RESEARCH ARTICLE

Study on freshwater algal flora on the territory of the Bulgarka Nature Park

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ABSTRACT
The study presents data on the diversity of freshwater algal flora on the territory of the Bulgarka Nature Park. One hundred ninety-four species, belonging to 11 divisions were identified. The conservation value of the identified species was assessed.

Key words: Bulgarka Nature Park, algae, distribution, conservation status

Introduction

Studies on algal flora in our country began as early as 1890 and they continue to present day. The general impression is that researchers limit their interests in the major groups of algae, as well as in types of water ponds and biotopes (Temniskova et al., 2005). Data about many of the rivers are insufficient. A number of regions can be considered unexplored – Sredna Gora Mountain, West Frontier Mountains, partially the Balkan Mountains.

Summaries of the research carried out on algal flora of Bulgaria were made by Temniskova et al. (2005). A review of the phytoplankton in the dams was conducted by Stoyneva & Michev (2007), followed by Beshkova et al. (2007).

There are no many literature sources describing hydrophilic blue-green algae spread in our country so far. In the recent years studies were carried out by Tsanev & Belkinova (2009), Teneva et al. (2010a, 2010b, 2011, 2014), Belkinova et al. (2012), Stoyanov et al. (2013, 2016).

Currently, the algal diversity in Bulgaria is represented by about 3063 species (Temniskova et al., 2005). Strict compliance with the status of the existing protected areas, in which there are water bodies, including those of the Bulgarka Nature Park, is needed for protecting the algal diversity.

Bulgarka Nature Park was proclaimed in 2002 by the Ministry of Environment and Waters. It covers a total area of 21772.2 ha. It is located on the ridges and the northern slopes of Shipka and Tryavna parts of Central Balkan Mountains. The park includes the springs of Yantra River and its major tributaries at the upper reaches of the river and the areas on 9 settlements located within the municipalities of Gabrovo, Tryavna and Muglizh. 'Hristo Smirnenski' dam also belongs to the Natural Park area. The average altitude of the park is 940 m and the displacement is 1120 m.

Materials and Methods

The inventory of freshwater algal flora in the Bulgarka Nature Park was conducted during May-October 2012 and in the spring of 2013 (Figure 1). Samples from 37 water sources

