STUDIA BOTANICA HUNGARICA
(Antea: Fragmenta Botanica)
XIV. 1980 p. 63-71

A new measure for comparing the shape of moss leaves

By

M. RAJCZY

(Received November 10, 1979)

Abstract: Two measures (leaf width/length and the new one called leaf part ratio, LPR) are proposed to characterize the shape of moss leaves. The method was tested on 33 moss leaves by means of cluster analysis.

Using various handbooks and floras I often had problems with the descriptions of leaf shapes. The terms used (e. g. "wide ovate", "elongate-lingulate", etc.) are very subjective. Recently Hickey elaborated an exact system to determine dicotyledonous leaf shapes. The system consists of five main categories (oblong, elliptic, ovate, obovate and special shapes), and of sub-categories within these main ones, which depend of the leaf length/leaf width ratio (Hickey 1973). This system is quite a good one but somewhat complicated to use. Another problem is that there is no category in this system for the deeply acuminate leaves which are very frequently found in mosses. For example the "widely cordate-triangular" leaf of Eurhynchium striatum (Plate II. No. 29) is "wide ovate" only by these categories. Of course, there are other methods to characterize leaf shapes e. g. that of Koponen who used the width of leaves in three places (in the middle, in the upper and lower quarter of leaf) in his study (Koponen 1967).

I propose a new measure to compare leaf shapes in mosses:

$$LPR = \frac{l_{dm}}{l - l_{dm2}}$$

where LPR is the new measure (Leaf Part Ratio); l is the length of the leaf; l_{dm} is the distance between the leaf base and the line where the width of leaf is maximum; l_{dm2} is the distance between the leaf base and the line where the width of leaf is half of the maximum width (see Fig. 1). The LPR is sensitive mainly to the shape of the upper half of the leaves and to the position to the maximum width. It is not sensitive to the relative width of the leaves at all, that is why it can be used together with the leaf width/length ratio.

METHODS

To test the new method I selected 33 drawings of leaves of various moss species, 30 from Dixon (1924) and 3 from Orbán (1974). The species used: Atrichum crispum (Jam.) Sull. et Lesq.; Atrichum undulatum (Hedw.) P. Beauv.; Atrichum angustatum (Brid.) B. S. G.; Pogonatum urnigerum (Hedw.) P. Beauv.; Pogonatum aloides (Hedw.) P. Beauv.; Tetraphis pellucida Hedw.; Rhabdoweisia crenulata (Mitt.) Jameson; Oreoweisia bruntonii (Sm.) Mild.; Racomitrium aciculare (Hedw.)

Brid.; Grimmia homodyction Dix.; Hedwigia ciliata (Hedw.) P. Beauv.; Pottia heimii (Hedw.) Hamp.; Pottia viridifolia Mitt.; Pottia starckeana (Hedw.) C. Muell.; Tortula cuneifolia (With.) Turn.; Desmatodon convolutus (Brid.) Grout.; Tortula laevipila (Brid.) Schwaegr.; Didymodon trifarius (Hedw.) Roehl.; Eucladium verticillatum (Brid.) B. S. G.; Encalypta streptocarpa Hedw.; Dialytrichia mucronata (Brid.) Broth.; Cinclidotus fontinaloides (Hedw.) P. Beauv.; Ulota bruchii Hornsch.; Splachnum wormskioldii Horn.; Bartramia stricta Brid.; Mnium hornum Hedw.; Orthothecium rufescens (Brid.) B.S.G.; Platyhypnidium riparoides (Hedw.) Dix.; Eurhynchium striatum (Hedw.) Schimp.; Grimmia atrata Hornsch.; Plagiomnium ellipticum (Brid.) Kop.; Rhizomnium pseudopunctatum (B.S.G.) Kop.; Cinclidium stygium Sw. The nomenclature is that of the Index Muscorum (Wijk et al. 1959-1969) and that of Koponen (1968) in the Mniaceae. I measured the following five characters: 1. the length of the leaf "l"; 2. the distance from the leaf base to the line where its width is reduced to the half of its maximum "l_{dm2}"; 3. the distance from the leaf base to the line where its width is maximum "l_{dm}"; 4. the maximum width of the leaf "dm"; 5. the width of the leaf base "db" (Fig. 1, Plate I-II). To get exact groups of the leaves I used average linkage cluster analysis (WPGMA), for the similarity matrix Hummon's "shared species diversity" function was used (Sneath and Sokal 1973, Hummon 1974). For the analysis characters 1-5 were standardized, and four ratios were calculated as characters 6-9; 6. 100 x dm/l; 7. 10 x LPR; 8. 100 x $(l_{dm2}-l_{dm})/l$; 9. 100 x l_{dm}/l.

