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Notes on the ecology and biology of *Scorpidium scorpioides* (Hedw.) Limpr.

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Abstract

The present paper is concerned with certain features of the growth cycle, both vegetative and reproductive, of the moss *Scorpidium scorpioides*. Some ecological factors are also discussed. Positive hygrotropism which occurs in young shoots prevents mosses from desiccation. Capsules of *Scorpidium scorpioides* are rare in Poland. *S. scorpioides* is markedly intolerant of shade and this may be a restricting factor in its competition with other plants. Experiments and literature indicate that *S. scorpioides* is indifferent to lime and can tolerate sites poor in calcium ions.

INTRODUCTION

Scorpidium scorpioides (Hedw.) Limpr. is a rather rare representative of the bryoflora of Poland. Ecological information on this species is very scant and the present study is an attempt at elucidation of some problems from the ecology and biology of this interesting moss species which is gradually disappearing from our flora.

Brotherus (1925, Herzog (1926), Szafran (1948), Podpera (1954), Jasnowski (1957a) and Kuc (1964) describe the distribution of *S. scorpioides*. In the northern hemisphere it appears irregularly, is more frequent in the north and reaches beyond the polar circle while in the south it is more rare. In Poland it constitutes a frequent element of rheophilous peat bogs, particularly in the north of this country. In the south its sites are rarely dispersed. *Scorpidium scorpioides* occurs as a rule on the lowland, but may also be found in the mountains — in the Tatra (1150 m a.s.l.) and Alps (1800—2000 m a.s.l.).

MATERIAL AND METHODS

Field observations were conducted on the peat bog near Kunice (Legnica district) and near Radecz (Wrocław district). Herbarium material was obtained from the collection of the Poznań, Warsaw and Wrocław Universities and from the Institute of Botany of the Polish Academy of Sciences in Cracow. The entire material for the experiments and the substrate originated from the peat bog in Kunice. Calcium was determined with EDTA-Na_2 in the presence of murexide, and pH electrometrically.

Experiment 1. Whole moss swards were cultivated in a glasshouse in two relative moisture combinations: 30 and 80 per cent. The purpose was to observe moss growth in relation to changes in air moisture.

Experiment 2. The same material as in experiment 1 was cultivated under artificial illumination of various intensity (fluorescent tubes) at 18°C. Light intensity was 1000, 1800, 2000 and 5000 lux. The plants were alternately kept under different light intensity. The observations concerned anomalies occurring in the development of the moss.

Experiment 3. The moss (ca. 20 g fresh mass) was placed in glass vessels with Knop's medium, pH 6.80 with various amounts of calcium added: 150, 50 and 20 mg/l. The culture was run in the glasshouse for 120 days. As control served a culture on a medium without calcium. Growth was measured in terms of biomass increment.

Experiment 4. Living *S. scorpioides* plants of similar habitus were placed on Knop's medium, pH 5.75. The temperature was maintained during the experiment at 18°C and light intensity was 2300 lux with 15-h daylength. The duration of the experiment was limited by the algae appearing in the culture medium after a certain time. The aim was to check the influence of *S. scorpioides* on the medium pH.

Herbarium specimens of the moss were analysed morphologically to follow its development. The material was, therefore, divided into 3 classes comprising various growth forms. The first class included individuals with stem 1 mm thick and lateral branches of maximally 6 mm length. To the second class belonged plants with a stem 1—2.5 mm thick and branches 7—10 mm long, and to the third individuals with a 3 mm thick stem and lateral branches exceding 10 mm. Forms with unnatural habitus (e.g. with sparse foliation and very thin stems) were excluded.

RESULTS AND DISCUSSION

Vegetative cycle

Scorpidium scorpioides is a hygrophyte occuring usually on inundated peat bogs rich in mineral compounds. It is also found in peat hags, ditches and lakes. In water bodies the moss grows as a rule at a depth

of 0,2—0,5 m. On peat bogs it frequently forms thick mats immersed in water and it hardly ever grows above the water surface. In experiment 1 at air moisture 80 per cent the moss grew vertically above the water surface but emerged parts of stems were very thin and poorly foliated. At air moisture 30 per cent the moos grew right under the water surface only. Lowering of air moisture from 80 per cent to 30 per cent caused bending of growing stems and immersing them back. If the moss has grown more than 2 cm above the water surface lowering of the air moisture did not cause bending of the stems, owing to their desiccation and dying back. Thus, the positive hydrotropism in the growing parts of the *S. scorpiodes stem* prevents its execessis emergence and desiccation.

