"BABEŞ-BOLYAI" UNIVERSITY, CLUJ-NAPOCA
FACULTY OF BIOLOGY AND GEOLOGY

THE GENERA *STAURASTRUM* MEYEN AND *STAURODESMUS* TEILING (ORD. DESMIDIALES) IN ROMANIA

Ph.D. Thesis Summary

IOANA ADRIANA NEAG
PH.D. STUDENT

SCIENTIFIC COORDINATOR
Prof. LEONTIN ŞTEFAN PÉTERFI Ph.D.
Correspondent Member of the Romanian Academy

CLUJ-NAPOCA
2014

CONTENT

Keywords: desmids, *Staurastrum*, *Staurodesmus*, morphology, Romanian distribution, numerical taxonomy, phenogram.

Introduction

The idea of developing a synthesis paper on algal flora of Romania was born many years ago, but the materialization of this idea is far from complete. Therefore, taxonomic study of two of the most representative, but also controversial desmids genera, *Staurastrum* Meyen and *Staurodesmus* Teiling, is a challenge.

The general aims of the present thesis are:

- taxonomic revision of both genera
- morphological description of the species and their classification
- tracking ecological preferences
- achieve chorological distribution maps
- numerical evaluation of the degree of intraspecific phenotypic similarity and thus hierarchical ordering based on these similarities,
- achieving key determining.

In order to identify and properly describe the Romanian *Staurastrum* and *Staurodesmus* species, algal samples were collected from different locations during 2005, 2006, 2007, 2008. So far 79 taxa of the genus *Staurastrum* and 15 taxa of the genus *Staurodesmus* have been recorded in Romania. They are briefly characterized as concerning their cell measurements and distribution in Romania. To achieve a synthesis concerning the distribution of the genera in Romania we used the database „*Algae of Romania* " - Cărăuş, 2002, 2010 and 2012; earlier bibliographic sources were used as well. The present taxonomic investigation is also based on previous descriptions of the taxa, available in the usual key books and recent monographs, widely used for similar purposes.

A total of 30 morphological characters of *Staurodesmus* species and 54 morphological characters of *Staurastrum* species, concerning semicell shape and size, position and length of the spines, features of the sinus and isthmus were used for numerical taxonomic analysis.

I. General characteristics of desmids

1.1. Thallus organization

Desmids represent a special class of green algae (Conjugatophyceae), extremely beautiful in appearance. On the basis of cell-wall structure, desmids are divided into two categories:

- desmids (fam. Mesotaeniaceae), in which the cell wall has a unitary, homogeneous aspect.
- placoderm desmids (fam. Desmidiaceae). Within the family Desmidiaceae cell wall consists generally of two symmetrical halves, of different ages, sometimes slightly overlap. The two cell halves are joined together by a central area called the isthmus, in which the nucleus is usually situated. The cell wall has often varied ornamentation or pores, which removes the mucilage. Cells are generally solitary, but sometimes they form amorphous colonies or simple unbranched filaments.

1.2 Characteristics of cell structure

1.2.1. The cell wall is composed of three layers: a mucilaginous outer layer and two internal layers of cellulose microfibrils. Outside, cellulose microfibrils tend to be oriented parallel to the long axis of the cell, and the internals are oriented transversely. Longitudinally oriented microfibrils were initially transverse orientation, but which is lost as the cells grow.

1.2.2. Nucleus and cell division

The cells are uninucleate. Mitosis is semi-closed and the telophase spindle is persistent. Cytokinesis is brought through the ingrowth of a cleavage furrow. Some desmids use an early phragmoplast, similar to those in embryophytes, to organize and guide the growing cell plate.

1.2.3. Chloroplasts take various forms (oval, star-shaped etc.). They are surrounded by a double membrane envelope, with no adjacent endoplasmic reticulum (ER). Chloroplasts contain one or more pyrenoids

1.2.4. Cell mobility. Most desmids move by mucilage removal. However, the mobility is low, about 1 μm per second. In *Staurastrum* species the mucilage is secreted only by the older half of the cell.

1.3. Peculiarities of desmids reproduction. Desmids are haplobiontic organisms. The life cycle includes the presence of a thick-walled hypnozygote. Conjugation does not involve flagellated gametes. Flagella and centrioles are actually completely missing from all desmids.

1.4. Aspects of the ecology of desmids

Diverse desmids floras are particularly characteristic of freshwater of low pH (4-5), poor in nutrients (oligotrophic) and rich in humic acids (dystrophic), such as the bog pools or the acid ponds lying over leached sands and gravels. Some species can be found in mesotrophic or eutrophic aquatic environments.

Methods of estimation of water quality based on desmids began to be increasingly widely used. The Danish hydro biologist Nygaard has designed a compound quotient, *t*, which makes it possible to convey an overall impression of the trophic status of a water body. This quotient includes desmids species. (t = (No. of species of Cyanophyta. + centric diatoms + Chlorococcales) / No. of species of Desmidiales) (Nygaard, 1949, cited Willen, 2000). Desmids were included in the method of assessing the degree of water trophicity, by phytoplankton composition analysis, proposed by the Romanian researcher M. Oltean, in 1977. Thus, desmids started its role of biomarkers, suitable for research the water quality.

II. Systematic position and phylogeny of the genera *Staurodesmus* Teiling and *Staurastrum* Meyen

The genera *Staurodesmus* and *Staurastrum* are placoderm desmids, with median constriction (Fam. Desmidiaceae). These in turn are part of the green algae class Conjugatophyceae. This group has suffered over time, a series of the most diverse taxonomic reorganizations. Some authors propose the inclusion of all the Conjugatophyceae in one order, Zygnematales. Others make a clearer distinction between placoderm desmids (order Desmidiales) and sacoderm desmids (Fam. Mesotaeniaceae) which are assigned to ord. Zygnematales (Fig. 2.1.). Whether it comes from one or two orders, the Conjugatophyceae are

considered as part of a monophyletic group within the class Charophyceae (sensu Wattox and Stewart, 1984).

III. Materials and Methods

The material used to describe the species was collected during the years 2005, 2006, 2007 and 2008 in various locations, but the most prolific samples proved to be: the July-September 2005, 2006 and 2007 in Călăţele Pădure, Dealu Negru, Beliş, Molhaşul Mare de la Izbuc (Cluj county); October 2005 and 2006 Mestecănişul de la Reci (Covasna county); September 2005, June 2006 and 2007 – Tăurile Sălicii (Cluj county), 2008 - Izvorul Arieşului (Alba county), Lacul Viţeilor (Bihor county).

3.1. Brief description of the sampling sites

There were developed several systems for classifying European habitats. We took the appropriate habitats codes for our sampling sites, from the paper "*Habitats from Romania*" (Doniţă et al., 2005) and seeked correspondence with European classification system - Natura 2000 (Gafta and Mountford, 2008). Alga Floristic research on Romanian peat bogs revealed a great wealth of desmids alga, including species of the *Staurodesmus* and *Staurastrum* genera, which are well represented. We choose the following sampling locations:

1. **Călăţele Pădure, Dealu Negru, Beliş, Molhaşul Mare de la Izbuc (Cluj county)**

Fig. 3.1. Molhaşul Mare de la Izbuc – oligotrophic peatbog

2. Mestecănişul de la Reci (Covasna county)

Fig. 3.2. Eutrophic peatbog at Mestecănişul de la Reci (Covasna county)

3. Sălicea - „Tăurile Sălicii” (Cluj county)

Fig. 3.4. Tăul cu Botile, Sălicea (Cluj county).

3.2. Methods for the collection of desmids samples

Plankton, benthos and metaphyton samples were collected, using standard methods. Because most desmids are present in the metaphyton, an effective method has been shown to be to collect the accumulated water through the *Sphagnum* stems (Figure 3.7.). Each sample was stored and preserved, immediately after collection in 4% formalin (final concentration). The examination and taxonomic identification was done by using optical microscope, Zeiss ‘’Docuval", 63x objective (numerical aperture 0.90). The present taxonomic investigation is also based on previous descriptions of the taxa, available in the usual key books and recent monographs, widely used for similar purposes. The microscopic images were made with an Olympus BX 41 microscope, equipped with a digital camera Olympus Camedia C 3040 Zoom.

3.3. Methods used to achieve gender monograph

For each species I made: a brief morphological description, specifying dimensions based on our own microscopic observations and literature; species distribution in Romania starting from database *Algae of Romania* - I. Cărăuş, 2002 and 2010, 2012 and subsequently published articles. For those species that were not present in the collected material, the morphological description has been made using specific literature. In this case, we tried as much as possible, to use literature data on Romanian algal flora. Thus, some of the images used in this paper are based on indigenous literature concerning alga of our country, reflecting structural peculiarities of the species. Distribution maps of *Staurastrum* and *Staurodesmus* species identified in Romania were made according to UTM system. Geocodes settlements were established on the basis of the work signed by Lehrer and Lehrer, 1990. Those locations that were not found in the cited work were established from the nearest village, which is assigned a geocode.