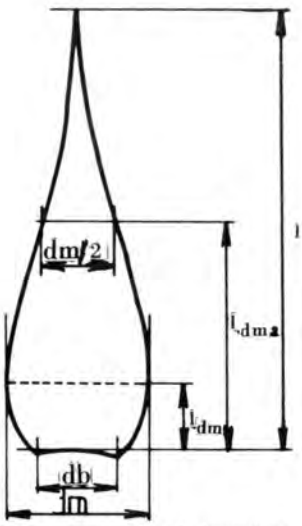


Fig. 1. Measurement of leaf characters

RESULTS AND DISCUSSION

The dendrogram on Fig. 2. shows the result of cluster analysis. It gives 13 sub- and 4 main categories whose outlines can be easily drawn by means of the two proposed measures. In group I we can find the lanceolate leaves ($0.1<dm/l<0.32$ and $0.05<LPR<0.8$). Group II contains the one widely triangular leaf ($dm/l=0.78$, $LPR=0.17$). In group III there are the ovate and elliptic leaves ($0.2<dm/l<0.8$ and $0.5<LPR<6$) and in group IV there are the obovate leaves ($10<LPR$). For details see Table 2. On the plot (Fig. 3) the groups can be recognized more easily because of the logarithmic transformation of LPR.

The new measure measure seems to be very useful in numerical studies when a comparison of various leaf shapes is wanted.

I wish to express my gratitude to Dr. L. Hajdu for reading and criticizing the manuscript and to Miss M. Hangya for drawing the figures.

Plate I-II: The leaves measured (for numbers see Table 1)
Numbers 1-20 were redrawn from Dixon et al (1924) and
Numbers 31-33 from Orbán (1974).

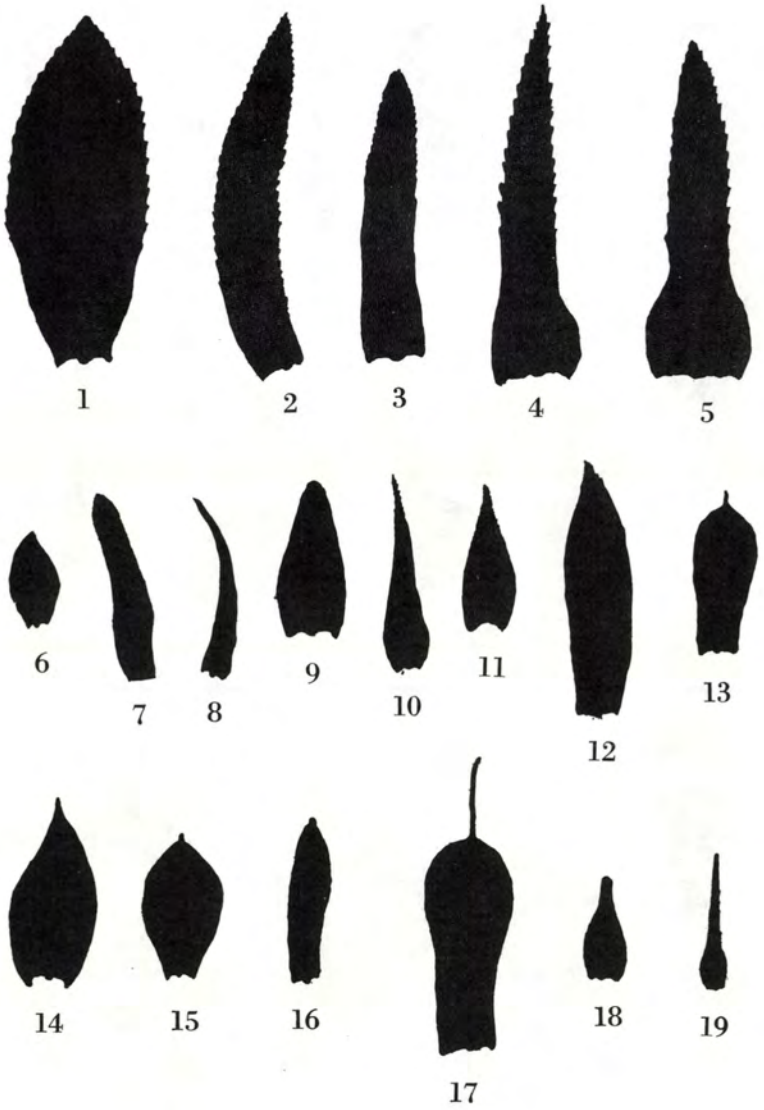
Table 1. The characters measured (for abbrevations see Fig. 1) (in mm)