Table 1

Percentual representation of the different growth classes in each month shown by specimens o *Scorpidium scorpioides*

Month		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Growth classes	1	—	—	37	37	36	34	23	38	56	26	57	—
	2	—	—	50	50	46	46	42	48	37	66	25	—
	3	—	—	13	13	18	21	25	15	7	8	18	—

Analysis of the herbarium specimens of *S. scorpiodes* made it possible to establish certain developmental characters of this moss. As seen from Table 1, the percentual contribution of all classes is more or less equal in the particular months. In each month individuals of all the growth classes may be found. This indicates a uniform growth of *S. scorpioides,* that is the side branchings develop with the growth of the stem. Thus, there are no development phases as may frequently be seen in other mosses (T a l l i s, 1959). This fact, among other things, makes impossible growth measurement by the method of marking the successive length increments in the course of the year.

In experiments 1 and 2 unfavourable illumination or moisture changes caused the formation of nontypical forms. Many of the described *S. scorpioides* forms are probably modifications conditioned by habitat conditions. Mosses may greatly change under the influence of the habitat, and the extent of these changes varies for various species (B i r s e, 1957; G i m i n g h a m and B i r s e, 1957; K a r c z m a r z, 1971). *S. scorpidioides* belongs to species very susceptible to the modifying influence of the habitat.

Reproduction

S. scorpioides is a dioecious moss producing gametangia in spring. Sporogonia are formed but seldom and the frequency of this phenomenon decreases in this species in southward direction. For instance,

according to Nyholm (1965), sporogonia appear rarely on the Scandinavian peninsula, and in Hungary Boros (1968) describes this species as sterile. Since no data are available for Poland the situation cannot be evaluated. In herbarium collections of *S. scorpioides* plants in this country only 2 per cent exhibit sporogonia or gametangia. In view of the fact that most of the material was collected in the optimal period for sporophyte production, the per cent found is very low. It would seem that sexual reproduction of *S. scorpioides* is rare in Poland.

For mosses growing in isolated habitats such as peat bogs, lakes without outflow etc. spore dissemination is frequently the only way of reaching new distant habitats. Regeneration of plants after periodical dying out owing to unfavourable changes in the habitat is also usually possible only by means of spore germination. The low resistance to drying up of vegetative parts, characteristic for many bryophytes (Biebl, 1965) greatly limits the possibility of spreading by wind or transfer by animals. The causes of rare sprogonia production are as a rule very complex and difficult to establish. Nevertheless, it is possible that in the case of *S. scorpioides* dioecism of this species may play a certain role. It is not excluded that the rare formation of sporogonia in this species may be connected with the age of the plants (cf. Szafran, 1948). Changes in the habitat leading to conditions unfavourable for *S. scorpioides* may lead, considering its restricted ability of spreading, to its recession particularly as at present such developmental phases of peat bogs are lacking which would favour the spread of this species (Jasnowski, 1957b).

Habitat factors

(a) Light

The results of experiment 2 indicate high light requirements of *S. scorpioides*. Under light of less than 2000 lux considerable changes were noted in the growth of this moss. The growing shoots were slender, sparsely foliated and had no branchings. When the moss was transferred to better light conditions (above 2000 lux) there were no growth disturbances and the new shoots showed a typical habitus.

A similar phenomenon was noted in field observations. Fragments of mats collected at 30-day intervals showed a distinct increase in the number of etiolated (Fig. 1) individuals in the months of most intensive growth of surrounding higher plants. The change in growth dynamics which occurs under conditions of light deficit ensures a uniform growth to the moss population. In a compact mat part of the individuals live constantly in conditions of light deficit, and, if the mat is shaded, these individuals become etiolated, this being manifested by accelerated growth

what allows them to reach a better illumination level. In dense moss mats individuals may often be found in which the lower part is etiolated while the upper is normally developed. The mass development of higher plants may greatly restrict light access to the moss layer and inhibit its development. The existence of two phases — a light and dark one — has been found in many habitats (R i c h a r d s, 1932). Thus, light may be an important factor conditioning the course of competition between higher plants and *S. scorpioides*. This moss has optimal light conditions on most habitats in spring or autumn when the shading effect of the higher vegetation is weaker.