3.4. Specific methods for numerical taxonomy

A total of 30 morphological unite characters of the *Staurodesmus* species and 54 morphological unite characters of the *Staurastrum* species (concerning semicell shape and size, position and length of the spines, features of the sinus and isthmus) were used for numerical taxonomic analysis of the 15 *Staurodesmus* species, respectively 79 *Staurastrum*

species. The data matrix obtained was searched for structure by cluster analyses. Similarity index of Jaccard was employed and phenograms were constructed running the statistical program PAST.

IV. Description and classification of the genus *Staurodesmus* Teiling

The genus *Staurodesmus* (gr. *stauron* – cross, *desmos* – bond) was established by Teiling (1948) fusing parts of the genera *Arthrodesmus* Ehr. ex Ralfs and *Staurastrum* Meyen. Species of *Staurodesmus* are marked by smooth-walled semicells which in apical view are bi- to multiradiate, and furnished with one single papilla, mucron or spine per radius (Figs. 4.1 and 4.2). The cell wall is smooth, but exhibits characteristically disposed punctae excreting mucilage (sometimes visible as distinct plugs) which is typical for some species. The cell walls are never ornamented by granules, and spines occur only at the angles.

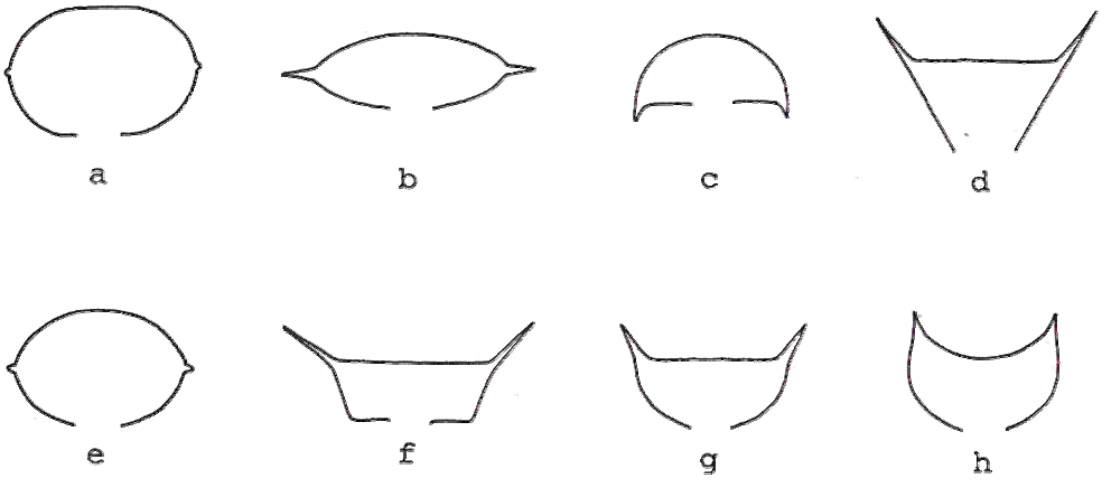

Fig. 4.1. *Staurodesmus* semicell forms (Coesel, 1991)

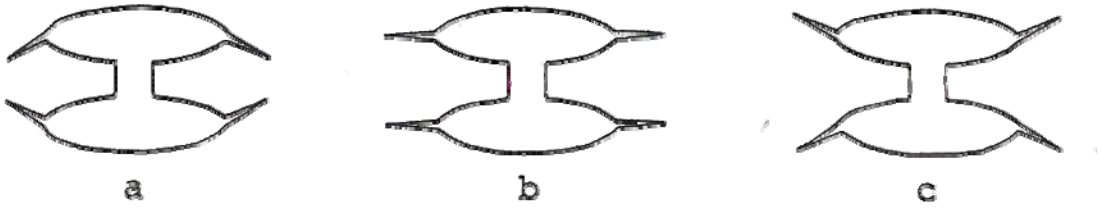

Fig. 4.2. *Staurodesmus* spines position: a) convergent; b) parallel; c) divergent (Coesel, 1991)

Staurodesmus usually occurs in the plankton or metaphyton of acidic, oligotrophic and dystrophic lakes, ponds and bogs, but some of its species can live in mesotrophic or even eutrophic water bodies.

Based on our personal microscopic observations we have made a determination key for *Staurodesmus* Teiling species, present in Romania.

V. Description and distribution of the genus *Staurodesmus* Teiling in Romania

The present paper presents the morphological description, ecology and distribution of 15 species occurring in Romania: *S. aristiferus*, S. *convergens*, *S. cuspidatus*, *S. dejectus*, *S. dickiei*, *S. extensus*, *S. glaber, S. incus*, *S. indentatus*, *S.mucronatus*, *S. patens*, *S. pterosporus*, *S. spencerianus*, *S. spetsbergensis*, *S. triangularis*.

For each species we made a presentation on the following aspects: scientific name, synonyms, morphological description, dimensions, ecology, diagram, occurrence, distribution maps of taxa. (e.g *Staurodesmus dickiei* (Ralfs) Lillieroth var. *dickiei*.).

E.g.: *Staurodesmus dickiei* (Ralfs) Lillieroth var. *dickiei* (fig. 5.9.)

Synonym: *Staurastrum dickiei* Ralfs var. *dickiei*

Morphological description: Cells tri- or rarely tetraradiate, sinus acute. Semicells oval with attenuated corners bearing a spine of moderate length and curved downwards. Punctae with mucilage often apparent over semicell surface.

L: 20-46µm, l: 42-50µm

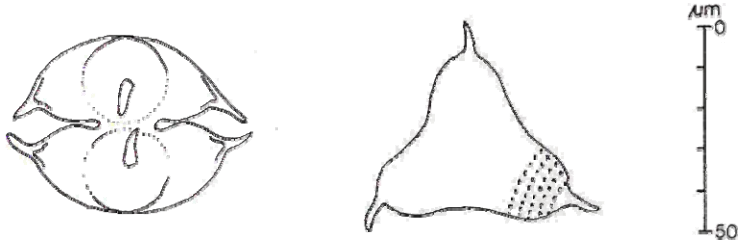

Fig. 5.9. *Staurodesmus dickiei* var. *dickiei* (Péterfi L. Şt., 1991-1992)

Ecology: present in oligotrophic habitats, type R5102: southeast Carpathian oligotrophic raised bogs with *Sphagnum magellanicum*; to eutrophic habitats, type R5414 - eu-mesotrophic southeastern Carpathian swamp, with *Schoenus nigricans.*

Distribution in Romania: Cluj county: Tăul cu Mesteceni (Sălicea) – transition bog, Tăul Mare (Sălicea) – transition bog, Tăul Măgurii (Sălicea) – bog, Tăul cu Arini (Sălicea) – eutrophic pond, Tăul cu Botele (Sălicea) – eutrophic pond, Dîmbul Negru – peat bog, Tăul fără Fund (Padiş Plateau) – *Sphagnum* peat bog, Valea Izbucului – raised peat bog, Călăţele Pădure – *Sphagnum* peat bog, Tulcea county: Delta Dunării – lakes and wetlands.

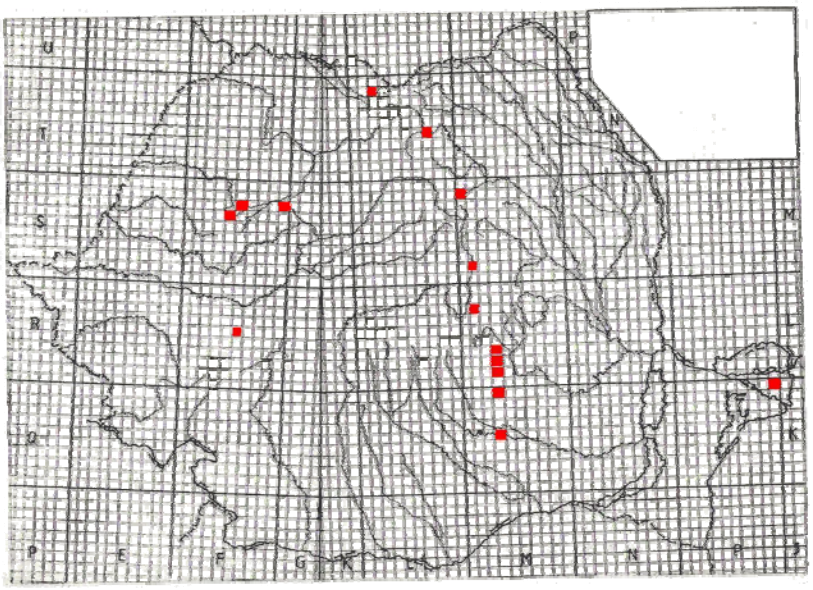

Fig. 5.10. Distribution map of the taxa: *Staurodesmus dickiei* (Ralfs) Lillieroth var. *dickiei, Staurodesmus dickiei* (Ralfs) Lillieroth var. *circulare* and *Staurodesmus dickiei* (Ralfs) Lillieroth var. *rhomboideus* (W. & G. S. West) Lillieroth în România.

