Study on moss-dwelling testate amoebae

By

J. TÖRÖK*

Abstract. Testate amoebae from six aerophilous moss species were observed. Forty-six testacean species were identified. Six of them are new for the Hungarian fauna. A short description is given about them. Quantitative investigations were carried out to determine the dominance and diversity of species.

Investigations on testaceans in Hungary have been made since the last decade of the XIXth century: SZELÉNYI (1896), KREPUSKA (1917), JACZÓ (1941), VARGA (1953, 1956), BICZÓK (1956), BERECZKY (1970, 1973, 1979, 1984). Their studies focused on the soil, *Sphagnum* and freshwater habitats. Remarkably less attention has, however, been paid to the testate amoebae of the aerophilous mosses, inspite of their high occurrence in almost every land biotopes. The only data on the subject were presented by ERTL (1960), VARGA (1960) and JEKKEL (1969). Considerably more articles on the same topic were published in foreign countries (BARTOS, 1936—1940, 1940, 1954; SCHÖNBORN, 1962, 1964, 1989; GOLEMANSKY, 1967a, 1967b; BEYENS et al., 1986). Their results served as references for my study, which had the purpose of getting new information about the moss-dwelling testate amoebae in Hungary.

Sampling sites, materials and methods

The moss-samples were collected in three areas near Budapest: Börzsöny Mountains, Visegrádi Mountains and Budai Mountains. The location of the sampling sites is presented in Fig. 1. Table 1 shows the list of samples and their natures. Nomenclature of mosses is according to ORBAN & VAJDA (1983).

Six moss species were collected in autumn, 1991. Fixation and sampling took place always on the following day. 1 cm^2 pieces were cut out of the mosses, then each of them was put into small glasses and filled up with 1 cm^3 destilled water. After fixation in $HgCl_2$ solution (9:1) and colouring with bromphenol-blue (BERECZKY, 1985) the material was suspended and observed under microscope.

* *Júlia Török*, ELTE Állatrendszertani és Ökológiai Tanszék (Department of Zoosystematics and Ecology of the Eötvös Loránd University), 1088 Budapest, Puskin u. 3, Hungary.

At the determination of species I compared the size-data of the testacean shells with those described by foreign authors. I measured only the most important characters, necessary for the determination of the testacean species.

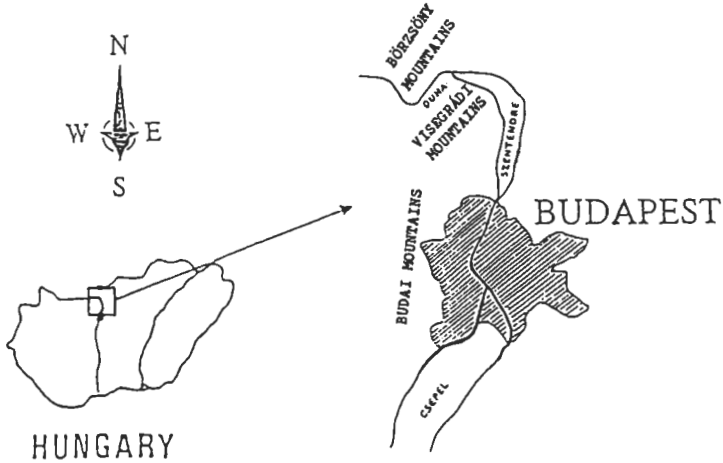

Fig. 1. Location of the sampling sites

Quantitative examination was carried out by direct counting of the coloured specimens, which seemed to be blue as a result of the colouring method. Diversity (D) values were calculated by the SHANNON-WEAVER formule:

$$D=-\Sigma\, p_i * \log_2 p_i \qquad p_i = \text{individual dominance of x species.}$$

In order to investigate the percentage distribution of the testaceans, I used dominance categories (intervals after MEISTERFELD, 1979).

SEM Photomicrographs were obtained using a JSM 50A scanning electron microscope operating at 15 kV.

Results

Forty-six species, belonging to eighteen genera were observed in the six moss species. The composition of the fauna is given in Table 2. Most of the recorded taxa have already been found in Hungary, however, six species are new for the Hungarian fauna. These are as follows: *Microcorycia radiata, Centropyxis orbicularis, Plagiopyxis labiata, Difflugia stoutii, Phryganella acropodia, Trinema penardi*

Microcorycia radiata PENARD, 1912

The shell is flexible, transparent and almost hemisphaerical from lateral view. From top view it is circular and long ridges radiate from the center of the aboral region. The aperture is situated at the opposite end, which is the most vulnerable part of the shell. Actually it is often missing.

