Acta ZooBot Austria **155**, 2018, 107–134

Diversity of diatoms and related quality of free-flowing rivers in Albania (the Vjosa catchment)

Aleko Miho, Klajdi Ngjela, Bledi Hoxha, Ina Sejdo & Marjol Meço

An overview of the periphyton communities of microscopic algae (diatoms-*Bacillariophyceae*) and related ecological quality of waters in various habitats of the Vjosa catchment (Albania) is reported here. 252 taxa of diatoms were found, mostly pennatae, of which more than 110 taxa were found directly at Vjosa River stations and 72 taxa were found in samples collected in Benja thermal springs (Lengarica tributary; Permeti). According to the diatom Index of Pollution Sensitivity (IPS), the waters were mostly of good quality within the whole watershed, representing low or moderate organic content (mostly II class) and low or moderate human impact; however, relatively high values of TI_{DIA} show that the content of nutrients (nitrogen and phosphorous) in waters is not negligible, and often corresponds with an eutrophic state.

Miho A., Ngjela K., Hoxha B., Sejdo I. & Meço M., 2018: Kieselalgen-Diversität und verbundene Qualität von freifließenden Flüssen in Albanien (Vjosa-Einzugsgebiet).
Der Artikel gibt einen Überblick über die mikroskopischen Algen (Diatomeen-Bacillariophyceae) im Periphyton von verschiedenen aquatischen Lebensräumen des Vjosa-Einzugsgebiets (Albanien). Es wurden 252 Taxa von Diatomeen gefunden, hauptsächlich Pennatae, von denen mehr als 110 Taxa direkt in der Vjosa gefunden wurden; in den Benja-Thermalquellen (Lengarica-Zufluss; Permeti) wurden 72 Taxa gefunden. Nach dem Diatomeenindex der Verschmutzungsempfindlichkeit (IPS) beurteilt, waren die Gewässer im der gesamten Einzugsgebiet meist von guter Qualität. Das entspricht einem niedrigen oder moderaten organischen Gehalt (meist II-Klasse) und menschlicher Beeinflussung. Relativ hohe Werte von TI_{DIA} zeigen jedoch, dass der Gehalt an Nährstoffen (Stickstoff und Phosphor) in Gewässern oft hoch ist.

Keywords: Albanian free-flowing rivers, Vjosa River, periphyton, diatoms, ecological river assessment.

Introduction

Free-flowing rivers such as the Vjosa are considered fundamental biodiversity resources (Opperman et al. 2015) and are also important for energy generation. Rivers in Albania are continuously disturbed through pollution due to scarce waste management, through strong erosion due to poor land use in watershed areas, through gravel mining in the riverbed, low levels of awareness and education regarding environmental and conservation matters, as well as through lax application of existing legislation. Recently, the development of hydropower plants (HPPs) and a large expansion of dams, tunnels, and channels in rivers represent an extraordinary pressure to harness these natural resources (Opperman et al. 2015). The Vjosa is one of Europe's last free-flowing rivers and harbours a great diversity of hydromorphological features. It drains a large area between Greece and Albania and forms an important delta in the Adriatic Sea.

Diatoms are the main group of eukaryotic algae that populate many aquatic environments. Their diversity is generally higher in waters of good quality, with low nutrients or pollutants, and in undisturbed habitats. Due to their ecology, diatom communities are a popular tool for monitoring ecological conditions, past and present, and are commonly used in studies of water-ecological quality (Whitton 2013, Fidlerová & Hlubikova 2016, Kahlert et al. 2012, etc.). An overview of the diversity of diatoms and the related ecological quality of waters within the Vjosa catchment (Vjosa river, its tributaries, springs and some reservoirs), based on periphyton samples collected over many years will be presented here. The data should aid authorities in developing conservation and management concepts for the future.

Material and methods

Collection of periphyton samples in the Vjosa catchment began in September 1996 and was continued sporadically until 2015. A total of more than 45 samples are considered here, of which about 20 samples are from the Vjosa river (from Mifoli to Çarshova), and the rest from tributaries (Drino, Shalsi, Kardhiqi, etc.), from springs (Kelcyra, Tepelena, Benja, Viroi, etc.), or reservoirs (Krahsi, Viroi, Gusmari, etc.) (Tab. 2 u. Fig. 1).

Sampling was mostly conducted following the standard EN13946:2003, brushing the upper surface of the hard substrata (submerged stones) or collecting submerged macrophytes and macroalgae. Samples were preserved and transported in plastic bottles in formaldehyde 4 % or denaturized ethanol 90 %. Cleaning of diatom frustules was done by boiling the material, mainly using H_2O_2 as described by Krammer & Lange-Bertalot (1986–2001) or the EU standard EN 14407:2004. Permanent microscopic slides were prepared using Naphrax (index 1.69). Samples and permanent slides are deposited at the Laboratory of Botany, University of Tirana.

Examinations, photos and counts were carried out using the optic microscopes Leica DLMB (Kupe 2006, Hoxha 2008, Jaupaj 2007, Sejdo 2010, Miho et al. 2008, 2010) and Motic BA310 (Meço 2013, Meço et al. 2014, Ngjela, 2016) at the Laboratory of Botany, FNS, University of Tirana. Hoxha (2008) used the microscope Nikon Eclipse 600 for his examinations of the Vjosa catchment, mostly at Benja thermal springs during his stay with Prof. A. Witkowski, Department of Palaeooceanology, Szczecin University, Poland, during May and July 2006. Most of the photos reported here in Plates I-X were taken with the Nikon camera, the rest with the Motic camera (CMOS 1/2" 3MP – 2048 x 1536 pixel). The most current names were used for taxonomic identification following Krammer & Lange-Bertalot (1986–2001), Lange-Bertalot (2001), Krammer (2002), Levkov et al. (2007) and other available literature online, i.e. AlgaeBase (Guiry & Guiry 2018), Grigorszky et al. 2017, Kahlert et al. 2012, Whitton 2013, Fidlerová & Hlubikova 2016, Acs et al. 2017a & b, etc.

More than 400 diatom valves were counted in each microscopic slide, thus obtaining statistically reliable results (confidence limit up to 95 %). Diatom trophic indices were calculated using the formula of Zelinka & Marvan (1961): Saprobic Index (SI) indicates the presence of degradable organic compounds (Rott et al. 1997); Trophic Index of Diatoms (TI_{DIA}) is based on the presence of the inorganic nutrients (nitrogen and phosphorous) (Rott et al. 1999); Specific Pollution Sensitivity Index (IPS) is correlated with parameters related to organic pollution, ionic strength, and eutrophication, and provides a complex estimation of water quality; IPS is the most used index at present; it is calculated using the formula of Zelinka & Marvan (1961) after Coste in Cemagref (1982), corrected after Eloranta & Kwandrans (1996); the ecological values (S_i and V_i) were taken from the Omnidia database (Lecointe et al. 1993). Numeric processing and all graphs were done in Microsoft Office Excel 2010, while photo processing was conducted in CorelDRAW X5.

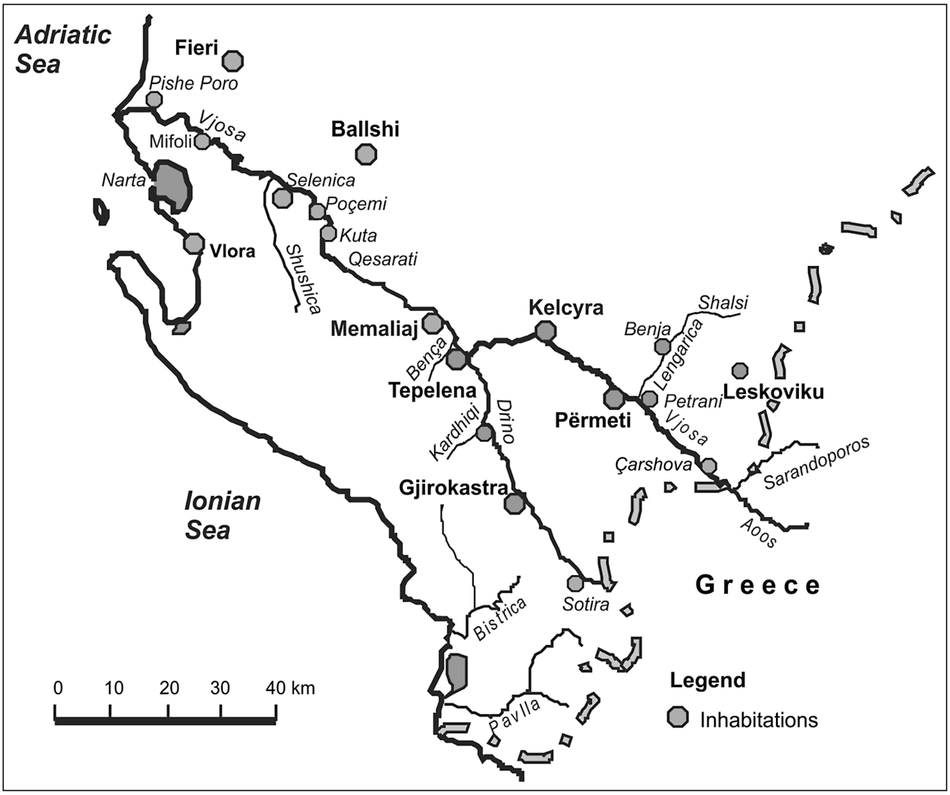


Fig. 1: Vjosa River with the most important mentioned sampling sites. – Abb. 1: Vjosa-Fluss mit den wichtigsten erwähnten Probenahmestellen.

Results and discussion

Fulfillment of environmental criteria is important for Albania's membership in the European Union (EU) (Albania 2018 Report; https://eeas.europa.eu/sites/eeas/files/20180417-albania-report.pdf). This includes monitoring the ecological status of surface waters according to the European Water Framework Directive (WFD 2000). Diatom composition and related indices are elements of this routine monitoring (Whitton 2013, Acs et al. 2017). The results reported here are part of several diploma theses in our efforts to examine algal diversity and to train yong experts in monitoring the ecological status of surface waters according to the WFD (2000). These theses include: Hoxha (2008) about Benja and Vjosa River (its upper part); Jaupaj (2007), Meço (2013) about rivers, including some habitats from Vjosa catchement; Sejdo (2012) about reservoirs, including also Viroi, Krahsi, and Ballshi in the Vjosa catchment; Ngjela (2016) about Vjosa river habitats. Part of this information is reported by Kupe (2006) in her PhD, or published in Miho et al. (2008, 2010), Meço et al. (2014). Phytoplankton and periphyton data in habitats of Narta lagoon (Vjosa delta) were provided by Dedej (2006) and Xhulaj (2009). Some taxonomic and ecological data were summarized by Miho & Witkowski (2005), Kupe & Miho (2007), Miho et al. (2005, 2013), Meço et al. (2014), and Miho (2014).

Taxonomic approach: 252 taxa of diatoms were found in Vjosa catchments waters (1996–2015) and are reported in the Annex I. Most of them are pennatae (about 230 taxa). Plates I to X show 141 microscopic photos, representing a total of 116 taxa – the most common, rare, and interesting ones.

More than 110 taxa were identified in samples from Vjosa River, 60 taxa in Viroi spring, 50 in Mifoli (Vjosa river), 47 in Lekli (Drino river) and 42 in Çajupi spring. About 70 taxa were found in 9 samples collected in Benja thermal springs (Lengarica tributary; Permeti) (HOXHA 2008, KUPE 2006). These thermal spring waters are densely populated by filamentous colonies of *Spirogyra* sp. (Fig. 2), *Oscillatoria* sp., or *Chara vulgaris var. gymnophylla* or *Chara vulgaris* f. *longibracteata* (KASHTA & MIHO 2016). The diatom community was dominated by *D. vulgaris* (69 %), and included *Achnanthes minutissima, Cocconeis pediculus, Diatoma moniliformis* and *Gomphonema olivaceum*.