VI. Numerical taxonomic analysis of the *Saurodesmus* species identified in Romania

For the numerical taxonomy 30 morphological characters were chosen. The arguments of choice were: availability for all the taxa, absence of redundancy, clear definition of the states of characters and the stability of these states at a taxonomic level. All these phenetic characters were treated of equal value (Adansonian weighting).

The *Staurodemus* taxa dealt with in this study, according to Teiling [20] are divided into the folowing groups: *sibiricus* group: *S. spetsbergensis*; *incus* group: *S. incus*, *S. extensus*; *triangularis* group: *S. triangularis*, *S. indentatus*; *dejectus* group: *S. dejectus*; *cuspidatus* group: *S. cuspidatus*; *connatus* group: *S. patens, S. pterosporus*; *megacanthus* group: *S. spencerianus, S. glaber*; *mucronatus* group: *S. mucronatus*; *convergens* group: *S. convergens* and finally *Dickiei* group*: S. dickiei*.

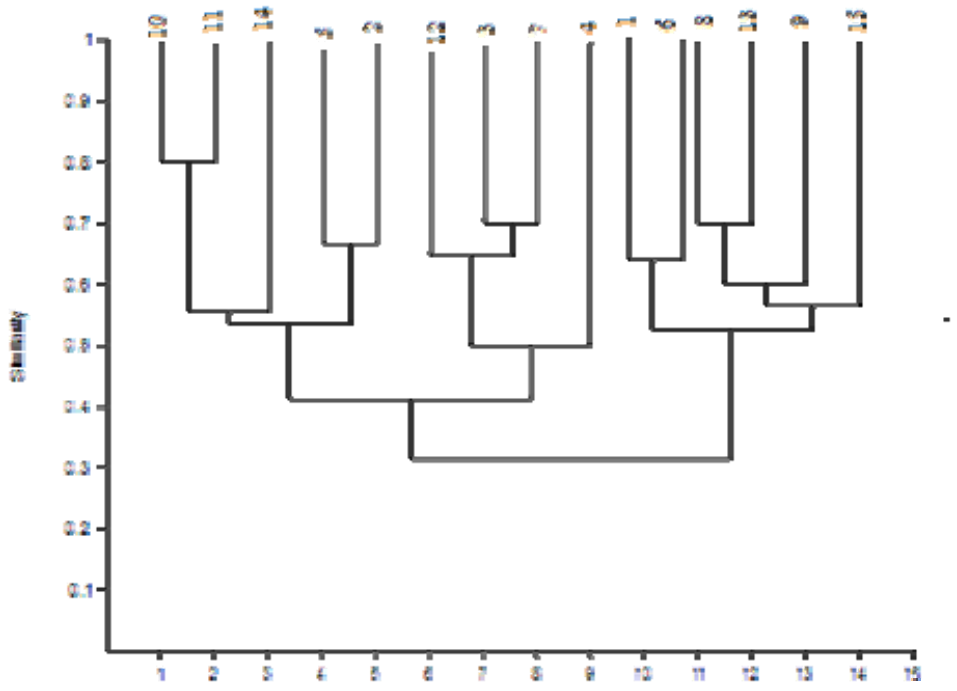

Fig. 6.1. Phenogram representing the grouping of *Staurodesmus* species (OTUs), based on phenetic similarity (1 – *S. aristiferus,* 2 – *S. convergens*, 3 – *S. cuspidatus*, 4 – *S. dejectus*, 5 – *S. dickiei*, 6 – *S. extensus*, 7 – *S. glaber*, 8 – *S. incus*, 9 – *S. indentatus*, 10 – *S. mucronatus*, 11 – *S. patens*, 12 – *S. pterosporus*, 13 – *S. spencerianus*, 14 – *S. spetsbergensis*, 15 – *S. triangularis*).

The phenogram (Fig. 6.1.) shows the clustering of the 14 operational taxonomic units (OTUs) based on the degree of phenetic similarity. According to this phenogram there are 3 major clusters joining at a phenon levels of about 50%. The distribution of taxa among the clusters is as follows: *S. convergens*, *S. dickiei*, *S. mucronatus*, *S. patens* and *S. spetsbergensis* are in cluster 1; *S. cuspidatus*, *S. dejectus*, *S. glaber* and *S. pterosporus* are in cluster 2; *S. aristiferus, S. extensus*, *S. incus*, *S. indentatus S. spencerianus*, *S. triangularis* are in cluster 3. These three major aggregates may be considered as sections and consist of smaller aggregates reflecting the groups established by Teiling that may be taken series. There are some contradictions between these two classifications: *S. spencerianus* is positioned close to *S. incus* whereas *S. glaber* is far from this group, and apparently more similar to *S. cuspidatus*

VII. General description of the genus Staurastrum Meyen

The genus was established in 1828 by Meyen and includes those forms which fall *Staurastrum* description suggested by etymology (gr. stauron – cross; astron - star). According to the principles established by Meyen, this genus include those species which have multiradiate apical aspect (tri-, tetraradiate etc.), having well-defined processes, ended with spines.

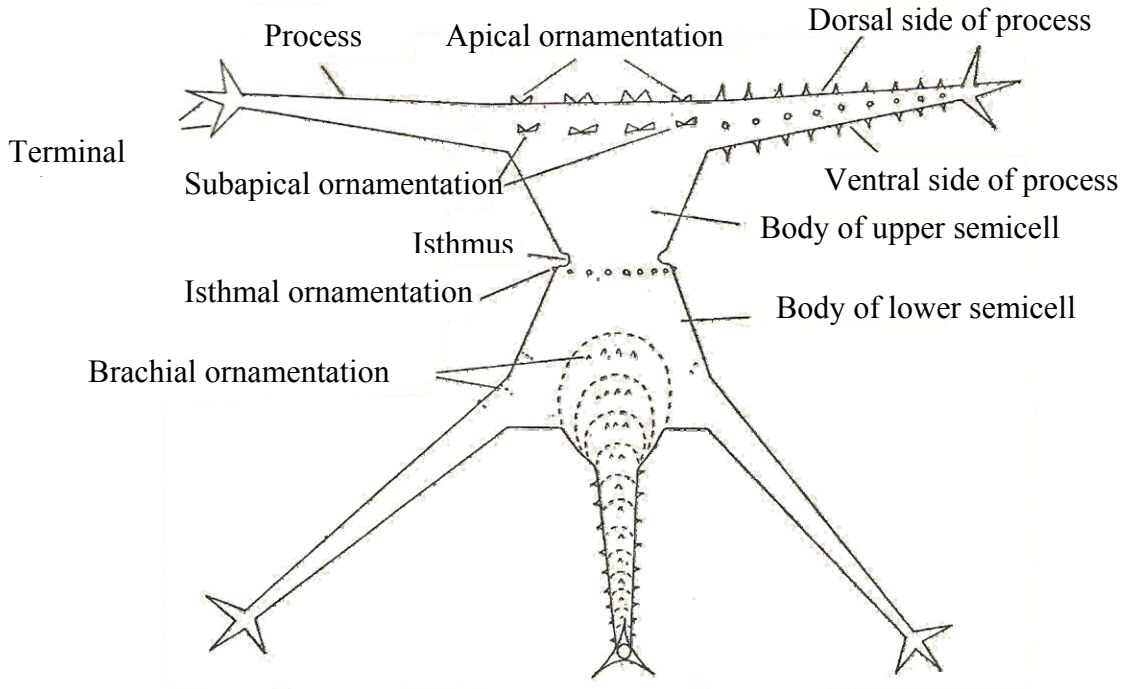

Fig. 7.2. Side view of *Staurastrum* cell (after Brook, A.J., 1959).

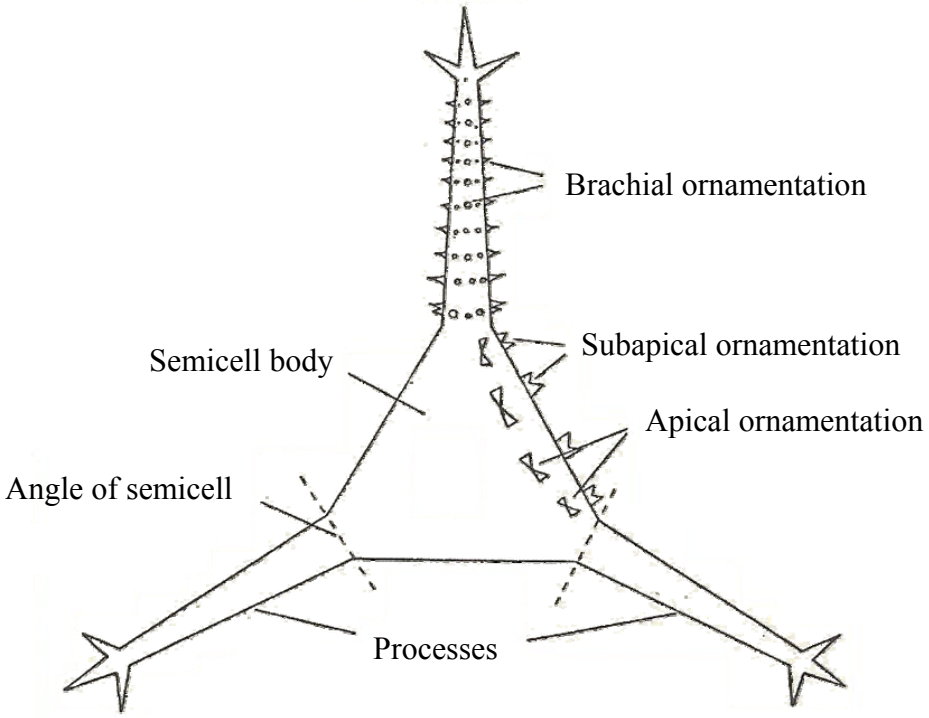

Fig. 7.3. Apical view of *Staurastrum* semicell (Brook, A.J., 1959).