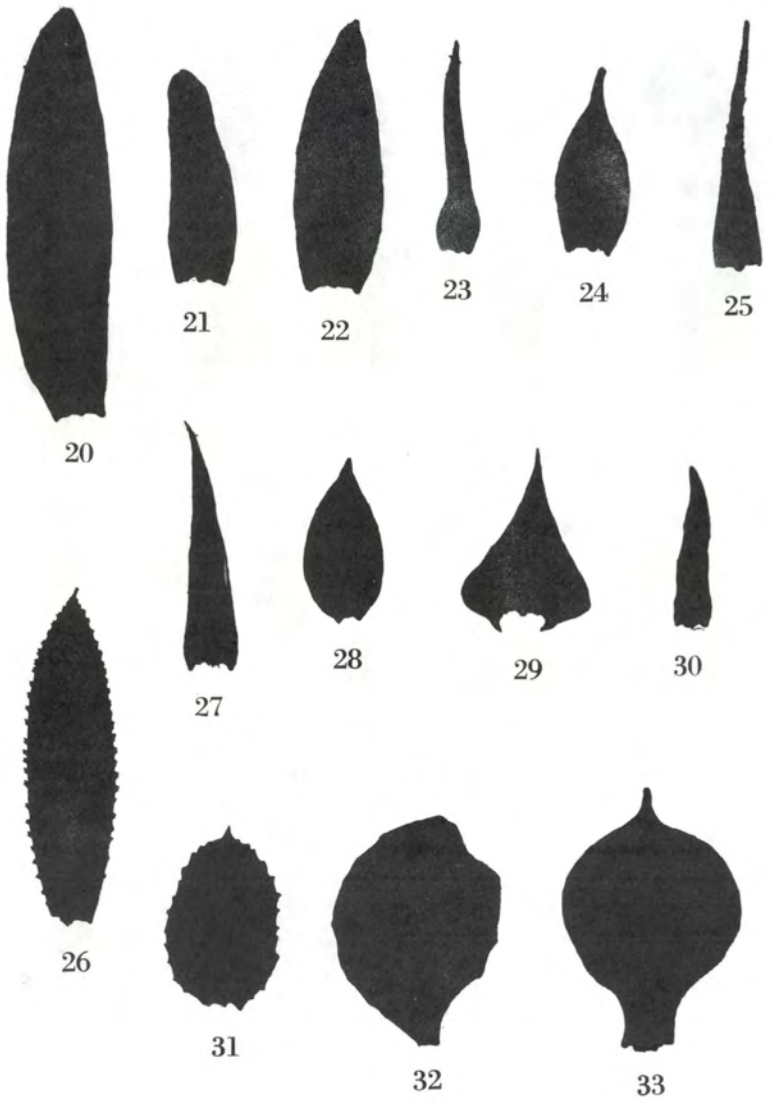
No.	Species	l	l_{dm2}	l_{dm}	dm	db
1	Atrichum crispum	73	64	36	30	12
2	Atrichum undulatum	48	41	23	13	7
3	Atrichum angustatum	62	54	6	13	12
4	Pogonatum urnigerum	80	46	5	19	16
5	Pogonatum aloides	72	52	8	22	19
6	Tetraphis pellucida	19.6	16	9	10.5	5
7	Rhabdoweisia crenulata	41	38	14	8	5
8	Oreoweisia bruntonii	40	17	2	6.2	5.5
9	Racomitrium aciculare	32	25.5	8	15	12
10	Grimmia homodyction	41.5	19	6.5	9.5	5.5
11	Hedwigia ciliata	30	19	5.5	11	9
12	Pottia heimii	55	46	29	14	8.5
13	Pottia viridifolia	32	30	22.6	13.5	8
14	Pottia starckeana	17.5	13.7	7.2	8.5	5
15	Tortula cuneifolia	29.2	25.5	16	17	6.5
16	Desmatodon convolutus	33.7	32.2	19.5	8.5	6.5
17	Tortula laevipila	45.5	43.2	32	18.5	11.5
18	Didymodon trifarius	22	13.5	5	9.2	6.5
19	Eucladium verticillatum	29	10.5	4	5.5	3
20	Encalypta streptocarpa	88	80	41	22	12
21	Dialytrichia mucronata	44	40.5	10	14.5	11.5
22	Cinclidotus fontinaloides	53	47	20.5	19	11
23	Ulota bruchii	45	17.3	4.5	9	7
24	Splachnum wormskioldii	38.5	26	12.5	16	9.5
25	Bartramia stricta	53	21	1.6	10	9.5
26	Mnium hornum	72	62	33	19	10
27	Orthothecium rufescens	53	32	3.8	11	10
28	Platyhypnidium riparoides	34	28	11.4	17	6
29	Eurhynchium striatum	36	15.5	3.4	28	23
30	Grimmia atrata	34	25.5	4.4	8	6.5
31	Plagiomnium ellipticum	38	32	15	23	9
32	Phizomnium pseudopunctatum	50	45	28	35	4
33	Cinclidium stygium	55	45	30	38	11

