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CHECKLIST OF LITHOPHYTIC ALGAE IN BULGARIA (1905-2024)

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Abstract. The present paper provides a specified Checklist of lithophytic algae recorded in Bulgaria during the last 120 years, with indication of their epilithic or endolithic type. Altogether 369 taxa from seven phyla were reported in scientific papers from Bulgarian and foreign scientists: Cyanoprokaryota (208), Chlorophyta (83) and Streptophyta (22), Ochrophyta (52), Rhodophyta (2), Pyrrophyta (1) and Euglenophyta (1). Most of these algae were found from epilithic samples (342), and only 27 were endolithes. The number of taxa, identified after application of cultivation procedures and following of different stages of their development, is significantly lower (147) than the number of algae identified from field material by direct microscopy (222). However, it has to be stressed that during the last two decades all reports of lithophytes were based on a preliminary cultivation. The paper underlines the importance of living algal cultures, including those of lithophytes, for wide spectrum of biotechnological applications and stresses the need for future studies of this ecological group in Bulgaria.

Keywords: aero-terreserrestrial algae, algal cultivation, cyanobacteria, cyanoprokaryotes, endolithes, epilithes, green algae

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INTRODUCTION

Aero-terrestrial algae are a diverse group of both pro- and eukaryotic algae, that permanently live outside of water environment and, as their name suggests, inhabit a wide range of aero-terrestrial substrates. One peculiar subgroup stands out from the rest, because even though all algae require some degree of moisture to survive, most lithophytes are known to thrive in almost completely dry environments, inhabiting both the surface and the inner parts of rocks and stones. The lithophytic algae, found on or inside rocky substrates, are an integral part of almost every ecosystem on Earth, serving as primary producers, but also playing an important role in rock weathering. Furthermore, the process of rock demineralization itself is crucial for the formation of the soil layer, giving it its unique properties such as chemical composition, density, water retention capability - all important factors for soil fertility. Even though this rather small, but quite diverse group of algae is involved in planetary scale processes, important for the wellbeing and survival of the human race, it is often overlooked and remains unexplored. This is due to the fact that these specific algae, as well as the aero-terrestrial group as a whole, require obligatory cultivation in a laboratory for their precise taxonomic identification. Ettl & Gärtner (1995, 2014) thoroughly explained that the reason behind the necessity of growing the collected material in artificial conditions is due to the need of tracking the complete life cycle - both young and adult stages, as well as the types of reproduction.

Lithophytes are split into several subgroups, divided on the basis of the specific inhabited part of the rocks or stone formations. According to different authors (for details see Ettl & Gärtner 1995, 2014) the three main distinguishable groups are epilithes, growing upon the surface of rocks, chasmolithes growing inside stone cracks and crevices, and endolithes, growing in the inner parts of the rock, usually inhabiting the outermost layers in transparent rocks, oftentimes around 1 cm in depth. The isolation process of the latter subgroup presents a significant challenge due to the need of disintegration (*i.e.* breaking) the substrate itself, since they cannot be examined directly inside the intact rock. Another challenge lies in emulating and maintaining the artificial conditions in the laboratory, required for the introduction of the isolated species into cultures and their subsequent long-term cultivation. Even though these unusual organisms, thriving in small pocketed and sometimes quite hostile habitats, as well as their unique adaptation mechanisms for survival, have captivated the attention of scientists in the past, the challenges surrounding their isolation and cultivation, make them one of the more difficult to work with subgroups of the aero-terrestrial fraction and thus one of the least studied and documented as a whole.

The first observations of lithophytic algae in Bulgaria date back to the

beginning of the previous century, when Petkov (1905) reported algal species, which grew on the surface of wet rocks, found in the Rila Mountains. His other early works,

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concerning the distribution of aero-terrestrial phycoflora, as well as those published by D. Vodenicharov and S. Draganov in the 60s, 70s and 80s, are compiled in a very detailed two parts review published by Uzunov et al. (2007, 2008). The review provides a complete history of the phycological studies of the aero-terrestrial algae in Bulgaria, as well as a checklist for all of the reported species belonging to this ecological group, lithophytes included. According to the list, provided by the authors, the total count of lithophytic algae is 169 species, 11 varieties and 2 forms. Among them 146 species, 10 varieties and 2 forms belong to algae that grow on rocks, and 23 species and 1 variety were recorded from stones. No clear distinction between the different types of lithophytes was made in the article, where it is briefly mentioned that the majority of the collected and examined species are epilithic and only a small percentage of the material could be regarded as being endolithic. The information provided by Uzunov et al. (2007,2008) serves as a basis of the present work, summarizing all the recorded data concerning the lithophytic algal flora described in the country during the last century. Much later, detailed review of the studies of aero-terrestrial algae along the Black Sea coast with some additions to the works of Uzunov et al. (2007, 2008) and emphasis on threatened and newly described species was published by Gärtner et al. (2018) and compared with the total algal biodiversity in the country estimated by Stoyneva (2014) as comprising of about 5500 species, varieties and forms from 650 genera of 8 divisions. In this review, eight publications were pointed as oriented towards epilithic algae (Petkov 1905, 1919, Komárek 1956, Vodenicharov 1962, Draganov 1964, Starmach 1964, Vodenicharov et al. 1971, Draganov et al. 1984), and one work (Draganov et al. 1984) was shown to provide data on endolithic algae from the region.

In all these reviews there is no information about the identification procedures and about application or not of cultivation of algae for their determination.

Therefore, below in the text, attention will be given to two papers, referred in Uzunov et al. (2007, 2008) since they are the first reports on Bulgarian lithophytic algae outside dark or artificially illuminated caves, obtained after cultivation on agar, enriched by Bold-Basal Medium (BBM). The first of them is Gärtner & Stoyneva's (2003) work, where the authors examine samples collected from the surface of some granite and limestone monuments in the country using direct observations and cultured material. This leads to the identification of three algal species from the green evolutionary lineage and to a record of free-living *Trebouxia arboricola* Puym., in particular. The second work belong to the same authors and presents the collected material from the rock surfaces in the Erma

Gorge, near the town of Trun and from the open cave Prohodna near Karlukovo village (Stoyneva & Gärtner 2006). After the introduction in cultures, followed by identification using direct light microscopy, the authors report the presence of four lithophytic species, confirming the presence of the free-living non-lichenized form of *Trebouxia arboricola*. Later on, Stoyneva et al. (2012) reported the finding of 48 lithophytic

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species collected from the Belogradchishki Skali complex, using the innovative technique for direct collection of aero-terrestrial algae developed a year earlier by Gärtner et al. (2010). Gärtner et al. (2012) published the first ultrastructural study of a lithophytic strain of *Vischeria stellata*, isolated from Belogradchik rocks. In a subsequent work Mancheva (2013) added 20 more species collected from the same locality. With that addition, the total of the species collected from the Belogradchishki Skali complex is 68 - 53 of them being epilithic and the other 15 belonging to the endolithic group, many of which are newfound for the country.

The most recent data, concerning the distribution of stone and rock dwelling algae, comes from the work of Stoyneva-Gärtner et al. (2024a), which focuses on the biodiversity of lithophytes inhabiting the surface of ancient megalithic structures located in South-Eastern Bulgaria. Using the aforementioned technique for direct isolation (Gärtner et al. 2010), samples were obtained from nine different megaliths, located in the region of Haskovo. After the subsequent long term cultivation and taxonomical identification of the collected material, the study reports the presence of 90 species, belonging to the lithophytic subgroup. All poly and monocultural samples from Erma Gorge, Prohodna cave, Belogradchik and Haskovo regions are cultivated, identified and later on deposited in the living Algal Collection of the University of Sofia (ACUS). The collection itself specializes in the storage and safekeeping of aero-terrestrial strains (Stoyneva et al., 2012), with special attention to lithophytes and soil algae, and is registered in the World Data

Centre for Microorganisms (WDCM) in 2010 (Uzunov et al. 2012). The present paper is a natural continuation to the previous phycological studies of aero-terrestrial algae in Bulgaria, focusing specifically on the lithophytic algae. It offers the first specified Checklist of lithophytic algae found in Bulgaria. The checklist aims to summarize the biodiversity of lithophytes reported from the country, both collected in the past and cultivated in recent years. Finally, this paper serves as a stepping stone and a guide for future investigations of the biodiversity and distribution of this unique, but quite neglected ecological group of algae.

MATERIALS AND METHODS

The provided Checklist of the species, varieties and forms of lithophytic algae

found in the country is based upon the information available in the forementioned published literature. The nomenclature follows mainly Ettl & Gärtner (1995, 2014) and the current status of each taxon is checked and updated accordingly with the help of various internet databases such as AlgaeBase (Guiry & Guiry 2025), Catalogue of Life (CoL), World Register of Marine Species (WoRMS) and others. Next to the currently accepted taxonomic name of the entities, in brackets are given the synonyms found in literature.

RESULTS AND DISCUSSION

To date, a total of 369 lithophytic algae, belonging to seven phyla have been identified in Bulgaria. Most of them belong to the blue-green evolutionary lineage, or Cyanoprokaryota, (208), followed by the green algae from Chloro- (83) and Streptophyta (22), and the yellow-brown algae, or Ochrophyta (52). Finally, from the red evolutionary lineage, or Rhodophyta, there are two reported species, and single species have been documented from each of the phyla Pyrrophyta and Euglenophyta. The identified and reported algal taxa are listed below (**Table 1**), following an alphabetical order in the frames of each phylum.

Table 1. Checklist of lithophytic algae found in Bulgaria. Based upon the available data in the published literature, for each of the enlisted species, it is pointed out if the taxonomical identification was made by direct microscopy of the collected material, without subsequent cultivation (-) or the identification is based upon cultivation and examination of the complete lifecycle of the species, available in the sample (+). Species identified directly by light microscope in earlier literature and after cultivation in newer publications are marked by -/+. Furthermore, depending on their original habitat, the species are split into two major groups – epiliths (Ep), growing on the surface of the substrate and endoliths (En), growing inside the substrate itself. There are some peculiar species that exhibit both epilithic and endolithic development marked as (Ep/En). Lastly, a point of reference to the corresponding article is given for every single one of the reported lithophytic algae.