Author:	Diameter:	Length:
BARTOS (1954):	30—40 μ	—
Own data:	24—35 μ	30—35 μ

Table 1. List of samples collected

Location		Moss species	Date of collection
Börzsöny	soil	*Plagiomnium undulatum*	09. 11. 1991
Mountains	soil	*Plagiothecium platyphyllum*	29. 09. 1991
(Oltár Valley)			09. 11. 1991
Visegrádi Mountains (Pap Field)	soil	*Amblystegium riparium*	30. 10. 1991
Budai Mountains (Remete Valley)	limestone	*Cirriphyllum tenuinerve*	20. 10. 1991
			08. 11. 1991
			24. 11. 1991
	hornbeam tree	*Brachythecium velutinum*	20. 10. 1991
			08. 11. 1991
			21. 10. 1991
	soil	*Atrichum undulatum*	08. 11. 1991
			24. 11. 1991

Biotop: bryobiont species, exclusively in mosses. It was observed in four of the mosses: *Plagiomnium*, *Plagiothecium*, *Cirriphyllum* and *Brachythecium*, however, with very low abundance.

Centropyxis orbicularis Deflandre, 1929

The shell consists of proteinaceous material, covered with debris and inorganic particles. From frontal view it is almost circular, from lateral view hemisphaerical. The pseudostome is oval.

Author:	Diameter:
Lüftenegger & al. (1986):	93—112 μ
Own data:	92—100 μ

Biotop: typically in wet mosses, *Sphagnum*, moor, sapropel. I found one specimen in *Plagiomnium* and another one in *Brachythecium*.

Plagiopyxis labiata Penard, 1910

The shell is ovoid, almost round, from lateral view it is hemisphaerical. Excentric and oval pseudostome is considered to be relatively large within the genus.

Author:	Diameter:
Schönborn (1964):	50—74 μ
Own data:	44—60 μ

Biotop: mosses, *Sphagnum*, soil. I found it in most of the investigated mosses (Figure 2a).

Difflugia stoutii Ogden, 1983

Table 2. Composition of the fauna in the moss samples

Testacea species	Moss species					
	Pu	*Pp*	*Ar*	*Ct*	*Bv*	*Au*
Microcorycia flava GREEFF, 1866	+	+	+	+	+	—
radiata PENARD, 1912	+	+	—	+	+	—
Arcella arenaria GREEFF, 1866	+	—	+	—	—	—
discoides EHRENBERG, 1872	+	—	—	—	—	—
Centropyxis aerophila DEFLANDRE, 1929	—	+	+	+	+	+
var. *sphagnicola* DEFLANDRE, 1929	+	+	+	+	+	+
f. *kryptostoma* SCHÖNBORN, 1964	—	+	—	—	—	—
cassis WALLICH, 1864	+	+	+	+	+	+
elongata (PENARD, 1890) THOMAS, 1959	+	+	+	—	—	—
minuta DEFLANDRE, 1929	+	—	—	+	—	—
orbicularis DEFLANDRE, 1929	+	—	—	—	—	—
platystoma PENARD, 1902	+	+	—	—	—	—
Cyclopyxis eurystoma DEFLANDRE, 1929	—	—	—	+	+	+
kahli DEFLANDRE, 1929	+	+	—	+	+	—
Plagiopyxis declivis BONNET & THOMAS, 1955	+	+	—	+	+	+
labiata PENARD, 1910	—	—	—	+	+	—
Hyalosphaenia subflava CASH & HOPKINSON, 1909	+	—	—	—	—	—
Heleopera petricola LEIDY, 1879	+	+	—	—	—	—
rosea PENARD, 1890	+	—	—	+	—	—
sylvatica PENARD, 1902	+	—	+	+	—	—
Nebela lageniformis PENARD, 1902	—	+	—	—	—	—
Quadrulella symmetrica WALLICH, 1863	+	+	—	—	—	—
Difflugia bryophila (PENARD, 1902) JUNG, 1942	+	—	—	—	—	—
lucida PENARD, 1890	+	+	—	+	+	—
oblonga EHRENBERG, 1838	+	—	—	—	—	—
stouti OGDEN, 1983	+	—	—	—	—	—
Phryganella paradoxa PENARD, 1902	—	+	—	+	+	—
acropodia HOPKINSON, 1909	—	+	—	—	+	—
Pseudodifflugia gracilis var. *terricola* BONNET & THOMAS, 1960	—	—	—	+	—	—
Euglypha acanthophora EHRENBERG, 1843	+	+	—	—	—	—
compressa CARTER, 1864	+	+	—	—	—	—
cristata LEIDY, 1879	+	—	—	—	—	—
filifera PENARD, 1890	+	—	—	—	—	—
laevis PERTY, 1849	+	—	+	+	+	+
rotunda WAILES, 1911	+	—	+	+	+	+
strigosa EHRENBERG, 1872	—	+	+	+	+	—
tuberculata DUJARDIN, 1841	+	—	—	—	+	—
Assulina muscorum GREEFF, 1883	—	+	+	—	+	—
Tracheleuglypha dentata MONIEZ, 1888	+	+	+	—	+	—
Trinema complanatum PENARD, 1890	+	+	+	—	+	+
enchelys EHRENBERG, 1838	+	+	+	—	+	+
lineare PENARD, 1890	+	+	+	+	+	+
penardi THOMAS & CHARDEZ, 1958	—	—	—	+	—	—
Corythion dubium TARANEK, 1882	—	+	—	+	+	+
pulchellum PENARD, 1890	+	+	+	—	—	+
Difflugiella oviformis (PENARD, 1890) BONNET & THOMAS, 1955	—	—	—	+	+	+

