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A checklist of desmids (Conjugatophyceae, Chlorophyta) of Serbia. III. Genus *Staurastrum*

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Résumé – Checklist des desmidiées (Conjugatophyceae, Chlorophyta) de Serbie. III. *Staurastrum*. Les premières données sur la distribution des Desmidées en Serbie datent de l'année 1883. Depuis cette date et jusqu'à la fin de 2010, 646 taxons ont été identifiés. Le genre *Straurastrum,* riche en espèces, est représenté par 116 taxons ou 18 % du nombre total des Desmidées de Serbie. Les taxons du genre *Staurastrum* occupent des habitats les plus divers en Serbie, mais la plus grande diversité a été enregistrée dans les tourbières de hautes montagnes. Jusqu'à présent un grand nombre de taxons du genre *Staurastrum* (40,5 %) n'ont été trouvés qu'en un seul site en Serbie (taxons exceptionnellement rares). Au contraire, *S. alternans, S. gracile, S. orbiculare, S. paradoxum, S. polymorphum* et *S. tetracerum* y sont largement distribuées. Dans cet article nous présentons une revue des principales caractéristiques taxonomiques et écologiques des taxons du genre *Staurastrum* observés en Serbie.

Liste floristique / desmidiées / *Staurastrum* / diversité / floristique / écologie / Serbie

Abstract – The first data about the distribution of desmids in Serbia derive from the year 1883 and from that time up to the end of 2010 there were identified 646 different taxa. The species-rich genus *Staurastrum* is represented with 116 taxa which is about 18% of the total number of desmids in Serbia. Taxa of the genus *Staurastrum* occur in a large variety of habitats in Serbia, but the greatest diversity was recorded in high mountain peat bogs. In Serbia till now, a large number of taxa of the genus *Staurastrum* (40.5%) has been found only on one locality (exceptionally rare taxa). In contrast, the species *S.alternans, S. gracile, S. orbiculare, S. paradoxum, S. polymorphum* and *S. tetracerum* belong to the most common species in Serbia. In this paper a review is presented of the main taxonomic and ecological characteristics of taxa of the genus *Staurastrum*, recorded from Serbia.

Checklist / Desmids / *Staurastrum* / diversity / floristics / ecology / Serbia

INTRODUCTION

The first data regarding the distribution of desmids in Serbia were published in 1883 (Schaarschmidt, 1883), and those regarding the distribution of *Staurastrum* in 1908 (Košanin, 1908b). Much of the credit for the study of the desmid flora in Serbia during the 20th century goes to Košanin, Katić, Đorđević and Milovanović (Stamenković *et. al*., 2008; Cvijan & Fužinato, 2010; Fužinato *et al*., 2011) who mostly surveyed desmids of high mountain peat bogs. Other data

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relating to desmid distribution, are mainly the result of routine analyses of algae of various habitats, in the first place of reservoirs, rivers and lakes, except for the detailed surveys of desmids of the major rivers and canals in Vojvodina (Stamenković, 2005).

A total of 646 desmid taxa have been recorded in Serbia. The cosmopolitan genus *Staurastrum* is the most abundant second only to the genus *Cosmarium,* and is represented by 116 taxa. The greatest diversity of the genus *Staurastrum* in Serbia has been recorded in high mountainous peat bog lakes and marshes. Besides, representatives of this genus have been found in various oligo-meso- and eutrophic stagnant and slow-running waters. The present study compile data on the distribution and ecology of taxa of the genus *Staurastrum* recorded until now from Serbia.

MATERIALS AND METHODS

This study presents a review of all taxa of the genus *Staurastrum,* recorded on the territory of Serbia from 1908 till today. The authors used all the available literature (papers, manuscripts and proceedings) regarding the distribution, ecology and diversity of the genus *Staurastrum* in Serbia. In addition, data from an extensive survey of desmids in the territory of Serbia in the period from 2007 to 2010 are included. During that survey taxa of the genus *Staurastrum* were recorded on 32 localities. An annotated list of all Staurastrum taxa reported from Serbia is given in the Appendix below.

Samples from the reservoirs of Serbia were collected in June, July, September, October and November 2007; from the locality of Horgoš in April, June, August and October 2008; from the locality of Pešter Plateau in June and September 2008 and May 2009; from Daićko Lake, located on Mt. Golija, in May and June 2009; from a peat bog „Crvene pode“, situated on the Mt. Tara, in June 2009.

New data on localities, where taxa of the genus *Staurastrum* were found during the survey of 2007-2010 are marked with “Ud.” fallowed by the initials of the locality where the appropriate taxon was found, put between brackets. Those are reservoirs of Bajina Bašta (BB), Banjska – Prvorek (BP), Bojnik (BJ), Bor (BO), Barje (BR), Bovan (BV), Bresnica (BS), Ćelije (Ć), Divčibare (D), Garaši (GA), Grlište (GR), Grošnica (GŠ), Gruža (GŽ), Kokin Brod (KB), Krajkovac (KR), Međuvršje (MV), Ovčar banja (OB), Podpeć (PD), Pridvorica (PR), Radoinja (RA), Sjenica (SJ), Visočica (VS), Vlasina (VL), Vrutci (VR), Zavoj (ZA), Zlatibor (ZL), Zvornik (ZV), as well as the fish pond Horgoš (RH), peat bog Horgoš (TH), peat bog in Pešterska Plateau (P), Daićko Lake (DL) and peat bog „Crvene pode“ (CP) (Fig. 1).