X. Classification of the genus *Staurastrum* Meyen

It is extremely difficult to establish logical links between species of this so artificial genus. Turner (1893) and later, Hirano (1955) and Bourrelly (1966) divided the genus into two subgenera: *Prostaurastrum* - no extra angular cells developed (multilobate in apical plan) and *Staurastrum* - with angular processes well developed, individualized arms (processes) (fig. 8.1.).

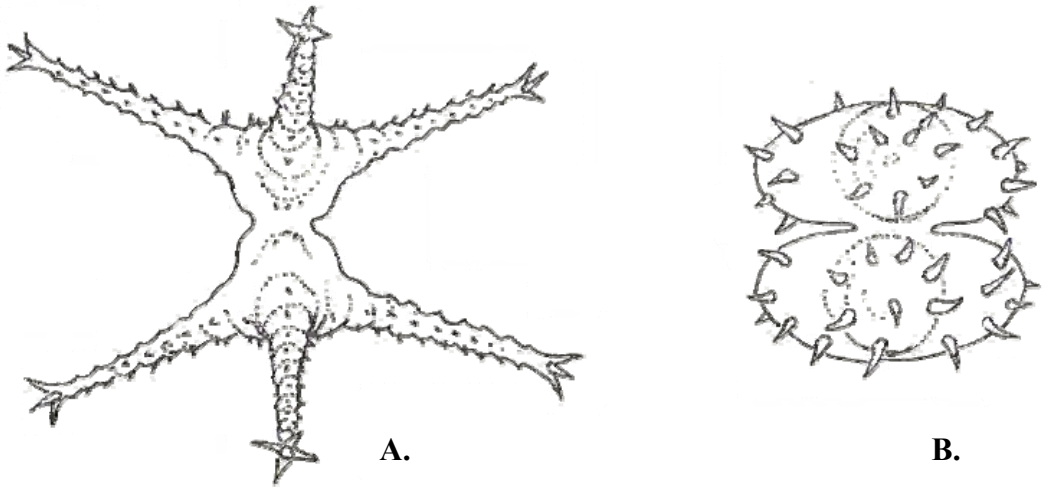

Fig. 8.1. *Staurastrum* (*Eustaurastrum*) (A) and *Prostaurastrum* (B) (Brook, A.J., 1959).

Based on personal microscopic observations and existing data in the literature we have realized an identification key for the *Staurastrum* species occurring in Romania.

IX. Description and distribution of the genus *Staurastrum* Meyen in Romania

There are 79 Staurastrum species present in Romania, some of them being reported in varieties and forms. For each species we made a presentation on the following aspects: scientific name, synonyms, morphological description, dimensions, ecology, diagram, occurrence, distribution map of taxon. (e.g. Staurastrum furcatum (Ehrenb. ex Ralfs) Brébisson var. furcatum).

E.g.: *Staurastrum furcatum* (Ehrenb. ex Ralfs) Brébisson var. *furcatum* (Fig. 9.51)
Synonym: *Staurastrum spinosum* (Brébisson) Ralfs

Morphological description: Cells have a deep median constriction, with acute and open sinus. In front view the semicell is subelliptical, subglobose, but mostly hexagonal in outline, with flat or slightly arched dorsal and lateral margins. The lateral angles are slightly produced and bear stout processes with bifid apices, the two terminal spines lying in the same vertical plane. The cell wall is smooth, sometimes slightly punctate. Apical view is tri- or tetra-radiate, with short angles and a pair of short bifid processes designed to each side edge.
Dimensions: L: 25-39 μm; l: 20-40 μm; isthmus 6-10 μm

Fig. 9.51. *Staurastrum furcatum* (Ehrenb. ex Ralfs) Brébisson var. *furcatum* (Péterfi L. Şt., 1991)

Ecology: present in oligotrophic habitat type R5102: southeast Carpathian oligotrophic raised bogs with *Sphagnum magellanicum*; rarely in the meso-eutrophic habitats, type R2203 - Danube communities with *Salvinia natans*, *Marsilea quadrifolia*, *Azolla car*oliniana, *A . filiculoides.*

Distribution in Romania: Alba county: Tăul fără Fund (lângă Alba-Iulia) (Péterfi, 1964); **Cluj county:** Tăul Măgurii bog (Sălicea), Tăul Mare bog (Salicea), Tăul cu Botele bog (Sălicea) (Péterfi, 1991-1992), Tăul după Hagău bog (Péterfi, 1943); **Covasna county:** Mestecănişul de la Reci (Péterfi, Ş., 1960), (Péterfi şi Momeu, 1988); **Harghita county**: Mohoş (Palik, 1960), (Nagy-Tóth, 1967); **Hunedoara county:** Lake Şurianu area (Momeu & Péterfi, 2002); **jud. Ilfov:** Lake Snagov (Şerbănescu, 1960); **Maramureş county:** Tăul Cendroiu, Tăul lui Dumitru, Iezerul Mare de la Poiana lui Ştefan, Iezerul din Poiana de sub Strunga Ţiganului, Tăul de la Hoteni (Momeu & Péterfi, 1985).

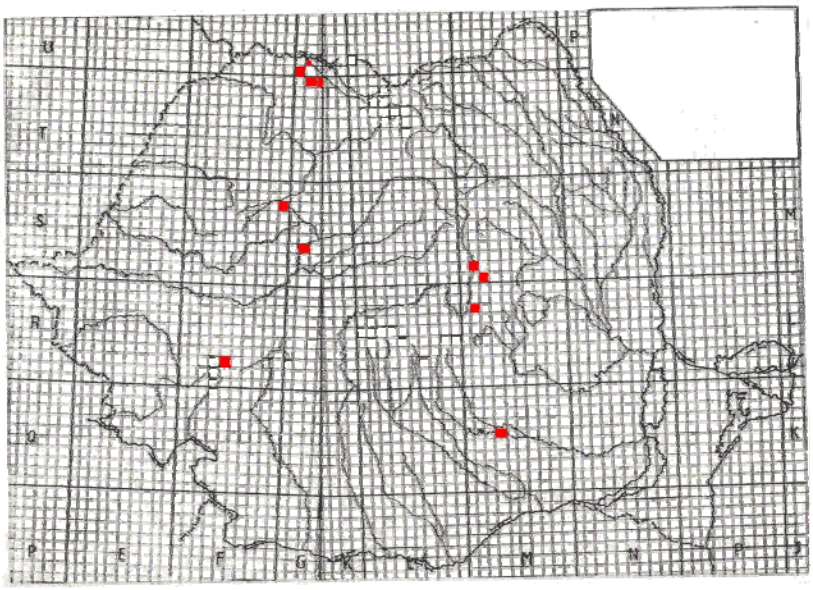

Fig. 9.52. Distribution map of the taxa: *Staurastrum furcatum* (Ehrenb. ex Ralfs) Brébisson var. *furcatum*, *Staurastrum furcatum* (Ehrenb. ex Ralfs) Brébisson var. *aciculiferum* (W.West) Coesel, *Staurastrum furcatum* (Ehr.) Brébisson var. *aculeatum* Schmidle, *Staurastrum furcatum* (Ehr.) Brébisson var. *candianum* (Delp.) Cooke, *Staurastrum furcatum* (Ehr.) Brébisson *f. mediae* Schmidle, *Staurastrum furcatum* (Ehr.) Brébisson *f. spinosa* (Ralfs) Nordstedt, *Staurastrum furcatum* (Ehrenb.) Brébisson *f. spinosissima* Ralfs în România.

The taxonomic analysis of the samples taken in the mentioned sites confirms the presence of 56 taxa belonging to the studied genera: 11 taxa of the genus *Staurodesmus* and 45 taxa of the genus *Staurastrum* (Table 9.1.).