№	Taxon	Type	Cultivation	Reference
	CYANOPROKARYOTA			
1	<i>Anabaena licheniformis</i> Bory 1822	Ep	-	Uzunov et al. (2008)
2	<i>Anabaena</i> sp. ster. 1 (? <i>Trichormus</i> sp.)	Ep	+	Stoyneva-Gärtner et al. (2024a)
3	<i>Anabaena</i> sp. ster. 2 (? <i>Isocystis</i> sp.)	Ep	+	Stoyneva-Gärtner

				et al. (2024a)
4	<i>Anabaena</i> sp. ster. 3	Ep	+	Stoyneva-Gärtner et al. (2024a)
5	<i>Anagnostidinema acutissimum</i> (Kufferath) Strunecký, Bohunická, J. R. Johansen et J. Komárek 2017 (Syn. <i>Oscillatoria acutissima</i> Kufferath 1914)	Ep	-	Starmach (1964)
6	<i>Anathece endophytica</i> (W. et G. S. West) Komárek, Kaštovský et Jezberová 2011 (Syn. <i>Aphanothece saxicola</i> f. <i>endophytica</i> (West et G. S. West) Elenkin 1938)	Ep	-	Starmach (1964)
7	<i>Anathece minutissima</i> (West) Komárek, Kaštovský et Jezberová 2011 (Syn. <i>Aph anothece saxicola</i> f. <i>minutissima</i> (West) Elenkin)	Ep	-	Starmach (1964)

№	Taxon	Type	Cultivation	Reference
8	<i>Aphanocapsa concharum</i> Hansgirg 1890	Ep	-	Uzunov et al. (2008)
9	<i>Aphanocapsa fuscolutea</i> Hansgirg 1893	Ep	+	Stoyneva-Gärtner et al. (2024a)
10	<i>Aphanocapsa grevillei</i> (Berkeley) Raben horst 1865	Ep	-	Uzunov et al. (2008)
11	<i>Aphanocapsa litoralis</i> Hansgirg 1892 (Syn. <i>Microcystis litoralis</i> (Hansgirg) Forti 1907)	Ep	-	Uzunov et al. (2008)
12	<i>Aphanocapsa marina</i> Hansgirg 1890	Ep	-	Uzunov et al. (2008)
13	<i>Aphanocapsa muscicola</i> (Meneghini) Wille 1919 (Syn. <i>Microcystis muscicola</i> (Meneghi ni) Elenkin 1936)	Ep	-	Starmach (1964)
14	<i>Aphanocapsa parasitica</i> (Kützing) Komárek et Anagnostidis 1995 (Syn. <i>Microcystis parasitica</i> Kützing 1843)	Ep	-	Starmach (1964), Vodenicharov et

				al., (1971)
15	<i>Aphanocapsa</i> cf. <i>rivularis</i> (Carmichael) Rabenhorst 1865	Ep	+	Stoyneva-Gärtner et al. (2024a)
16	<i>Aphanocapsa</i> sp. 1	Ep	+	Stoyneva-Gärtner et al. (2024a)
17	<i>Aphanocapsa</i> sp. 2	En	+	Stoyneva-Gärtner et al. (2024a)
18	<i>Aphanothece castagnei</i> (Kützing) Rabenhorst 1865 (Syn. <i>Gloeothece heufleri</i> Grunow ex Rabenhorst 1865)	Ep	-	Uzunov et al. (2008)
19	<i>Aphanothece elabens</i> (Meneghini) Elenkin 1936	Ep	-	Starmach (1964)
20	<i>Aphanothece longior</i> Naumann 1921	Ep	-	Starmach (1964)
21	<i>Aphanothece</i> cf. <i>saxicola</i> Nägeli 1849	Ep	+	Stoyneva-Gärtner et al. (2024a)
22	<i>Aphanothece stagnina</i> (Sprengel) A. Braun 1863	Ep	-	Vodenicharov et al. (1971)
23	<i>Aphanothece</i> sp. 1	Ep	+	Stoyneva-Gärtner et al. (2024a)
24	<i>Aphanothece</i> sp. 2	Ep	+	Stoyneva-Gärtner et al. (2024a)
25	<i>Brachytrichia quoyi</i> Bornet et Flahault 1886	Ep	-	Uzunov et al. (2008)
26	<i>Calothrix aeruginea</i> Thuret ex Bornet et Flahault 1886	Ep	-	Uzunov et al. (2008)
27	<i>Calothrix braunii</i> Bornet et Flahault 1886	Ep	-	Uzunov et al. (2008)

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№	Taxon	Type	Cultivation	Reference
28	<i>Calothrix confervicola</i> C.Agardh ex Bornet et Flahault 1886 (Syn. <i>Calothrix</i>	Ep	-	Komárek 1956; Uzunov et al.

	<i>crustacea</i> Thuret)			(2008)
29	<i>Calothrix parietina</i> Thuret ex Bornet et Flahault 1886	Ep	-	Uzunov et al. (2008)
30	<i>Calothrix pulvinata</i> C.Agardh ex Bornet et Flahault 1886	Ep	-	Uzunov et al. (2008)
31	<i>Calothrix scopulorum</i> C.Agardh ex Bornet et Flahault 1886	Ep	-	Uzunov et al. (2008)
32	<i>Calothrix</i> sp. juv. (ad <i>Calothrix fusca</i> Bornet et Flahault)	Ep	+	Stoyneva-Gärtner et al. (2024a)
33	<i>Calothrix</i> spp.	Ep	-	Uzunov et al. (2008)
34	<i>Chamaesiphon polonicus</i> (Rostafinski) Hansgirg 1893	Ep	-	Uzunov et al. (2008)
35	<i>Chondrocystis dermochroa</i> (Nägeli ex Kütz ing) Komárek et Anagnostidis 1995 (Syn. <i>Gloeocapsa dermochroa</i> Nägeli ex Kützing 1849)	Ep	-	Starmach (1964)
36	<i>Chroococcidiopsis</i> sp.	En	+	Mancheva (2013)
37	<i>Chroococcidium</i> sp.	En	+	Mancheva (2013)
38	<i>Chroococcopsis</i> sp.	En	+	Mancheva (2013)
39	<i>Chroococcus cohaerens</i> (Brébisson) Nägeli 1849	Ep	-	Uzunov et al. (2008)
40	<i>Chroococcus globosus</i> (Elenkin) Hindák 1978 (Syn. <i>Aphanothece globosa</i> Elenkin 1914)	Ep	-	Starmach (1964)
41	<i>Chroococcus helveticus</i> Nägeli 1849	Ep	-	Uzunov et al. (2008)
42	<i>Chroococcus membraninus</i> (Meneghini) Nägeli 1849	Ep	-	Uzunov et al. (2008)
43	<i>Chroococcus minor</i> (Kützing) Nägeli 1849	Ep	-	Uzunov et al. (2008)
44	<i>Chroococcus minutus</i> (Kützing) Nägeli 1849	Ep	-	Komárek 1956, Uzu nov et al. (2008)

45	<i>Chroococcus obliteratus</i> Richter 1885 (Syn. <i>Chroococcus minutus</i> f. <i>obliteratus</i> (Richter) Hansgirg)	Ep	-	Uzunov et al. (2008)
46	<i>Chroococcus turgidus</i> (Kützinger) Nägeli 1849	Ep	-	Komárek (1956), Uzunov et al. (2008)
47	<i>Chroococcus varius</i> A. Braun 1876	Ep	-	Uzunov et al. (2008)
48	<i>Chroococcus</i> sp.	Ep	+	Mancheva (2013)

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№	Taxon	Type	Cultivation	Reference
49	<i>Clastidium setigerum</i> O. Kirchner 1880	Ep	-	Uzunov et al. (2008)
50	<i>Coleodesmium</i> sp.	Ep	+	Mancheva (2013)
51	<i>Cyanothece major</i> (Schröter) Komárek 1976 (Syn. <i>Synechococcus major</i> J. Schröter 1884)	Ep	-	Uzunov et al. (2008)
52	<i>Cyanobacterium cedrorum</i> (Sauvageau) Komárek, J. Kopecký et Cepák (Syn. <i>Synechococcus cedrorum</i> Sauvageau 1892)	Ep	-	Starmach (1964)
53	<i>Cylindrospermum majus</i> Kützinger ex Bornet et Flahault 1888	Ep	-	Uzunov et al. (2008)
54	<i>Dermocarpa</i> sp.	Ep	-	Uzunov et al. (2008)
55	<i>Desmonostoc muscorum</i> (Bornet et Flahault) Hrouzek et Ventura 2013 (Syn. <i>Nostoc muscorum</i> C. Agardh ex Bornet et Flahault 1888)	Ep	-	Uzunov et al. (2008)
56	<i>Dichothrix gypsophila</i> Bornet et Flahault 1886	Ep	-	Uzunov et al. (2008)
57	<i>Dichothrix orsiniana</i> Bornet et Flahault 1886	Ep	-	Uzunov et al. (2008)
58	<i>Entophysalis granulosa</i> Kützinger 1843	Ep	-	Draganov et al. (1984)