Phytoplankton samples were collected by towing a plankton net (mesh size 25μm) through the open water. Samples of phytobenthos were collected with a pipette from the bottom deposits. Epiphytic samples were collected by squeezing out the dominant submerged macrophytes and mosses. Water and air temperature was measured at the sampling site by digital thermometer, with an accuracy 0.1^{o}C.

Physical-chemical analyses of water from the sampling site were conducted in the Institute of Public Health of Serbia „Dr Milan Jovanović-Batut“ and Republic Hydro-meteorological Service of Serbia by applying JUS-ISO (APHA, AWWA, WPCF, 1989) standard methods.

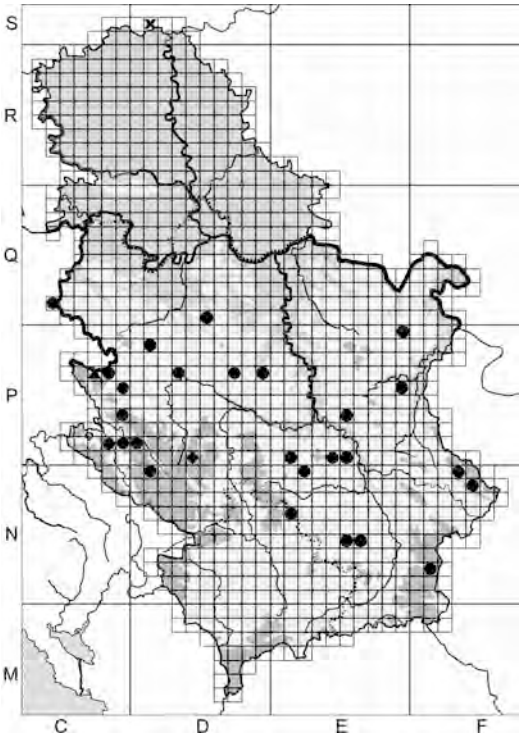

Fig. 1. UTM map of Serbia (10 × 10 km) showing the new locations of the habitats of the genus *Staurastrum*. ● – reservoirs, ▲ – „Crvene pode“ peat bog on Tara mountain; ◆ – Daićko Lake on Golija mountain; **x** – Horgoš pet bog and fish pond.

Algological material was analyzed using Carl Zeiss AxioImager. M1 microscope and digital camera AxioCam MRc5 with AxioVision 4.8 software.

The individual *Staurastrum* taxa were identified using relevant literature (Růžička, 1977; Lenzenweger, 1997; Brook & Johnson, 2003; Coesel & Meesters, 2007).

Frequency of each taxon is expressed on the following scale: exceptionally rare (ER) – taxa found in one locality only; rare (R) – taxa found in less than 10 % of the localities surveyed; frequent (F) – taxa found in 10-50 % of the localities surveyed; common (C) – taxa found in more than 50 % of the localities surveyed.

New taxa for the desmid flora of Serbia are marked with an asterisk (*).

RESULTS AND DISCUSSON

The genus *Staurastrum* comprises 116 taxa or 18% of the total number of desmids, which till now were recorded on the territory of Serbia.

About 40% of the taxa were found in one locality only (exceptionally rare), whereas about 47% of the *Staurastrum* taxa were discovered in less than 10% of the surveyed localities (rare taxa).

Many of those taxa are also rare in other European countries such as Austria (Lenzenweger, 1997, Lenzenweger, 2003), Czech Republic (Št'astný, 2008, 2009, 2010; Štěpánková *et al*., 2008), France (Kouwets, 1987), Great Britain (Brook & Johnson, 2003), Lithuania (Kostkeviciene *et al*., 2003; Briskaite *et al*., 2008), The Netherlands (Coesel & Meesters, 2007), Poland (Tomaszewicz, 1988; Tomaszewicz & Kowalski, 1993), Russia (Sterlyagova, 2008), Slovenia (Krivograd-Klemenčić & Vrhovšek, 2003) and Turkey (Şahin, 2005).

Distribution, ecology and biogeography of *Staurastrum* taxa in Serbia

Taxa of the genus *Staurastrum* are widely distributed in Serbia, and represent the most abundant genus of desmids in Serbia second only to the genus *Cosmarium*. Text-figure 1 in Stamenković *et al*. (2008) and Text-figure 1 in Fužinato *et al*. (2011) show the location of the habitats of different taxa of the elongate baculiform desmid taxa, the genus *Cosmarium* and the genus *Staurastrum*. In addition, 32 newly investigated habitats, which contain representatives of the genus *Staurastrum* are presented in Figure 1 in the present paper.

Taxa of the genus *Staurastrum* were found in the benthos and plankton of a variety of habitats. Unfortunately, in general phycologists provided only the lists of taxa in their publications, without additional explanations or illustrations, so that a thorough revision of taxa of the genus *Staurastrum* was not possible.

Physical-chemical characteristics of the localities that were previously surveyed in Serbia were reported by Stamenković *et al*. (2008) and Fužinato *et al*. (2011). The results of physical-chemical analysis of water from the reservoirs in Serbia for the year 2007 were published in the Hydrological Annual – Water Quality (2007) of the Republic Hydro-meteorological Service of Serbia. The trophic status of reservoirs in Serbia is mesotrophic up to eutrophic, and the water pH varies between 7.1-8.6, except for Vlasina reservoir, in which pH is below 7 most of the year. Vlasina reservoir was formed on the site of marshy, sphagnum peat bog in the period from 1949 to 1954, with a whole series of changes in hydrological regime, physical-chemical water properties and present desmid flora over a prolonged period (Milovanović, 1973; Cvijan & Laušević, 1991a, b).