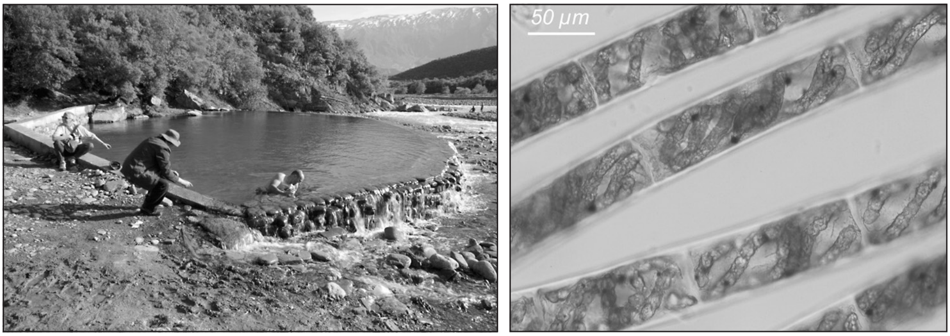


Fig. 2: a, *Spirogyra* sp. in Benja thermal springs, Permeti (11 May 2014); b, filaments at the microscope (KASHTA & MIHO 2016). – Abb. 2: a, *Spirogyra* sp. in Benja Thermalquellen, Permeti (11 Mai 2014); b, Filamente am Mikroskop (KASHTA & MIHO 2016).

Cladophora glomerata seems to be the most common filamentous green alga in the Vjosa River and its tributaries, as in most other Albanian rivers (MIHO et al. 2005, KUPE 2006, KASHTA & MIHO 2016). In the late spring and summer season (May-July), algae were blooming mostly in slower-flowing parts of the river, with less turbidity or moderate-good quality. It is worth mentioning the dense growth of river water-crowfoot *Ranunculus fluitans* in Viroi Spring and its related reservoir, mixed also with the water moss *Fontinalis* sp. *R. fluitans* is an IUCN Red List taxa (LC status).

Dense growth of *Chara vulgaris* var. *gymnophylla* was also observed in Çajupi karst spring, situated on the western slope (1100 m). In a net sample from a small karst lake in Gramozi mountain (2400 m), a very dense growth of zooplankton was present; from microscopic algae we can mention the diatoms *Cymbopleura amphicephala*, *Caloneis silicula*, the green algae *Spirogyra* sp., *Scenedesmus* cf. *crassus*, *Cosmarium* cf. *granatum*, *Pediastrum* cf. *boryanum* var. *typicum*, fo. *reticulatum*, the cyanobacterium *Merismopedia* cf. *elegans*, etc.

Compared to other Albanian rivers and springs (KUPE 2005, MIHO et al. 2005, 2008, 2010, MEÇO et al. 2014, etc.), Vjosa waters are distinguished by a relatively high number of species (Tab. 1). In order to represent their ecological importance, Table 2 reports the checklist of dominant taxa (exceeding 3 %) in 9 river stations of Vjosa, Drino, etc. (NGJELA 2016). Table 3, meanwhile, reports the dominant taxa (exceeding 3 %) with their maximum relative abundance (RA) and their presence (%) in 9 various habitats of Benja thermal springs (Lengarica River) (Hoxha 2008).

The most frequent of the centric diatoms were *Cyclotella glabriuscula* (in 55 % of samples), *Melosira varians* (45 %) and *Cyclotella distinguenda* (36 %); *Cyclotella glabriuscula* was found in 16 % & 22 % of samples from Viroi spring, *Melosira varians* was also abundant in Viroi (up to ca. 20 %). From the pennatae diatoms, *Achnanthidium minutissimum*, *Nitzschia linearis* and *Nitzschia palea* were found almost in all samples (100 %), followed by *Cocconeis placentula, Gomphonema olivaceum, Gomphonema tergestinum* and *Nitzschia dissipata* (91 %), *Amphora pediculus, Cymbella affinis, Diatoma moniliformis* and *Diatoma vulgaris* (82 %), *Navicula tripunctata, Surirella brebissoni* and *Ulnaria ulna* (73 %), *Encyonema ventricosum, Diatoma mesodon, Fragilaria capucina, Meridion circulaire* and *Navicula cryptotenelloides* (64 %), Cymbe*lla helvetica, Fragilaria acus, Gomphonema parvulum* and *Gomphonema pumilum* (55 %), *Gomphonema clavatum, Navicula antonii, Navicula caterva, Navicula oligotraphenta* and *Nitzschia lacuum* (45 %), *Cymatopleura solea, Diatoma ehrenbergii, Encyonema prostratum* and *Fragilaria biceps* (36 % of samples).

Among pennatae, the most abundant were *Achnanthidium minutissimum* (i.e. up to 17 % of diatom community in Viroi spring, 26 % in Kardhiqi river, 29 % in Bença – Tepelena, 31 % in Lekli, more than 44 % in Shalsi river, Mifoli and Benja); abundance of *Brachysira neoexilis* was 68 % in Benja thermal springs; *Cocconeis placentula* up to 65 % in Viroi, 50 % & 52 % in Dragoti & Qesarati, 41 % in Viroi, 37 % in Memaliaj, 21 % in Permeti, more than 30 % in Benja and Tepelena springs; *Cocconeis pediculus* up to 16 in Viroi springs; *Cymbella affinis* up to 52 % in Qesarati; *Cymbopleura amphicephala*, *Diatoma moniliformis* up to 20 % in Mifoli and Kordhoca, 29 % & 47 % in Dragoti, 38 % in Tepelena spring, 20 % in Lekli; *Gomphonema olivaceum* 23 % in Dragoti; *Meridion circulaire* 21 % in Sotira torrent; *Craticula halophila* 28 % in Benja thermal springs; *Nitzschia fonticola* 26 % in Kelcyra spring; *Nitzschia palea* 28 % in Benja; *Nitzschia incospicua* 30 % in Benja; *Nitzschia frustulum* 34 % in Benja springs; *Reimeria sinuata* up to 20 % in Çarshova; *Ulnaria ulna* 36 % in Shalsi springs.

Rare and little known species appear to present in Vjosa waters as well. *Caloneis* aff. *acedonica* Hustedt (Plate IV, Fig. 6) is likely to be a new species; it is mentioned also in other Albanian rivers by Kupe (2006), Mihoa et al. (2005), Kupe & Miho (2007), Hoxha (2008), Meço (2013), Ngjela (2016). Other difficult species include *Amphora* sp. (Plate III, Fig. 11), *Craticula* cf. *buderi* (Plate IV, Figs. 15–16), *Navicula* cf. *subrhynchocephala* (Plate V, Fig. 1), *Cymbopleura* cf. *diminuta* (Plate VII, Figs. 3–4), *Nitzschia* cf. *bremensis* (Plate IX, Fig. 6) and other taxa not reported in photos. Their exact determination, however, requires more expertise and further details, and probably a close cooperation with foreign experts.

Ecological approach: Diatom indices are reported in Table 1. TI_{DIA} ranged from 1.13 (Memaliaj, October 2006) to 2.81 in Çarshova (April 2010) (Kupe 2006, Kupe & Miho 2007). Relatively high values of TI_{DIA} show that the waters are polluted by inorganic matter and nutrients (nitrogen and phosphorous); considering the TI_{DIA} values, after Rott et al. (1999) the mean annual of the total phosphorous would be up to 0.1 mg/l (>0.65 mg/l as extreme value). But the SI values mainly indicate a low or moderate content of organic matter, and low or moderate impact, which is likely explained by a high capacity for self-purification of the Vjosa waters and its tributaries (Rott et al. 1997). From more than 45 periphyton

Tab. 1: Diatom indices from the Vjosa catchments (1996–2015); SI, Saprobic Index (Rott et al. 1997); TI_{DIA}, Trophieindex (Rott et al. 1999); IPS, Specific Pollution Sensitivity Index (Costein Cemagref 1982; corrected after Eloranta & Kwandrans 1996); N, Number of identified taxa; H', Shannon index (Shannon & Weaver 1949); Margalef Index, d (Margalef 1958); codes after AKM (2017). – Tab. 1: Diatomeenindizes aus den Vjosa-Einzugsgebieten (1996–2015); SI, Saprobitischer Index (Rott et al. 1997); TI_{DIA}, Trophieindex (Rott et al. 1999); IPS, spezifischer Verschmutzungsempfindlichkeitsindex (Coste in Cemagref 1982; korrigiert nach Eloranta & Kwandrans 1996); N, Anzahl der identifizierten Taxa; H ', Shannon-Index (Shannon & Weaver 1949); Margalef Index, d (Margalef 1958); Codes nach AKM (2017).

Station code or name	River	Station name	N	H'	d	TIDIA	TIDIAClass	SI	SI Class	IPS	IPS Class
06.09.1996 (Miho et al. 2005, Kupe 2006)											
Radova (Leskoviku)	*Çarshova*	Radova spring	13	2.4	1.89	2.8	Eupolytroph	1.6	I–II	14.59	Good
ALGW_607	Drino	Tepelena spring	17	2.7	2.49	2.6	Eutroph	1.6	I–II	14.09	Good
11.05.2002 & 12.05.2002 (Miho et al. 2005, Kupe 2006)											
AL70R_Lg20	Shalsi	Germenj (Leskoviku)	31	7.1	4.77	1.8	Mesotroph	1.7	I–II	15..94	Good
AL70R_Lg20	Shalsi	Germenj (Leskoviku)	25	3	3.80	2.9	Eupolytroph	1.7	I–II	15.47	Good
Radova (Leskoviku)	*Çarshova*	Radova spring	13	2.6	1.97	2.6	Eutroph	2.1	II	11.59	Moderate
Kelcyra (Permeti)	Vjosa	Kelcyra spring	26	2.5	3.68	2.0	Mesoeutroph	2.1	II	15.47	Good
Kelcyra (Permeti)	Vjosa	Kelcyra spring	26	3.4	4.00	2.3	Eutroph	1.8	II	15.30	Good
ALGW_607	Drino	Tepelena spring	22	3.0	3.31	2.3	Eutroph	1.5	I–II	16.80	Good
Sotira (Gjirokastra)	Drino	Sotira torrent	19	3.2	2.86	2.5	Eutroph	1.8	II	17.06	Good
10.05.2004 (Miho et al. 2005, Kupe 2006)											
AL70R_Lg20	Shalsi	Germenj (Leskoviku)	35	2.51	5.46	1.9	Mesoeutroph	–	–	17.38	Good
AL70R_Vj40 / AL060E02	Vjosa	Dragoti	44	3.29	6.76	2.1	Mesoeutroph	–	–	14.31	Good
AL70R_Vj50	Vjosa	Mifoli	28	2.92	4.32	1.5	Oligo-mesotroph	–	–	16.61	Good
22.10.2005 (Hoxha 2008)											
Benja	Lengarica	Benja thermal springs	9–23	2.1–3.3	1.74–4.78	1.4–3.3	Oligo- to Eu-polytroph	1.6–2.4	I–II to II	5.33–17.54	Poor – High
06.10.2006 & 07.10.2006 (Jaupaj 2007, Miho et al. 2008, 2010)											
AL70R_Vj10	Vjosa	Çarshova	28	4.18	4.35	2.81	Eu-polytroph	1.95	II	14.9	Good
AL70R_Vj20	Vjosa	Permeti	23	2.15	4.19	2.61	Eutroph	1.91	II	13.1	Good
AL70R_Vj40 / AL060E02	Vjosa	Dragoti	24	2.85	3.67	2.39	Eutroph	1.85	II	15.5	Good
AL70R_Di60	Drino	Lekli	32	3.28	4.91	2.31	Eutroph	1.72	I–II	15.4	Good