Tabel. 9.1. Distribution of studied taxa in sampling sites

	Sampling sites where we reconfirmed the presence of Staurastrum and Staurodesmus taxa						
Taxa	**Călăţele Pădure**	**Dealu Negru**	**Beliş**	**Sălicea**	**Mestecănişul de la Reci**	**Molhaşul Mare de la Izbuc**	**Lacul Viţeilor (Bihor)**
Genus *Staurodesmus* Teiling							
1. *Staurodesmus aristiferus* (Ralfs) Teiling							
2. *Staurodesmus convergens* (Ehr. ex Ralfs) Lillieroth	+	+					
3. *Staurodesmus cuspidatus* (Bréb. ex Ralfs) Teiling					+		
4. *Staurodesmus dejectus var. dejectus* (Bréb. ex Ralfs) Teiling				+			
5. *Staurodesmus dickiei var. dickiei* (Ralfs) Lillieroth	+	+					
6. *Staurodesmus extensus var. extensus* (Borge) Teiling				+			
7. *Staurodesmus glaber* ([Ehr.] ex Ralfs) Teiling					+		
8. *Staurodesmus incus* (Ehr.) Teiling						+	
9. *Staurodesmus indentatus var. indentatus* (W. & G. S. West) Teiling	+					+	
10. *Staurodesmus mucronatus* (Ralfs ex Bréb.) Croasdale	+						
11. *Staurodesmus patens* (Nordst.) Teiling							
12. *Staurodesmus pterosporus* (Lund.) Bourrelly					+		
13. *Staurodesmus spencerianus* (Nordst.) Teiling					+		
14. *Staurodesmus spetsbergensis* (Nordst.) Teiling							
Genus *Staurastrum* Meyen							
1. *Staurastrum aculeatum* (Ehrenb.) Menegh. ex Ralfs					+		
2. *Staurastrum alternans* (Bréb.) Ralfs	+		+				
3. *Staurastrum anatinum* Cooke et Wills	+						
4. *Staurastrum arnellii* Boldt var. ***spiniferum*** W. et G.S.West							
5. *Staurastrum avicula* Brébisson var. avicula							
6. *Staurastrum benkoei* Schaarschmidt							
7. Staurastrum bicoronatum Johnson							
8. *Staurastrum bieneanum* Rabenh**.**				+			
9. *Staurastrum bifidum* (Ehr.) Brébisson							
10. *Staurastrum boreale* W. et G.S.West				+	+		
11. *Staurastrum botrophillum* Wolle							
12. *Staurastrum brachyatum* Ralfs	+						
13. *Staurastrum brebissonii* Archer							
14. *Staurastrum capitulum* Brébisson							+
15. *Staurastrum chaetoceras* (Schröd.) G.M.Smith							+
16. *Staurastrum crenulatum* (Nägeli) Delponte					+		
17. *Staurastrum cingulum* (W. et G.S.West) G.M. Smith **var. *obesum*** G. M. Smith							
18. Staurastrum commutatum (Kützing) G.L.Rabenhorst							

19. *Staurastrum cristatum* (Nägeli) W.Archer					+		
20. *Staurastrum denticulatum* (Nägeli) W.Archer							
21. *Staurastrum dilatatum* Ehrenberg var. dilatatum	+						
22. *Staurastrum dispar* Brébisson **var. dispar**				+			
23. *Staurastrum dubium* Eichler-Gutwinski							
24 *Staurastrum echinatum* Brébisson							
25. *Staurastrum forficulatum* Lundell	+		+				
26. *Staurastrum furcatum* (Ehrenb. ex. Ralfs) Brébisson					+		
27. *Staurastrum furcigerum* (Bréb. ex Ralfs) **var. *furcigerum***	+				+		
28. *Staurastrum gemelliparum* Nordst.							
29. *Staurastrum gracile* Ralfs **var. *gracile***	+	+			+		
30. *Staurastrum grande* Bulnh.							
31. *Staurastrum haaboeliense* Wille				+			
32. *Staurastrum heimerlianum* Lütkem.					+		
33. *Staurastrum hexacerum* (Ehrenb.) Wittrock							
34. *Staurastrum hirsutum* (Ehr.) Brébisson							
35 *Staurastrum hystrix* Ralfs		+					
36. *Staurastrum inconspicuum* Nordst. **var. *inconspicuum***	+	+				+	
37. *Staurastrum inflexum* Brébisson	+			+			
38. *Staurastrum kaiseri* Ružička				+			
39. *Staurastrum laeve* (Kützing) Ralfs							
40. *Staurastrum lanceolatum* Archer **f. *minor*** Nordstedt							
41. *Staurastrum latiusculum* W. et G.S.West							
42. *Staurastrum leptocladum* Nordstedt							
43. *Staurastrum lunatum* Ralfs				+	+		
44. *Staurastrum manfeldtii* Delponte							
46. *Staurastrum megalonotum* Nordstedt							
47. *Staurastrum meriani* Reinsch							
47. *Staurastrum margaritaceum* (Ehrenb.) Menegh. ex. Ralfs	+	+	+		+	+	
48. *Staurastrum micron* W. et G.S.West				+		+	
49. *Staurastrum monticulosum* (Bréb.) Bréb. ex. Ralfs							
50. *Staurastrum muricatum* (Bréb.) Ralfs	+	+	+				
51. *Staurastrum muticum* (Bréb.) Bréb. ex Ralfs	+	+					
52. *Staurastrum oligacanthum* Brébisson							
53. *Staurastrum orbiculare* (Ehrenb.) Ralfs	+			+	+		
54. *Staurastrum pachyrhynchum* Nordst**.**					+		
55. *Staurastrum paradoxum* Meyen ex. Ralfs	+				+		
56. *Staurastrum pilosum* (Näg.) Archer		+		+	+		
57. *Staurastrum polymorphum* Brébisson				+			
58. *Staurastrum polytrichum* (Perty) Rabenh.		+					
59. *Staurastrum pseudosebaldi* Wille							

60. *Staurastrum punctulatum* Brébisson	+			+			
61. *Staurastrum pungens* Brébisson							
62. *Staurastrum pyramidatum* W.West		+					
63. *Staurastrum scabrum* Brébisson							
64. *Staurastrum sebaldi* Reinsch							
65. *Staurastrum sexangulare* (Bulnh.) Rabenhorst							
66. *Staurastrum sexcostatum* (Bréb.) Ralfs **var. *productum*** West	+						
67. *Staurastrum simonyi* Heimerl					+	+	
68. *Staurastrum spongiosum* (Bréb.) Bréb. ex Ralfs **var. *spongiosum***		+		+			
69. *Staurastrum subavicula* (West) W. et G.S.West	+	+			+		
70. *Staurastrum subbrebissonii* Schmidle (Coesel & Kooijmanvan)							
71. *Staurastrum subcruciatum* Cooke et Wills							
72. *Staurastrum subgracillimum* W. et G.S.West							
73. *Staurastrum subteliferum* Roy et Bisset							
74. *Staurastrum striatum* (W. et G.S. West) Ružička				+			
75. *Staurastrum teliferum* Ralfs					+		
76. ***Staurastrum tetracerum*** (Kütz.) Ralfs							
77. *Staurastrum turgescens* De Notaris							
78. ***Staurastrum varians*** Raciborski							
79. *Staurastrum vestitum* Ralfs					+		

X. Numerical taxonomic analysis of the *Staurastrum* species identified in Romania

In order to achieve, taxonomic numerical analysis of the *Staurastrum* species, identified in Romania we selected 54 morphological characters grouped in 16 categories. The arguments of choice were: availability for all the taxa, absence of redundancy, clear definition of the states of characters and the stability of these states at a taxonomic level.

These phenetic characters were treated of equal value (Adansonian weighting), thus we may notice some changes in the classification of species proposed by Turner, namely West. This gives us useful information about the level of similarity existing between species in order to revert to the infrageneric classification.

The phenogram (Fig.10.1) exhibits the clustering of the 79 operational taxonomic units (OTUs) based on the degree of phenetic similarity. According to this phenogram there are 4 major clusters joining at the phenon levels of about 40%.