Table 2. The groups formed by cluster analysis with the values of the two proposed measures

Group		LPR	$\frac{dm}{l}$	Limits of		Remarks
				LPR	$\frac{dm}{l}$	
I	25	0.05	0.19	0.0 -0.1	0.15-0.2	Narrowly triangular
	8	0.09	0.16			
	4	0.15	0.24	0.15-0.2	0.2 -0.25	Lanceolate
	27	0.18	0.21			
	23	0.16	0.20	0.15-0.3	0.2 -0.25	Lanceolate
	19	0.22	0.19			
	10	0.29	0.23			
	5	0.40	0.31	0.4 -0.5	0.2 -0.3	Linear lanceolate
	30	0.52	0.24			
	3	0.75	0.21			Oblong lanceolate
II	29	0.17	0.78			Widely triangular
III	11	0.50	0.37	0.5 -1.3	0.35-0.5	Narrow ovate
	18	0.59	0.42			
	24	1.00	0.42			
	9	1.23	0.47			
	21	2.86	0.33			Broadly lingulate
	14	1.89	0.49	1.8 -2.5	0.5 -0.6	Elliptic
	28	1.90	0.50			
	6	2.50	0.54			
	31	2.50	0.61			
	33	3.00	0.69	3.0 -6.0	0.6 -0.7	Wide elliptic
	15	4.32	0.58			
	32	5.60	0.70			
	12	3.22	0.25	3.0 -6.0	0.25-0.4	Narrow elliptic
	2	3.29	0.27			
	26	3.30	0.26			
	22	3.42	0.36			
	1	4.00	0.41			
	20	5.13	0.25			
	7	4.67	0.20			Lingulate
IV	13	11.30	0.42	11.0 -14.0	0.25-0.45	Obovate
	16	13.00	0.25			
	17	13.90	0.41			