Pu=Plagiomnium undulatum
Pp=Plagiothecium platyphyllum
Ar=Amblystegium riparium
Ct=Cirriphyllum tenuinerve
Bv=Brachythecium velutinum
Au=Atrichum undulatum

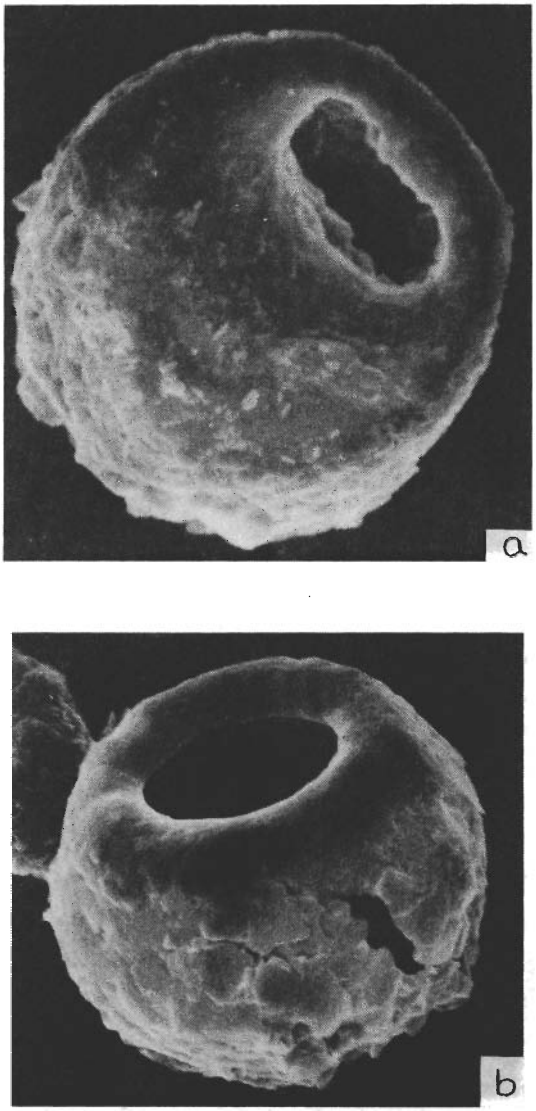

Fig. 2. Testacean shells; a: *Plagiopyxis labiata* PENARD, 1910 (60 μm); b: *Phryganella acropodia* HOPKINSON, 1909 (33 μm)