59	<i>Entophysalis major</i> Ercegovic 1932	Ep	-	Uzunov et al. (2008)
60	<i>Gloeobacter violaceus</i> Rippka, J. B. Waterbury et Cohen-Bazire 1974 (Syn. <i>Aphanotheca caldariorum</i> P. G. Richter 1880)	Ep/ En	-/+	Starmach (1964),
61	<i>Gloeocapsa alpina</i> Nägeli 1865 (Syn. <i>Gloeocapsa fusco-lutea</i> Kirchner 1878)	Ep	-	Uzunov et al. (2008)
62	<i>Gloeocapsa atrata</i> Kützing, nom. illeg. 1843	Ep	-	Uzunov et al. (2008)
63	<i>Gloeocapsa sanguinea</i> (C. Agardh) Kützing 1843 (Syn. <i>Gloeocapsa itzigsohnii</i> Bornet 1882)	Ep	-	Uzunov et al. (2008)
64	<i>Gloeocapsa</i> sp.	Ep	-	Uzunov et al. (2008)
65	<i>Gloeocapsopsis crepidinum</i> (Thuret) Geitler ex Komárek 1993	Ep	-	Komárek (1956), Uzunov et al. (2008)
66	<i>Gloeocapsopsis magma</i> (Brébisson) Komárek et Anagnostidis ex Komárek 1993	Ep	-	Uzunov et al. (2008)
67	<i>Gloeotheca confluens</i> Nägeli 1849	Ep	+	Stoyneva-Gärtner et al. (2024a)
68	<i>Gloeotheca palea</i> (Kützing) Nägeli 1849	Ep	-	Starmach (1964)
69	<i>Gloeotheca rupestris</i> (Lyngbye) Bornet 1880	Ep	-	Uzunov et al. (2008)

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№	Taxon	Type	Cultivation	Reference
70	<i>Hassallia byssoidea</i> Hassall ex Bornet et Flahault 1886 (Syn. <i>Tolypothrix byssoidea</i> Kirchner 1898)	Ep	-	Uzunov et al. (2008)
71	<i>Heteroleibleinia infixa</i> (Frémy) Anagnostidis et Komárek 1988	Ep	-	Uzunov et al. (2008)

72	<i>Homoeothrix juliana</i> (Gomont) Kirchner 1898	Ep	-	Vodenicharov et al. (1971)
73	<i>Homoeothrix margalefii</i> Komárek et Kalina, nom. illeg. 1965	Ep	-	Uzunov et al. (2008)
74	<i>Hydrococcus rivularis</i> Kützing 1833	Ep	-	Vodenicharov et al. (1971)
75	<i>Hyella</i> cf. <i>balani</i> Lehmann 1903	En	-	Uzunov et al. (2008)
76	<i>Isactis plana</i> Thuret ex Bornet et Flahault 1886	Ep	-	Komarek (1956), Uzunov et al. (2008)
77	<i>Jaaginema geminatum</i> (Schwabe ex Go mont) Anagnostidis et Komárek 1988	Ep	-	Uzunov et al. (2008)
78	<i>Jaaginema kuetzingianum</i> (Nägeli ex Go mont) Anagnostidis et Komárek 1988	Ep	-	Uzunov et al. (2008)
79	<i>Jaaginema longiarticulata</i> Anagnostidis et Komárek 1988: 396 (as ' <i>longiarticulatum</i> ')	Ep	-	Uzunov et al. (2008)
80	<i>Jaaginema neglectum</i> (Lemmermann) Anag nostidis et Komárek 1988 (Syn. <i>Oscillatoria neglecta</i> Lemmermann 1910)	Ep	-	Starmach (1964)
81	<i>Jaaginema pseudogeminatum</i> (G. Schmid) Anagnostidis et Komárek 1988 (Syn. <i>Oscil latoria pseudogeminata</i> G. Schmid 1914)	Ep	-	Starmach (1964)
82	<i>Kamptonema laetevirens</i> (H. M. Crouan et P. L. Crouan ex Gomont) Strunecký, Komárek et J. Smarda 2014 (Syn. <i>Phormidium laetev irens</i> (P. Crouan et H. Crouan ex Gomont) Anagnostidis et Komárek 1988)	Ep	-	Uzunov et al. (2008)
83	<i>Kyrtuthrix dalmatica</i> Ercegovic 1929	En	-	Uzunov et al. (2008)
84	<i>Leibleinia epiphytica</i> (Hieronymus) Compère 1985 (Syn. <i>Lyngbya epiphytica</i> Hieronymus 1898)	Ep	-	Uzunov et al. (2008)

85	<i>Leptolyngbya</i> ‘Albertano-Kovacik green’ 1992	Ep	+	Stoyneva-Gärtner et al. (2024a)
86	<i>Leptolyngbya amplivaginata</i> (Goor) Moli nari et Guiry 2021 (Syn. <i>Lyngbya amplivagi nata</i> Goor 1918)	Ep	-	Starmach (1964)

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№	Taxon	Type	Cultivation	Reference
87	<i>Leptolyngbya calotrichoides</i> (Gomont) Anagnostidis et Komárek 1988	Ep	-	Uzunov et al. (2008)
88	<i>Leptolyngbya compacta</i> Komárek 2001	Ep	+	Stoyneva-Gärtner et al. (2024a)
89	<i>Leptolyngbya</i> cf. <i>gloeophila</i> (Borzi) Anagnostidis et Komárek 1988	Ep	+	Stoyneva-Gärtner et al. (2024a)
90	<i>Leptolyngbya foveolarum</i> (Gomont) Anagnostidis et Komárek 1988	Ep	-/+	Uzunov et al. (2008), Stoyneva-Gärtner et al. (2024a)
91	<i>Leptolyngbya gracilis</i> (Lindstedt) Anagnostidis et Komárek 1988	Ep	-	Uzunov et al. (2008)
92	<i>Leptolyngbya gracillima</i> (Hansgirg) Anagnostidis et Komárek 1988	Ep	-	Uzunov et al. (2008)
93	<i>Leptolyngbya lagerheimii</i> (Gomont) Anagnostidis et Komárek 1988 (Syn. <i>Lyngbya lagerheimii</i> Gomont 1892)	Ep	-	Starmach (1964)
94	<i>Leptolyngbya nostocorum</i> (Bornet ex Gomont) Anagnostidis et Komárek 1988 (Syn. <i>Plectonema nostocorum</i> Bornet ex Gomont 1892)	Ep	-	Starmach (1964)
95	<i>Leptolyngbya perelegans</i> (Lemmermann) Anagnostidis et Komárek 1988 (Syn. <i>Lyngbya perelegans</i> Lemmermann 1899)	Ep	-	Starmach (1964)
96	<i>Leptolyngbya terebrans</i> (Bornet et Flahault ex Gomont) Anagnostidis et	Ep/En	-/+	Uzunov et al. (2008), Mancheva

	Komárek 1988			(2013)
97	<i>Leptolyngbya</i> cf. <i>subtilissima</i> (Hansgirg) Komárek 2001	Ep	+	Stoyneva-Gärtner et al. (2024a)
98	<i>Leptolyngbya</i> sp. 1 (ad <i>Leptolyngbya com pacta</i> Komárek)	Ep	+	Stoyneva-Gärtner et al. (2024a)
99	<i>Leptolyngbya</i> sp. 2	Ep	+	Stoyneva-Gärtner et al. (2024a)
100	<i>Leptolyngbya</i> sp. 3	Ep	+	Stoyneva-Gärtner et al. (2024a)
101	<i>Leptolyngbya</i> sp. 4 (? <i>Leibleinia</i> sp.)	Ep	+	Stoyneva-Gärtner et al. (2024a)
102	<i>Limnothrix redekei</i> (Goor) Meffert 1988 (Syn. <i>Oscillatoria redekei</i> Goor 1918)	Ep	-	Starmach (1964)
103	<i>Lyngbya confervoides</i> C. Agardh ex Gomont 1892	Ep	-	Uzunov et al. (2008)

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№	Taxon	Type	Cultivation	Reference
104	<i>Lyngbya lutea</i> Gomont 1892 (Syn. <i>Porphy rosiphon luteus</i> (Gomont) Anagnostidis et Komárek 1988)	Ep	-	Uzunov et al. (2008)
105	<i>Lyngbya martensiana</i> Meneghini ex Gomont 1892	Ep	-	Uzunov et al. (2008)
106	<i>Lyngbya semiplena</i> J.Agardh ex Gomont 1892	Ep	-	Komarek (1956), Uzunov et al. (2008)
107	<i>Lyngbya</i> spp.	Ep	-	Uzunov et al. (2008)
108	<i>Microchaete grisea</i> Thuret ex Bornet et Flahault 1886	Ep	-	Uzunov et al. (2008)
109	<i>Microcoleus amoenus</i> (Gomont) Strunecky, Komárek et J. R. Johansen	Ep	-	Uzunov et al. (2008)

	2013 (Syn. <i>Phor midium amoenum</i> Kützing 1988)			
11 0	<i>Microcoleus autumnalis</i> (Gomont) Stru necky, Komárek et J. R. Johansen 2013 (Syn. <i>Phormidium autumnale</i> Gomont 1892)	Ep	-	Uzunov et al. (2008)
11 1	<i>Microcoleus paludosus</i> Gomont 1892	Ep	-	Uzunov et al. (2008)
11 2	<i>Microcoleus vaginatus</i> Gomont 1892	Ep	-/+	Uzunov et al. (2008)
11 3	<i>Microcystis pulvere</i> a (H. C. Wood) Forti 1907	Ep	+	Uzunov (2008)
11 4	<i>Microcystis smithii</i> Komárek et Anagnostidis 1995 (Syn. <i>Aphanocapsa pulchra</i> (Kützing) Rabenhorst 1865)	Ep	-	Draganov et al. (1984)
11 5	<i>Nostoc calcicola</i> Brébisson ex Bornet et Flahault 1886	Ep	-	Uzunov et al. (2008)
11 6	<i>Nostoc commune</i> Vaucher ex Bornet et Flahault 1888	Ep	-/+	Stoyneva & Gärtner (2006), Uzunov et al. (2008)
11 7	<i>Nostoc ellipsosporum</i> Rabenhorst ex Bornet et Flahault 1886	Ep	-	Uzunov et al. (2008)
11 8	<i>Nostoc humifusum</i> Carmichael ex Bornet et Flahault 1886	Ep	-	Uzunov et al. (2008)
11 9	<i>Nostoc linckia</i> Bornet ex Bornet et Flahault 1886	Ep	-/+	Uzunov et al. (2008), Stoyneva-Gärtner et al. (2024a)
12 0	<i>Nostoc microscopicum</i> Carmichael ex Bornet et Flahault 1886	Ep	+	Uzunov et al. (2008)
12 1	<i>Nostoc minutum</i> Desmazières ex Bornet et Flahault 1886	Ep	+	Stoyneva-Gärtner et al. (2024a)