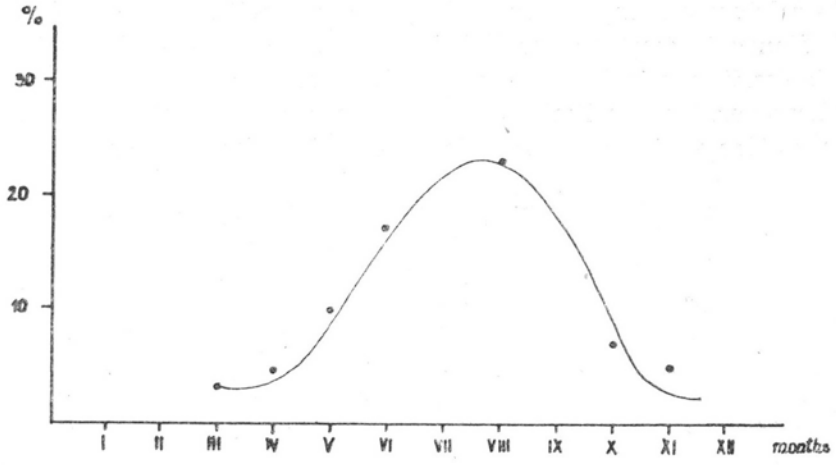

Fig. 1. Percentual representation of etiolated shoots in mats of *Scorpidium scorpioides*

(b) Edaphic factors

The requirements of *S. scorpioides* as regards calcium have so far not been established, It is considered as a calciphilous species or its requirements are believed to be moderate (K u c, 1956; J a s n o w s k i, 1957a; W a t s o n, 1959; K a r c z m a r z, 1963, B o r o s, 1968). Cultivation of *S. scorpioides* on medium with various calcium content (exp. 3) did not demonstrate any influence of this element on biomass increment in this moss. In all experimental combinations the mass increment was the same, amounting to about 35 per cent. Only on the medium without calcium (control), after an initial period of normal growth, dying of the plants was observed. The calcium content in *S. scorpioides* habitats varies widely, changing from very low to very high amounts (Table 2). This points to a considerable tolerance of *S. scorpioides* as regards the calcium level. The moss is frequently reported from sites with a high

Table 2

pH and Ca values on various sites of *Scorpidium scorpioides*

pH	Ca mg/l	Sampling sites
6.8	2	Byrgslagen, after Sjörs (1948)
6.9	173	Peat bog Bodzisławskie, after Wąs (1965)
6.8	44	Peat bog Salmonowskie, after Wąs (1965)
6.7	30	Peat bog Kunice
6.8	44	Peat bog Radecz

content of this element. This may be explained by the fact that as a rule calcium content is positively correlated with the general trophic level. Hence it may be concluded that *S. scorpioides* finds the best trophic conditions in habitats with a high calcium content; a low content, however, is not a limiting factor. Observations of the occurrence of *S. scorpioides* on the peat bog at Kunice lead to the same conclusion.