Tab. 1 continued – Fortsetzung

Station code or name	River	Station name	N	H'	d	TIDIA	TIDIAClass	SI	SI Class	IPS	IPS Class
AL70R_Vj50	Vjosa	Memaliaj	54	2.74	–	1.13	Oligotroph	1.91	II	14.8	Good
AL100E01	Vjosa	Qesarati	21	1.95	3.57	2.36	Eutroph	1.74	I–II	15.7	Good
Kuta	Vjosa	Kuta	62	4.34	9.65	2.38	Eutroph	1.73	I–II	14.89	Good
AL70R_Vj50	Vjosa	Mifoli	17	0.85	2.44	1.47	Oligo-meso-troph	1.60	I–II	16.73	Good
Date 01.02.2010 & 16.04.2010 (Reservoirs) (Sejdo 2010)											
Ballshi	Vjosa	Ballshi reservoir	38	2.88	4.98	1.8	Mesotroph	1.7	I–II	17.52	High
AL70LK_Kr20	Vjosa	Krahsi, Tepelena	35, 56	3.90, 4.33	8.37, 8.94	2.7, 1.8	Eupolytroph–Mesotroph	2.1, 1.3	II, I	11.08, 16.17	Moderate – Good
AL70LK_Vi10	Drino	Viroi spring, Gji-rokastra	22–59	1.95–3.27	3.2–4.5	2.0–2.4	Mesoeu-troph–Eu-troph	1.7–1.8	I–II	17.35–17.57	High
November 2011 (Black Spring); date 17 & 21.04.2012 (Meço 2013, Meço et al., 2014)											
Black spring	Vjosa	Black spring	41	1.92	6.31	2.3	Eutroph	2.1	II	15.28	Good
AL70LK_Vi10	Drino	Viroi spring	34	2.82	5.30	2.2	Eutroph	1.7	I–II	18.06	High
AL70LK_Vi10	Drino	Viroi reservoir	29	2.9	4.39	1.6	Oligo-meso-troph	1.4	I–II	15.28	Good
AL70R_Vj50	Vjosa	Mifoli	23	1.42	3.48	2.2	Eutroph	1.8	II	16.01	Good
Mifoli in 30.03.2015; Çajupi **spring in 22.03.2014; Gusmari in 19.07.2004; the others on 04 April, 2015 (Ngjela 2016)**											
AL70R_Vj50	Vjosa	Mifoli	50	–	7.53	–	–	–	–	15.58	Good
AL100E01	Vjosa	Qesarati	24	–	3.64	–	–	–	–	15.43	Good
AL70R_Vj40 / AL060E02	Vjosa	Dragoti	26	–	4.03	–	–	–	–	15.76	Good
AL70R_Di60	Drino	Lekli	47	–	7.39	–	–	–	–	14.36	Good
Bença	Bença	Tepelena	28	–	4.40	–	–	–	–	16.46	Good
AL70R_Di30 / AL030E02	Drino	Drino river, Viroi	60	–	9.47	–	–	–	–	11.88	Moderate
AL70R_Di30	Drino	Viroi spring	23	–	3.54	–	–	–	–	15.70	Good
AL70R_Di40	Kardhiqi	Kardhiqi	25	–	3.90	–	–	–	–	13.70	Good
AL70R_Di20 / AL030E01	Drino	Kordhoca	22	–	3.30	–	–	–	–	15.70	Good
Çajupi	Çajupi	Çajupi spring	42	–	6.70	–	–	–	–	15.60	Good
Gusmari	Gusmari	Gusmari reservoir	27	–	4.21	–	–	–	–	14.97	Good

Tab. 2: List of the dominant taxa (exceeding 3 %) in 9 river stations of Vjosa, Drino, etc. in 05.04.2015, except Kordhoca / Drino in 03.04.2016 (Ngjela 2016). – Tab. 2: Liste der dominanten Taxa (über 3 %) in 9 Flussstationen von Vjosa, Drino usw. am 05.04.2015, außer Kordhoca / Drino am 03.04.2016 (Ngjela 2016).

***Name of species* / Station / River**	**Mifoli / Vjosa**	**Qesarati / Vjosa**	**Dragoti / Vjosa**	**Lekli / Vjosa**	**Tepelena / Vjosa**	**Viroi / Drino**	**Viroi / Spring**	**Kardhiqi / River**	**Kordhoca / Drino**
Centrales									
Melosira varians Agardh	0.1	0.2		1		17.9		0.2	
Pennales									
Achnanthidium minutissimum (Kützing) Czarnecki	8.8	4.5	5.7	10.8	37	8.1	17	26.4	29.2
Amphora pediculus (Kützing) Grunow	0.6		0.8	1.6	5.9	2	3.6	3.2	1.2
Cocconeis placentula Ehrenberg var. placentula	3.7		0.6	1.2	2.6	8.1	64.5	0.2	0.5
*Cymbella affinis K*ützing	2.4	51.9	1.2	0.8		1.2	0.2	0.2	1.2
Diatoma ehrenbergii Kützing	0.1	0.5		3.2				0.2	
Diatoma moniliformis Kützing	20.7	8.3	47	19.7	0.7	3.4		1.3	20.6
Fragilaria capucina Desmazières agg.	2.4		5.5	2.4		2.4			2.7
Gomphonema olivaceum (Hornemann) Brebisson gr.	22.8	16.8	15.7	12.4	1.3	5.1	0.2	16.9	14.9
Gomphonema pumilum (Grunow) Reichardt & Lange-Bertalot	1.9			0.4	3.3	1		8.9	
Gomphonema tergestinum Fricke	1	7.4	7.3	4.9	16.7	3.2	0.2	12.9	6.3
Navicula caterva Hohn & Hellerman	3.4			0.2	1.5	2.6			
Navicula cryptotenelloides Lange-Bertalot		0.2	0.4	3	1.1	0.8		2.3	
Navicula tripunctata (O. F. Müller) Bory	3.4		1.6	3.4	1.3	1.4	2.6	0.6	0.7
Nitzschia dissipata (Kützing) Grunow	10.9	0.4	4.1	7.3	0.9	6.1	1.4		6.9
Nitzschia dissipata var. *media* (Hantzsch) Grunow								8.5	
Nitzschia incospicua Grunow	0.1								
Nitzschia lacuum Lange-Bertalot		0.2			13.3	0.4		0.6	
Nitzschia linearis (Agarth) W. Smith	1.5	0.7	0.6	0.6	0.2	3.2	0.2	0.2	1.5
Nitzschia littoralis Grunow					0			0	
Nitzschia palea (Kützing) W. Smith	2.1	0.9	0.6	7.1	3.7	12.8	1.4	11.2	2.4
Surirella brebissoni Krammer & Lange-Bertalot	2.1		1	3.2	0.4	4.5		0.4	1.9
Ulnaria ulna (Nitzsch) Compère	1.8	2.9	1.6	2		1.8	0.8		3.8

Tab. 3: List of the dominant taxa (exceeding 3 %) with their maximum relative abundance (RA) and their presence (%) in 9 various habitats of Benja thermal springs (Lengarica River) in 22.10.2005 (Hoxha 2008). – Tab. 3: Liste der dominanten Taxa (über 3 %) mit ihrer maximalen relativen Häufigkeit (RA) und ihrer Anwesenheit (%) in 9 verschiedenen Lebensräumen der Benja Thermalquellen (Lengarica River) am 22.10.2005 (Hoxha 2008).

Name of species	**Maximal RA (%)**	**Presence (%)**
Centrales		
Cyclotella commensis Hustedt	9.8	56
Pennales		
Achnanthes exigua var. elliptica Hustedt	27	44
Achnanthidium minutissimum (Kützing) Czarnecki	48.6	100
Amphora pediculus (Kützing) Grunow	34.3	33
Brachysira neoexilis Lange-Bertalot	68	33
Caloneis sp. (nov. sp.)	4.8	56
Cocconeis placentula Ehrenberg	33.3	67
Craticula halophila (Grunow) D.G.Mann	28.1	22
Cymbella affinis Kützing	4.4	22
Denticula tennius Kützing	12.1	11
Diatoma mesodon (Ehrenberg) Kützing	19.3	11
Diatoma moniliformis Kützing	48.2	11
Diatoma tenuis Agardh	4.2	22
Diatoma vulgaris Bory gr.	22.1	22
Encyonema ventricosum (C.Agardh) Grunow	5.7	33
Fragilaria biceps (Kützing) Hustedt	7	11
Fragilaria capucina Desmazières agg.	3.9	11
Frustulia vulgaris (Thwaites) De Toni	3.9	22
Gomphonema olivaceum (Hornemann) Brebisson gr.	5.2	11
Gomphonema pumilum (Grunow) Reichardt & Lange-Bertalot	10.4	33
Meridion circulaire (Grewille) Agardh var. *circulaire*	10.9	22
Navicula capitatoradiata Germain	11.2	11
Navicula caterva Hohn & Hellerman	5.3	11
Navicula cryptotenelloides Lange-Bertalot	8.6	55
Navicula erifuga Lange-Bertalot	8.0	33
Navicula veneta Kützing	15.1	11
Navicymbula pusilla (Grunow) Krammer	4.9	33
Nitzschia denticula Grunow	4.7	22
Nitzschia dissipata (Kützing) Grunow	9.6	22
Nitzschia frustulum (Kützing) Grunow	34.1	11
Nitzschia incospicua Grunow	30.0	33
Nitzschia palea (Kützing) W. Smith var. *palea*	28.3	55
Nitzschia palea var. debilis (Kützing) Grunow	18.5	22
Nitzschia recta Hantzsch	5.9	11
Rhopalodia brebissonii Krammer	3.4	11
Tryblionella apiculata Gregory	4.1	44
Ulnaria ulna (Nitzsch) Compère	13.1	44

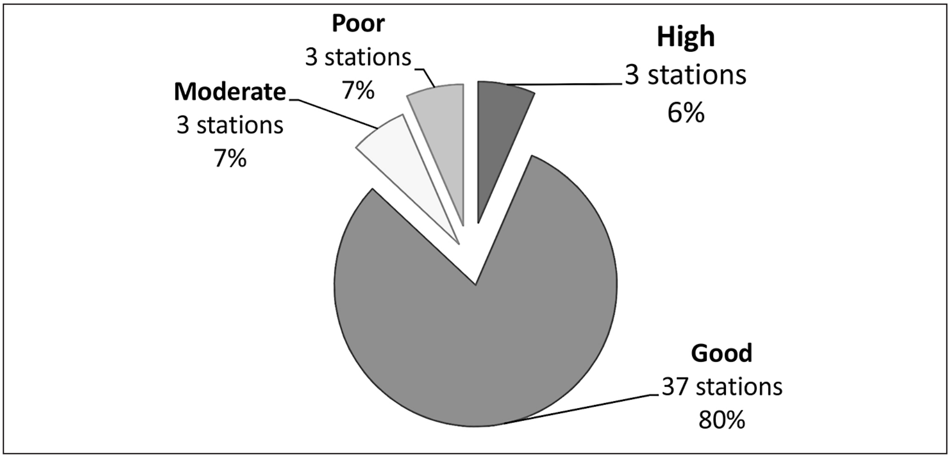


Fig. 3: Ecological quality overview in the Vjosa basin (up to yr. 2015, Tab. 1) according to the IPS; the colours are after Water Framework Directive (WFD 2000). – Abb. 3: Überblick über die ökologische Qualität im Vjosa-Becken (bis zum Jahr 2015; Tab. 1) gemäß dem IPS; Die Farben sind nach der Wasserrahmenrichtlinie (WFD 2000).

samples assessed, IPS classes in 40 samples were of Good or High quality. Only 6 samples were of Poor or Moderate quality, most of them in Benja springs (Tab. 1, Fig. 3) (quality colors after WFD, 2000).

Of the similar studies on the ecological quality of the Vjosa catchment, Gjini et al. (2015) should be mentioned here. The team studied diatoms in Viroi lake (Gjirokastra) during the summer of 2011. A total of 83 taxa were identified, belonging to *Nitzschia* (16 taxa), *Navicula* (10 taxa), *Gomphonema* (6 taxa), *Surirella* (6 taxa), and *Cymbella* (4 taxa). Based on the presence of indicator species, the ecological water quality was I-II (oligo-mesosaprobious to beta-mesosaprobious). Gjini et al. (2013) also reported the diatoms in Drino River (Gjirokastra); 5 stations were sampled during autumn of 2012; about 69 taxa were identified, belonging to *Nitzschia* (12 taxa), *Navicula* (9 taxa), *Cocconeis* (3 taxa), *Surirella* (4 taxa) etc. According to the bioindicator species, the ecological quality of waters was classified into class II (beta-mesosaprobic).

According to Prifti et al. (2014), the phosphorous content in the Vjosa river varied from 0.01 to 0.39 mg/l (average 0.095–0.2 mg/l), measured twice during June-December 2012 in only 2 stations: Tri Urat (Çarshova) and Mifoli. Duka & Vallja (pers. comm.) report that the level of phosphorous varied from about 0.01 mg/l P-PO4 in the River Bença (Tepelena town), to more than 0.072 mg/l P-PO4 in Mifoli (Vjosa River). Setting aside the fact that the reported data are very general, they show that the trophic state of waters change from meso- to hypertrophic (OECD 2006, Carlson & Simpson 1996), providing confirmation of our diatom indexes reported in Table 1.