In the present paper, there are also presented, in addition to literature sources, the results of the analyses of algological samples collected from 27 reservoirs, a peat bog lake in Pešter Plateau, from Daićko Lake, peat bog „Crvene pode" and the peat bog and fish pond Horgoš are presented.

Physical-chemical characteristics of peat bog lake in Pešter Plateau are presented in Fužinato *et al*. (2011).

Daićko Lake is situated on the north-west side of Mt. Golija (Fig. 1) in a small depression at an altitude of 1556 m. It is a triangle like, without tributaries and effluents and with a maximal depth of 3 m. According to the vegetation covering the depression it can be concluded that once the whole depression was filled with water. The lake's area has been gradually reduced and this process is still continuing. The first algological survey of Daićko Lake was conducted by Košanin (1908b), whereas Milovanović (1960c) dealt solely with the desmid flora.

At the time of sampling, pH of Daićko Lake water was 7.3. Oxygen concentration of the in water is high (11.6 mg/l) and BOD_5 too (>20 mg/l), which

points to high organic loading. Ion concentration was low, which was expected given that it is a high mountain peat bog. Increased nitrate (2.3 mg/l) and ammonia concentrations (1.2 mg/l) seem to derive from the surrounding areas that are used for cattle grazing.

Mt. Tara is located in the west of Serbia (Fig. 1). It is characterized by a great number of karst depressions and vrtača (funnel shaped hole in the limestone formations) the bottom of which is composed of impermeable material (Tešić *et al*., 1979), which prevents draining and enabled the formation of marshes. Through the time, due to the accumulation of natural organic material and an accelerated process of humification, gradually an alkaline substratum developed, providing favourable conditions for the development of a rich desmid flora. The peat bog „Crvene pode" is situated at an altitude of 1080 m. Most of this peat bog is forested (forest-peat bog) and its smaller part is overgrown with peat-bog mosses, the peat thickness being up to 3.5 m (Tešić *et al*., 1979). At the time of sampling water pH was 6.8, organic load (BPK_5 = 0.4 mg/l) and ion concentration were low.

Horgoš peat bog is situated in the north of Serbia, next to Hungarian border (Fig. 1). In the peat bog's vicinity is a fish pond, which was created due to peat exploitation over a number of years. During the survey water pH in the peat bog ranged from 6.5 to 7.8, and in the fish pond between 6.8 and 8.0. In April and June nitrate concentrations were increased both in the peat bog and fish pond, being in the peat bog 7.1 mg/l and 34 mg/l respectively, and in the fish pond 9.6 mg/l and 34 mg/l respectively. At the end of August and in the middle of October nitrate concentrations both in the peat bog and fish pond were lower than 0.5 mg/l. Given that in the immediate vicinity of the fish pond and peat bog the land is cultivated, frequently with grazing cattle, it is certain that the increased nitrate concentration originates from the surrounding land.

In Serbia, as expected the largest number of *Staurastrum* taxa (70 or about 60% of the total number) was recorded in high mountain peat bogs and oligotrophic glacial and nival lakes.

A total of 42 *Staurastrum* taxa were found only in high mountain peat bogs of which as many as 27 taxa are exceptionally rare (*S. asperum, S. avicula* var. *subarcuatum, S. boreale* var. *quadriradiatum, S. controversum, S. cosmarioides, S. cosmospinosum, S. dorsidetiferum, S. erasum* var. *espinulosa, S. forficulatum, S. furcatum* var. *aciculiferum, S. gracile* var. *nanum, S. grallatorium, S. hantzschii, S. hirsutum* var. *muricatum, S. inconspicum, S. intricatum, S. longispinum, S. monticulosum, S. orbiculare* var. *denticulatum, S. ornatum* var. *asperum, S. pentacladum, S. proboscideum, S. scabrum, S. sebaldi v*ar. *ornatum, S. sexangulare, S. subavicula, S. varians*).

Water of high mountain peat bogs in Serbia is slightly acid to neutral. The most abundant cations are calcium and magnesium, the most abundant anions hydrogen carbonates. Due to human impact the concentration of organic compounds has increased. Changed climatic and ecological conditions contribute to the increase in the number of ubiquitous and indifferent forms, and a decrease and disappearance of typical high mountain forms.

About 50% of the *Staurastrum* taxa were found in mesotrophic and eutrophic stagnant and running waters. Some of them were found only in rivers and irrigation canals in the territory of Vojvodina (*S. anatinum* var. *vestitum, S. bloklandiae, S. boreale, S. cyclacanthum* var. *cyclacanthum, S. cyclacanthum* var. *dissimile, S. eurycerum, S. floriferum, S. gracile* var. *coronulatum, S. granulosum, S. pingue, S. retusum, S. sublongipes, S. irregulare, S. tetracerum* f. *trigona*). Those waters are characterized by higher concentrations of nitrates and phosphates and

a reduced quantity of dissolved oxygen, and water pH ranges from 6.5 to 9.0 (Stamenković, 2005). From an ecological point of view, the species *S. bloklandiae*, found in 5 localities in the period from May 2002 to April 2003, is of particular interest (Stamenković & Cvijan, 2008c).

Frequent species (*S. avicula, S. capitulum, S. chaetoceras, S. crenulatum, S. dilatatum, S. margaritaceum, S. polytrichum, S. punctulatum, S. teliferum*) account almost 8% of the total number of taxa of the genus *Staurastrum*.