№	Taxon	Typ e	Culti vatio n	Reference
12 2	<i>Nostoc sphaericum</i> Vaucher ex Bornet et Flahault 1886	Ep	-	Uzunov et al. (2008)
12 3	<i>Oscillatoria corallinae</i> Gomont 1890	Ep	-	Komarek (1956), Uzunov et al. (2008)
12 4	<i>Oscillatoria funiformis</i> (Vouk) Komárek 2001	Ep	-	Komarek (1956), Uzunov et al. (2008)
12 5	<i>Oscillatoria longiarticulata</i> P. Crouan et H. Crouan ex Gomont 1892	Ep	-	Draganov et al. (1984)
12 6	<i>Oscillatoria princeps</i> Vaucher ex Gomont 1892	Ep	-	Uzunov et al. (2008)
12 7	<i>Oscillatoria sancta</i> f. <i>aequinoctialis</i> (Gomont) Elenkin 1949	Ep	-	Uzunov et al. (2008)
12 8	<i>Oscillatoria sancta</i> f. <i>caldariorum</i> Elenkin 1949	Ep	-	Uzunov et al. (2008)
12 9	<i>Oscillatoria simplicissima</i> Gomont 1892	Ep	-	Uzunov et al. (2008)
13 0	<i>Petalonema alatum</i> (Borzi ex Bornet et Flahault) Wolle 1887	Ep	-	Uzunov et al. (2008)
13 1	<i>Phormidesmis mollis</i> (Gomont) Turicchia, Ventura, Komárková et Komárek 2009 (Syn. <i>Phormidium molle</i> Gomont 1892)	Ep	-	Uzunov et al. (2008)
13 2	<i>Phormidiochaete crustacea</i> (Borzi ex Bornet et Flahault) Bohunická et Johansen 2011 (Syn. <i>Leptochaete crustacea</i> Borzi ex Bornet et Flahault 1886)	Ep	-	Vodenicharov et al. (1971)
13 3	<i>Phormidium ambiguum</i> Gomont 1892	Ep	+	Mancheva (2013)
13 4	<i>Phormidium breve</i> (Kützing ex Gomont) Anagnostidis et Komárek 1988	Ep	-	Uzunov et al. (2008)
13 5	<i>Phormidium corium</i> Gomont 1892	Ep	-	Uzunov et al. (2008)

13 6	<i>Phormidium diguetii</i> (Gomont) Anagnostidis et Komárek 1988 (Syn. <i>Lyngbya diguetii</i> Gomont 1895)	Ep	-	Starmach (1964)
13 7	<i>Phormidium hormoides</i> Setchell et N. L. Gardner 1918	Ep	-	Uzunov et al. (2008)
13 8	<i>Phormidium irriguum</i> (Kützing ex Gomont) Anagnostidis et Komárek 1988	Ep	-	Uzunov et al. (2008)
13 9	<i>Phormidium nigroviride</i> (Thwaites ex Go mont) Anagnostidis et Komárek 1988 (Syn. <i>Oscillatoria nigrovirides</i> Thwaites ex Gomont 1892)	Ep	-	Uzunov et al. (2008)
14 0	<i>Phormidium papyraceum</i> Gomont 1892	Ep	-	Uzunov et al. (2008)

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№	Taxon	Type	Cultivation	Reference
14 1	<i>Phormidium subfuscum</i> Kützing ex Gomont 1892	Ep	-	Uzunov et al. (2008)
14 2	<i>Phormidium subfuscum</i> var. <i>inaequale</i> Nägli ex Forti 1907	Ep	-	Uzunov et al. (2008)
14 3	<i>Phormidium terebriforme</i> (C. Agardh ex Gomont) Anagnostidis et Komárek 1988	Ep	-	Uzunov et al. (2008)
14 4	<i>Phormidium</i> sp. 1	Ep	+	Mancheva (2013)
14 5	<i>Phormidium</i> sp. 2	En	+	Mancheva (2013)
14 6	<i>Phormidium</i> spp.	Ep	-	Uzunov et al. (2008)
14 7	<i>Planktolyngbya bipunctata</i> (Lemmermann) Anagnostidis et Komárek 1988 (Syn. <i>Lyngbya bipunctata</i> Lemmermann 1899)	Ep	-	Starmach (1964)

14 8	<i>Planktothrix agardhii</i> (Gomont) Anagnostidis et Komárek 1988	Ep	-	Uzunov et al. (2008)
14 9	<i>Pleurocapsa fuliginosa</i> Hauck 1885	Ep	-	Uzunov et al. (2008)
15 0	<i>Pleurocapsa minor</i> Hansgirg 1891 (Syn. <i>Scopulonema minus</i> (Hansgirg) Geitler 1942)	Ep	-	Vodenicharov et al. (1971)
15 1	<i>Pleurocapsa minuta</i> Geitler 1931	Ep	-	Uzunov et al. (2008)
15 2	<i>Pleurocapsa</i> sp.	Ep	-	Uzunov et al. (2008)
15 3	<i>Porphyrosiphon versicolor</i> (Gomont) An agnostidis et Komárek 1988 (Syn. <i>Lyngbya versicolor</i> Gomont 1892)	Ep	-	Starmach (1964)
15 4	<i>Pseudophormidium battersii</i> (Gomont) Anagnostidis 2001	Ep	-	Uzunov et al. (2008)
15 5	<i>Pseudophormidium golenkinianum</i> (Gomont) Anagnostidis 2001	Ep	-	Komárek (1956), Uzunov et al. (2008)
15 6	<i>Pseudophormidium hollerbachianum</i> (Elenkin) Anagnostidis 2001	Ep	+	Stoyneva-Gärtner et al. (2024a)
15 7	<i>Pseudophormidium phormidioides</i> (Gomont) Anagnostidis et Komárek 1988	Ep	+	Mancheva (2013), Stoyneva-Gärtner et al. (2024a)
15 8	<i>Rivularia atra</i> Roth ex Bornet et Flahault 1886	Ep	-	Uzunov et al. (2008)
15 9	<i>Rivularia bullata</i> Berkeley ex Bornet et Flahault 1886	Ep	-	Komárek (1956), Uzunov et al. (2008)
16 0	<i>Rivularia haematites</i> C.Agardh ex Bornet et Flahault 1886	Ep	-	Uzunov et al. (2008)
16 1	<i>Rivularia rufescens</i> Nägeli ex Bornet et Flahault 1886	Ep	-	Uzunov et al. (2008)

№	Taxon	Typ e	Culti vatio n	Reference
16 2	<i>Rhabdoderma lineare</i> Schmidle et Lauter born 1900	Ep	-	Starmach (1964)
16 3	<i>Romeria minima</i> (Lemmermann) Komárek 2001 (Syn. <i>Rhabdoderma minimum</i> Lem mermann 1908)	Ep	-	Starmach (1964)
16 4	<i>Schizothrix cresswellii</i> Harvey ex Gomont 1892	Ep	-	Komárek (1956), Uzunov et al. (2008)
16 5	<i>Schizothrix coriacea</i> Gomont 1892	Ep	-	Starmach (1964)
16 6	<i>Schizothrix fasciculata</i> Gomont 1892	Ep	-	Starmach (1964)
16 7	<i>Schizothrix heufleri</i> Grunow ex Gomont 1892	Ep	-	Uzunov et al. (2008)
16 8	<i>Schizothrix lardacea</i> Gomont 1892	Ep	+	Uzunov et al. (2008), Mancheva (2013)
16 9	<i>Schizothrix lateritia</i> Gomont 1892	Ep	-	Starmach (1964)
17 0	<i>Schizothrix tenuis</i> Woronichin 1923	Ep	-	Starmach (1964)
17 1	<i>Schizothrix vaginata</i> Gomont 1892	Ep	-	Uzunov et al. (2008)
17 2	<i>Scytonema hoffmannii</i> C. Agardh ex Bornet et Flahault 1886	Ep	-	Uzunov et al. (2008)
17 3	<i>Scytonema mirabile</i> Bornet 1889	Ep	-	Uzunov et al. (2008)
17 4	<i>Scytonema myochrous</i> C. Agardh ex Bornet et Flahault 1886	Ep	-	Uzunov et al. (2008)
17 5	<i>Scytonema</i> sp.	Ep	+	Stoyneva-Gärtner et al. (2024a)

17 6	<i>Scytonematopsis crustacea</i> (Thuret ex Bor net et Flahault) Kováčik et Komárek 1988 (Syn. <i>Calothrix crustacea</i> Thuret ex Bornet et Flahault 1886)	Ep	-	Komarek (1956), Uzunov et al. (2008)
17 7	<i>Spelaeopogon</i> sp.	Ep	+	Mancheva (2013)
17 8	<i>Sphaeronema</i> sp.	Ep	-	Draganov et al. (1984)
17 9	<i>Spirulina adriatica</i> Hansgirg 1890	Ep	-	Uzunov et al. (2008)
18 0	<i>Spirulina meneghiniana</i> Zanardini ex Gomont 1892	Ep	-	Uzunov et al. (2008)
18 1	<i>Spirulina subsalsa</i> Oersted ex Gomont 1892	Ep	-	Petkov (1905, 1919), Komárek (1956), Starmach (1969), Draganov et al. (1984)
18 2	<i>Spirulina</i> sp.	Ep	-	Uzunov et al. (2008)