Plate I




20
21
22
23
24
25
26
27
28
29
30
31
32
33

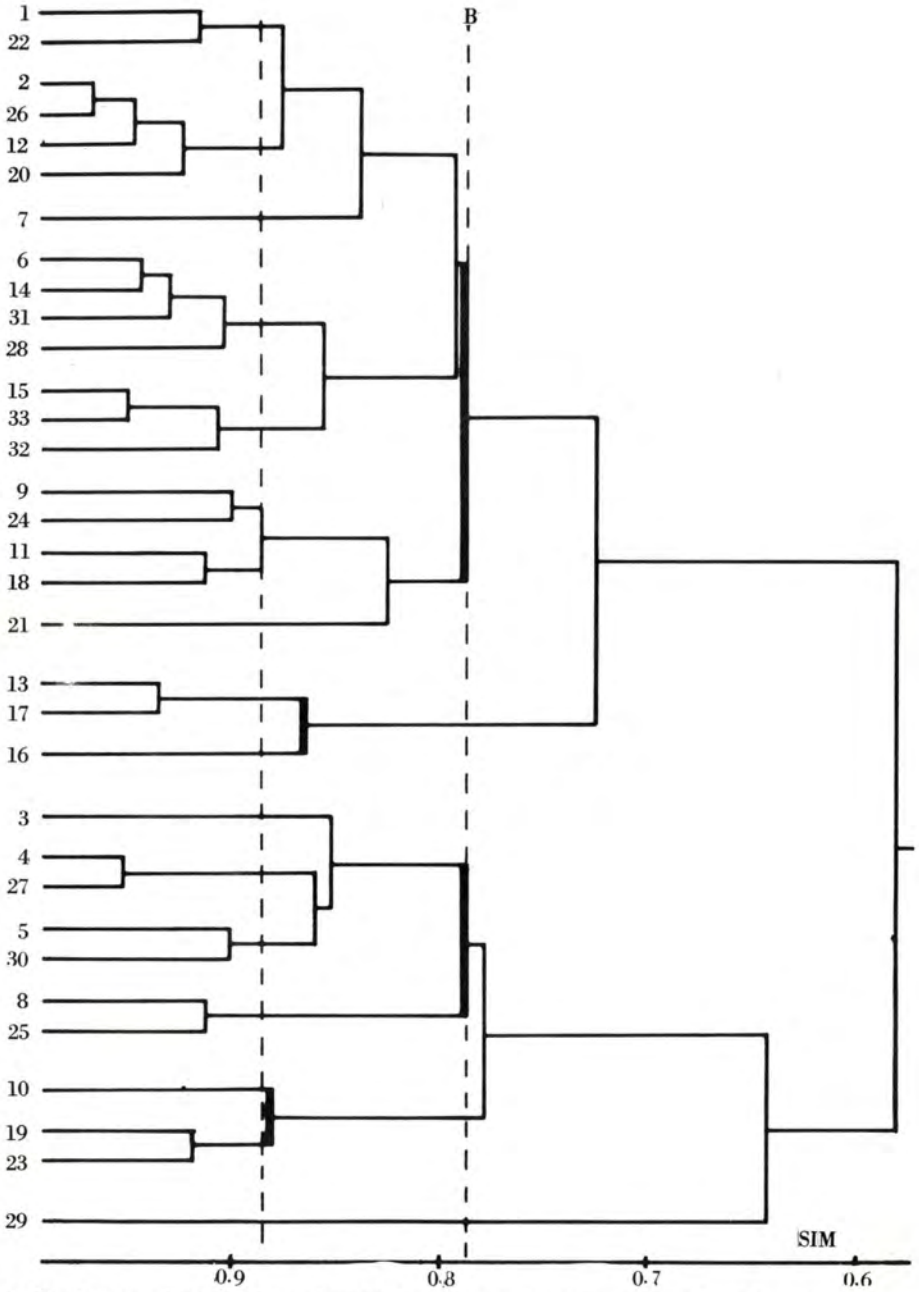


Fig.2. Dendrogram showing relationships of the leaf shapes. A-line: $S_{min}+(S_{max}-S_{min})/4$
B-line: $S_{min}+(S_{max}-S_{min})/2$