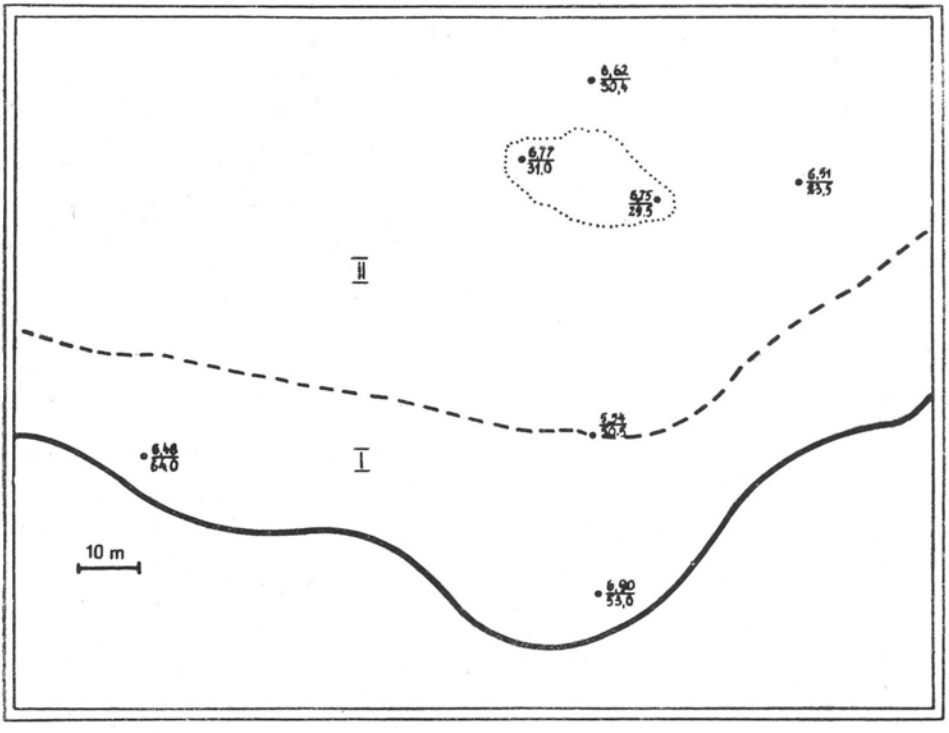

Fig. 2. Ca and pH values and *Scorpidium scorpioides* distribution on the peat bog Kunice

Legend: I — eutrophic part; II — mesotrophic part. Dotted are — site of *Scorpidium scorpioides*; points — $\frac{\text{pH}}{\text{Ca in mg/l}}$

This moss occupies the central part of the peat bog, however, it is absent in the littoral zone richest in calcium (Fig. 2). The peat bog is an example of distinctly outlined trophic zonality. The changing level of mineral components produces changes in the vegetation (Marek and Siedlak, 1972). The occurrence of *S. scorpioides* on habitats with a very low calcium content remains an open question. In experiment 3 normal growth of the moss was observed for 40 days on medium deprived of calcium. This may be explained by the possibility of partial substitution of calcium by magnesium, sodium or potassium (Bell and Lodge, 1963) or else by the transport of biogenic elements from the older part of the plant to the younger one (Goulder and Boatman, 1971). The reported results indicate a wide ecological scale of *S. scorpioides* in reference to calcium, thus it cannot serve as an indicator of the calcium level.

Table 3

Effect of *Scorpidium scorpioides* on hydrogen ion concentration in nutrient solution (x-algae present)

No.	Hydrogen ion concentration (pH) time (h)					
	0	24	48	72	96	120
1	5.75	7.60	7.70	7.76	7.80	7.84
2	5.75	7.62	7.72	7.80	7.74	7.72
3	5.75	7.86	—*	—	—	—
4	5.75	7.84	7.80	7.90	7.90	7.90
5	5.75	7.84	7.20	7.30	7.30	7.24
6	5.75	6.50	7.20	7.20	7.18	7.22
7	5.75	7.50	7.52	7.50	7.60	7.54
$\bar{x}$	5.75	7.53	7.52	7.57	7.58	7.57

A change in the pH of the medium caused by *S. scorpioides* was revealed in experiment 4. A considerable shift of the pH in alkaline direction occurred as early as after 24 h, further no changes were noted (Table 3). The changed pH values due to the growing moss differ from those of natural habitats (Table 2). Maybe, this could be explained by the different conditions prevailing in an artificial culture (e.g. the substrate lacks buffer properties). Nevertheless the phenomenon of pH modification explains some problems connected with the moss food uptake.

It is rather the availability of the elements than their absolute amount that decides of the trophic level of the habitat, and the former is largely dependent on pH. The possibility of pH adjustment in the medium allows the plant to utilize even low amounts of nutrient substances and this might explain the calcium problem. The change of

the medium pH by bryophytes has been described by numerous authors (Montgomery, 1931; Garjeanne, 1932; Richards, 1932; Bell, 1959; Daubenmire, 1974). These changes usually tend to the maintenance of the range of pH optimal for the given species. Little, however, is known on the influence of plant populations on the pH of the substrate and this problem requires further study.

REFERENCES

Bell P. R., 1959. The ability of *Sphagnum* to absorb cations preferentially from dilute solutions resembling natural waters. J. Ecol. 47:351-56.

Bell P. R., Lodge E., 1963. The reliability of *Cratoneuron commutatum* as an indicator moss. J. Ecol. 51:113-22.

Biebl R., 1965. Protoplasmatische Ökolgie der Pflanzen. (Russ. edit.) Mir, Moskva: 463 pp.