Only 6 species (*S. alternans, S. gracile, S. orbiculare, S. paradoxum, S. polymorphum* and *S. tetracerum*), can be considered common in the territory of Serbia – they were found in high mountain peat bogs, oligotrophic mountain lakes as well as in fishponds, irrigation canals and other meso- to eutrophic waters.

The three species of the genus *Staurastrum* most often found in Serbia are *S. gracile, S. polymorphum* and *S. tetracerum.* The species *S. gracile* inhabits moderately nutrient-rich waters, but it may also be found in peat bogs and marshes (Brook & Johnson, 2003). The species *S. polymorphum* is indifferent in terms of pH values and may be found in acid to alkaline habitats (Milovanović, 1959) whereas *S. tetracerum* has a wide distribution in the plankton of nutrient-rich waters and has a broad tolerance with respect to pH values ranging from 6-10 (Brook & Johnson, 2003). *S. gracile* and *S. polymorphum* are very morpologicaly variable species. It maybe one of reasons why they frequently reported.

Most of these taxa are also widely distributed in other European countries such as Austria (Lenzenweger, 2003), Great Britain (Brook & Johnson, 2003) and Poland (Tomaszewicz, 1988).

The majority of taxa of the genus *Staurastrum* that have been recorded in the territory of Serbia are cosmopolites, which is in accordance with very wide distribution of this genus (Coesel, 1996; Brook & Johnson, 2003; Lenzenweger, 2003; Şahin, 2005; Kosteviciene *et al*., 2003; Sterlyagova, 2008).

The presence of subalpine, alpine and arcto-alpine elements in Serbia (*S. capitulum*, *S. controversum, S. cosmospinosum, S. meriani, S. ornatum* var. *asperum, S. pyramidatum)* in the first place in high mountain peat bogs, points to glacial origin of these peat bogs (Milovanović, 1959).

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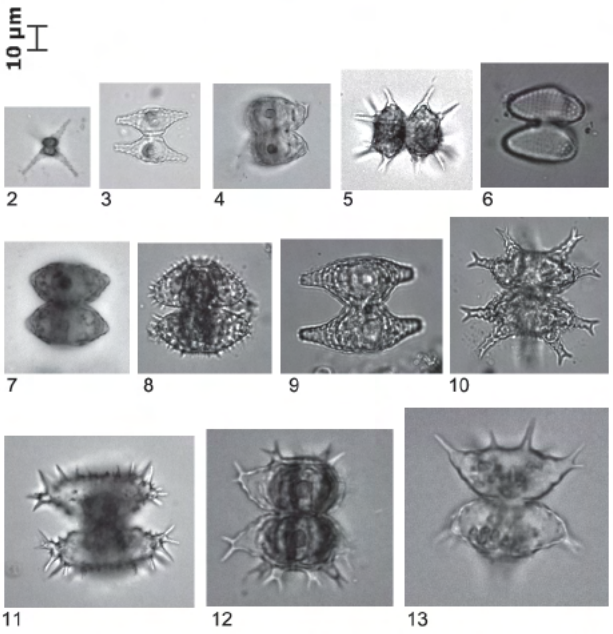
APPENDIX

List of *Staurastrum* taxa in Serbia

Literature (Lit).: the numbers on the literature column refer to the numbers in brackets after the references in the References list. New, unpublished data are designated as Ud, fallowed by the initials (between brackets) of the localities in which the taxon has been found.

Bas.: basionym; **Syn**.: synonym



Figs 2-13. **2**. *Staurastrum tetracerum* (RA); **3**. *S. margaritaceum* (TH); **4**. *S. lunatum* (VL); **5**. *S. pungens* (P); **6**. *S. alternans* (SJ); **7**. *S. striatum* (P); **8**. *S. brebissonii* (VL); **9**. *S. proboscideum* (P); **10**. *S. furcigerum* (PD); **11**. *S. aculeatum* (P); **12**. *S. subarcuatum* (P); **13**. *S. arcuatum* (P).

Habitats: 1 – rivers; 2 – canals; 3 – lakes; 4 – ponds; 5 – marsh; 6 – fish ponds; 7 – barren ponds; 8 – irrigation canals; 9 – reservoirs; 10 – high mountain peat bogs; 11 – high mountain glacial lakes; 12 – high mountain nival lakes; 13 – thermo-mineral springs; 14 – sublacustrine springs.
Frequency: exceptionally rare (ER); rare (R); frequent (F); common (C).

S. aculeatum Menegh. *ex* Ralfs 1848 (Fig. 11) – Lit.: 4, 5, 7, 12, 20, 39, 78, Ud. (P). – Hab.: 10, 11. – R

S. alternans Bréb. *ex* Ralfs 1848 (Fig. 6) – Lit.: 3, 5, 12, 27, 38, 39, 42, 48, 49, 68, 70, 71, 78, 80, 81, 82, Ud (BB, BV, D, ZV, MV, SJ). – Hab.: 1, 7, 8, 9, 10, 11, 12, 14. – C

S. anatinum Cooke *et* Wills 1881 var. *anatinum* – Lit.: 16. – Hab.: 9. – ER

S. anatinum var. *anatinum* f. *pelagicum* (W. *et* G. S. West) Brook 1959 (Bas.: *S. anatinum* var.
pelagicum W. *et* G. S. West 1902) – Lit.: 15. – Hab.: 1. – ER