Conclusions: The diatom community from more than 45 periphyton samples from Vjosa catchment is considered here, sporadically collected during the period 1996–2015. About 20 samples are from the Vjosa river (from Mifoli to Çarshova), the rest from its tributaries (Drino, Shalsi, Kardhiqi, etc.), springs (Kelcyra, Tepelena, Benja, Viroi, etc.), or reservoirs (Krahsi, Viroi, Gusmari, etc.). 252 taxa of diatoms were identified, most of them pennatae (about 230 taxa); more than 110 taxa were found in the Vjosa River. Beside the examination of algal diversity, our efforts were focussed on training young experts to be able to monitor the ecological status of surface waters according to the Water Framework Directive (WFD 2000); several diatom indices were calculated: SI, Saprobic Index (Rott et al. 1997); TI_{DIA}, Trophic Index (Rott et al. 1999); IPS, Specific Pollution Sensitivity Index (Coste in Cemagref 1982; corrected after Eloranta & Kwandrans 1996), etc. Based on these indices, the ecological quality of waters in the Vjosa catchment appears to be of good quality. However, the waters may contain pollution from inorganic mater, nutrients (nitrogen and phosphorous), but with a low or moderate impact, probably due to the self-purification capacity of rivers. High microbiological values were also found in the parts of the river close to urban centres (Hamzaraj et al., pers. comm.).

Many countries have adopted a single, well-described approach for monitoring river water quality, which involves the use of indices related to diatom composition at a site. Albania is making efforts to meet EU environmental criteria, including monitoring the ecological state of surface waters according to the European Water Framework Directive (WFD 2000). Diatom composition and related indices belong to the elements of routine monitoring and can be easily applied and supported, including to the waters of the Vjosa catchment. Applying these methods would help authorities in developing future conservation and management concepts, especially regarding the large-scale expansion of dams and non-sustainable hydropower development plans in the near future.

Acknowledgments

Part of the study was carried out within the framework of the project *Assessment of biodiversity and bioquality of Vjosa riverscape and its tributaries* (June 2016 – May 2017), supported by FNS, UT. Field trips were partly supported by the Save the Blue Heart of Europe campaign. Authors are thankful to EcoAlbania for the logistic support provided during field survey. We would like to thank Dr. Bohuslav Uher who kindly revised the English style of the submitted version.

Annex

Annex I: Checklist of diatoms found in different aquatic habitats (given in table 1) of Vjosa catchment. – Anhang I: Checkliste der Kieselalgen in verschiedenen aquatischen Lebensräumen (in Tabelle 1) des Vjosa-Einzugsgebiets.

Centrales

Cycllotella distinguenda Hustedt
Cycllotella radiosa (Grunow) Lemmermann
Cyclotella commensis Hustedt
Cyclotella cyclopuncta Håkansson
Cyclotella ocellata Pantocsek
Cyclotella pseudostelligera Hustedt
*Handmannia glabriuscula (*Grunow) Kociolek & Khursevich
Melosira varians Agardh
Stephanodiscus alpinus Hustedt
Stephanodiscus hantzschii Grunow
Stephanodiscus medius Håkansson
Stephanodiscus parvus Håkansson

Pennales

Achnanthes brevipes C.Agardh
Achnanthes exigua var. *elliptica* Hustedt
Achnanthidium caledonicum (Lange-Bertalot) Lange-Bertalot) (=*Achnanthes minutissima* var. *scotica* (Carter) Lange-Bertalot)
Achnanthidium catenatum (Bily & Marvan) Lange-Bertalot

Achnanthidium eutrophilum (Lange-Bertalot) Lange-Bertalot
Achnanthidium exile (Kützing) Heiberg
Achnanthidium minutissimum (Kützing) Czarnecki
Adlafia minuscula var. *muralis* (Grunow) Lange-Bertalot
Amphipleura pellucida Kützing
Amphora inariensis Krammer
Amphora lybica Ehrenberg
Amphora montana Krasske
Amphora ovalis (Kützing) Kützing
Amphora pediculus (Kützing) Grunow
Amphora sp.
Anomoeoneis sphaerophora Pfitzer
Brachysira calcicola Lange-Bertalot
Brachysira neoexilis Lange-Bertalot
Caloneis aff. *macedonica* Hustedt
Caloneis bacillum (Grunow) Cleve
Caloneis fontinalis (Grunow) Cleve-Euler
Caloneis hyalina Hustedt
Caloneis lancettula (Schulz) Lange-Bertalot & Witkowski
Caloneis macedonica Hustedt
Caloneis schumanniana (Grunow) Cleve
Caloneis silicula (Ehrenberg) Cleve agg.
Caloneis tenuis (Gregory) Krammer
Cocconeis neodiminuta Krammer
Cocconeis pediculus Ehrenberg
Cocconeis placentula Ehrenberg var. *placentula*
Cocconeis placentula var. *lineata* (Ehrenberg) Van Heurck
Craticula accomoda (Hustedt) D.G.Mann
Craticula cf. *buderi (Hustedt) Lange-Bertalot*
Craticula cuspidata (Kutzing) D.G.Mann
Craticula halophila (Grunow) D.G.Mann
Craticula molestiformis (Hustedt) Mayama
Ctenophora pulchella (Ralfs ex Kützing) Williamms et Round
Cymatopleura solea (Brebisson) W. Smith
Cymbella affinis Kützing
Cymbella aspera (Ehrenberg) H.Peragollo
Cymbella cantonati Krammer
Cymbella cf. *turgidula* Grunow (cf. var. *venezuelana* Krammer)
Cymbella cistula (Ehrenberg) Kirchner
Cymbella cymbiformes Agardh
Cymbella helvetica Kützing
Cymbella laevis Nägeli
Cymbella lanceolata (Ehrenberg) Kirchner
Cymbella lange-bertalotii Krammer
Cymbella subhelvetica Krammer
Cymbella tumida (Brebissoni) Van Heurck
Cymbopleura amphicephala (Nägeli) Krammer
Cymbopleura cf. *diminuta (Grunow) Krammer*
Cymbopleura cuspidata (Kützing) Krammer
Cymbopleura incerta (Grunow) Krammer
Delicata delicatula (Kützing) Krammer (=*Cymbella delicatula* Kützing)
Denticula tennius Kützing
Diatoma ehrenbergii Kützing
Diatoma hyemalis (Roth) Heiberg
Diatoma hyemalis (Roth) Heiberg
Diatoma mesodon (Ehrenberg) Kützing
Diatoma moniliformis Kützing
Diatoma tenuis C. Agardh
Diatoma vulgaris Bory gr.
Diatoma vulgaris var. *ovalis* (Fricke) Hustedt
Diploneis ellyptica (Kützing) Cleve
Diploneis marginestriata Hustedt
Diploneis notabilis (Greville) Cleve
Diploneis oblongella (Nägeli) Cleve-Euler
Diploneis oculata (Brebisson) Cleve
Diploneis ovalis (Hilse) Cleve
Diploneis puella (Schumann) Cleve
Encyonema leibleinii (C.Agardh) W.J.Silva, R.Jahn, T.A.Veiga Ludwig & M.Menezes (=*Encyonema prostratum* (Berkeley) Kützing)
Encyonema minutiforme Krammer
Encyonema minutum (Hilse) D.G.Mann
Encyonema silesiacum (Bleisch) D.G.Mann
Encyonema ventricosum (C.Agardh) Grunow
Encyonopsis descripta (Hustedt) Krammer
Encyonopsis microcephala (Grunow) Krammer gr.
Encyonopsis subminuta Krammer & Reichardt
Eolimna minima (Grunow) Lange-Bertalot & W.Schiller
Epithemia adnata (Kützing) Brebisson
Epithemia smithii Carruthers
Epithemia sorex Kützing
Epithemia turgida (Ehrenberg) Kützing
Eunotia arcus Ehrenberg
Eunotia bidens Ehrenberg
Eunotia sp.

Fallacia lenzii (Hustedt) Lange-Bertalot
Fallacia pygmaea (Kützing) Stickle & D.G.Mann
Fistulifera saprophila (Lange-Bertalot & Bonik) Lange-Bertalot
Fragilaria acus Kützing
Fragilaria biceps (Kützing) Hustedt
Fragilaria capucina Desmazières agg.
Fragilaria capucina var. *capitellata* (Grunow) Lange-Bertalot
Fragilaria capucina var. *distans* (Grunow) Lange-Bertalot
Fragilaria capucina var. *gracilis* (Oestrup) Hustedt
Fragilaria capucina var. *rumpens* (Kützing) Lange-Bertalot
Fragilaria capucina var. *vaucheriae* (Kützing) Lange-Bertalot
Fragilaria construens (Ehrenberg) Grunow fo. *construens*
Fragilaria crotonensis Kitton
Fragilaria exigua Grunow
Fragilaria lata (A.Cleve) Renberg
Fragilaria tenera (W.Smith) Lange-Bertalot
Frustulia spicula Amosse
Frustulia vulgaris (Thwaites) De Toni
Geissleria decussis (Ostrup) Lange Bertalot & Metzeltin
Gomphoneis transsilvanica (Pantocsek) Krammer
Gomphonema acuminatum Ehrenberg
Gomphonema angustatum (Kützing) Rabenhorst
Gomphonema capitatum Ehrenberg
Gomphonema clavatum Ehrenberg
Gomphonema exilissimum (Grunow) Lange-Bertalot & Reichardt
Gomphonema hebridense Gregory
Gomphonema insigne Gregory
Gomphonema micropus Kützing
Gomphonema minutiforme Lange-Bertalot & Reichardt
Gomphonema minutum (Agardh) Agardh agg.
Gomphonema olivaceum (Hornemann) Brebisson gr.
Gomphonema parvulum Kützing agg.
Gomphonema pseudotenellum Lange-Bertalot
Gomphonema pumilum (Grunow) Reichardt & Lange-Bertalot
Gomphonema pumilum var. *elegans* Reichardt & Lange-Bertalot
Gomphonema sarcophagus Gregory
Gomphonema tergestinum Fricke
Gomphonema truncatum Ehrenberg
Gomphonema vibrio Ehrenberg
Grunowia solgensis (A.Cleve) Aboal (=*Nitzschia sinuata* var. *delognei* (Grunow) Lange-Bertalot)
Grunowia tabellaria (Grunow) Rabenhorst (=*Nitzschia sinuata* var. *tabellaria* (Grunow) Grunow)
Gyrosigma acuminatum (Kützing) Rabenhorst
Gyrosigma nodiferum (Grunow) Reimar
Gyrosigmas calproides (Rabenhorst) Cleve
Halamphora veneta (Kützing) Levkov (=*Amphora veneta* Kützing)
Hannaea arcus (Ehrenberg) R.M.Patrick
Hantzschia amphyoxys (Ehrenberg) Grunow
Hippodonta capitata (Ehrenberg) Lange-Bertalot, Metzeltin & Witkowski
Kolbesia gessneri (Hustedt) Aboal (=*Achnanthes ploenensis* var. *gessneri* (Hustedt) Lange-Bertalot)
Luticola cohnii (Hilse) D.G.Mann
Luticola nivalis (Ehrenberg) D.G. Mann
Luticula mutica (Kützing) D. G. Mann
Luticula paramutica (W. Bock) D.G.Mann
Mastoglia cf. *pumilla* (Grunow) Cleve
Mastogloia elliptica (Agardh) Cleve
Mastogloia smithii Thwaites var. smithii
Mastogloia smithii var. lacustris Grunow
Mayamaea atomus (Kützing) Lange-Bertalot
Meridion circulaire (Grewille) Agardh var. *circulaire*
Navicula amphiceropsis Lange-Bertalot & Rumrich
Navicula antonii Lange-Bertalot
Navicula capitatoradiata Germain
Navicula cari Ehrenberg
Navicula caterva Hohn & Hellerman
Navicula cf. *microcari* Lange-Bertalot
Navicula cf. *subrhynchocephala* Hustedt
Navicula cincta (Ehrenberg) Ralfs
Navicula cryptocephala Kützing
Navicula cryptotenella Lange-Bertalot
Navicula cryptotenelloides Lange-Bertalot
Navicula dealpina Lange-Bertalot
Navicula digitoconvergens Lange-Bertalot