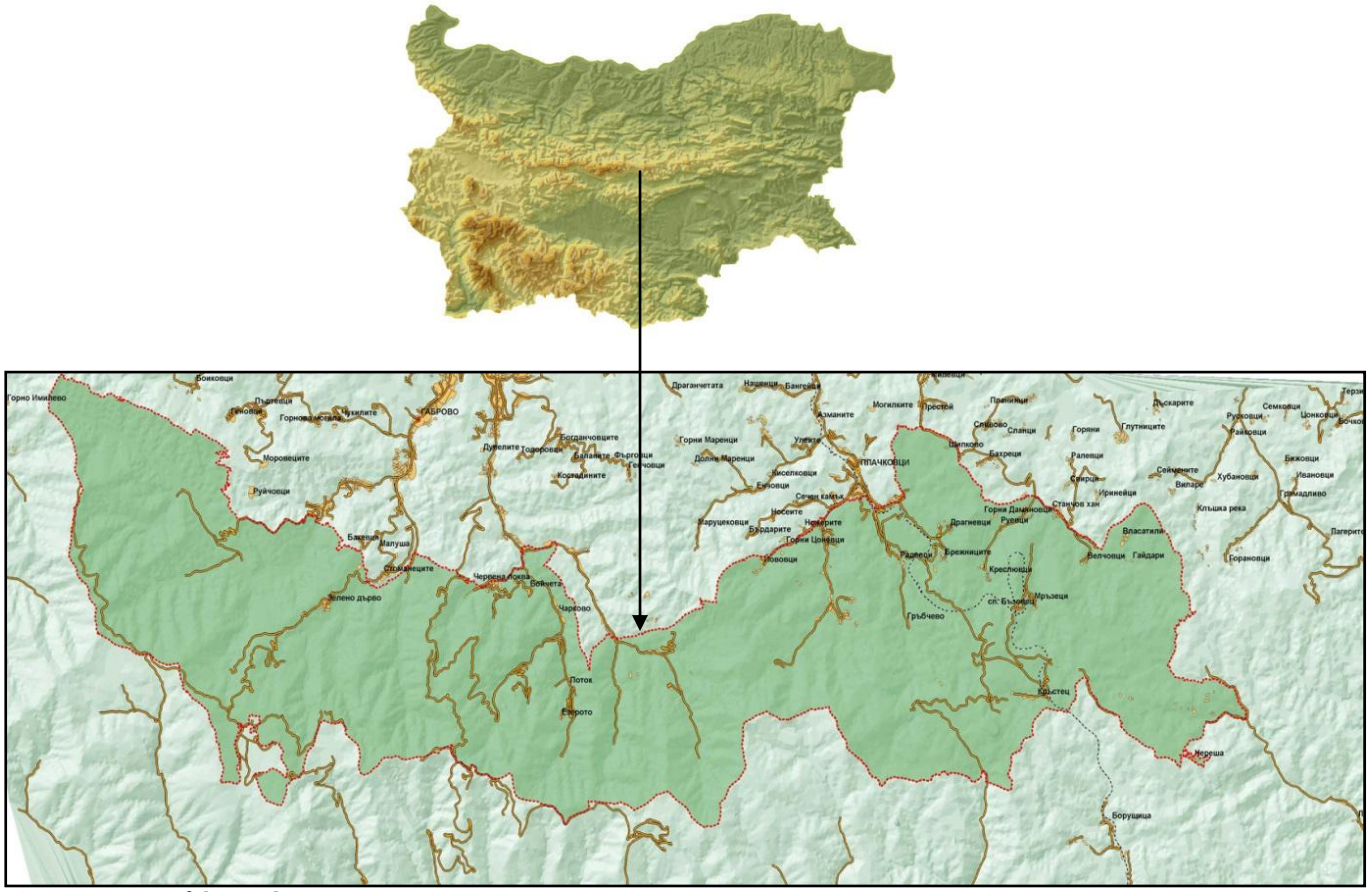

Figure 1. *Map of the study area.*

(dams, rivers, streams and fountains) were collected (Table 1). GARMIN 530 portable GPS receiver was used during the inventory visits.

Initially the sampling location and its depth were determined. The collected sample was stored in formalin. For the periphyton study, the algae were collected together with the substrate, and then fixed with formalin (Belkinova et al., 2013).

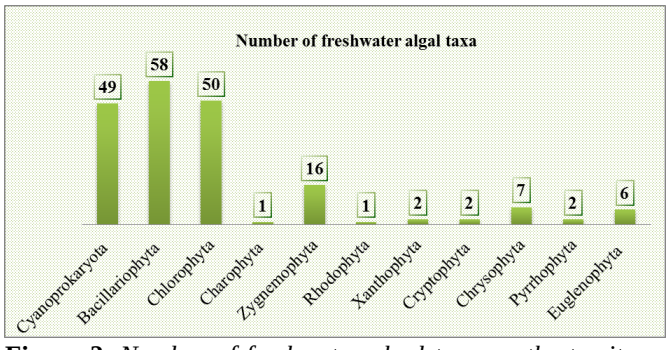

Figure 2. *Number of freshwater algal taxa on the territory of the Bulgarka Nature Park.*

The taxonomic composition was determined by using a light microscope MAGNUM-T, with 10x40 magnification, equipped with 3 Mpx digital camera and the guide of John et al. (2003), Komárek & Fott (1983), Komárek & Anagnostidis (1999, 2005), Krammer & Lange-Bertalot (1986-1991), Hasler et al. (2014), Komárek et al. (2011), Komárková et al. (2010), Anagnostidis (2001), Komárek et al. (2013), Strunecky et al. (2013).