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№	Taxon	Type	Cultivation	Reference
18 3	<i>Stanieria minima</i> (Geitler) S. M. F. Silva et R. N. Pienaar 2000 (Syn. <i>Cyanocystis minima</i> (Geitler) Komárek et Anagnostidis 1986)	Ep	-	Uzunov et al. (2008)
18 4	<i>Stanieria sphaerica</i> (Setchell et N. L. Gardner) Anagnostidis et Pantazidou 1991	Ep	-	Uzunov et al. (2008)
18 5	<i>Stigonema hormoides</i> Bornet et Flahault 1886	Ep	-	Uzunov et al. (2008)
18 6	<i>Stigonema</i> cf. <i>hormoides</i> Bornet et Flahault 1886	Ep	+	Stoyneva-Gärtner et al. (2024a)

18 7	<i>Stigonema informe</i> Kützing ex Bornet et Flahault 1886	Ep	-	Uzunov et al. (2008)
18 8	<i>Stigonema mamillosum</i> C. Agardh ex Bornet et Flahault 1887	Ep	-	Uzunov et al. (2008)
18 9	<i>Stigonema mirabile</i> Beck 1929	Ep	-	Uzunov et al. (2008)
19 0	<i>Stigonema ocellatum</i> Thuret ex Bornet et Flahault 1886	Ep	-	Vodenicharov et al. (1971)
19 1	<i>Stigonema panniforme</i> Bornet et Flahault 1887	Ep	-	Uzunov et al. (2008)
19 2	<i>Stigonema turfaceum</i> Cooke ex Bornet et Flahault 1887	Ep	-	Uzunov et al. (2008)
19 3	<i>Symploca dubia</i> Gomont 1892	Ep	-	Starmach (1964)
19 4	<i>Symploca</i> cf. <i>dubia</i> Gomont 1892 (? <i>Leptol yngbya</i> sp.)	Ep	+	Stoyneva-Gärtner et al. (2024a)
19 5	<i>Symploca erecta</i> Pevalek 1916	Ep	+	Mancheva (2013)
19 6	<i>Symploca flotowiana</i> Kützing ex Gomont 1892	Ep	+	Mancheva (2013)
19 7	<i>Symploca fuscescens</i> Rabenhorst ex Forti 1907	Ep	+	Starmach (1964), Mancheva (2013)
19 8	<i>Symploca laeteviridis</i> Gomont 1892	Ep	-	Uzunov et al. (2008)
19 9	<i>Symploca meneghiniana</i> Kützing ex Gomont 1892	Ep	-	Vodenicharov et al. (1971)
20 0	<i>Symploca muscorum</i> Gomont 1892	Ep	-	Uzunov et al. (2008)
20 1	<i>Tolypothrix tenuis</i> Kützing ex Bornet et Flahault 1886	Ep	-	Uzunov et al. (2008)
20 2	<i>Trichocoleus delicatulus</i> (West et G. S. West) Anagnostidis 2001 (Syn. <i>Microcoleus delicatulus</i> West et G. S.	Ep	-	Starmach (1964)

	West 1896)			
20 3	<i>Trichocoleus tenerrimus</i> (Gomont) Anag nostidis 2001 (Syn. <i>Microcoleus tenerrimus</i> Gomont 1892)	Ep	-	Uzunov et al. (2008)

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№	Taxon	Type	Cultivation	Reference
20 4	<i>Xenococcus pallidus</i> (Hansgirg) Komárek et Anagnostidis 1995	Ep	-	Uzunov et al. (2008)
20 5	<i>Xenococcus schousboei</i> Thuret 1880	Ep	-	Uzunov et al. (2008)
20 6	<i>Xenococcus</i> sp.	Ep	-	Uzunov et al. (2008)
20 7	<i>Xenotholos kernerii</i> (Hansgirg) M. Gold-Morgan, G. Montejano et J. Komárek 1994 (Syn. <i>Xenococcus kernerii</i> Hansgirg 1887)	Ep	-	Vodenicharov et al. (1971)
20 8	<i>Yonedaella</i> sp.	Ep	-	Uzunov et al. (2008)
	RHODOPHYTA			
1	<i>Chroodactylon ornatum</i> (C. Agardh) Basson 1979 (Syn. <i>Asterocytis smaragdina</i> (Re insch) Forti 1907)	Ep	-	Uzunov et al. (2008)
2	<i>Porphyridium purpureum</i> (Bory) K. M. Drew et R. Ross 1965 (Syn. <i>Porphyridium cruentum</i> (S. F. Gray) Nägeli 1849)	Ep	-	Uzunov et al. (2008)
	CHLOROPHYTA			

1	<i>Apatococcus lobatus</i> (Chodat) Petersen 1928	Ep	+	Gärtner & Stoyneva (2003), Stoyneva & Gärtner (2006), Uzunov et al. (2008), Mancheva (2013), Stoyneva-Gärtner et al. (2024a)
2	<i>Borodinella polytetras</i> V. V. Miller 1927	Ep	-	Uzunov et al. (2008)
3	<i>Chaetomorpha aerea</i> (Dillwyn) Kützing 1849	Ep	-	Uzunov et al. (2008)
4	<i>Chaetomorpha linum</i> (O. F. Müller) Kützing 1845	Ep	-	Vodenicharov et al. (1971)
5	<i>Chlorella miniata</i> (Kützing) Oltmanns 1904	Ep	+	Uzunov et al. (2008), Mancheva (2013)
6	<i>Chlorella vulgaris</i> Beijerinck 1890	Ep	+	Mancheva (2013), Stoyneva-Gärtner et al. (2024a)
7	<i>Chlorella</i> sp.	Ep	+	Stoyneva-Gärtner et al. (2024a)
8	<i>Chlorella</i> sp. 1	Ep	+	Mancheva (2013)
9	<i>Chlorella</i> sp. 2	En	+	Mancheva (2013)
10	<i>Chlorella</i> sp. 3	Ep	+	Mancheva (2013)

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№	Taxon	Type	Cultivation	Reference
11	<i>Chloroidium ellipsoideum</i> (Gerneck) Darien ko et al. 2010	Ep/ En	+	Mancheva (2013), Stoyneva-Gärtner

				et al. (2024a)
12	<i>Chloroidium</i> cf. <i>ellipsoideum</i> (Gerneck) Darienko et al. 2010	Ep	+	Mancheva (2013)
13	<i>Choricystis parasitica</i> (K. Brandt) Pröschold et Darienko 2011 (Syn. <i>Choricystis minor</i> (Skuja) Fott 1976)	Ep	+	Mancheva (2013), Stoyneva-Gärtner et al. (2024a)
14	<i>Chromochloris zofingiensis</i> (Dönz) Fucíková et Lewis 2012 (Syn. <i>Muriella zofingiensis</i> (Dönz) Hindák 1982)	Ep	+	Stoyneva-Gärtner et al. (2024a)
15	<i>Cladophora glomerata</i> var. <i>genuina</i> f. <i>marina</i> Hanck (Syn. <i>Cladophora glomerata</i> f. <i>marina</i> (Kützinger) Hauck 1884)	Ep	-	Uzunov et al. (2008)
16	<i>Cladophora vagabunda</i> (Linnaeus) Hoek 1963	Ep	-	Uzunov et al. (2008)
17	<i>Coccomyxa confluens</i> (Kützinger) Fott 1974	Ep	+	Mancheva (2013)
18	<i>Coccomyxa subglobosa</i> Pascher 1915	Ep	+	Stoyneva-Gärtner et al. (2024a)
19	<i>Coccomyxa</i> sp.	Ep	+	Gärtner & Stoyneva (2003)
20	<i>Coccomyxa</i> sp. 1	Ep	+	Mancheva (2013)
21	<i>Coccomyxa</i> sp. 2	En	+	Mancheva (2013)
22	<i>Coelastrella terrestris</i> (Reisigl) Hegewald et Hanagata 2002	Ep	+	Stoyneva-Gärtner et al. (2024a)
23	<i>Coelastrella</i> sp.	Ep	+	Mancheva (2013)
24	<i>Coenobotrys gloeobotrydiformis</i> (Reisigl) Kostikov et al. 2002 (Syn. <i>Coccomyxa gloeobotrydiformis</i> Reisigl 1969)	Ep/ En	+	Mancheva (2013), Stoyneva-Gärtner et al. (2024a)
25	<i>Desmococcus olivaceus</i> (Persoon ex Acharius) Laundon 1985 (Syn. <i>Protococcus viridis</i> C. Agardh 1824; <i>Pleurococcus vulgaris</i> Nägeli 1849)	Ep	+	Uzunov et al. (2008), Mancheva (2013), Stoyneva-Gärtner et al. (2024a)

26	<i>Desmococcus</i> cf. <i>olivaceus</i> (Persoon ex Acharius) Laundon 1985	Ep	+	Mancheva (2013)
27	<i>Desmococcus</i> sp. 1	Ep	+	Mancheva (2013)
28	<i>Desmococcus</i> sp. 2	En	+	Mancheva (2013)
29	<i>Deuterostichococcus tetrallantoideus</i> (Kol) Pröschold et Darienko 2020	Ep	+	Stoyneva-Gärtner et al. (2024a)