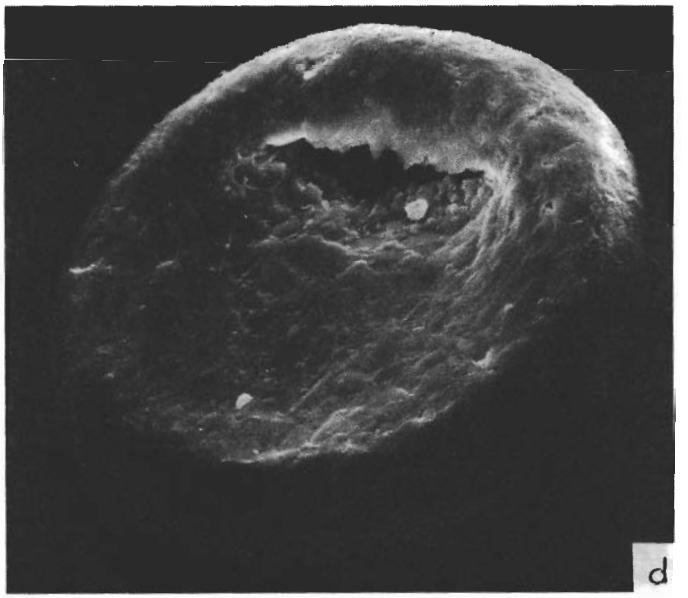

Fig. 3. Testacean shells; c: *Euglypha* sp. (65 μm); d: *Plagiopyxis declivis* BONNET & THOMAS, 1955 (78 μm)

The shell is elongated, oval, consists of relatively small xenosomes, diameter circular. Round pseudostome is situated at the end of the shell.

Author:	Length:	Width:	Pseudostome:
OGDEN (1983):	47—59 μ	33—36 μ	9—12 μ
Own data:	53 μ	36 μ	8 μ

Biotop: *Sphagnum* (OGDEN, 1983). I observed one specimen in *Plagiomnium.*

Phryganella acropodia HOPKINSON, 1909

The shell is hemisphaerical, made of xenosomes. The pseudostome is located in the flat side, surrounded by organic cement.

Author:	Diameter:
LÜFTENEGGER & al.:	32—45 μ
Own data:	31—38 μ

Biotop: it is one of the most frequent species in forest soils. This species had the highest occurrence in *Brachythecium* and in addition I found 5 specimens in *Plagiothecium* (Figure 2b).

Trinema penardi THOMAS & CHARDEZ, 1958

The oval shell consists of two diverse parts: one, above the pseudostome stands of smaller platelets in contrast with the aboral region.

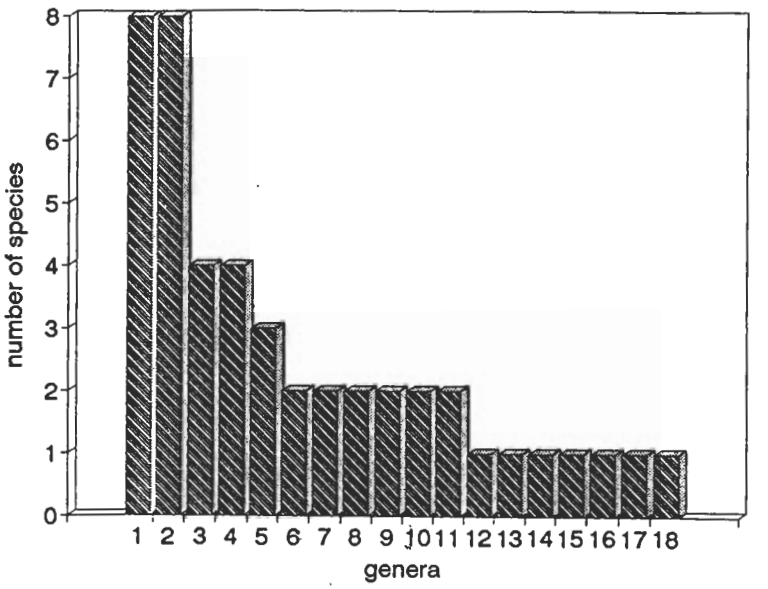

Fig. 4. Number of species according to each genus. 1: *Centropyxis,* 2: *Euglypha,* 3: *Difflugia,* 4: *Trinema,* 5: *Heleopera,* 6: *Microcorycia,* 7: *Arcella,* 8: *Cyclopyxis,* 9: *Plagiopyxis,* 10: *Phryganella,* 11: *Corythion,* 12: *Hyalosphaenia,* 13: *Nebela,* 14: *Quadrulella,* 15: *Pseudodifflugia,* 16: *Assulina,* 17: *Tracheleuglypha,* 18: *Difflugiella*

Author:	Length:	Width:	Depth:	Pseudostome:
LÜFTENEGGER & al.:	30—65 μ	16—35 μ	15—30 μ	8—16 μ
Own data:	40—44 μ	26—29 μ	18—20 μ	12—13 μ

Biotop: *Sphagnum*, mosses, soil. It was a characteristic species of *Cirriphyllum* and occurred also in *Brachythecium*.