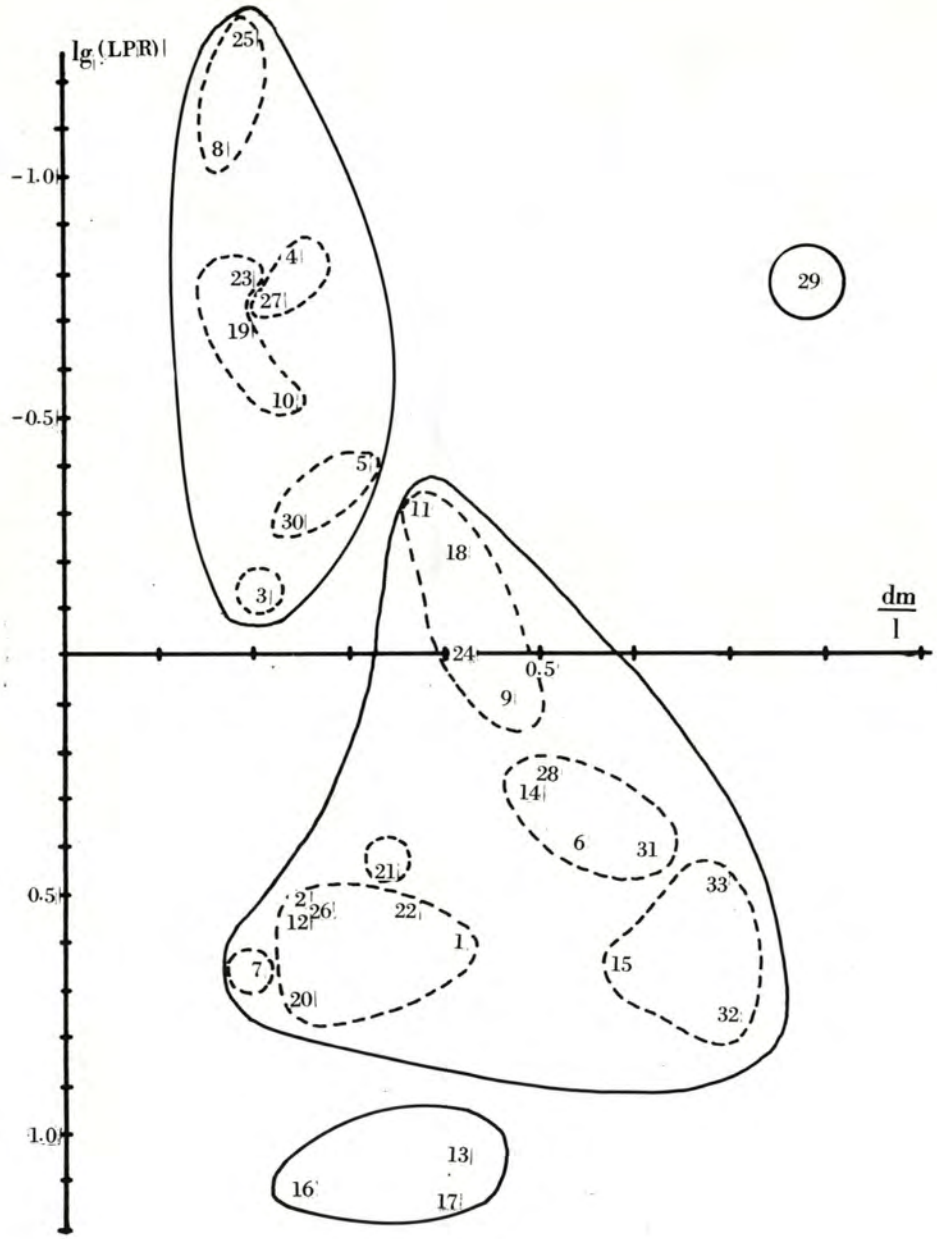


Fig. 3. Plot showing the relationship of dm/l to lg (LPR). (dashed lines: groups formed by cluster analysis under line A; solid lines: groups formed by cluster analysis under line B)

REFERENCES

DIXON, H. N. and JAMESON, H. G. (1924): The Student's Handbook of British Mosses. 3rd ed. - London, 582 pp.

HICKEY, L. J. (1973): Classification of the architecture of dicotyledonous leaves. - Amer. J. Bot., 60: 17-33.

HUMMON, W. D. (1974): S_H,: A Similarity Index Based on Shared Species Diversity, Used to Asses Temporal and Spatial Relations among Intertidal Marine Gastritricha. - Oecologia (Berlin) 17: 203-220.

KOPONEN, T. (1967): Biometrical analysis of a mixed stand of Mnium affine Funck and M. medium B. S. G. - Ann. Bot. Fennici, 4: 67-73.

KOPONEN, T. (1968): Generic revision of Mniaceae Mitt. (Bryophyta). - Ann. Bot. Fennici, 5: 117-151.

ORBÁN, S. (1974): A Mniaceae család fajainak elterjedése a Kárpátok és a Kárpátmedence területén. - Ph.D. Thesis in the Eötvös Loránd University of Sciences, Budapest, 161 pp. (Manuscript)

SNEATH, P. H. A. and SOKAL, R. R. (1973): Numerical taxonomy. The principles and practice of numerical classification. - W. H. Freeman and Company, San Francisco, 573 pp.

WIJK, R. van der, MARGADANT, W. D. and FLORSCHÜTZ, P. A. (1959-1969): Index Muscorum. I.-V. - Utrecht. 3138 pp.

Author's address: M. RAJCZY
Botanical Department of the
Hungarian Natural History Museum
H - 1476 Budapest, Pf. 222
HUNGARY