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№	Taxon	Type	Cultivation	Reference
30	<i>Edaphochlorella mirabilis</i> (Andreeva) Darienko et Pröschold 2016 (Syn. <i>Chlorella mirabilis</i> Andreeva 1973)	Ep/En	+	Stoyneva-Gärtner et al. (2024a)
31	<i>Elliptochloris bilobata</i> Tschermak-Woess 1980	Ep/En	+	Stoyneva-Gärtner et al. (2024a)
32	<i>Elliptochloris reniformis</i> Darienko et Pröschold 2016	En	+	Mancheva (2013)
33	<i>Elliptochloris subsphaerica</i> (Reisigl) Ettl et Gärtner 1995	Ep	+	Stoyneva-Gärtner et al. (2024a)
34	<i>Eubrownia aggregata</i> (R. M. Brown et Bold) Shin Watanabe et Lewis 2017	Ep	+	Stoyneva-Gärtner et al. (2024a)
35	<i>Gloeotheca rupestris</i> (Lyngbye) Bornet 1880 (Syn. <i>Gloeocystis rupestris</i> (Lyngbye) Rabenhorst 1863)	Ep	-	Uzunov et al. (2008)
36	<i>Haematococcus lacustris</i> (Girod-Chantrons) Rostafinski 1875 (Syn. <i>Haematococcus pluvialis</i> Flotow 1844)	Ep	-	Vodenicharov et al. (1971)
37	<i>Hormidiospora</i> sp.	En	+	Mancheva (2013)
38	<i>Hormotila mucigena</i> Borzi 1883	Ep	-	Uzunov et al. (2008)
39	<i>Jaagichlorella luteoviridis</i> (Chodat) Darienko et Pröschold 2019 (Syn. <i>Chlorella luteoviridis</i> Chodat 1913)	Ep	+	Mancheva (2013)

40	<i>Keratococcus raphidioides</i> (Hansgirg) Pascher 1915 (Syn. <i>Dactylococcus raphidioides</i> Hansgirg 1887)	Ep	-	Vodenicharov et al. (1971)
41	<i>Lobosphaera undulata</i> (Shin Watanabe) Ettl et Gärtner 1995	Ep	+	Stoyneva-Gärtner et al. (2024a)
42	<i>Lobosphaeropsis lobophora</i> (Andreeva) Ettl et Gärtner 1995	Ep	+	Mancheva (2013), Stoyneva-Gärtner et al. (2024a)
43	<i>Mesotaenium pyrenoidosum</i> (P. A. Broady) Petlovany 2015 (Syn. <i>Fottea pyrenoidosa</i> P. A. Broady 1976)	Ep	+	Mancheva (2013)
44	<i>Monoraphidium nanum</i> (Ettl) Hindák 1980	Ep	+	Stoyneva-Gärtner et al. (2024a)
45	<i>Muriella decolor</i> Vischer 1936	Ep	+	Stoyneva-Gärtner et al. (2024a)
46	<i>Muriella terrestris</i> J. B. Petersen 1932	Ep	+	Stoyneva-Gärtner et al. (2024a)
47	<i>Muriella</i> sp.	En	+	Mancheva (2013)

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№	Taxon	Type	Cultivation	Reference
48	<i>Mychonastes homosphaera</i> (Skuja) Kalina et Puncochárová 1987	Ep/En	+	Mancheva (2013), Stoyneva-Gärtner et al. (2024a)
49	<i>Neglectella solitaria</i> (Wittrock) Stenclová et Kaštovský 2017 (Syn. <i>Oocystis solitaria</i> Wittrock 1879)	Ep	-	Starmach (1964)
50	<i>Neocystis brevis</i> (Vischer) Kostikov et Hoffmann 2002	Ep	+	Stoyneva-Gärtner et al. (2024a)
51	<i>Oocystis rupestris</i> Kirchner 1880	Ep	-	Uzunov et al. (2008)
52	<i>Palmella mucosa</i> Kützing 1843	Ep	-	Uzunov et al. (2008)

53	<i>Parachlorella kessleri</i> (Fott et Nováková) Krienitz et al. 2004	Ep	+	Stoyneva-Gärtner et al. (2024a)
54	<i>Pleurastrum minutum</i> (Starr) Sciuto et al. 2023	Ep	+	Stoyneva-Gärtner et al. (2024a)
55	<i>Prasiola crispa</i> (Lightfoot) Kützing 1843	Ep/ En	+	Uzunov et al. (2008), Mancheva (2013)
56	<i>Prasiola</i> sp.	Ep	+	Mancheva (2013)
57	<i>Printzina lagenifera</i> (Hildebrand) Thompson et Wujek 1992 (Syn. <i>Trentepohlia lagenifera</i> (Hildebrand) Wille 1878)	Ep	+	Mancheva (2013), Stoyneva-Gärtner et al. (2024a)
58	<i>Pseudodictyochloris multinucleata</i> (Broady) Ettl et Gärtner 1987	Ep	+	Stoyneva-Gärtner et al. (2024a)
59	<i>Pseudostichococcus monallantoides</i> var. <i>exiguus</i> (Gerneck) Pröschold et Darienko 2020 (Syn. <i>Stichococcus exiguus</i> Gerneck 1907)	Ep	+	Mancheva (2013), Stoyneva-Gärtner et al. (2024a)
60	<i>Radiococcus bilobatus</i> (Broady) Kostikov et al. 2002	Ep	+	Stoyneva-Gärtner et al. (2024a)
61	<i>Rhizoclonium riparium</i> (Roth) Harvey 1849 (Syn. <i>Rhizoclonium implexum</i> (Dillwyn) Kützing 1845)	Ep	-	Vodenicharov et al. (1971)
62	<i>Scenedesmus obtusus</i> Meyen 1829 (Syn. <i>Scenedesmus ovalternus</i> Chodat)	Ep	-	Uzunov et al. (2008)
63	<i>Scotiella tuberculata</i> Bourrelly 1952	Ep	+	Stoyneva-Gärtner et al. (2024a)
64	<i>Sphaerococomyxa olivacea</i> (Petersen) Kostikov et al. 2002	Ep	+	Stoyneva-Gärtner et al. (2024a)
65	<i>Stephanosphaera pluvialis</i> Cohn 1852	Ep	-	Vodenicharov et al. (1971)

№	Taxon	Type	Cultivation	Reference
66	<i>Stichococcus bacillaris</i> Nägeli 1849 (Syn. <i>Stichococcus bacillaris</i> var. <i>major</i> (Nägeli) Rabenhorst 1868)	Ep/ En	+	Uzunov (2008), Mancheva (2013), Stoyneva-Gärtner et al. (2024a)
67	<i>Stichococcus chlorelloides</i> Grintzesco et S. Péterfi 1932	Ep	+	Stoyneva-Gärtner et al. (2024a)
68	<i>Stichococcus minutus</i> Grintzesco et S. Péterfi 1932	Ep/ En	+	Mancheva (2013), Stoyneva-Gärtner et al. (2024a)
69	<i>Stichococcus mirabilis</i> Lagerheim 1893	Ep/ En	+	Stoyneva-Gärtner et al. (2024a)
70	<i>Stichococcus</i> sp.	En	+	Mancheva (2013)
71	<i>Tetracystis pulchra</i> R. M. Brown et Bold 1964	Ep	+	Stoyneva-Gärtner et al. (2024a)
72	<i>Trebouxia arboricola</i> Puymaly 1924	Ep	+	Gärtner & Stoyneva (2003), Stoyneva & Gärtner (2006), Uzunov et al. (2008)
73	<i>Trebouxia</i> sp. (ad <i>Asterochloris excentrica</i> (Archibald) Skaloud et Peksa)	Ep	+	Stoyneva-Gärtner et al. (2024a)
74	<i>Trentepohlia abietina</i> (Flotow ex Kützing) Hansgirt 1886	Ep	+	Mancheva (2013)
75	<i>Trentepohlia arborum</i> (Agardh) Hariot 1889	Ep	+	Stoyneva-Gärtner et al. (2024a)
76	<i>Trentepohlia aurea</i> (Linnaeus) C. Martius 1817	Ep	+	Uzunov et al. (2008), Stoyneva & Gärtner (2006)

77	<i>Trentepohlia jolithus</i> (Linnaeus) Wallroth 1833	Ep	+	Uzunov et al. (2008), Stoyne va-Gärtner et al. (2024a)
78	<i>Trentepohlia</i> cf. <i>jucunda</i> (Cesati) Harriot 1889	En	+	Stoyneva-Gärtner et al. (2024a)
79	<i>Trentepohlia umbrina</i> (Kützinger) Bornet 1873	Ep	+	Mancheva (2013)
80	<i>Trentepohlia</i> cf. <i>umbrina</i> (Kützinger) Bornet 1874	Ep	+	Mancheva (2013)
81	<i>Trentepohlia</i> sp.	Ep	+	Mancheva (2013)
82	<i>Ulothrix tenerrima</i> (Kützinger) Kützinger 1843 (Syn. <i>Ulothrix variabilis</i> Kützinger 1849)	Ep	+	Mancheva (2013)

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№	Taxon	Type	Cultivation	Reference
83	<i>Uvulifera mucosa</i> (Broadly et Ingerfeld) Molinari 2016	Ep	+	Stoyneva-Gärtner et al. (2024a)
	STREPTOPHYTA			
1	<i>Cosmarium crenatum</i> var. <i>nanum</i> Wittrock 1883	Ep	-	Uzunov et al. (2008)
2	<i>Cosmarium curtum</i> var. <i>exiguum</i> f. <i>polymorpha</i> Petkoff	Ep	-	Uzunov et al. (2008)
3	<i>Cosmarium curtum</i> var. <i>exiguum</i> Hansgirg	Ep	-	Uzunov et al. (2008)
4	<i>Cosmarium laeve</i> Rabenhorst 1868	Ep	-	Starmach (1964)
5	<i>Cosmarium notabile</i> Brébisson 1856	Ep	-	Uzunov et al. (2008)
6	<i>Cosmarium tumens</i> Nordstedt 1872	Ep	-	Uzunov et al. (2008)