There are also some problematic specimens, belonging to the genus *Euglypha*, which could not be identified because of the low abundance and the lack of living individuals (Figure 3c).

The highest species richness was found in the genera *Centropyxis* and *Euglypha*. This observation agrees for the most part with the data of BEYENS & al. (1986, 1990) and GOLEMANSKY (1967a). Figure 4 shows the numbers of species according to each genus.

The diversity values are considerably high and although there are no other data on moss-biotopes from this geographical area to compare with, we can conclude, that these values exceed those ones found in the arctic mosses (BEYENS & al., 1986). The results of the quantitative investigations are given in tables 3 and 4.

The species have been ranged by their dominance as well (Table 4). There are twenty-six eudominant and dominant species in the six moss species, but altogether

Table 3. Total diversity values in the six moss species

Moss species	D	S	N
Plagiomnium undulatum	4.36	34	216
Plagiothecium platyphyllum	3.65	26	471
Amblystegium riparium	2.60	14	375
Cirriphyllum tenuinerve	*2.98*	*21*	*485*
Brachythecium velutinum	3.52	27	844
Atrichum undulatum	2.80	14	285

D = diversity value calculated by the SHANNON-WEAVER formule
S = number of species
N = number of inviduals per 1 cm^2 of moss

Table 4. The most dominant testacean species in the mosses

Mosses:	*Plagiomnium undulatum*	*Plagiothecium platyphyllum*	*Amblystegium riparium*
Eudominant species	*Traccheleuglypha dentata* *Trinema enchelys* *Difflugia lucida*	*Tracheleuglypha dentata* *Trinema enchelys* *Corythion dubium*	*Trinema enchelys* *Euglypha laevis* *Trinema lineare*
Dominant species	*Plagiopyxis declivis*	*Microcorycia flava*	*Microcorycia flava* *Euglypha rotunda*
Mosses:	***Cirriphyllum tenuinerve***	***Brachythecium velutinum***	***Atrichum undulatum***
Eudominant species	*Microcorycia flava* *Plagiopyxis declivis*	*Euglypha rotunda*	*Trinema complanatum* *Trinema enchelys*
Dominant species	*Euglypha rotunda* *Trinema penardi*	*Difflugia lucida* *Euglypha laevis*	*Centropyxis aerophila* var. *sphagnicola* *Plagiopyxis declivis* *Trinema lineare* *Difflugiella oviformis*

thirteen testacean species vary between the two categories in different distribution. All the *Trinema* taxa found in the samples are present here, illustrating the well known eurytopic character of these species. *Brachythecium* is the only moss species, where the *Trinema* species do not reach such high dominance (*Trinema lineare* is subdominant there).

Majority of species complete the subdominant, recedent and subrecedent categories. Those species, described for the first time in Hungary are included in these categories because of their low abundances. *Trinema penardi* is the only exception, which is dominant in *Cirriphyllum.*

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REFERENCES

1. BARTOS, E. (1936—1940): Korenonozci nasich mechu, I—VI. — Brno.

2. BARTOS, E. (1940): Studien über die moosbewohnenden Rhizopoden der Karpaten. — Arch. Protistenkd., 94: 93—160.

3. BARTOS, E. (1954): Korenonozce Radu Testacea. — Bratislava: 1—190.

4. BERECZKY, M. Cs. (1970): Untersuchungen über die Rhizopodenfauna der Aggteleker "Baradla"-Höhle. Biospeleologica Hungarica, XXXII. — Opusc. Zool. Budapest, X/1: 69—82.

5. BERECZKY, M. Cs. (1973): Kennzeichnung des Schlammes im offenen Wasser des Balatons mit Hilfe des Testaceen-Fauna. — Verh. Internat. Verein. Limnol., 18: 1406—1412.

6. BERECZKY, M. Cs. (1979): Vergleichende Untersuchungen über die Gestaltung der in Plankton vorkommenden Testaceen im Haupt- und Nebenarm der Donau bei Göd (Stromkm 1669). — Ann. Univ. Sci. Sec. Biol., 20—21: 229—236.