S. anatinum var. *vestitum* (Ralfs) Brook 1959 (Bas.: *S. vestitum* Ralfs 1848) – Lit.: 68. – Hab.: 1. – ER

S. arcuatum Nordst. 1873 (Fig. 13) – Lit.: 5, 12, Ud. (P) – Hab.: 10. – R

**S. asperum* Bréb. *ex* Ralfs 1848 – Lit.: Ud. (T). – Hab.: 10. – ER

S. avicula Bréb. *ex* Ralfs 1848 var. *avicula* – Lit.: 5, 12, 39, 45, 68, Ud. (BO, Ć, GŽ, KB). – Hab.: 6, 8, 9, 10. – F

S. basidentatum Borge 1892 – Lit.: 4, 5, 7, 68, 78, 82. – Hab.: 1, 10, 11. – R

S. bieneanum Rabenh. 1862 [Syn.: *Didymidium muticum* f. *bieneanum* (Rabenh.) Reinsch 1866; *S. orbiculare* var. *bieneanum* Rabenh. 1868; *S. muticum* var.

*bieneanum (*Rabenh.) Riabinine 1888; *Staurodesmus bieneanus* (Rabenh.) Florin 1957] – Lit.: 3, 68, 72. – Hab.: 7, 8. – R

S. bloklandiae Coesel *et* Joosten 1996 – Lit.: 68, 71, 73. – Hab.: 1, 8. – R

S. boreale W. *et* G. S. West 1905 var. *boreale*– Lit.: 68. – Hab.: 8. – ER

**S. boreale* var. *quadriradiatum* Korshikov 1941 – Lit.: Ud. (P.) – Hab.: 10. – ER

S. brachiatum Ralfs 1848 – Lit.: 5, 6, 21, 23, 24, 39, Ud. (CP.) – Hab.: 10. – R

S. brebissonii Arch. *in* Pritch. 1861 (Syn.: S*. pilosum* Bréb. 1856) (Fig. 8) – Lit.: 5, 12, Ud. (BJ, BP, BR, KR, VL.) – Hab.: 9, 10. – R

S. capitulum Bréb. *in* Ralfs 1848 [Syn.: *S. amoenum* Hilse 1866; *S. capitulum* var. *amoenum* (Hilse) Rabenh. 1868] – Lit.: 5, 12, 27, 38, 39, 40, 42, 78, 82. – Hab.: 10, 11. – F

S. chaetoceras (Schröd.) Smith 1924 (Bas.: *S. polymorphum* var. *chaetoceras* Schröd. 1898) – Lit.: 9, 10, 11, 29, 56, 64, 65, 68, 71, Ud. (MV, VL.) – Hab.: 1, 2, 6, 8, 9, - F

S. cingulum (W. *et*. G. S. West) Smith 1922 (Bas.: *S. paradoxum* var. *cingulum* W. *et* G. S. West 1903) – Lit.: 56, 58, Ud. (P, ZL, ZV.) – Hab.: 4, 9. – R

S. commutatum (Kütz.) Rabenh. 1868 (Bas.: *Phycastrum commutatum* Kütz. 1849) – Lit.: 5, 12, 84. – Hab.: 3, 10. – R

S. controversum Bréb. *ex* Ralfs 1848 – Lit.: 6, 22, 41. – Hab.: 10. – ER

S. cosmarioides Nordst. 1870 – Lit.: 5, 12. – Hab.: 10. – ER

S. cosmospinosum (Børgensen) W. *et* G. S. West 1900 (Bas.: *S. aculeatum* var. *cosmospinosum* Børgensen 1889) – Lit.: 41. – Hab.: 10. – ER

S. crenulatum (Näg.) Depl. 1877 var. *crenulatum* (Bas.: *Phycastrum crenulatum* Näg. 1849) – Lit.: 3, 68, 71, 72, Ud. (Ć, DJ, GŽ, KB) – Hab.: 2, 7, 8, 9, 10. – F

S. crenulatum var. *britannicum* Messik. 1927 – Lit.: 34, 45, 68. – Hab.: 2, 6, 8. – R

S. cristatum (Näg.) Arch. *in* Pritch. 1861 (Bas.: *Phycastrum cristatum* Näg. 1849) – Lit.: 5, 6, 21, 23, 33. – Hab.: 10, 13. – R

S. cyclacanthum W. *et*. G. S. West 1902 var. *cyclacanthum* – Lit.: 68. – Hab.: 1. – R

S. cyclacanthum var. *dissimile* Palamar-Mordvintseva 1961 – Lit.: 68. Hab.: 2. – ER

S. cyrtocerum Bréb. *ex* Ralfs 1848 – Lit.: 2, 68, 71. Hab.: 1, 3, 4, 8. – R

S. denticulatum (Näg.) Arch. *in* Pritch. 1861 (Bas.: *Phycastrum denticulatum* Näg. 1849) – Lit.: 31, 32, 68, Ud. (BR, GŽ, ZL.) – Hab.: 2, 9 – R