7	<i>Deuterostichococcus marinus</i> (Deason) Pröschold et Darienko 2020 (Syn. <i>Klebsormidium marinum</i> (Deason) P. C. Silva, K. M. Mattox et W. H. Blackwell 1972)	Ep	+	Mancheva (2013)
8	<i>Disphinctium</i> sp.	Ep	-	Uzunov et al. (2008)
9	<i>Euastrum binale</i> Ehrenberg ex Ralfs 1848	Ep	-	Uzunov et al. (2008)
10	<i>Klebsormidium crenulatum</i> (Kützing) Lok horst 1985	Ep	+	Stoyneva-Gärtner et al. (2024a)
11	<i>Klebsormidium dissectum</i> (F. Gay) H. Ettl et G. Gärtner 1995	Ep	+	Mancheva (2013), Stoyneva-Gärtner et al. (2024a)
12	<i>Klebsormidium flaccidum</i> (Kützing) P. C. Silva, Mattox et W. H. Blackwell 1972 (Syn. <i>Hormiscia flaccida</i> var. <i>varia</i> (Kütz.) De Wild, <i>Hormiscia subtilis</i> var. <i>albicans</i> (Kütz.) Hansgirg)	Ep	+	Uzunov et al. (2008), Mancheva (2013), Stoyneva-Gärtner et al. (2024a)
13	<i>Klebsormidium</i> cf. <i>flaccidum</i> (Kützing) P. C. Silva, Mattox et W. H. Blackwell 1972	Ep	+	Stoyneva-Gärtner et al. (2024a)
14	<i>Klebsormidium klebsii</i> (G. M. Smith) P. C. Silva, K. R. Mattox et W.H. Blackwell 1972	Ep	+	Mancheva (2013), Stoyneva-Gärtner et al. (2024a)
15	<i>Klebsormidium pseudostichococcus</i> (Heering) H. Ettl et G. Gärtner 1995	Ep	-	Uzunov et al. (2008)
16	<i>Klebsormidium subtile</i> (Kützing) Mikhailov, Glaser, Holzinger et Karsten 2015	Ep	-	Uzunov et al. (2008)
17	<i>Mesotaenium chlamydosporum</i> De Bary 1858	Ep	-	Starmach (1964)

№	Taxon	Type	Cultivation	Reference
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18	<i>Mesotaenium macrococcum</i> (Kützing) J. Roy et Bisset 1894	Ep	+	Uzunov et al. (2008), Mancheva (2013)
19	<i>Mougeotia nummuloides</i> (Hassall) De Toni 1889	Ep	-	Uzunov et al. (2008)
20	<i>Roya obtusa</i> (Brébisson) West et G. S.West 1896	Ep	-	Uzunov et al. (2008)
21	<i>Spirogyra varians</i> (Hassall) Kützing 1849	Ep	-	Uzunov et al. (2008)
22	<i>Zygnema</i> sp.	Ep	-	Uzunov et al. (2008)
	OCHROPHYTA			
	Bacillariophyceae			
1	<i>Achnantheidium minutissimum</i> (Kützing) Czarnecki 1994 (Syn. <i>Achnanthes minutissima</i> Kützing 1833)	Ep	-	Starmach (1964)
2	<i>Amphora pediculus</i> (Kützing) Grunow 1875 (Syn. <i>Amphora ovalis</i> var. <i>pediculus</i> (Kützing) Van Heurck 1885)	Ep	-	Starmach (1964)
3	<i>Craticula cuspidata</i> (Kützing) D. G. Mann 1990 (Syn. <i>Navicula cuspidata</i> Kützing 1844)	Ep	-	Starmach (1964)
4	<i>Cymbella affinis</i> Kützing 1844	Ep	-	Starmach (1964)
5	<i>Cymbella cymbiformis</i> C. Agardh 1830	Ep	-	Starmach (1964)
6	<i>Denticula elegans</i> Kützing 1844	Ep	-	Starmach (1964)
7	<i>Diatoma vulgare</i> Bory 1824	Ep	-	Starmach (1964)
8	<i>Epithemia gibba</i> (Ehrenberg) Kützing 1844 (Syn. <i>Rhopalodia gibba</i> (Ehrenberg) O.Müller 1895)	Ep	-	Starmach (1964)
9	<i>Frustulia amosseana</i> Lange-Bertalot 2000 (Syn. <i>Frustulia vulgaris</i> var. <i>capitata</i> Krasske 1923)	Ep	-	Starmach (1964)
10	<i>Frustulia vulgaris</i> (Thwaites) De Toni 1891	Ep	-	Starmach (1964)

11	<i>Gomphonema gracile</i> Ehrenberg 1838	Ep	-	Starmach (1964)
12	<i>Halamphora coffeiformis</i> (C. Agardh) Mere schkowsky 1903 (Syn. <i>Amphora coffeiformis</i> (C. Agardh) Kützing 1844)	Ep	-	Starmach (1964)
13	<i>Hantzschia amphioxys</i> (Ehrenberg) Grunow 1880	En	+	Mancheva (2013)
14	<i>Mastogloia elliptica</i> (C. Agardh) Cleve 1893	Ep	-	Starmach (1964)

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№	Taxon	Type	Cultivation	Reference
15	<i>Mastogloia smithii</i> Thwaites ex W. Smith 1856	Ep	-	Starmach (1964)
16	<i>Navicula cryptocephala</i> Kützing 1844	Ep	-	Starmach (1964)
17	<i>Navicula gregaria</i> Donkin 1861	Ep	-	Starmach (1964)
18	<i>Navicula</i> sp.	Ep	+	Mancheva (2013)
19	<i>Navicula</i> sp. s.l.	Ep	+	Stoyneva-Gärtner et al. (2024a)
20	<i>Neidium dubium</i> (Ehrenberg) Cleve 1894	Ep	-	Starmach (1964)
21	<i>Nitzschia communis</i> Rabenhorst 1860	Ep	-	Starmach (1964)
22	<i>Nitzschia palea</i> (Kützing) W. Smith 1856	Ep	-	Starmach (1964)
23	<i>Nitzschia vitrea</i> G.Norman 1861	Ep	-	Starmach (1964)
24	<i>Pinnularia decrescens</i> (Grunow) Krammer 2000 (Syn. <i>Pinnularia subsolaris</i> (Grunow) Cleve 1895)	Ep	-	Starmach (1964)
25	<i>Pinnularia biceps</i> f. <i>minutissima</i> (Hustedt) A. Cleve 1955 (Syn. <i>Pinnularia interrupta</i> f. <i>minutissima</i> Hustedt 1930)	Ep	-	Starmach (1964)
26	<i>Pinnularia</i> sp.	Ep	+	Stoyneva-Gärtner et al. (2024a)

27	<i>Stauroneis</i> sp.	Ep	+	Mancheva (2013)
28	<i>Sellaphora pupula</i> (Kützing) Mereschkovsky 1902 (Syn. <i>Navicula pupula</i> Kützing 1844)	Ep	-	Starmach (1964)
29	<i>Toxarium undulatum</i> var. <i>ponticum</i> Petkoff 1919	Ep	-	Uzunov et al. (2008)
30	<i>Ulnaria ulna</i> (Nitzsch) Compère 2001 (Syn. <i>Synedra ulna</i> (Nitzsch) Ehrenberg 1832)	Ep	-	Starmach (1964)
	Eustigmatophyceae			
31	<i>Chloridella minuta</i> Gayral et Mazancourt 1958	Ep	+	Stoyneva-Gärtner et al. (2024a)
32	<i>Chlorobotrys gloeotheca</i> Pascher 1938	Ep	+	Stoyneva-Gärtner et al. (2024a)
33	<i>Gloeobotrys piriformis</i> Reisinger 1964	Ep	+	Stoyneva-Gärtner et al. (2024a)
34	<i>Gloeobotrys terrestris</i> Reisinger 1964	Ep	+	Stoyneva-Gärtner et al. (2024a)

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№	Taxon	Type	Cultivation	Reference
35	<i>Vischeria magna</i> (J. B. Petersen) Kryvenda, Rybalka, Wolf et Friedl 2018 (Syn. <i>Eustigmatos magnus</i> (J. B. Petersen) D. J. Hibberd 1981)	Ep	+	Mancheva (2013), Stoyneva-Gärtner et al. (2024a)
36	<i>Vischeria polyphem</i> (Pitschmann) Kryvenda, Rybalka, Wolf et Friedl 2018 (Syn. <i>Eustigmatos polyphem</i> (Pitschmann) D. J. Hibberd 1981)	Ep	+	Mancheva (2013)
37	<i>Vischeria stellata</i> (Chodat) Pascher 1938	Ep	+	Gärtner et al. (2012) Mancheva (2013), Stoyneva-Gärtner et al.

				(2024a)
38	<i>Vischeria</i> cf. <i>stellata</i> (Chodat) Pascher 1938	Ep	+	Mancheva (2013)
39	<i>Vischeria vischeri</i> (Hibberd) Kryvenda, Ry balka, Wolf et Friedl 2018 (Syn. <i>Eustigmatos vischeri</i> D.J.Hibberd 1981)	Ep	+	Mancheva (2013)
	Xanthophyceae			
40	<i>Botrydiopsis</i> sp.	Ep	+	Stoyneva-Gärtner et al. (2024a)
41	<i>Botryochloris simplex</i> Pascher 1938	Ep	+	Mancheva (2013)
42	<i>Bumilleriopsis</i> cf. <i>brevis</i> (Gerneck) Printz 1914	Ep	+	Mancheva (2013)
43	<i>Chlorellidium astigmatum</i> Schwarz 1979	Ep	+	Stoyneva-Gärtner et al. (2024a)
44	<i>Ellipsoidion perminimum</i> Pascher 1938	Ep	+	Stoyneva-Gärtner et al. (2024a)
45	<i>Heterococcus</i> sp.	Ep	+	Mancheva (2013)
46	<i>Monodus</i> cf. <i>cocomyxa</i> Pascher 1938	Ep	+	Mancheva (2013)
47	<i>Monodus guttula</i> Pascher 1938	Ep	+	Stoyneva-Gärtner et al. (2024a)
48	<i>Pleurochloris commutata</i> Pascher 1925	Ep	+	Stoyneva-Gärtner et al. (2024a)
49	<i>Tribonema minus</i> (Wille) Hazen 1902	Ep	+	Stoyneva-Gärtner et al. (2024a)
50	<i>Vaucheria racemosa</i> (Vaucher) De Candolle 1805	Ep	-	Uzunov et al. (2008)
51	<i>Vaucheria geminata</i> (Vaucher) De Candolle 1805	Ep	-	Uzunov et al. (2008)