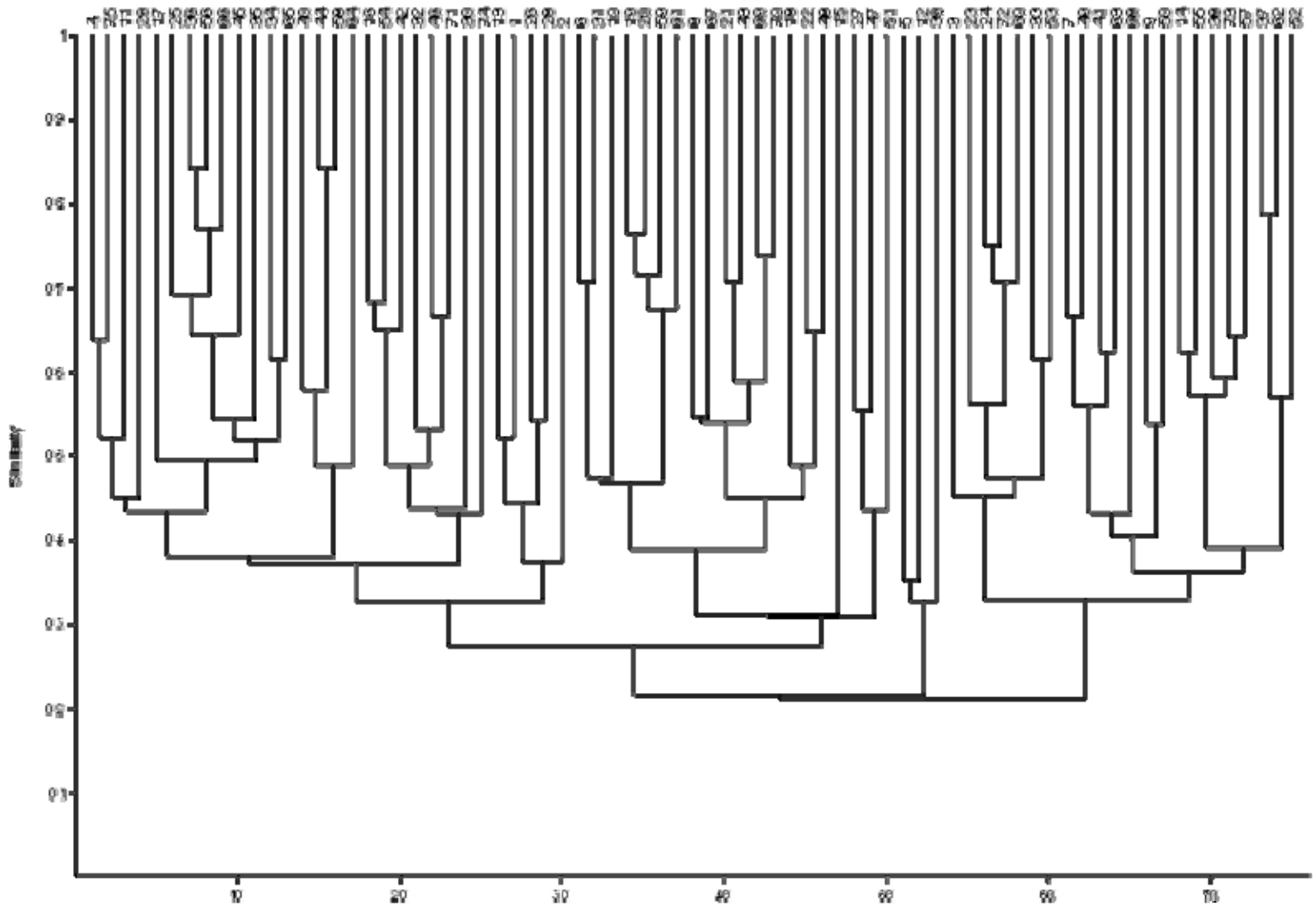

Fig. 10.1.. Phenogram representing the grouping of *Staurastrum* species (OTUs), based on phenetic similarity

XI. Microscopic images

Fig. 11.1. *Staurastrum capitulum* Brébisson

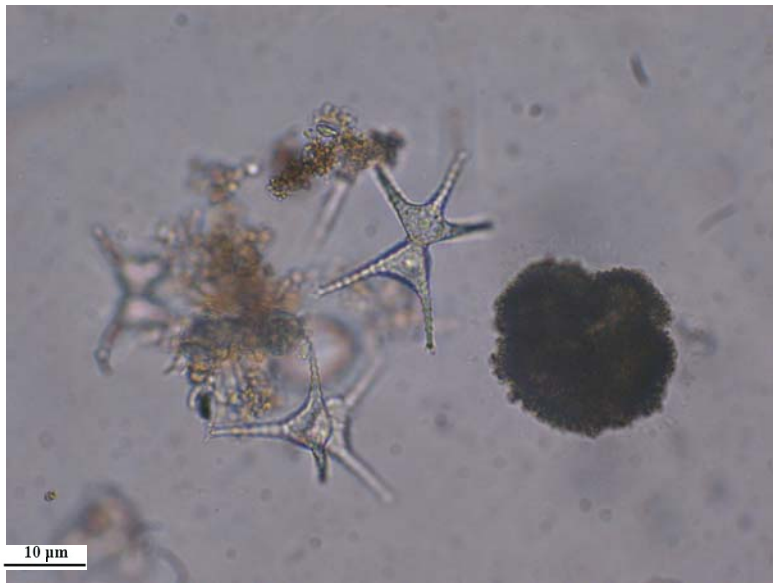

Fig. 11.3. *Staurastrum tetracerum* (Kütz.) Ralfs

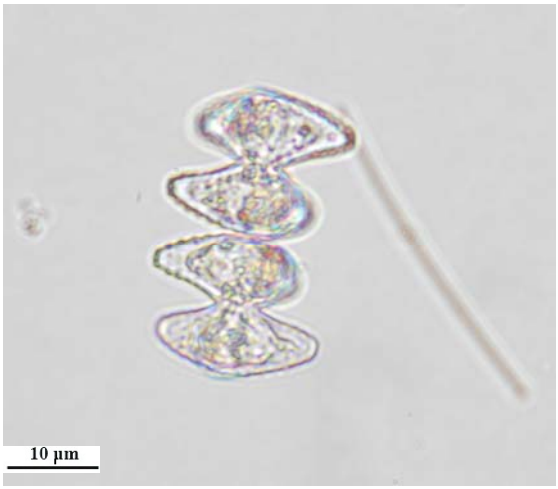

Fig. 11.5. ***Staurastrum dispar*** **Brébisson**

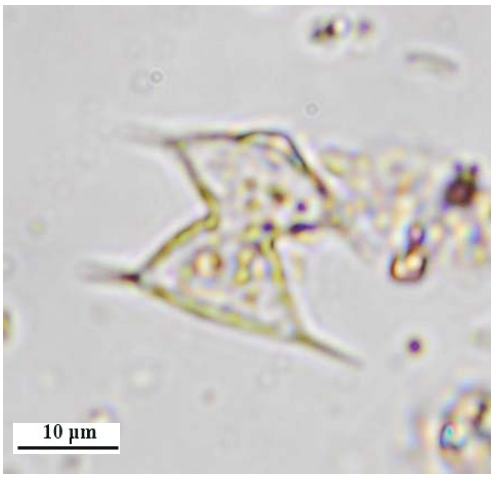

Fig. 11.20. ***Staurodesmus extensus var. extensus*** (Borge) Teiling

Fig. 11.10. ***Staurastrum paradoxum*** **(sânga) şi** ***Staurastrum margaritaceum*** **(Ehrenb.) (dreapta)**