S. dilatatum Ehrenb. *ex* Ralfs 1848 - Lit.: 3, 5, 12, 39, 45, 78, 82, Ud. (DL.) – Hab.: 6, 7, 10, 11. – F

S. diplacanthum De Not. 1867 – Lit.: 78, 82. – Hab.: 11. – ER

S. dispar Bréb. 1856 – Lit.: 68, 71, Ud. (DL.) – Hab.: 1, 2, 8, 10. – R

**S. dorsidentiferum* W. *et* G. S. West 1906 – Lit.: Ud. (CP.) – Hab.: 10. – ER

S. echinatum Bréb. *ex* Ralfs 1848 – Lit.: 5, 6, 12, 22, Ud. (P.) – Hab.: 10. – R

S. erasum Bréb. var. *espinulosa* Lund. 1871 – Lit.: 5, 12.– Hab.: 10 – ER

S. eurycerum Skuja 1948 – Lit.: 68, 72. – Hab.: 2. – ER

S. floriferum W. *et* G. S. West 1896 – Lit.: 68, 71. – Hab.: 1, 8. – R

**S. forficulatum* Lund. 1871 – Lit.: Ud. (P.) – Hab.: 10. – ER

S. furcatum Bréb. 1856 var. *furcatum* – Lit.: 5, 39, 78, 82, Ud. (P.) – Hab.: 10, 11. – R

**S. furcatum* var. *aciculiferum* (W. West) Coesel 1996 [Bas.: *S. avicula* var. *aciculiferum* W. West 1889; Syn.: *S. aciculiferum* (W. West) Andersson 1890] – Lit.: Ud. (CP.) – Hab.: 10. – ER

S. furcigerum (Bréb. *ex* Ralfs) Arch. *in* Pritch. 1861 f. *furcigerum* (Bas.: *Didymocladon furcigerum* Bréb. *ex* Ralfs 1848) (Fig. 10) – Lit.: 4, 5, 6, 7, 12, 21, 23, 39, 45, 63, Ud. (Ć, OB, GA, P, PD.) – Hab.: 3, 6, 9,10. – R

S. furcigerum f. *armigerum* (Bréb.) Nordst. 1888 (Bas.: *S. armigerum* Bréb. 1856; Syn.: *S. pseudofurcigerum* Reinsch 1866) – Lit.: 5, 12, Ud. (VL, P.) – Hab.: 9, 10. – R

S. furcigerum f. *eustephanum* (Ralfs) Nordst. 1888 (Bas.: *S. eustephanum* Ralfs 1848) – Lit.: 5, 39, 42. – Hab.: 10. – R
S. gladiosum Turn. 1885 – Lit.: 5, 39, 68, 78, 82, Ud. (GR, RA, VL.) – Hab.: 8, 9, 10, 11. – R
S. gracile Ralfs 1848 var. *gracile*– Lit.: 3, 4, 5, 7, 8, 9, 10, 13, 28, 31, 34, 35, 36, 39, 44, 45, 46, 47, 51, 52, 53, 54, 55, 57, 63, 64, 65, 66, 68, 69, 70, Ud. (Ć, D, MV, P, VR, VL, VS, ZL.) – Hab.: 1, 2, 3, 6, 7, 8, 9, 10. – C
S. gracile var. *coronulatum* Boldt 1885 – Lit.: 68. – Hab.: 8. – ER
S. gracile var. *nanum* Wille 1880 – Lit.: 4, 5, 7. – Hab.: 10. – ER
S. grallatorium Nordst. 1870 – Lit.: 5, 12. – Hab.: 10. – ER
S. granulosum Ralfs 1848 – Lit.: 68. – Hab.: 8. – ER
**S. hantzschii* Reinsch 1866 – Lit.: Ud. (CP.) – Hab.: 10. – ER
S. hexacerum Wittr. 1872 – Lit.: 58, Ud. (DL, SJ, VL, ZL.) – Hab.: 4, 10. – R
S. hirsutum Ralfs 1848 var. *hirsutum* – Lit.: 27, 38, 40, 41, 42, Ud. (VL, ZL.) – Hab.: 9, 10. – R
**S. hirsutum* var. *muricatum* (Bréb. ex Ralfs) Förster 1970 [Bas.: *S. muricatum* Bréb. *ex* Ralfs 1848; Syn.: *Phycastrum muricatum* (Bréb. *ex* Ralfs) Kütz. 1849] – Lit.: Ud. (CP.) – Hab.: 10. – ER
**S. hystrix* Ralfs 1848 – Lit.: Ud. (P.) – Hab.: 10. – ER
S. inconspicuum Nordst. 1873 – Lit.: 6, 22, 41. – Hab.: 10. – ER
S. inflexum Bréb. 1856 [Syn.: *S. margaritaceum* var. *inflexum* (Bréb.) Rabenh. 1868] – Lit.: 3, 5, 39, 64, 65, Ud. (BB, BV, Ć, D, GR, VS, ZA.) – Hab.: 1, 7, 9, 10. – R
S. intricatum Delp. 1878 – Lit.: 5, 6, 21, 23, 24. – Hab.: 10. – ER
S. irregulare W. *et* G. S. West 1894 – Lit.: 68. – Hab.: 2. – ER
**S. johnsonii* W. *et* G. S. West 1896– Lit.: Ud. (CP, P.) – Hab.: 10. – R
S. laeve Ralfs 1848 (Syn.: S. *gemelliparum* var. *fabrisii* f. *simplex* Capdev. 1983) – Lit.: 45. – Hab.: 6. – ER
S. lapponicum (Schmidle) Grönbl. 1926 (Bas.: *S. punctulatum* var. *muricatiforme* f. *lapponica* Schmidle 1898) – Lit.: 4, 5, 7, Ud. (DL.) – Hab.: 10. – R
S. longipes (Nordst.) Teiling 1946 (Bas.: *S. paradoxum* var. *longipes* Nordst. 1873; Syn.: *S. paradoxum* var. *longipes* f. *permagna* W. *et* G. S. West 1905) – Lit.: 5, 12, 68, 70. –*H*ab.: 1, 10. – R
**S. longispinum* (Bailey) Arch. 1861 (Bas.: *Didymocladon longispinum* Bailey 1851) – Lit.: Ud. (P.) – Hab.: 10. – ER
S. lunatum Ralfs 1848 var. *lunatum* (Fig. 4) – Lit.: 5, 39, Ud. (BO, VL, ZL.) – Hab.: 9, 10. – R
S. lunatum var. *planctonicum* W. *et* G. S. West 1903 – Lit.: 5, 6, 23, 39, Ud. (DL.) – Hab.: 10. – R
S. manfeldtii Depl. 1878 (Syn.: *S. pseudosebaldii* subsp. *duacense* W. West 1892, *S. submanfeldtii* W. *et* G. S. West 1902) – Lit.: 5, 6, 17, 18, 19, 21, 24, 39, 44, 45, 68, Ud. (DL.) – Hab.: 5, 6, 8, 9, 10. – R
S. margaritaceum Menegh. *ex* Ralfs 1848 (Fig. 3) – Lit.: 5, 6, 38, 39, 68, 72, 76, 82, Ud. (TH.) – Hab.: 8, 10, 11. - F
S. meriani Reinsch 1866 – Lit.: 5, 27, 38, 39, 40, 80, 82. – Hab.: 10, 12. – R
S. monticulosum Bréb. *ex* Ralfs 1848 – Lit.: 5, 12. – Hab.: 10. – ER
S. muticum Bréb. *ex* Ralfs 1848 var. *muticum* – Lit.: 4, 5, 7, 12, 20, 39, 41, 78, 82. – Hab.: 10, 11. – R
S. muticum var. *subcurtum* (Nordst.) Croasd. 1994 (Bas.: *S. coarctatum* var. *subcurtum* Nordst. 1887; Syn.: *S. coarctatum* Bréb. 1856) – Lit.: 78, 82, Ud. (VL.) – Hab.: 9, 11. – R