Birse E. M., 1957. Ecological studies on growth-form in bryophytes. II. J. Ecol. 45:721-34.

Boros A., 1968. Bryogeographie u. Bryoflora Ungarns. Akad. Kiadó. Budapest: 466 pp.

Brotherus V. F., 1925. Musci. In Engler-Prantl Die natürlichen Pflanzenfamilien. Leipzig: 701-1246.

Daubenmire R. F., 1973. Rośliny i środowisko. PWN, Warszawa:522 pp.

Garjeanne J. M., 1932. Physiology in Manual of Bryology. Ed. Ferdoorn. The Hague:485 pp.

Gimingham C. M., Birse E. M., 1957. Ecological studies on growth-form in bryophytes. J. Ecol. 59:533-45.

Goulder R., Boatman D. J., 1971. Evidence that nitrogen supply influences the distribution of a freshwater macrophyte *Ceratophyllum demersum*. J. Ecol. 59:783-92.

Herzog Th., 1926. Geographie d. Moose. G. Fischer. Jena:439 pp.

Jasnowski M., 1957a. Flora mchów z czwartorzędowych osadów torfowisk reofilnych. Acta Soc. Bot. Pol. 26:597-629.

Jasnowski M., 1957b. *Calliergon trifarium* w układzie stratygraficznym i florze torfowisk holoceńskich Polski. Ibid:701.

Karczmarz K., 1963. Mchy pojezierza Łęczyńsko-Włodawskiego I. Ann. Univ. MSC, sect. C, 18:367-410.

Karczmarz K., 1971. A monograph of the genus *Calliergon* (Sull.) Kindb. Monogr. Bot. 34:1-208.

Kuc M., 1964. Bryogeografia wyżyn południowych Polski. Monogr. Bot. 17:1-173.

Marek S., Siedlak S., 1972. Torfowisko Kunice a osada Łużycka w Grzybianach k. Legnicy. Bad. Fizjogr. Pol. Zach. 23:156-67.

Montgomery Ch. E., 1931. Ecology of the mosses of Graund de Tour Region of Illinois, with special references to pH relations. Bot. Gaz. 91:225-51.

Nyholm E., 1965. Illustrated moss flora of Fennoscandia. Lund, Fasc. 5:407-647.

Podpera J., 1954. Conspectus muscorum Europaeum. Č.A.V. Praha:697 pp.

Richards P. W., 1932. Ecology in Manual of bryology. Ed. Ferdoorn. The Hauge:485 pp.

Sjörs H., 1948. Myrvegetation i Byrslagen. Acta Phytogeogr. Suec. 21:1-229.

Szafran B., 1948. Przeżytki z epok ubiegłych we florze mchów Polski i wschodnich krain sąsiednich. Ochrona. Przyr. 18:41-65.

Tallis J. H., 1958. Studies in the biology and ecology of *Racomitrium lanuginosum*, II. J. Ecol. 47:271-89.
Watson E. V., 1959. Mosses and liverworts. Univ. Press, Cambridge:419 pp.
Wąs S., 1965. Geneza, sukcesje i mechanizm rozwoju warstw mszystych torfu. Zesz. Probl. Post. N. Roln. 57:305-93.

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Uwagi o ekologii i biologii Scorpidium scorpioides [Hedw.] Limpr.

Streszczenie

Praca dotyczy obserwacji nad biologią i ekologią mchu *Scorpidium scorpioides*. Na podstawie przeprowadzonych badań terenowych, doświadczeń hodowlanych oraz analizy zbiorów zielnikowych uzyskano niektóre dane ekologiczne i biologiczne charakteryzujące ten gatunek.

1. Hygrotropizm dodatni występujący w rosnących łodyżkach mchu umożliwia roślinie stały wzrost bez wynurzania się nad powierzchnię wody, co zapobiega wysychaniu mchu.
2. Sporofit *S. scorpioides* występuje w Polsce bardzo rzadko.
3. Wyniki doświadczeń oraz występowanie *S. scorpioides* w siedliskach z różną zawartością wapnia wskazują na szeroką skalę ekologiczną mchu względem tego pierwiastka.
4. Możliwość zmiany odczynu podłoża decyduje o pobieraniu pierwiastków przez *S. scorpioides*.
5. Znaczne wymagania świetlne odgrywają ważną rolę w konkurencji *Scorpioidium scorpioides* z innymi roślinami.