B_S varies considerably and its variation is closely connected with the water regime of the site (Fig. 1). Fig. 1 shows that greater average values of potential evaporation are accompanied by greater values of the constant B_S .

If we compare the drying speeds of mosses which belong to different life forms, we will find that *Dicranum angustum* (tall turfs), *Racomitrium lanuginosum* (large cushions), *Schistidium apocarpum* (small cushions), and *Dicranoweisia crispula* (small turfs) dry at the slowest speeds. These species form a typical moss cover on open areas, where the evaporation from moss surface is the greatest.

The constant B_V which characterizes the drying speed of single plants is relatively stable (Fig. 2). This is understandable as the growth form of mosses is genetically more fixed. It was observed in many cases that the constant B_V decreased when potential evaporation increased. In connection with this the ability of a single plant to resist drying also diminished.

It can be concluded from this that for most mosses the growth form does not affect the formation of the water regime to a great extent. The water regime is formed mainly at the level of life form.

The ratio B_S/B_V shows how many times the speed of moss drying slows down (and, therefore, the duration of photosynthesis increases) due to the preventive effect of life form on evaporation. The ratio can be regarded as the "efficiency" of life form with regard to water regime (Fig. 3). Fig. 3 shows that life form has especially great importance as a stabilizer of water regimes in dry sites.

The water regime of the genus *Polytrichum* is peculiar. Table 2 shows that mosses of this genus contain less water than other moss species. The species of *Polytrichum* are regarded as typical endohydric mosses (Buch, 1947a, b). They absorb water from substrate and transfer it inside the plant into the leaves and other transpirative tissues. The surface of leaves is hydrophobic and no water film is formed, although the water film is typical of other mosses. This favours the movement of CO_2 between the environment and the leaves and helps to accelerate photosynthesis.

However, internally transported water is not sufficient for constant transpiration. Therefore, in the case of these moss species the decreasing effect of life form on evaporation is also important. Data in Table 2 confirm this supposition, showing that the ratio B_S/B_V is quite big even in the case of these species.

The growing conditions of mosses in sedgegrass tundra are interesting. Thanks to the constant adding of permafrost and melting waters of snow, mosses contain an almost optimum amount of water for photosynthesis during greater part of the vegetation period. At the same time there exists relatively high evaporation. Table 2 shows that under such growing conditions a sufficiently thick sod is formed which lessens evaporation to a great extent. Therefore, life form plays an important role in the stabilization of the water regime of mosses even in such site conditions.

On most sites the availability of water is the main factor limiting the growth of mosses. As life forms have an important role in the formation of the water regime, they are an important investigation object.

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