S. orbiculare Menegini *ex* Ralfs 1848 var. *orbiculare* [Syn.: *S. orbiculare* var. *hibernicum* W. *et* G. S. West 1912, *Cosmoastrum orbiculare* (Ralfs) Tomaszevisz 1988] – Lit.: 3, 4, 5, 6, 7, 12, 21, 24, 30, 31, 33, 39, 45, 74, 78, 82, Ud. (Ć, D, MV, PR, VL.) – Hab.: 2, 4, 5, 6, 7, 9, 10, 11, 13. – C

S. orbiculare var. *denticulatum* Nordst. 1870 – Lit.: 5, 6, 21, 24. – Hab.: 10. – ER

S. orbiculare var. *ralfsii* W. *et* G. S. West 1912 – 4, 5, 7, 37, 44. – Hab.: 4, 5, 10. – R

S. ornatum Turn. 1892 var. *ornatum* – Lit.: 5, 6, 21, 22, 39. – Hab.: 10. – R

S. ornatum var. *asperum* (Perty) Schmidle 1896 (Bas.: *Phycastrum asperum* Perty 1849) – Lit.: 6, 41. – Hab.: 10. – ER

S. ornithopodum W. *et* G. S. West 1896 – Lit.: 56. – Hab.: 4. – ER

S. paradoxum Meyen *ex* Ralfs 1848 f. *paradoxum* (Syn.: *S. anatiunum* var. *anatinum* f. *paradoxum* Brook 1959) – Lit.: 1, 2, 3, 6, 15, 16, 17, 18, 19, 22, 40, 43, 45, 56, 59, 60, 61, 62, 68, 74,83. – Hab.: 1, 3, 4, 6, 7, 8, 9, 10. – C

S. paradoxum f. *minor* Istvanfy 1888 – Lit.: 41, 45. – Hab.: 6, 10. – R

S. paradoxum var. *parvum* (W. West) Carter 1923 (Bas.*: S. paradoxum* f. *parva* W. West 1892) – Lit.: 62, 68. – Hab.:1, 3. – R

S. pentacladum Wolle 1881- Lit.: 5, 12. – Hab.: 10. – ER

S. pingue Teiling 1942 (Syn.: *S. paradoxum* var. *evolutum* W. West 1923) – Lit.: 68. – Hab.: 8. – ER

**S. planctonicum* Teiling 1946 [Syn.: *S. manfeldtii* var. *planctonicum* Lütkem. 1942, *S. sebaldii* var. *ornatum* f. *planctonicum* (Lütkem.) Teiling 1947] – Lit.: Ud. (DL, RH.) – Hab.: 6, 9, 10. – R

S. polymorphum Bréb. *ex* Ralfs 1848 – Lit.: 3, 5, 6, 12, 15, 16, 17, 18, 19, 20, 21, 23, 24, 27, 32, 33, 34, 37, 38, 39, 45, 59, 62, 68, 78, Ud. (Ć, KB, MV, OB, SJ, VL, ZV.) – Hab.: 1, 2, 3, 4, 6, 7, 8, 9, 10, 11. – C

S. polytrichum (Perty) Rabenh. 1868 (Bas.: *Phycastrum polytrichum* Perty 1852; Syn.: *S. pringsheimii* Reinsch 1866) – Lit.: 4, 5, 6, 7, 21, 23, 24, 39, 53, 76, 78, 80, 82. – Hab.: 5, 10, 11, 12. – F

**S. proboscideum* (Bréb. *ex* Ralfs) Arch. 1861 (Bas.: *S. asperum* var. *proboscideum* Bréb. *ex* Ralfs 1848) (Fig. 9) – Lit.: Ud. (P.) – Hab.: 10. – ER