Navicula erifuga Lange-Bertalot
Navicula jakovljevicii Hustedt
Navicula leptostriata Jørgensen
Navicula menisculus Schumann
Navicula minima Grunow
Navicula novasiberica Lange-Bertalot
Navicula oligotraphenta Lange-Bertalot & Hofmann
Navicula pseudoppugnata Lange-Bertalot & Miho
Navicula radiosa Kützing
Navicula reichardtiana Lange-Bertalot
Navicula schroeteri Meister
Navicula sp.
Navicula splendicula Van Landingham
Navicula tripunctata (O. F. Müller) Bory
Navicula trivialis Lange-Bertalot
Navicula veneta Kützing
Navicula viridula (Kützing) Ehrenberg
Navicymbula pusilla (Grunow) Krammer
Nitzschia acicularis (Kützing) W.Smith
Nitzschia alpina (Hustedt) Lange-Bertalot
Nitzschia amphibia Grunow
Nitzschia angustata (W. Smith) Grunow
Nitzschia angustatula Lange-Bertalot
Nitzschia cf. *bremensis* Hustedt
Nitzschia clausii Hantzsch
Nitzschia denticula Grunow
Nitzschia dissipata (Kützing) Grunow
Nitzschia dissipata var. *media* (Hantzsch) Grunow
Nitzschia draveillensis Coste et Ricard
Nitzschia dubia W.Smith
Nitzschia elegantula Grunow
Nitzschia fonticola Grunow
Nitzschia frustulum (Kützing) Grunow
Nitzschia gracilis Hantzsch
Nitzschia heufleriana Grunow
Nitzschia incospicua Grunow
Nitzschia intermedia Hantzsch
Nitzschia lacuum Lange-Bertalot
Nitzschia linearis (Agarth) W. Smith var. *linearis*
Nitzschia littoralis Grunow
Nitzschia palea (Kützing) W. Smith var. *palea*
Nitzschia palea var. *debilis* (Kützing) Grunow
Nitzschia perminuta (Grunow) M.Peragallo
Nitzschia recta Hantzsch
Nitzschia sigmoidea (Nitzsch) W. Smith
Nitzschia solita Hustedt
Nitzschia sp.
Nitzschia subacicularis Hustedt
Nitzschia vermicularis (Kützing) Hantzsch
Pinnularia brebissonii (Kützing) Rabenhorst
Pinnularia interrupta W.Smith
Pinnularia microstauron (Ehrenberg) Cleve
Pinnularia neomajor Krammer
Pinnularia obscura Kraske
Pinnularia sp.
Pinnularia viridiformis Krammer
Placoneis placentula (Ehrenberg) Mereschkowsky
Planothidium frequentissimum (Lange-Bertalot) Lange-Bertalot
Planothidium lanceolatum (Brébisson ex Kützing) Lange-Bertalot
Reimeria sinuata (W.Gregory) Kociolek & Stoermer
Rhoicosphenia abbreviata (Agardh) Lange-Bertalot
Rhopalodia brebissonii Krammer
Rhopalodia gibba (Ehrenberg) O. Müller
Sellaphora bacillum (Ehrenberg)D.G.Mann
Sellaphora pupula (Kützing) Mereschkowksy
Sellaphora seminulum (Grunow) D.G.Mann
Sellaphora submuralis (Hustedt) C.E.Wetzel, L.Ector, B.Van de Vijver, Compère & D.G.Mann
Stauroneis agrestis Petersen
Stauroneis anceps Ehrenberg
Surirella angusta Kützing
Surirella brebissoni Krammer & Lange-Bertalot
Surirella brebissonii var. *kuetzingii* Krammer & Lange-Bertalot
Surirella gracilis Grunow
Surirella linearis var. *helvetica* (Brun) F. Meister
Surirella linearis W. Smith var. *linearis*
Surirella minuta Brébisson
Surirella ovalis Brébisson
Surirella sp.
Surirella splendida (Ehrenberg) Kützing
Surirella tenera W. Gregory
Tryblionella apiculata Gregory (=Nitzschia constricta (Kützing) Ralfs)
Ulnaria ulna (Nitzsch) Compère

Plate I: 1, *Stephanodiscus medius*; 2, *Handmannia glabriuscula*; 3, *Cyclotella cyclopuncta*; 4, *C. comensis*; 5, *C. ocellata*; 6, *C. meneghiniana*; 7, *Melosira varians*; 8–9, *Meridion circulaire*; 10, *Diatoma mesodon*; 11, *D. vulgaris*; 12, *D. moniliformis*; 13, *D. tenuis*; 14, *D. hyemalis* (9, Gramozi lake, Erseka; the rest from Benja thermal springs, Permeti). – Tafel I: 1, *Stephanodiscus medius*; 2, *Handmannia glabriuscula*; 3, *Cyclotella cyclopuncta*; 4, *C. comensis*; 5, *C. ocellata*; 6, *C. meneghiniana*; 7, *Melosira varians*; 8–9, *Meridion circulaire*; 10, *Diatoma mesodon*; 11, *D. vulgaris*; 12, *D. moniliformis*; 13, *D. tenuis*; 14, *D. hyemalis* (9, Gramozi See, Erseka; der Rest von Benja Thermalquellen, Permeti).

PLATE I

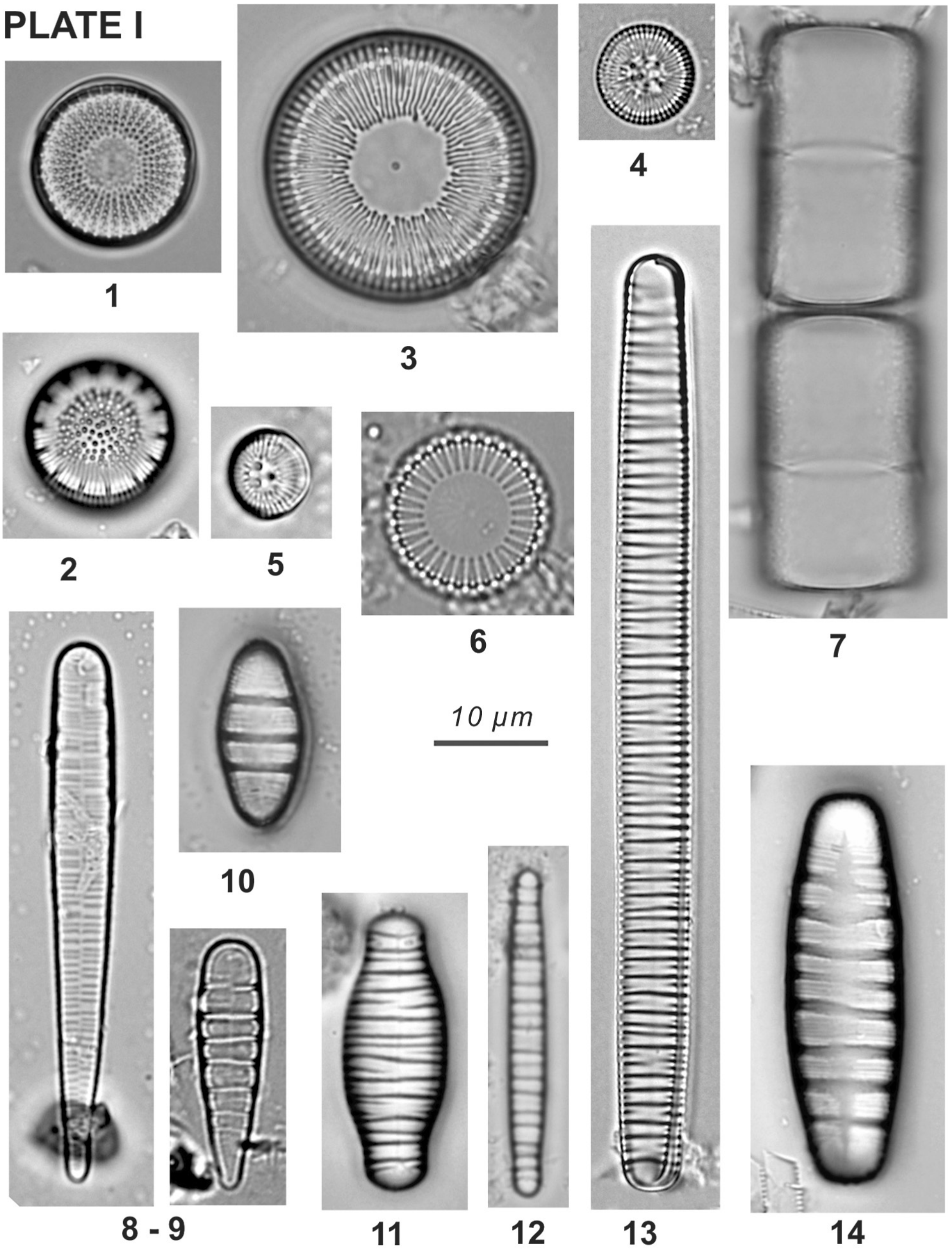


Plate II: 1, Diatoma ehrenbergii; 2, *Ulnaria ulna*; 3, *Fragilaria tenera*; 4, *Ctenophora pulchella*; 5, *Fragilaria capucina* var. *rumpens*; 6, *F. capucina*; 7–8, *F. capucina* var. *gracilis*; 9, *F. biceps*; 10, *F. acus*; 11–12, *Achnanthidium minutissimum*; 13, *A. eutrophilum*;14–15, *Planothidium lanceolatum* (5, Lekli, Drino river, Tepelena; 10, Black spring, Permeti; 15, Viroi spring, Gjirokastra; 16, Zhuka, Vjosa river, Vlora; the rest from Benja thermal springs, Permeti). – Tafel II: 1, Diatoma ehrenbergii; 2, *Ulnaria ulna*; 3, *Fragilaria tenera*; 4, *Ctenophora pulchella*; 5, *Fragilaria capucina* var. *rumpens*; 6, *F. capucina*; 7–8, *F. capucina* var. *gracilis*; 9, *F. biceps*; 10, *F. acus*; 11–12, *Achnanthidium minutissimum*; 13, *A. eutrophilum*;14–15, *Planothidium lanceolatum* (5, Lekli, Drino, Tepelena; 10, Schwarzer Quelle, Permeti; 15, Viroi Quelle, Gjirokastra; 16, Zhuka, Vjosa Fluss, Vlora; der Rest von Benja Thermalquellen, Permeti).