7. BERECZKY, M. Cs. (1984): Zönologische Untersuchungen über die Thekamöbenfauna der Donau. — Arbeitstagung der IAD, Szentendre/Ungarn: 73—76.

8. BERECZKY, M. Cs. (1985): Fixation- and color rapid methods in the quantitative ecological investigations of the protozoans in the inland waterways. — Arch. Protistenkd., 129: 187—190.

9. BEYENS, L., CHARDEZ, D. & LANDTSHEER, R. (1986): Testate Amoebae populations from moss and lichen habitats in the Arctic. Polar Biol., 5:: 165—173.

10. BEYENS, L., CHARDEZ, D. & DE BAERE, D. (1990): Ecology of terrrestrial testate amoebae assemblages from coastal lowlands on Devon Island (NWT, Canadian Arctic). — Polar Biol., 10: 431—440.

11. BICZÓK, F. (1956): A pápakovácsi rét rhizoszféra-protozoáinak vizsgálata. — Állatt. Közlem., XLV (1—2): 21—32.

12. ERTL, M. (1960): Beiträge zur Kenntnis der moosbewohnenden Thekamöben Ungarns. — Opusc. Zool., 4: 31—37.

13. GOLEMANSKY, V. (1967a): Études sur la faune de Rhizopodes (Sarcodina, Rhizopoda) des mousses epiphytes et terricoles en Bulgarie. — Acad. Bulg. Sci., Bull. Inst. Zool. Mus., 24: 103—119.

14. GOLEMANSKY, V. (1967b): Tecamebianos Muscicolas (Rhizopoda, Testacea) de Mexico, — Rev. Soc. Mex. Hist. Nat., 18: 73—77.

15. JEKKEL, A. (1969): Magyarország talajaiban és moháiban élő Testaceák. Mohokban élő Testaceák vizsgálata. — Szakdolgozat. ELTE Állatrendszertani Tanszék, Budapest.

16. JACZÓ, I. (1941): Néhány dunántúli átmeneti tőzegmohaláp és Sphagnum előfordulás házas Rhizopodáiról — Állatt. Közlem., 38: 18—34.

17. KREPUSKA, Gy. (1917): Budapest véglényei — Állatt. Közlem. 16: 1—60.

18. LÜFTENEGGER, G., PETZ, W., BERGER, H. & FOISSNER, W., ADAM (1988): Morphologic and biometric characterization of twenty-four soil testate amoebae (Protozoa, Rhizopoda). — Arch. Protistenkd., 136: 153—189.

19. MEISTERFELD, R. (1979): Clusteranalytische Differenzierung der Testaceenzönosen (Rhizopoda, Testacea) in Sphagnum. — Arch. Protistenkd., 121: 270—307.

20. OGDEN, C. (1983): Observations on the systematics of the genus Difflugia in Britain (Rhizopoda, Protozoa). — Bull. Brit. Mus. Nat. Hist. Zool., 44: 1—73.

21. ORBÁN, S. & VAJDA, L. (1983): Magyarország mohaflórájának kézikönyve. — Akadémia Kiadó, Budapest.

22. SCHÖNBORN, W. (1962): Zur Ökologie der sphagnikolen, bryokolen und terrikolen Testaceen. — Limnologica (Berlin), 1/3: 231—254.

23. SCHÖNBORN, W. (1964): Bodenbewohnende Testaceen aus Deutschland. — Limnologica (Berlin), 2/1: 105—122.

24. SCHÖNBORN, W. (1989): The topophenetic analysis as a method to elucidate the phylogeny of testate amoebae (Protozoa, Testacealobosia and Testaceafilosia). — Arch. Protistenkd., 137: 223—245.

25. SZELÉNYI, K. (1896): Adatok a Budapesten és környékén mohok alatt élő gyökérlábúak ismeretéhez. — Budapest.

26. VARGA, L. (1953): Adatok az erdőtalajok Protozoonjainak földrajzi elterjedéséhez. — MTA TBK Évk., 21: 145—151.

27. VARGA, L. (1956): Adatok a hazai Sphagnum-lápok vízi mikrofaunájának ismeretéhez. — Állatt. Közlem., 45: 149—159.

28. VARGA, L. (1960): Ereszcsatorna mohás törmelékanyagának mikrofaunájáról. — Ann. Biol. Tihany, 27: 169—182.