Results and Discussion

One hundred ninety-four species that belong to 11 divisions were described during the inventory, carried out on the territory of the Bulgarka Nature Park (Figure 2).

A full list of the freshwater algal species found on the territory of the Bulgarka Nature Park is presented in Table 2.

Table 2 shows that *Cyanoprokaryota* division is represented by 29 genera, including 49 taxa, out of them 46 species and 3 unidentified taxa (sp.). *Bacillariophyta* division is represented by 58 taxa, out of them 50 species and 8 unidentified taxa (sp.), belonging to 24 genera. *Chlorophyta* is the second largest division. It includes 31 genera with 50 taxa, out of which 49 species and one unidentified taxa (sp.). From *Charophyta* division, only the species *Chara vulgaris* was established. *Zygnemophyta* division includes 8 genera with 15 species and one unidentified taxon (sp.). *Rhodophyta* division is represented by the species *Bangia atropurpurea*. The divisions *Xanthophyta*, *Cryptophyta* and *Pyrrhophyta* are represented

Table 1. *Localities, from which samples were collected for establishing the algal diversity.*

№	Sampling points	GPS coordinates
1.	Kozya reka River	N 42°48`30.0" E 25°18`15.4"
2.	Kozya reka River	N 42°47`50.9" E 25°18`11.5"
3.	Kozya reka River	N 42°46`13.3" E 25°18`02.6"
4.	Belilska River	N 42°48`30.0" E 25°18`15.4"
5.	Voneshta voda (Radetski quarter)	N 42°48`85.1" E 25°18`36.8"
6.	Dragomirova Fountain (Uzana locality)	N 42°48`23.4" E 25°16`92.9"
7.	Fountain (Zeleno darvo village)	N 42°48`23.4" E 25°16`92.9"
8.	Panicharka River	N 42°49`62.1" E 25°12`80.5"
9.	Panicharka River	N 42°49`57.1" E 25°12`85.0"
10.	Borushtitsa River	N 42°49`68.1″ E 25°12`73.4″
11.	Levicharka River	N 42°48`51.6″ E 25°13`95.8″
12.	Hristo Smirnenski dam (stream)	N 42°48`39.6" E 25°16`06.0"
13.	Hristo Smirnenski dam (stream)	N 42°48`16.5" E 25°15`39.6"
14.	Hristo Smirnenski dam (stream)	N 42°48`07.8" E 25°15`28.7"
15.	Hristo Smirnenski dam (stream)	N 42°47`59.9" E 25°14`26.8"
16.	Hristo Smirnenski dam	N 42°48`29.2" E 25°14`09.8"
17.	Hristo Smirnenski dam	N 42°49`01.4" E 25°15`54.4"
18.	Stream (Yabalka quarter, Gabrovo)	N 42°45`55.7" E 25°24`49.3"
19.	Yantra River (Yabalka quarter, Gabrovo)	N 42°45`10.7" E 25°25`01.1"
20.	Sivyak River	N 42°48`19.0" E 25°20`58.3"
21.	Sivyak River	N 42°46`46.9" E 25°21`49.5"
22.	Fountain (Potok village)	N 42°46`16.5" E 25°22`02.5"
23.	Karstovo Lake (Ezero village)	N 42°45`50.5" E 25°21`48.6"
24.	Byala reka River (Shumeli quarter, Gabrovo)	N 42°46`33.8" E 25°23`02.5"
25.	Spring (Shumeli quarter, Gabrovo)	N 42°46`30.9" E 25°23`02.8"
26.	Yantra River (spring)	N 42°44`10.6" E 25°25`18.7"
27.	Sivyak River	N 42°48`15.6" E 25°20`46.1"
28.	Fountain (Sokolski Monastery, Gabrovo)	N 42°47`54.0" E 25°20`20.6"
29.	Neikovska River	N 42°49`08.5" E 25°29`56.6"
30.	Radevska River	N 42°48`55.9" E 25°29`19.6"
31.	Stoevska River	N 42°47`35.1" E 25°28`13.5"
32.	Stanchov han River	N 42°48`23.2" E 25°34`49.0"
33.	Toplika spring	N 42°48`36.4" E 25°34`04.9"
34.	Ruevska River	N 42°49`08.8" E 25°33`10.8"
35.	Stream (Mahnati skali locality)	N 42°45`58.9" E 25°29`04.0"
36.	Fountain (Mahnati skali locality)	N 42°45`51.8" E 25°28`28.8"
37.	Suhata reka River	N 42°44`54.6" E 25°31`41.5"