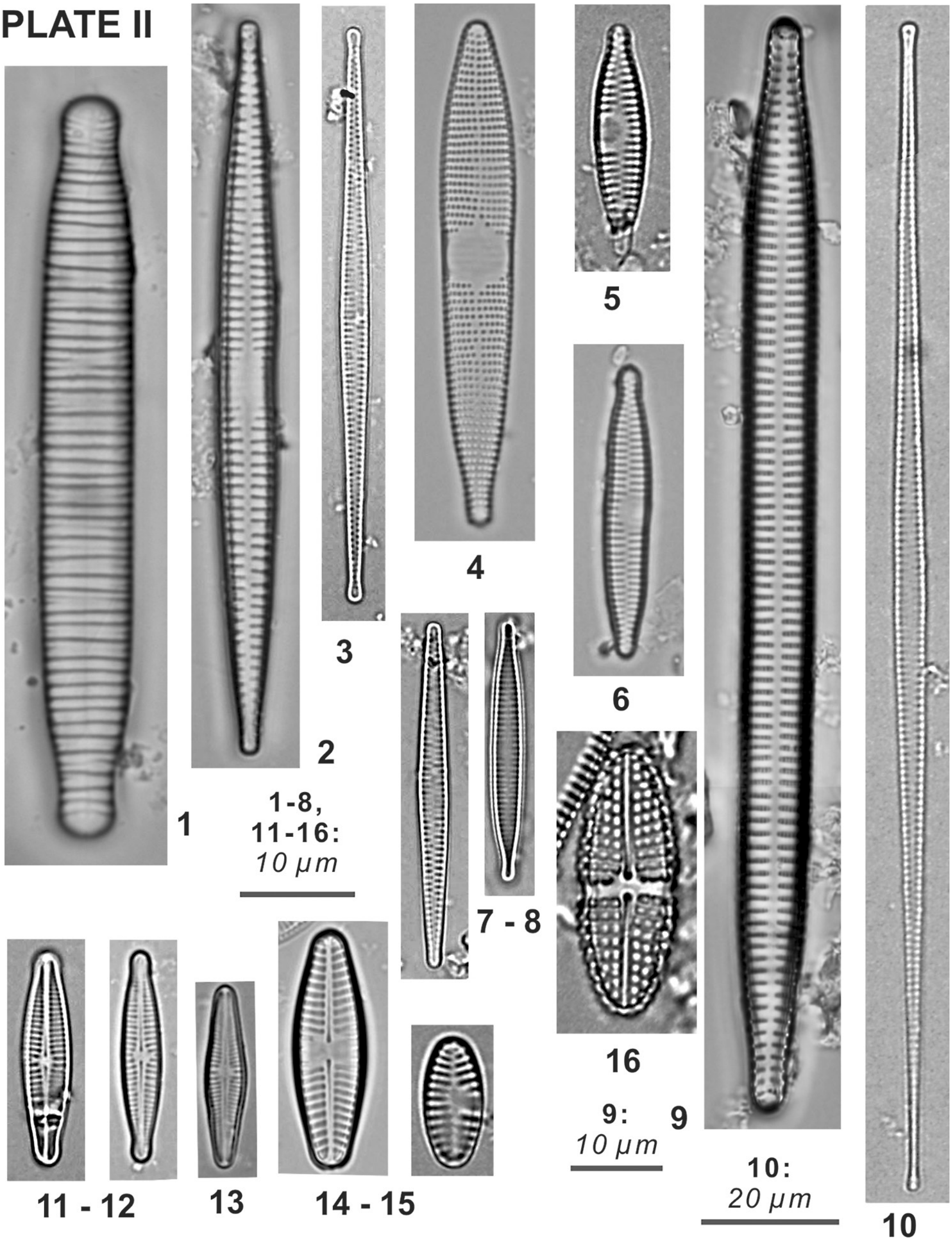


Plate III: 1, *Cocconeis pediculus*; 2–3, *C. placentula* var. *lineata*; 4, *C. neodiminuta*; 5–6, *Rhoicosphenia abbreviata*; 7, *Amphora pediculus*; 8, *A. libyca*; 9–10, *Halamphora veneta*; 11, *Amphora* sp.; 12–13, *Brachysira neoexilis*; 14–15, *Luticola mutica*; 16, *L. nivalis*; 17, *Navicula minima* (3, Mifoli, Vjosa river; 5–6, Black spring, Permeti; 7–9, Viroi spring, Gjirokastra; the rest from Benja thermal springs, Permeti). – Tafel III: 1, *Cocconeis pediculus*; 2–3, *C. placentula* var. *lineata*; 4, *C. neodiminuta*; 5–6, *Rhoicosphenia abbreviata*; 7, *Amphora pediculus*; 8, *A. libyca*; 9–10, *Halamphora veneta*; 11, *Amphora* sp.; 12–13, *Brachysira neoexilis*; 14–15, *Luticola mutica*; 16, *L. nivalis*; 17, *Navicula minima* (3, Mifoli, Vjosa Fluss; 5–6, Schwarzer Quelle, Permeti; 7–9, Viroi Quelle, Gjirokastra; der Rest von Benja Thermalquellen, Permeti).

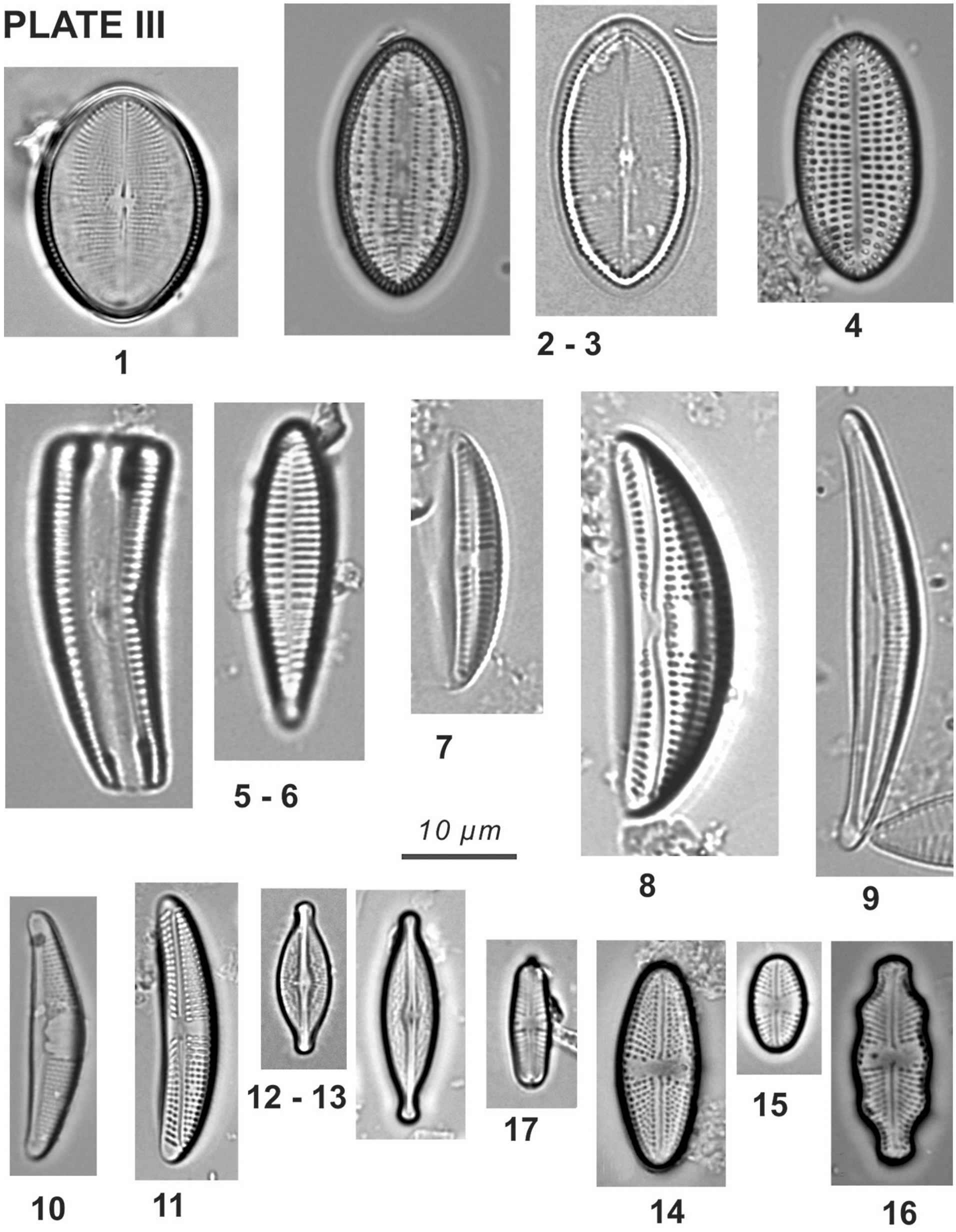


Plate IV: 1, *Mastogloia elliptica*; 2–3, 4?, *M. smithii*; 5, *Sellaphora pupula*; 6, *Caloneis* aff. *macedonica*; 7, *C. macedonica*; 8, *C. silicula*; 9–10, *C. lancettula*; 11, *Caloneis fontinalis*; 12, *Pinnularia obscura*; 13, *Craticula halophila*; 14, *C. cuspidata*; 15–16, *Craticula* cf. *Buderi* ?? (10, from Çajupi springs, the rest from Benja thermal springs, Permeti). – Tafel IV: 1, *Mastogloia elliptica*; 2–3, 4?, *M. smithii*; 5, *Sellaphora pupula*; 6, *Caloneis* aff. *macedonica*; 7, *C. macedonica*; 8, *C. silicula*; 9–10, *C. lancettula*; 11, *Caloneis fontinalis*; 12, *Pinnularia obscura*; 13, *Craticula halophila*; 14, *C. cuspidata*; 15–16, *Craticula* cf. *Buderi* ?? (10, aus Çajupi Quellen, der Rest von Benja Thermalquellen, Permeti).

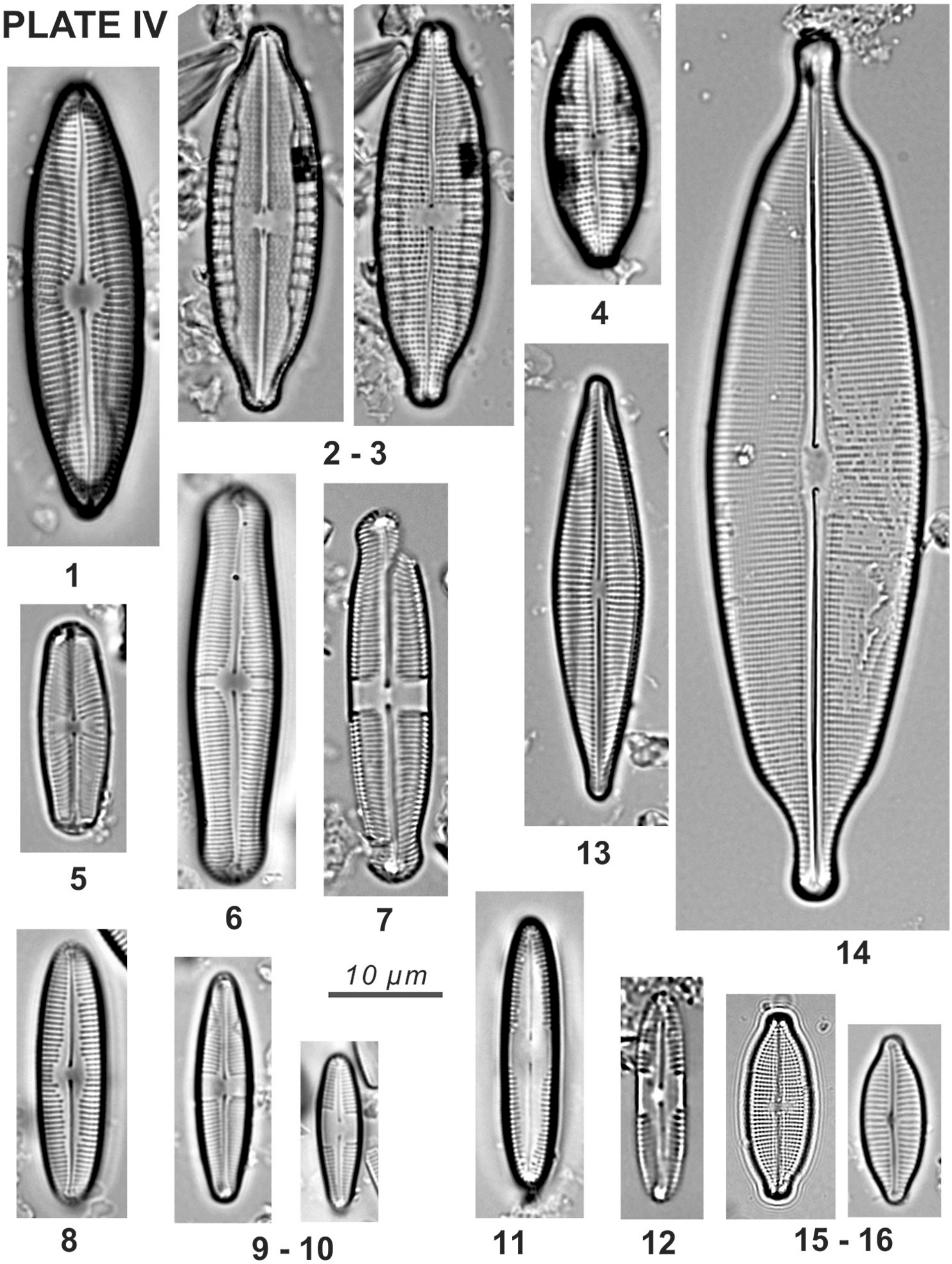


Plate V: 1, *Navicula* cf. *subrhynchocephala*; 2, *N. tripunctata*; 3, *N. dealpina*; 4, *N. jakovljevicii*; 5, *Navicula radiosa*; 6, *N. splendicula*; 7, *N. capitatoradiata*; 8–9, 16, *N. cincta*; 10–12, *N. cryptotenelloides*; 13, *N. cryptotenella*; 15, *N. veneta*; 15, *N. antonii* (from Benja thermal springs, Permeti). – Tafel V: 1, *Navicula* cf. *subrhynchocephala*; 2, *N. tripunctata*; 3, *N. dealpina*; 4, *N. jakovljevicii*; 5, *Navicula radiosa*; 6, *N. splendicula*; 7, *N. capitatoradiata*; 8–9, 16, *N. cincta*; 10–12, *N. cryptotenelloides*; 13, *N. cryptotenella*; 15, *N. veneta*; 15, *N. antonii* (von Benja Thermalquellen, Permeti).