S. pseudosebaldi Wille 1880 (Syn.: *S. manfeldtii* var. *annulatum* W. *et* G. S. West 1902) – Lit.: 67. – Hab.: 1. – ER

S. punctulatum Bréb. *ex* Ralfs 1848 var. *punctulatum* – Lit.: 3, 4, 5, 12, 27, 38, 40, 50, 68, 69, 75, 76, 77, 82, Ud. (P.) – Hab.: 1, 7, 8, 10, 11. – F

S. punctulatum var. *pygmaeum* (Bréb. *ex* Ralfs) W. *et* G. S. West 1912 (Bas.: *S. pygmaeum* Bréb. *ex* Ralfs 1848) – Lit.: 25, 26, 27, 68, 78, 82, Ud. (P.) – Hab.: 1, 10, 11. – R

S. pungens Bréb. *ex* Ralfs 1848 (Fig. 5) – Lit.: 79, 82, Ud. (P.) – Hab.: 10, 12. – ER

S. pyramidatum W. West 1892 (Syn.: *S. muricum* var. *acutum* W. West 1890, *Cosmoastrum pyramidatum* Palamar-Mordvintseva 1982) – Lit.: 5, 27, 38, 39, 42. – Hab.: 10. – R

S. quadrangulare Bréb. *ex* Ralfs 1848 – Lit.: 45. – Hab.: 6. – ER

S. retusum Turn. 1893 – Lit.: 68, 70, 72. – Hab.: 1. – ER

**S. scabrum* Bréb. *in* Ralfs 1848 (Syn.: *S. subscabrum* Nordst. 1878) – Lit.: Ud. (T.) – Hab.: 10. – ER

S. sebaldi Reinsch 1866 var. *sebaldi* – Lit.: 5, 12, Ud. (CP, HT, P.) –Hab.: 10. – R

S. sebaldi var. *ornatum* Nordst. 1873 – Lit.: 5, 39. – Hab.: 10. - ER

S. senarium Ralfs 1848 (Syn.*: Desmidium senarium* Ehrenb. 1843) – Lit.: 45, Ud. (BP, BV, D, HR, KR, VL.) – Hab.: 6, 9. – R

**S. sexangulare* (Bulnh.) Lund. 1881 (Bas.: *Didymocladon sexangularis* Bulnh. 1861) – Lit.: Ud. (P.)– Hab.: 10. – ER

S. sexcostatum Bréb. *ex* Ralfs 1848 (Syn.: *S. sexcostatum* var. *productum* W. West 1892) – Lit.: 5, 39, 42. – Hab.: 10. – R
S. simonyi Heimerl 1891 – Lit.: 80, 82, Ud. (CP.) – Hab.: 10, 12. – R
S. smithii Teiling 1946 (Syn.: *S. bibrachiatum* Reinsch 1875, *S. contortum* Smith 1924) – Lit.: 2, 14, 68, 72. – Hab.: 1. – R
S. spongiosum Bréb. *ex* Ralfs 1848 var. *spongiosum* – Lit.: 7, Ud. (VL, ZL.) – Hab.: 9, 10. – R
S. spongiosum var. *griffithsianum* (Näg.) Lagerh. 1886 (Bas.: *Phycastrum griffithsianum* Näg. 1849) – Lit.: 6, 22, 41. – Hab.: 10. – R
S. spongiosum var. *perbifidum* W. West 1892 – Lit.: 5, 6, 22, 27, 38, 39, 40, 41, 42. – Hab.: 10. – R
S. striatum (W. *et* G. S. West) Růžička 1957 (Bas.: *S. punctulatum* var. *striatum* W. *et* G. S. West 1912) (Fig. 7) – Lit.: 25, 26, 27, Ud. (P.) – Hab.: 1, 10. – R
S. striolatum (Näg.) Arch. *in* Pritch. 1861 (Bas.: *Phycastrum striolatum* Näg. 1849) – Lit.: 68. – Hab.: 2, 8. – R
S. subarcuatum Wolle 1880 (Fig. 12) – Lit.: 5, 12, Ud. (P) – Hab.: 10. – ER
**S. subavicula* (W. West) W. *et* G. S. West 1894 (Bas.*: S. arcuatum* subsp. *subavicula* W. West 1892) – Lit.: Ud. (P.) – Hab: 10. – ER
S. subcruciatum Cooke *et* Wills 1887 – Lit.: 5, 12, 56, Ud. (P.) – Hab.: 4, 9, 10. – R
S. sublongipes Smith 1922 – Lit.: 68, 71. – Hab.: 1. – ER
S. teliferum Ralfs 1848 – Lit.: 4, 5, 12, 21, 23, 34, 37, 39, 41, 45, 63, 68, 70, Ud. (P.) – Hab.: 2, 3, 4, 6, 8, 10, 13. – F
S. tetracerum Ralfs 1848 var. *tetracerum* (Fig. 2) – Lit.: 15, 17, 18, 19, 45, 56, 61, 62, 67, 68, 69, 70, 72, Ud. (Ć, MV, OB, RA, SJ.) – Hab.:1, 3, 4, 6, 9, 10. – C
S. tetracerum f. *trigona* Lund. 1871 – Lit.: 68, 71. – Hab.: 1. – R
S. turgescens De Not. 1867 – Lit.: 25, 26, 27, 41. – Hab.: 1, 10. – R
**S. varians* Racib. 1885 – Lit.: Ud. (P.) – Hab.: 10. – ER
S. vestitum Ralfs var. *persplendidum* Messik. 1942 – Lit.: 45. – Hab.: 6. – ER