Table 2. *List of algal species found on the territory of the Bulgarka Nature Park.*

№	Divisio Cyanoprokaryota
1.	*Anathece minutissima* (West) Komárek, Kastovsky & Jezberová [Syn.: *Aphanothece minutissima* (W. West) Komárková-Legnerová et Cronberg
2.	*Aphanothece* sp.
3.	*Borzia trilocularis* Cohn ex Gomont
4.	*Calothrix braunii* Born. et Flah.
5.	*Calothrix elenkinii* Kossnsk.
6.	*Calothrix parietina* (Näg.) Thuret
7.	*Chroococcus disperses* (Keissler) Lemmermann
8.	*Chroococcus minimus* (Keissler) Lemmermann
9.	*Chroococcus minutus* (Kützing) Nägeli

10. *Chroococcus turgidus* (Kützing) Nägeli
11. *Cylindrospermum muscicola* Kütz.
12. *Geitlerinema amphibium* (Agardh ex Gomont) Anagnostidis
13. *Gloeothece fuscolutea* (Nägeli ex Kützing) Nägeli [Syn.: *Gloeocapsa fuscolutea* (Näg.) Kützing]
14. *Heteroleibleinia rigidula* (Kütz. ex Hansgirg) Hoffmann
15. *Jaaginema gracile* (Böcher) Anagnostidis et Komárek
16. *Johanseninema constrictum* (Szafer) Hasler, Dvorák & Poulícková [Syn.: *Anabaena constricta* (Szaf.) Geitl.]
17. *Leptolyngbya foveolarum* (Rabenhorst ex Gomont) Anagnostidis ex Komárek
18. *Leptolyngbya perelegans* (Lemmermann) Anagnostidis et Komárek
19. *Limnococcus limneticus* (Lemmermann) Komárková, Jezberová, O. Komárek & Zapomelová [Syn.: *Chroococcus limneticus* Lemmermann]
20. *Limnoraphis hieronymusii* (Lemmermann) J.Komárek, E.Zapomelová, J.Smarda, J.Kopecky, E.Rejmánková, J.Woodhouse, B.A.Neilan & J.Komárková [Syn.: *Lyngbya hieronymusii* Lemm.]
21. *Lyngbya rigidula* (Kutz.) Hansg.]
22. *Lyngbya stagnina* Kützing ex Gomont
23. *Merismopedia* sp.
24. *Merismopedia tenuissima* Lemm.
25. *Microcoleus amoenus* (Gomont) Strunecky, Komárek & J.R.Johansen [Syn.: *Phormidium amoenum* Kütz. ex Anagn. et Komárek]
26. *Microcoleus autumnalis* (Gomont) Strunecky, Komárek & J.R.Johansen [Syn.: *Phormidium autumnale* (Agardh) Trevisan ex Gomont]
27. *Oscillatoria curviceps* Agardh ex Gomont
28. *Oscillatoria limosa* Agardh ex Gomont
29. *Phormidium breve* (Kützing ex Gomont) Anagnostidis et Komárek
30. *Phormidium kuetzingianum* (Kirchner) Anagnostidis et Komárek
31. *Phormidium stagninum* Anagnostidis [Syn.: *Lyngbya stagnina* Kützing ex Gomont]
32. *Phormidium terebriforme* (Agardh ex Gomont) Anagnostidis et Komárek
33. *Phormidium uncinatum* Gomont ex Gomont
34. *Pseudanabaena catenata* Lauterborn
35. *Pseudanabaena galeata* Böcher
36. *Pseudanabaena minima* (G.S. An) Anagnostidis
37. *Pseudanabaena mucicola* (Naumann et Huber-Pestalozzi) Schwale
38. *Romeria elegans* (WoŁoszyńska in Koczwara) WoŁoszyńska et Koczwara ex Geitler
39. *Schizothrix* sp.
40. *Scytonema mirabile* (Dillw.) Bornet
41. *Scytonema ocellatum* Lyngb.
42. *Snowella arachnoidea* Komárek et Hindák
43. *Snowella atomus* Komárek & Hindák
44. *Spirulina major* Kützing ex Gomont
45. *Symploca muscorum* Gomont ex Gomont
46. *Synechococcus capitatus* Bailey-Watts et Komárek
47. *Synechococcus elongatus* (Nägeli) Nägeli
48. *Synechocystis minuscula* Voronichin
49. *Xenotholos kerneri* (Hansgirg) Gold-Morgan et al.