№	Taxon	Type	Cultivation	Reference
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52	<i>Xanthonema</i> sp.	Ep	+	Mancheva (2013)
	PYRROPHYTA			
1	<i>Gloeodinium montanum</i> G. A. Klebs 1912	Ep	-	Uzunov et al. (2008)
	EUGLENOPHYTA			
1	<i>Trachelomonas irregularis</i> var. <i>minor</i> Svirenko 1914	Ep	-	Starmach (1964)

As it could be seen from this table, most of the reported species are real epilithes (342) and only a small number (27) are endolithes, with 16 of them being real endolithes and the other 11 being able to grow both epi- and endolithically. Most of the endolithes belong to the green evolutionary lineage, namely Chlorophyta – 17, where eight of them are endolithes and the other nine exhibit mixed (Ep/ En) development, followed by the blue-green lineage (Cyanoprokaryota) with nine endolithes, two of which were found to grow both epi- and endolithically. Lastly, there are the Ochrophytes with a single pure endolithic specimen, belonging to the class of Bacillariophyceae. Of the total 369 reported species, 147 are identified upon introducing them in cultures and examining their complete life cycle, including young and adult stages. The other 222 taxa are described by using direct microscopy of the collected field material, without growing them in artificial conditions. Predominantly these are the species reported during the past century. It has to be underlined that some of the species, reported from samples collected from moist rocks, are not typical lithophytes, but classical aquatic inhabitants and their finding should be considered as occasional (e.g., *Mougeotia*, *Spirogyra*, *Trachelomonas* and most diatoms).

In the different phyla, listed in **Table 1** and summarized on **Figure 1**, the cultivated to non-cultivated ratio is as follows – for Cyanoprokaryota (208) the cultivated species are 47 and the non-cultivated species are 161. In the green evolutionary lineage – Chlorophyta (83) the cultivated species are 68, the non cultivated – 15, and in Streptophyta (22) – seven of the listed species are cultivated (predominantly belonging to the genus of *Klebsormidium*) and the other 15 species have not been introduced into cultures. For the yellow-brown evolutionary lineage, Ochrophyta (52) – 25 of the reported species has undergone long-term cultivation and the remaining 27 have been reported from direct microscopic observations. The red evolutionary lineage – Rhodophyta is represented by 2 species, which haven't been cultivated, and finally the pyrro- and euglenophytes are represented by a single species each, which also haven't been introduced into culture.

The presented data clearly show that most species that have undergone

cultivation in laboratory setting belong to the green evolutionary lineage (Chlorophyta - 68 out

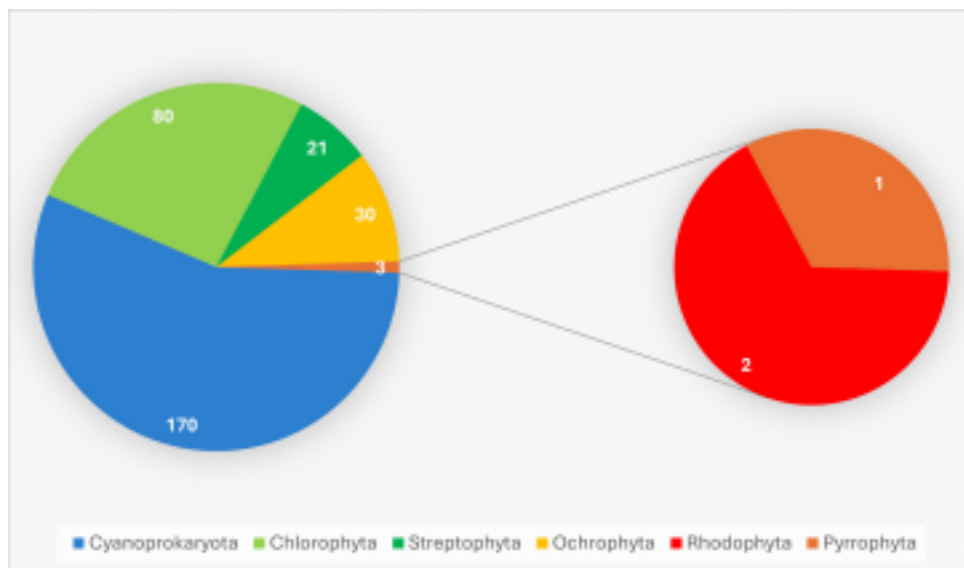


Fig. 1. Species distribution in seven of the main algal phyla. Total number of identified species is shown on each corresponding slice.

of 83, and Streptophyta - 7 out of 22), followed by Ochrophyta (25 of 52). The less common cultivated species are the cyanoprokaryotes (47 out of 208), most of which (161) are identified by direct microscopy methods, without introduction into culture (**Figure 2**). Finally, the red algae, the pyrrophytes and euglenophytes haven't been cultivated in artificial conditions, making them the only three phyla the species of which have been identified using direct microscopy only.

CONCLUSION

A rich biodiversity of lithophytes has been documented from different rock and stone substrates in Bulgaria: 369 algal taxa from seven phyla, most of which belong to the blue-green algae, or Cyanoprokaryota, (208), followed by the green algae from Chloro- (83) and Streptophyta (22), and the yellow-brown algae, or Ochrophyta (52), whereas from the red algae, or Rhodophyta, only two species have been reported, and from each of the phyla Pyrrophyta and Euglenophyta only one species was recorded. Most of these algae were found from epilithic samples (342), and only 27 were endolithes. The number of algae, identified after application of cultivation procedures and following of different stages of their development, is significantly lower (147) than the number of algae identified

from field material by direct microscopy (222). However, it has to be stressed that during the last two decades all reports of lithophytes were based on a preliminary cultivation.

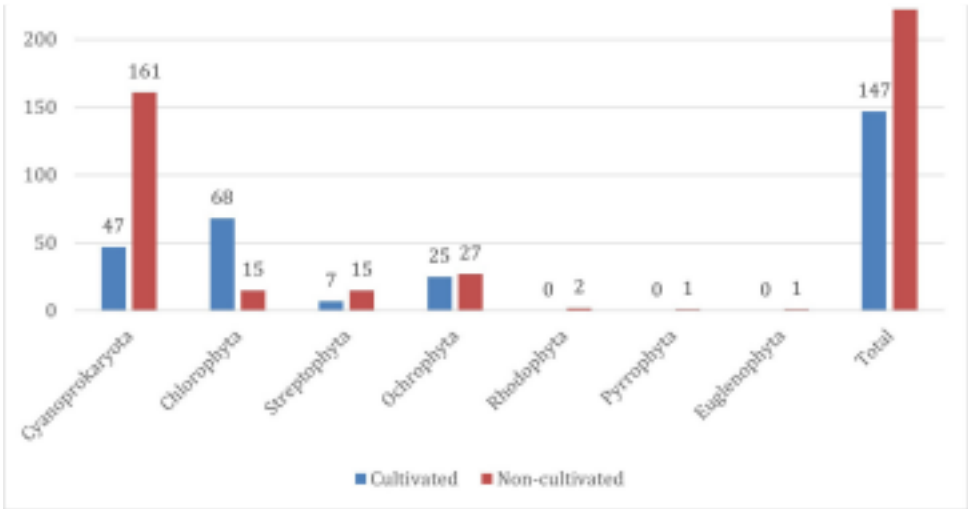


Fig. 2. Comparison between numbers of algae identified after cultivation procedure (“Cultivated”) and algae identified from field material by direct light microscopy (“Non-cultivated”) in each of the major algal phyla.

The application of cultivation is an important step when working with aero terrestrial algae and lithophytes in particular. The ability to examine every single stage of their lifecycle is crucial for the precise taxonomical identification of the collected material. Observing both young and adult stages of species development, their unique morphological, reproductive, ecological and biochemical characteristics, provides key insights on the adaptational mechanisms of this peculiar group of algae and their ability to survive in harsh and sometimes even extreme habitats.

The cultivation strategy plays an important role not only for taxonomical studies, but also for screening and selection of promising biotechnological strains. Applying this cultivation strategy to purified monocultures could not only serve as a living archive of biodiversity (Stoyneva 2014), but could yield a substantial amount of information regarding the pigment composition, stored substances and specific biomolecules accumulated inside the cell – all important features for future industrial and biotechnological implementations (Stoyneva-Gärtner et al. 2019a). Among such strains are five strains of the eustigmatophycean genus *Vischeria*, which shows great potential for accumulation of various carotenoids (Stoykova et al. 2019, Stoyneva-Gärtner et al. 2019b) and is a promising source for lipids (Stoyneva-Gärtner et al. 2022). Another example includes strain of the

filamentous streptophyte *Klebsormidium*, which is known for its great biotechnological potential (Stoyneva-Gärtner et al. 2019c) and currently has been shown as a promising agent of water purification (Valchev et al.

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2019, 2021, 2023). Furthermore, the constant demand for clean, ecological and biocompatible cosmetics, harmless both to humans and the environment we live in, has reached its peak in the recent years. As shown by Stoyneva-Gärtner et al. (2020, 2024b), this bio trend calls for researching the inclusion of algae and algal byproducts in the various cosmetics people use in their everyday lives, where lithophytic algae could play a crucial role. These are only a few examples of the lithophytes, collected in Bulgaria, available from the living algal collection ACUS but it is possible to suppose that future studies will demonstrate their untapped biotechnological potential and more species will be found after conducting of more field trips in different parts of the country.

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CONFLICT OF INTERESTS

The author declare that there is no conflict of interests regarding the publication of this article.

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