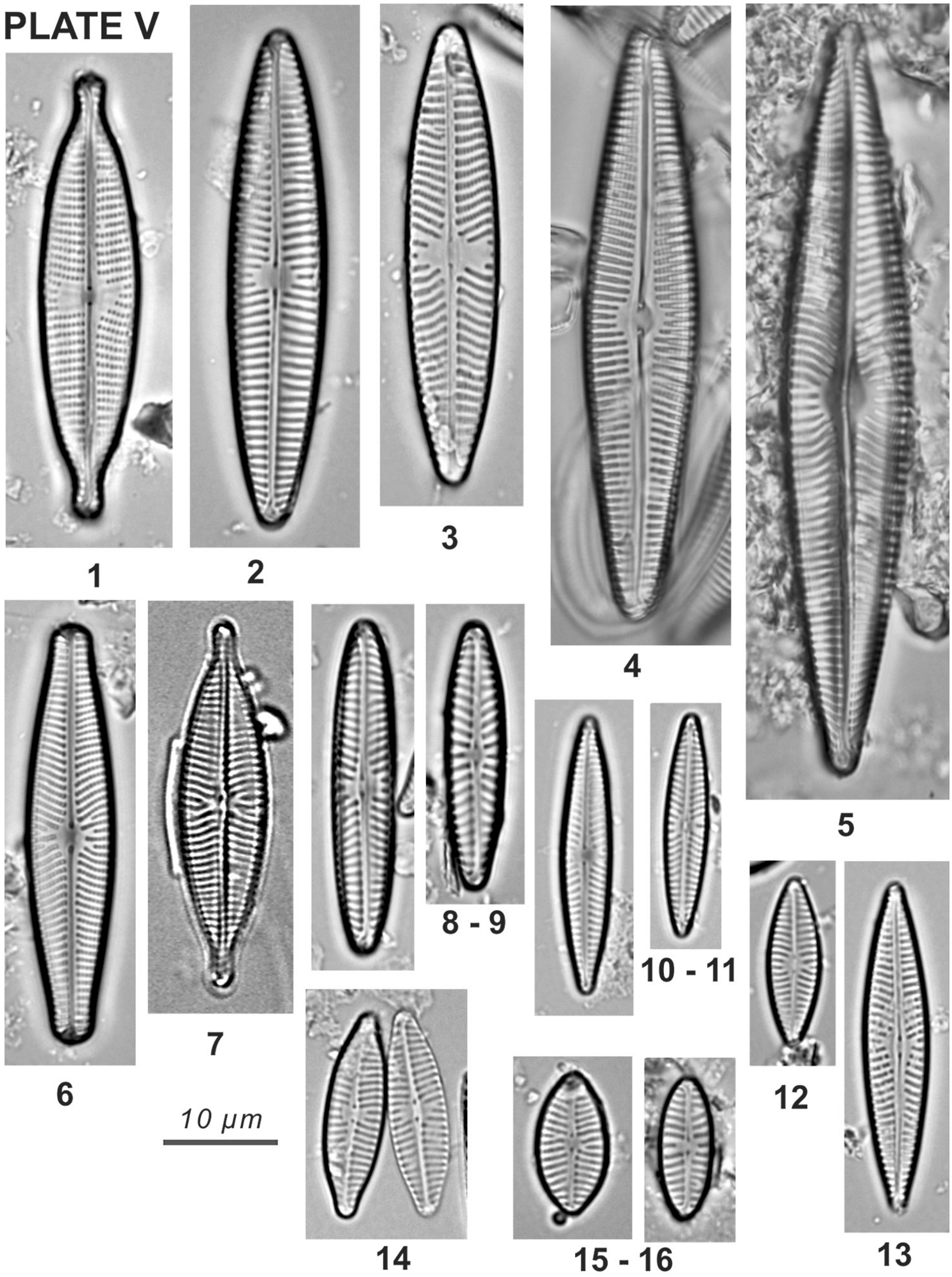


Plate VI: 1, *Gomphoneis transsilvanica*; 2, *Gomphonema truncatum*; 3, *G. acuminatum*; 4, *G. clavatum*; 5, *G. olivaceum*; 6, *G. sarcophagus*; 7, *G. parvulum*; 8, *G. tergestinum*; 9–10, *G. pumilum* var. *elegans*; 11–12, *G. pseudotenellum*; 13–14, *Encyonopsis microcephala*; 15, *E. descripta*; 16, *Navicula cryptocephala* ; 17, *Diploneis notabilis* (3, Viroi spring, Gjirokastra; 17, Zhuka, Vjosa river, Vlora; the rest from Benja springs, Permeti). – Tafel VI: 1, *Gomphoneis transsilvanica*; 2, *Gomphonema truncatum*; 3, *G. acuminatum*; 4, *G. clavatum*; 5, *G. olivaceum*; 6, *G. sarcophagus*; 7, *G. parvulum*; 8, *G. tergestinum*; 9–10, *G. pumilum* var. *elegans*; 11–12, *G. pseudotenellum*; 13–14, *Encyonopsis microcephala*; 15, *E. descripta*; 16, *Navicula cryptocephala* ; 17, *Diploneis notabilis* (3, Viroi Quelle, Gjirokastra; 17, Zhuka, Vjosa Fluss, Vlora; der Rest von Benja Thermalquellen, Permeti).

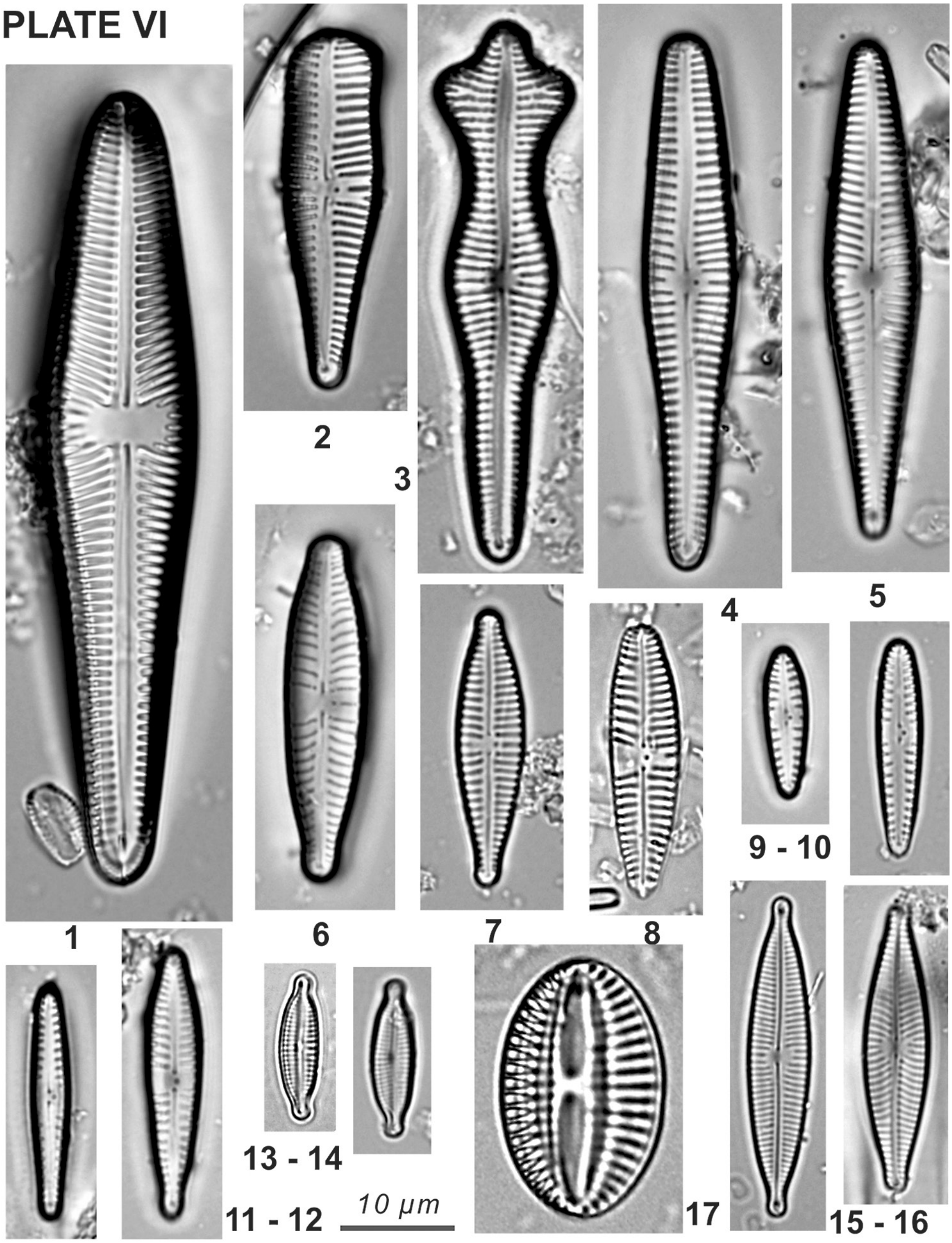


Plate VII: 1, *Encyonema prostratum*; 2, *Cymbella cistula*; 3–4, *Cymbopleura* cf. *diminuta*; 5, *Cymbella helvetica*; 6, *Cymbopleura amphicephala*; 7, *Cymbella affinis*; 8, *Encyonema silesiacum*; 9, *E. ventricosum*; 10, *Reimeria sinuata* (10, Mifoli, Vjosa river, Vlora; the rest from Benja thermal springs, Permeti). – Tafel VII: 1, *Encyonema prostratum*; 2, *Cymbella cistula*; 3–4, *Cymbopleura* cf. *diminuta*; 5, *Cymbella helvetica*; 6, *Cymbopleura amphicephala*; 7, *Cymbella affinis*; 8, *Encyonema silesiacum*; 9, *E. ventricosum*; 10, *Reimeria sinuata* (10, Mifoli, Vjosa Fluss, Vlora; der Rest von Benja Thermalquellen, Permeti).