Divisio Bacillariophyta

50. *Achnanthes brevipes* Ag.
51. *Achnanthes* f. *lanceolata* (Bréb.) Grun.
52. *Achnanthes exigua* Grun.
53. *Achnanthes lanceolata* (Bréb.) Grun.
54. *Amphora ovalis* Kütz.
55. *Aulacosera distans* (Ehrenberg) Simonsen
56. *Caloneis* sp.

57. *Cocconeis pediculus* Ehrengerg
58. *Cocconeis placentula* Ehr.
59. *Craticula ambigua* (Ehrenberg) D.G.Mann
60. *Cyclotella meneghiniana* Kütz.
61. *Cyclotella ocellata* Pant.
62. *Cymbella aspera* (Ehr.) Cl.
63. *Cymbella* cf. *cuspidata* Kütz.
64. *Cymbella cuspidata* Kütz.
65. *Cymbella cymbiformis* (Kütz.) V. H.
66. *Cymbella* sp.
67. *Cymbella tumida* Bréb.
68. *Cymbella turgida* (Greg.) Cl.
69. *Diatoma anceps* (Ehr.) Kirch.
70. *Diatoma hiemale* (Lyngb.) Heib.
71. *Diatoma hiemalis* (Roth) Heiberg
72. *Diatoma mesodon* (Ehr.) Kütz.
73. *Diatoma vulgaris* Bory
74. *Eunotia arcus* Ehr.
75. *Eunotia* cf. *praerupta* Ehr.
76. *Eunotia faba* (Ehr.) Grun
77. *Fragilaria capucina* Desmaz.
78. *Fragilaria* cf. *berolinensis* (Lemmermann) Lange-Bertalot
79. *Fragilaria construens* (Ehr.) Grun.
80. *Fragilaria ulna* (Nitzsch) Lange-Bertalot
81. *Fragilarioforma virescens* (Ralfs) D.M.Williams & Round
82. *Gomphonema acuminatum* Ehr.
83. *Gomphonema constrictum* Ehr.
84. *Gomphonema gracile* Ehr.
85. *Gomphonema parvulum* (Kütz.) Grun.
86. *Gomphonema* sp.
87. *Gyrosigma angulatum* (Quekett) Griffith & Henfrey
88. *Luticola* sp.
89. *Melosira varians* C.Agardh
90. *Meridion circulare* (Grev.) De Toni
91. *Meridion circulare* Ag.
92. *Navicula* cf. *radiosa* Kütz.
93. *Navicula* sp.
94. *Nitzschia acicularis* (Kütz.) W. Smith
95. *Nitzschia* cf. *linearis* (C.Agardh) W.Smith
96. *Nitzschia palea* (Kütz.) W. Sm.
97. *Nitzschia* sp.
98. *Pinnularia gibba* Ehr.
99. *Pinnularia major* Kütz.
100. *Pinnularia* sp.
101. *Pinnularia viridis* (Nitzsch.) Ehr.
102. *Rhoicosphaenia curvata* (Kütz.) Grun.
103. *Rhoicosphenia abbreviata* (Agardh) Lange-Bert.
104. *Rhopalodia gibba* (Ehr.) O.Müll.
105. *Stauroneis anceps* Ehr.
106. *Stauroneis* sp.
107. *Stephanodiscus hantzschii* Grun.