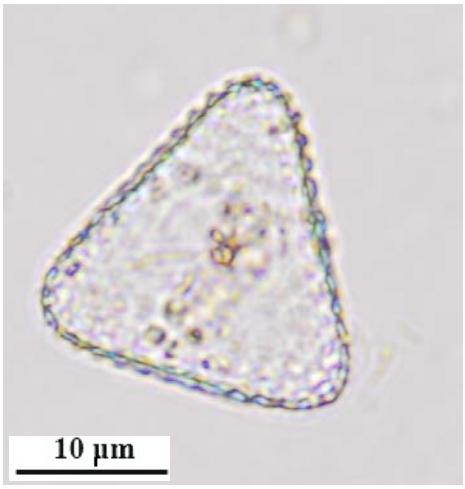

Fig. 11.16. ***Staurastrum hirsutum*** **(Ehr.) Brébisson**

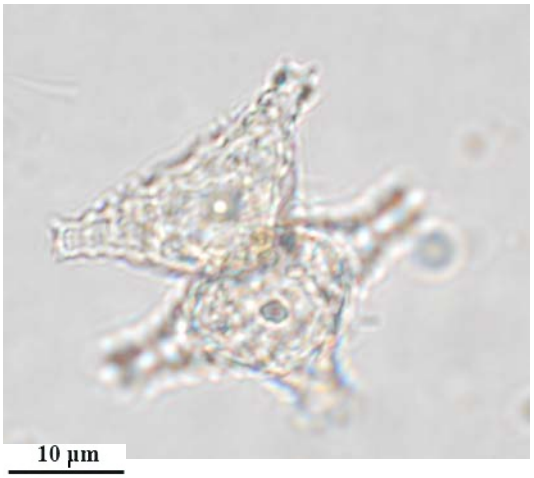

Fig. 11.17. ***Staurastrum polymorphum*** **Brébisson**

Fig. 11.18. ***Staurastrum cingulum*** **(W. et G.S. West) G.M.Smith**

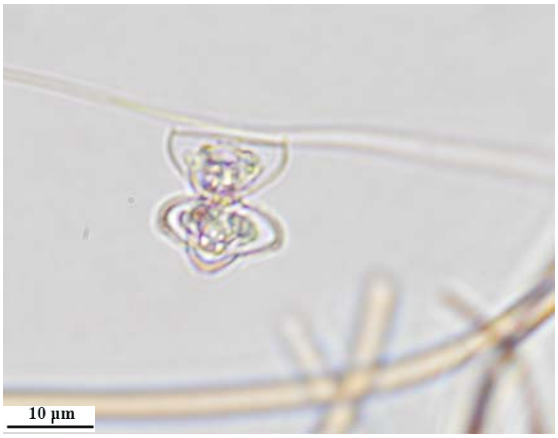

Fig. 11.19. ***Staurodesmus dejectus*** **(Bréb. ex Ralfs)**

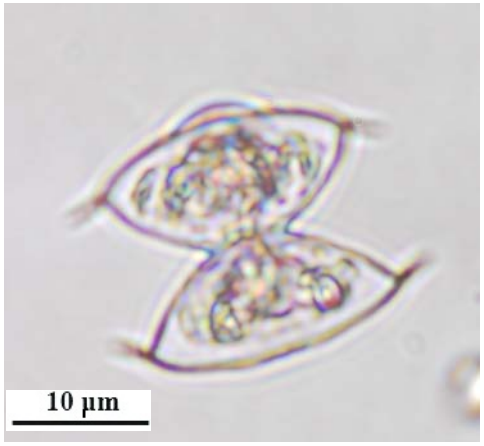

Fig. 11.21. ***Staurodesmus glaber*** **(Ehr. ex Ralfs) Teiling**

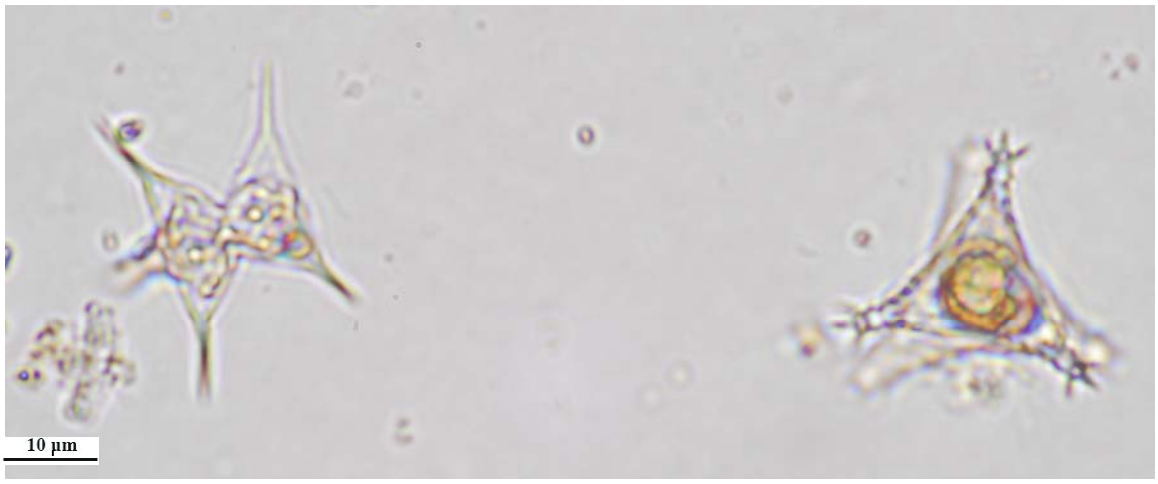

Fig. 11.31. ***Staurodesmus spencerianus*** **(Nordst.) Teiling (stânga) and*Staurastrum paradoxum* Meyen ex. Ralfs (aspect apical)**

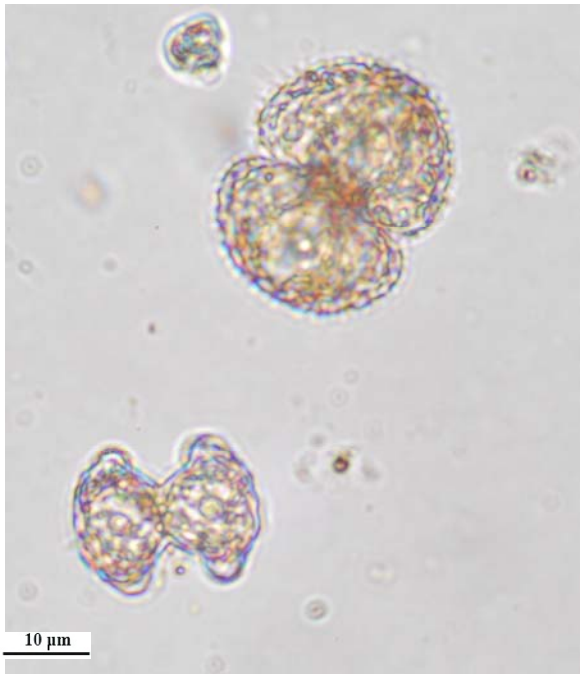

Fig. 11.32. *Staurastrum hirsutum* (Ehr.) Brébisson (sus) and *Staurastrum margaritaceum* (Ehrenb.) Menegh. ex. Ralfs (jos)

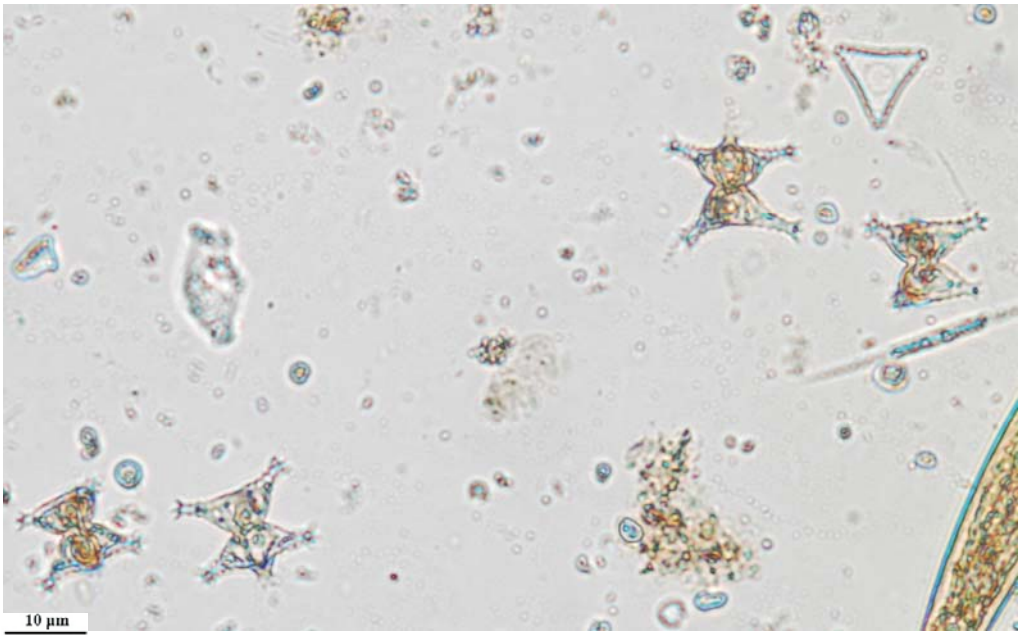

Fig. 11.11-15 *Staurastrum paradoxum* Meyen ex. Ralfs

Conclusions:

- There are 15 *Staurodesmus* species present in Romania: *S. aristiferus, S. convergens*, *S. cuspidatus*, *S. dejectus*, *S. dickiei*, *S. extensus*, *S. glaber, S. incus*, *S. indentatus*, *S.mucronatus*, *S. patens*, *S. pterosporus*, *S. spencerianus*, *S. spetsbergensis*, *S. triangularis.*

- *Staurodesmus apiculatus* and *S. joshuae* are cited as species in several articles, but they are actually varieties of the species *S. dejectus*, respectively *S. extensus*.

- The phenogram shows the clustering of the 14 operational taxonomic units (OTUs) based on the degree of phenetic similarity. According to this phenogram there are 3 major clusters joining at the phenon levels of about 50%. The distribution of taxa among the clusters is as follows: *S. convergens*, *S. dickiei*, *S. mucronatus*, *S. patens* and *S. spetsbergensis* are in cluster 1; *S. cuspidatus*, *S. dejectus*, *S. glaber* and *S. pterosporus* are in cluster 2; *S. extensus*, *S. incus*, *S. indentatus S. spencerianus*, *S. triangularis* are in cluster 3.

- These three major aggregates may be considered as sections and consist of smaller aggregates reflecting the groups established by Teiling that may be taken series. There are some contradictions between these two classifications: *S. spencerianus* is positioned close to *S. incus* whereas *S. glaber* is far from this group, and apparently more similar to *S. cuspidatus.*

- There have been recorded 79 species of the genus *Staurastrum* Meyen in Romania, some of them being represented by different varieties and forms. Their number could be higher, with the accumulation of new data by future algological studies in less or uninvestigated areas.

- The present paper presents the morphological description, ecology and distribution of the taxa occurring in Romania. Our investigations strengthen the particular preference of most

Staurastrum species towards low pH conditions, although they seem to be wide spread or even cosmopolitan.

- The distribution maps of the taxa reflect in many cases the occurrence of the particular habitats the desmids live in (e.g. peat bogs), as well as the "intensity" of algological investigation (e.g. Cluj-Napoca, Bucharest, Iaşi), than their real distribution in Romania.

- Due to the highly accentuated polymorphism is often difficult to determine the exact identity of *Staurodesmus* and *Staurastrum* species. Therefore, in order to avoid possible confusions, we considered necessary to provide the detailed description of the taxa present in the flora of our country.