Divisio Chlorophyta

108.	*Actinastrum hantchii* Lagerh.
109.	*Ankistrodesmus gracilis* (Reinsch) Korš.
110.	*Chlamydomonas lapponica* Skuja
111.	*Chlamydomonas planctogloea* Skuja
112.	*Cladophora glomerata* (Linnaeus) Kützing
113.	*Cladophora fracta* (Dillw.) Kütz.
114.	*Closteriopsis longissima* (Lemm.) Lemm.
115.	*Coelastrum polychordum* (Korš.) Hind.
116.	*Crucigeniella crucifera* (Wolle) Kom.
117.	*Elakatothrix genevensis* (Reverd.) Hind.
118.	*Gonium pectorale* O.F. Müller
119.	*Kirchneriella dian*ae (Bohl.) Comas
120.	*Koliella stagnalis* Hindák
121.	*Lagerheimia wratislaviensis* Schröd.
122.	*Micractinium pusillum* Fresenius
123.	*Microspora stagnorum* (Kütz.) Lagerh.
124.	*Microspora tumidula* Hazen
125.	*Microthamnion kuetzingianum* Nägeli ex Kützing
126.	*Microthamnion strictissimum* Rabenh.
127.	*Monoraphidium arcuatum* (Korš.) Hind.
128.	*Monoraphidium contortum* (Thur.) Kom.-Legn.
129.	*Monoraphidium convolutum* (Corda) Kom.-Legn.
130.	*Monoraphidium griffithii* (Berk.) Kom.-Legn.
131.	*Monoraphidium minutum* (Näg.) Kom.-Legn.
132.	*Oedogonium pusillum* Kirchn.
133.	*Oedogonium* sp.
134.	*Oocystis lacustris* Snow.
135.	*Pandorina morum* (O.F. Müller) Bory
136.	*Pediastrum duplex* Meyen
137.	*Pediastrum duplex* var. *gracillimum* W. & G.S. West
138.	*Phacotus pallidus* Korschikoff
139.	*Polyedriopsis spinulosa* (Schmidle) Schmidle
140.	*Protoderma frequens* (Butsher) Printz
141.	*Protoderma viride* Kütz.
142.	*Scenedesmus bernardii* G.M. Smith
143.	*Scenedesmus communis* Hegew.
144.	*Scenedesmus obliquus* (Turp.) Kütz.
145.	*Scenedesmus opoliensis* P.G. Richter var. *mononensis* Chodat
146.	*Scenedesmus pectinatus* Meyen
147.	*Scenedesmus semipulcher* Hortobágyi
148.	*Scenedesmus suspicatus* Chodat
149.	*Sphaerocystis schroeteri* Chod.
150.	*Stichococcus variabilis* W. et G. S. West
151.	*Stigeoclonim lubricum* (Dillw.) Kütz.
152.	*Stigeoclonium tenue* (Ag.) Kütz.
153.	*Tetraedron minimum* (A. Braun) Hansgirg
154.	*Tetrastrum komarekii* Hind.
155.	*Ulothrix subtilis* Kütz.
156.	*Ulothrix subtilissima* Rabenh.
157.	*Ulothrix tenuissima* Kütz.
	Divisio Charophyta
158.	*Chara vulgaris* L.

	Divisio Zygnemophyta
159.	*Closterium acerosum* (Schrank.) Ehr.
160.	*Cosmarium bioculatum* Bréb.
161.	*Cosmarium reniforme* (Ralfs) W.Archer
162.	*Cosmarium speciosum* P.Lundell
163.	*Desmidium swartzii* (Ag.) Ralfs
164.	*Gonatozygon brebissonii* De Bary
165.	*Gonatozygon kinahanii* (W.Archer) Rabenhorst
166.	*Gonatozygon monotaenium* De Bary
167.	*Mougeotia scalaris* Hass.
168.	*Mougeotia* sp.
169.	*Mougeotia viridis* (Kützing) Wittrock
170.	*Penium spinospermum* Josh.
171.	*Spirogyra crassa* (Kütz.) Petit
172.	*Spirogyra inflata* (Vaucher) Kützing
173.	*Zygnema cruciatum* (Vaucher) C.Agardh
174.	*Zygnema pectinatum* (Wauch.) Ag.
	Divisio Rhodophyta
175.	*Bangia atropurpurea* (Roth) C.Agardh
	Divisio Xanthophyta
176.	*Tribonema utriculosum* (Kütz.) Hanzen
177.	*Tribonema vulgare* Pasch.
	Divisio Cryptophyta
178.	*Chroomonas acuta* Uterm.
179.	*Cryptomonas erosa* Ehr.
	Divisio Chrysophyta
180.	*Chromulina* sp.
181.	*Chrysococcus cordiformis* Naumann
182.	*Chrysococcus punctiformis* Pasch.
183.	*Chrysococcus rufescens* Klebs
184.	*Dinobryon divergens* Imh.
185.	*Dinobryon divergens* Imh. var. *angulatum* (Sel.) Brunnth.
186.	*Kephyrion francevi* Gus.
	Divisio Pyrrhophyta
187.	*Ceratium furcoides* (Levander) Langhans
188.	*Peridinium inconspicuum* Lemmermann
	Divisio Euglenophyta
189.	*Trachelomonas bacillifera* Playfair
190.	*Trachelomonas hispida* (Perty) F. Stein emend.
191.	*Trachelomonas planctonica* Swir. var. *longicolis* Skv.
192.	*Trachelomonas similis* Stokes
193.	*Trachelomonas volvocina* Ehr.
194.	*Trachelomonas volvocinosis* Swir.

by two species each. *Chrysophyta* division includes 4 genera with 7 taxa, out of which 6 species and 1 unidentified taxon (sp.). Six species belonging to one genus are identified from *Euglenophyta* divison.

Bacillariophyta division is represented by the largest species diversity. They are a dominant group of organisms in biomass and in number of species in lakes, springs, upper and middle river reaches in Europe, being the major primary producers in them. Over the last decade, wetlands in mountain areas have been increasingly studied with the aim of protection and conservation (Brittain & Milner, 2001). The preservation of those habitats is a priority because the rate of biodiversity loss in freshwater ecosystems is five times faster compared to land and marine ecosystems. According to Werum (2001) and some other authors, they remain the last freshwater habitats, which have not been or have only

partially been influenced by anthropogenic activities, serving as 'refuges' and 'habitat islands' for many species.

Conclusion

As a result of the study, 194 species, belonging to 104 genera of 11 divisions were identified. Among them there are no algal species of conservation importance included in the Red List of macroalgae according to Temniskova et al. (2008). Nevertheless, some macroalgal species as *Bangia atropurpurea* (Roth) C. Agardh, *Chara vulgaris* L. and microalgae (*Chrysococcus rufescens* Klebs, *Calothrix parietina* [Näg.] Thuret, *Chroococcus limneticus* Lemm.) are described as indicators of olygosaprobe, clean waters (Wasser et al., 1989).

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