- The future expansion of the researches on the species present in different regions (especially of the uninvestigated ones) could provide useful information on the variability of morphological characters considered diagnostic, but also on the very plastic ones, and therefore cannot be taken into account in defining taxonomic units.

Selective Bibliography

1. Brook, A.J., 1959, *Staurastrum paradoxum* Meyen and *S. gracile* Ralfs in British freshwater plankton and revision of *S. anatinum*-group of radiate desmids, *Trans. R. Soc. Edinb*., **63**, 3: 589-628.
2. Brook, A.J., Williamson, D.B., 1983, On *Staurastrum botrophilum* Wolle, a rare and inadequately described desmid, *Br. phycol. J.*, **18**: 69-72.
3. Cărăuş, I., 2002, The algae of Romania, *Stud. şi Cercet.*, *Biologie*, Univ. Bacău, **7**: 1-704.
4. Cărăuş, I., 2012, *Algae of Romania. A distributional checklist of actual algae*. Version 2.3 third revision, Univ. Bacău.
5. Coesel, P.F.M., 1991, *De Desmidiaceeën van Nederland*, Deel 4, Fam. Desmidiaceae (2), Stichting Uitgeverij Koninklijke Nederlandese, Natuurhistorische Vereniging.
6. Doniţă, N., Popescu, A., Comanescu Paucă, M., Mihăilescu, S., Biris, I.A., 2005. *Habitatele din România*, Editura Tehnica Silvica, Bucuresti.
7. Felföldy, L., 1981, *A zöldalgák Desmidiales rendjének kishatározója*, Vízügyi Hidrobiológia 10, Országos Vízügyi Hivatal, Budapest.
8. Gafta, D.; Mountford, J. O., 2008, *Manual de interpretare a habitatelor Natura 2000 din România [Romanian Manual for Interpretation of EU Habitats]*. Cluj-Napoca: Risoprint.
9. Gontcharov, Andrey A., 2008, Phylogeny and classification of Zygnematophyceae (Streptophyta): current state of affairs, *Fottea*, **8**(2): 87–104.
10. Guiry, Michael D., 2013, Taxonomy and nomenclature of the Conjugatophyceae (= Zygnematophyceae), *Algae*, **28**(1): 1-29.
11. Kiss, A., Momeu, L., Gudasz, C., Péterfi, L.Ş., 2005, Preliminary studies on the algal communities occurring in the ponds of the Central Park Cluj-Napoca (Transylvania, Romania), *Contrib. Bot.*, **XL**: 163-171.
12. Lind, E.M., Brook, A.J., 1980, *Desmids of the English District Freshwater*, Biological Association.
13. McCourt, R. M., 1995, Green algal phylogeny, *Trends in Ecology and Evolution*, **10**: 159-163.

14. McCourt, R. M., Kenneth, K. G., Bell, J., Grajewska, A., Wojciechowski, M. F., Hoshaw, R., 2000, Phylogeny of the conjugating green algae (Zygnemophyceae) based on *rbc*L sequences, *Journal of phycology*, **36**: 747-758.
15. Momeu L., Péterfi, L.Ş., 1983, Structura şi organizarea comunităţilor algale sfagnofile din Molhaşul cel Mare de la Izbuc, Padiş-Tămaşca şi Valea Vadului, *Contrib. Bot.*: 3-15.
16. Momeu L., Péterfi, L.Ş., 1989, Comunităţile algale sfagnofile din molhaşurile de pe Muntele Dobrinu (M-ţii Apuseni), *Ocrot. Nat. Med. Inconj. Bucureşti*, **38** (2): 113-118.
17. Momeu L., Péterfi, L.Ş., 1990, Structura comunităţilor algale sfagnofile din tinovul "Tăul de la Hoteni", *Contrib. Bot.*: 39-44.
18. Momeu, L., R Momeu, L., Péterfi, L. Şt., 2002, Algal flora of the transition peat bog located near the Iezeru Şurianu glacial lake (Sebeşului Mountains. Romanian southern Carpathians), *Contrib.Bot*., **XXXVII**: 119-126.
19. Rasiga, A., Péterfi, L. Şt., Kozma, A., 1999, Algal communities of the Cibin River and of wetlands situated on the upper and middle course of the Olt River, *Transylv. Rev. Syst. Ecol. Res*., **1**: 49-65.
20. Momeu, L., Péterfi, L.S., Tudorancea, C., 2003, Algal communities of the "Călăţele Pădure" peat bog (Romanian Western Mountains), *Contrib. Bot.*, **XXXVIII**, 1: 25-36.
21. Oltean, M., 1977, În legătură cu aprecierea gradului de troficitate al apelor stagnante pe baza structurii fitoplanctonului, *Hidrobiologia*, **15**: 97-102.
22. Péterfi, L.Ş., 1971, Contribuţii la cunoaşterea algoflorei Parcului Naţional Retezat, *Contrib. Bot.*: 19-31.
23. Péterfi, L.Ş., 1973, Studii comparative asupra comunităţilor de alge din unele mlaştini de turbă din Munţii Apuseni, *Contrib. Bot.*: 17-39.
24. Péterfi, L.Ş., 1974, Structure and pattern of desmid communities occuring in some Romanian ombrophilous peat bogs, *Nova Hedwigia,* **25**: 651-664.
25. Péterfi L.Ş., Galló, Ş., 1974, Phytosociological and ecological affinities of some Romanian Desmids based on correlation analysis, *Rev. Roum. Biol.*, **19**, 1: 29-36.
26. Péterfi, L.Ş., 1974, Flora algală din complexul mlăştinos Valea Judele - Zănoaga, Parcul Naţional Retezat, *Acta Musei Devensis, Sargetia, Ser. Sci. Nat.*, **X**.: 85-94.

27. Péterfi, L.Ş., Momeu, L., 1976, Composition and structure of the algal communities of the Mohoş, Luci and Poiana Stampei peat bogs, *Rev. Roum. Biol.*, *Biol. Véget.*, **21**, 2: 75-85.
28. Ralfs, J., M.R.C., 1848, *The British Desmidieæ*, Reeve, Benham, and Reeve, King William Street, Strand, London.
29. Schaarschmidt, G., 1882 (issued 1883), Tanulmányok a Magyarhoni Desmidiaceákról. Adatok keleti Magyarország Desmidiacea Florájához, *Mathematikai és Természettudományi Közlemények*, **XVII**: 259-280.
30. Sokal, R.R., Sneath, P.H.A., 1963, *Principles of numerical taxonomy*, Ed.W.H. Freeman and Company, San Francisco.
31. Tarnavschi, I., 1931, Contribuţii la cunoaşterea algelor din Bucovina. II, *Bul. Facult. Ştiinte din Cernăuţi*, **V**, 1: 135-157.
32. Tarnavschi, I., Jitrariu, G., Rădulescu, D., Mitroiu, N, 1956, Contribuţii la studiul florei şi vegetaţiei algologice turficole din bazinul Dornelor (reg.Suceava), *Bul Ştiinţ. Sect. Biol. Şt. Agric.*, **III**, 2: 273-327.
33. Teiling, E. 1948, *Staurodesmus, genus novum*. *Botanica Notiser*: 49-83.
34. Teiling, E., 1967, *The desmid genus Staurodesmus*, Arkiv Bot., **6,** 11: 467-629.
35. Teodorescu, E.C., 1908, Matériaux pour la flore algologique de la Roumanie, *Beihefte Bot. Centralblatt*, **XXI**, II, 2: 103-219.
36. Török, L., 2009, The analysis of the information on algae and revised checklist from Danube Delta Biosphere Reserve, *Sci.Annals of Danube Delta Institute* (Tulcea), **15**: 47-66.
37. Turner, W.B., 1893 - '1892', Algae aquae dulcis Indiae orientalis. The freshwater algae (principally Desmidieae) of East India, *Kungliga Svenska Vetenskaps-Akademiens Handlingar*, **25(5)**: 1-187.
38. West, W., West, G.S., Carter, N., 1923, *The British Desmidiaceae V*, Ray Society, London.
39. Willén, E., 2000, Phytoplankton in water quality assessment – an indicator concept. In Heinomen, P., Ziglio, A. Van der Beken (Eds*.), Hydrobiological and limnological aspects*, Ed. John Wiley&sons.

Scientific papers published in the domain of the Ph.D. Thesis:

1. Neag, I., Péterfi, L. Ş., Momeu, L., 2006, Contributions to the knowledge of the genus *Staurodesmus* Teiling (Ord. Desmidiales) in România, *Contrib. Bot.*, **41** (1): 47-53.
2. Neag, I., Péterfi, L. , Momeu,L., 2008, Contributions to the knowledge of the genus S*taurastrum* Meyen (Ord. Desmidiales) in Romania, *Contrib. Bot.*, Vol. **43**: 91-101.

Scientific papers published outside the domain of the Ph.D. Thesis:

1. Neag, I., Momeu, L., Péterfi, L. Ş., 2005, Algal communities from some aquatic habitats of the ”Alexandru Borza” Botanical Garden, Cluj-Napoca, România, *Contrib. Bot.*, **40**: 153-163.