PLATE VII

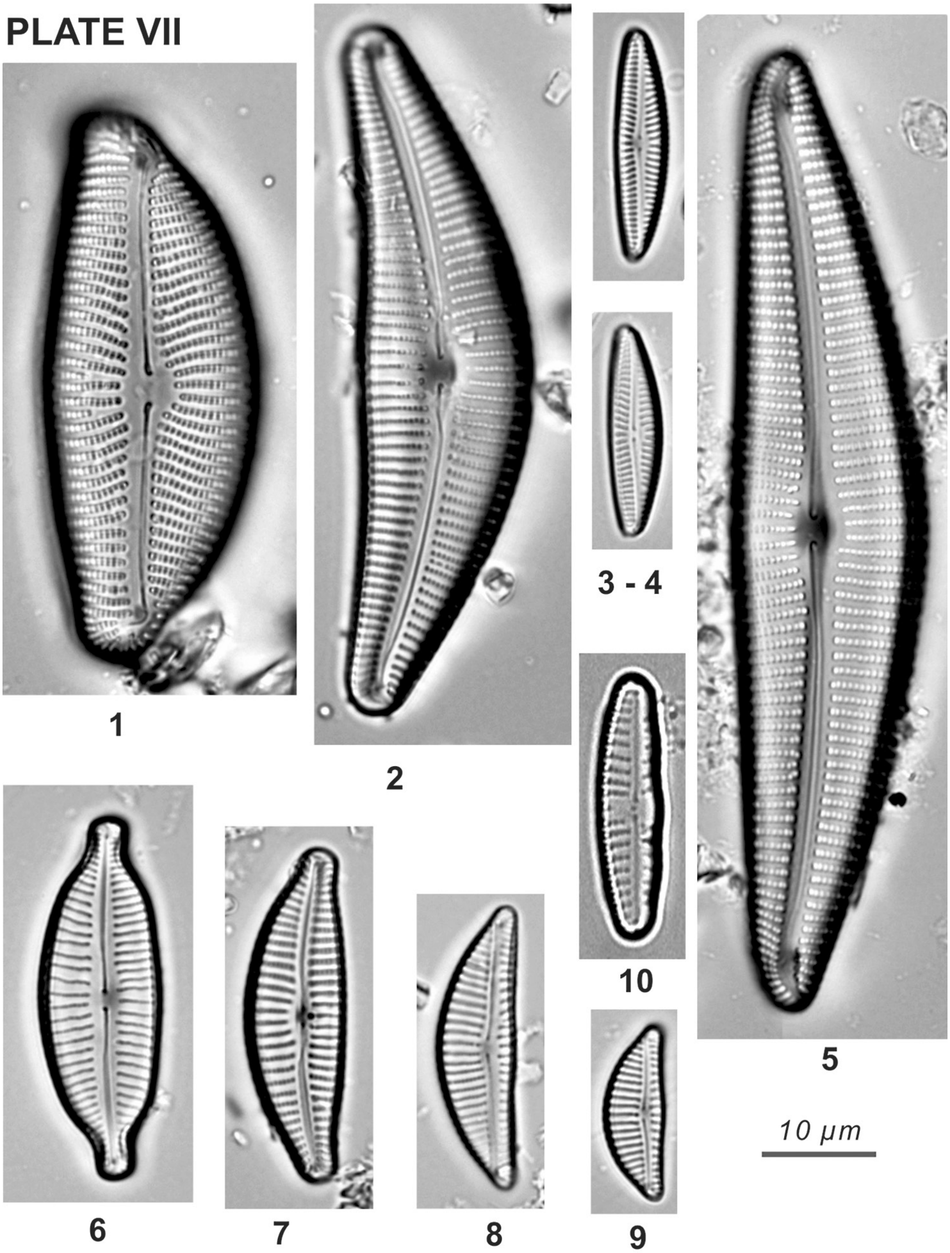


Plate VIII: 1, *Cymbella subhelvetica*; 2, *C. cantonati*; 3, *Cymbopleura incerta*; 4, *Delicata delicatula*; 5, *Gomphonema insigne*; 6, *Diploneis elliptica*; 7, *Neidium binodis*; 8, *Sellaphora bacillum*; 9–10, *Grunowia solgensis*; 11–12, *Denticula tennius*; 13–14, *Nitzschia incospicua*; 15, *Tryblionella apiculata* (5, 8, Viroi spring, Gjirokastra; 7, Lekli, Drino river, Tepelena; the rest from Benja thermal springs, Permeti). – Tafel VIII: 1, *Cymbella subhelvetica*; 2, *C. cantonati*; 3, *Cymbopleura incerta*; 4, *Delicata delicatula*; 5, *Gomphonema insigne*; 6, *Diploneis elliptica*; 7, *Neidium binodis*; 8, *Sellaphora bacillum*; 9–10, *Grunowia solgensis*; 11–12, *Denticula tennius*; 13–14, *Nitzschia incospicua*; 15, *Tryblionella apiculata* (5, 8, Viroi Quelle, Gjirokastra; 7, Lekli, Drino Fluss, Tepelena; der Rest von Benja Thermalquellen, Permeti).

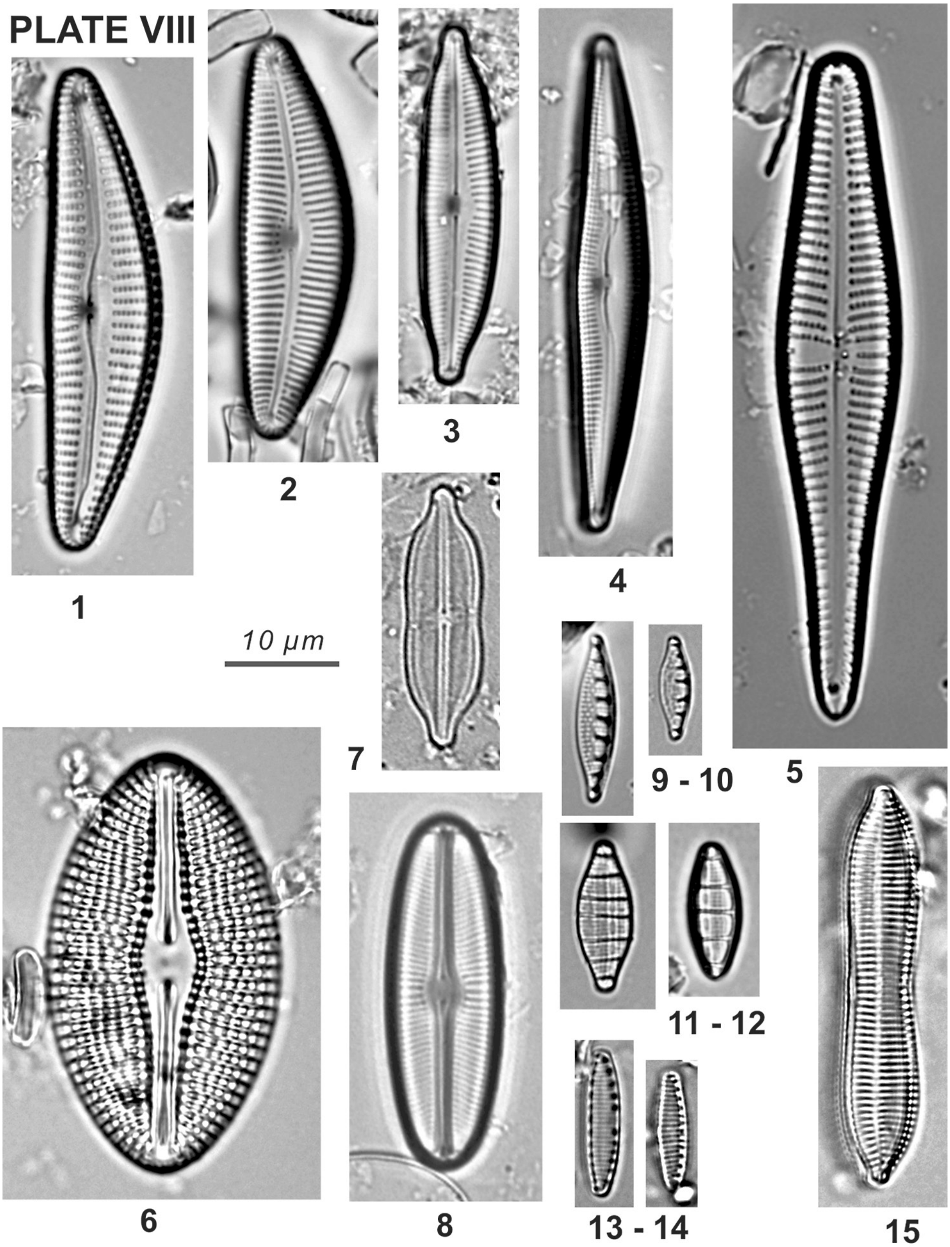


Plate IX: 1, *Gyrosigma nodiferum*; 2, *G. scalproides*; 3, *Nitzschia linearis*; 4, *N. gracilis*; 5, *N. intermedia*; 6, *Nitzschia* cf. *bremensis*; 7, *N. amphibia*; 8, *N. dissipata*; 9, *N. palea*; 10–11, *N. elegantula*; 12, *N. fonticola*; 13, *N. solita*; 14, *N. clausii* (from Benja thermal springs, Permeti). – Tafel IX: 1, *Gyrosigma nodiferum*; 2, *G. scalproides*; 3, *Nitzschia linearis*; 4, *N. gracilis*; 5, *N. intermedia*; 6, *Nitzschia* cf. *bremensis*; 7, *N. amphibia*; 8, *N. dissipata*; 9, *N. palea*; 10–11, *N. elegantula*; 12, *N. fonticola*; 13, *N. solita*; 14, *N. clausii* (von Benja Thermalquellen, Permeti).

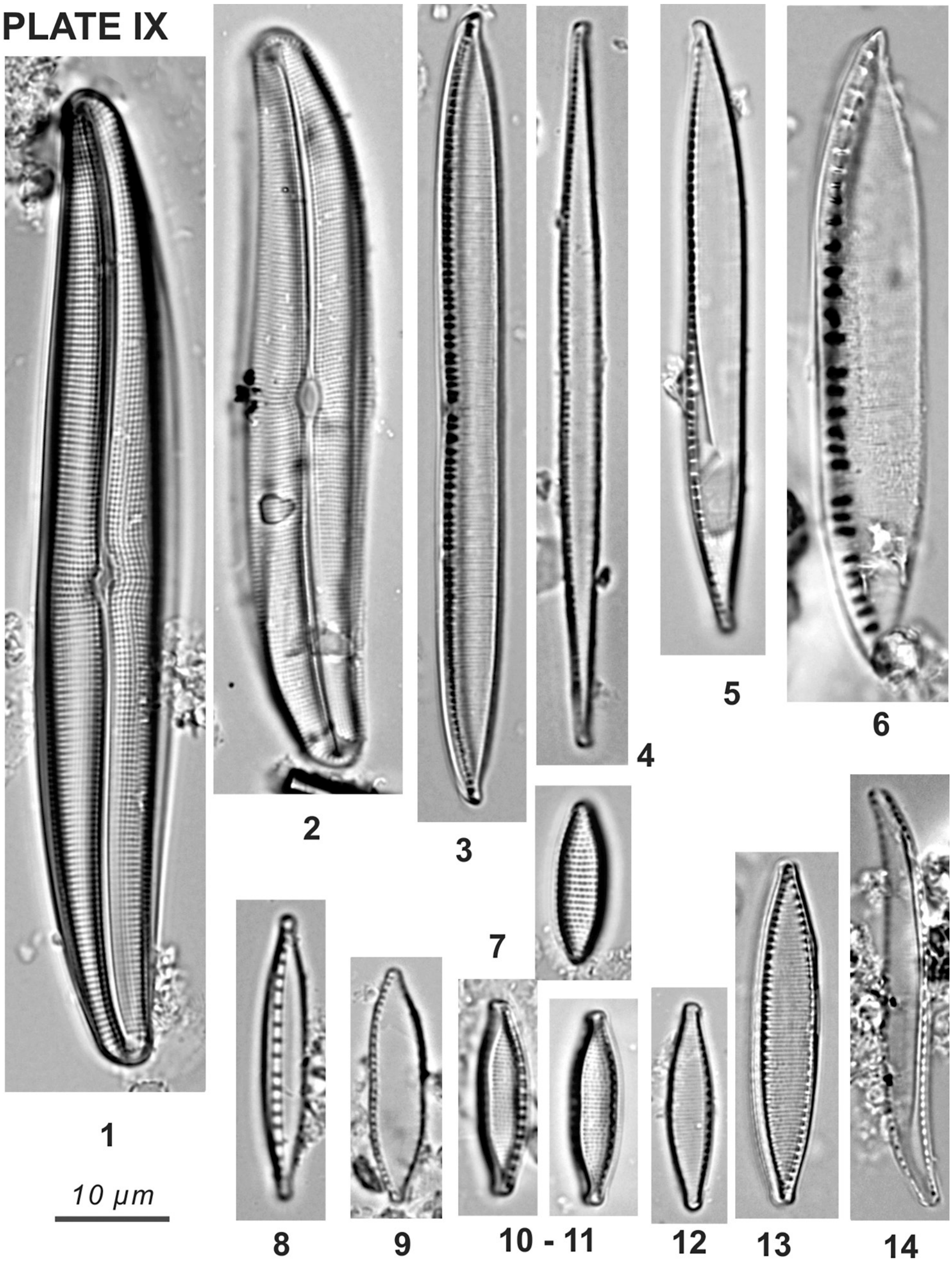
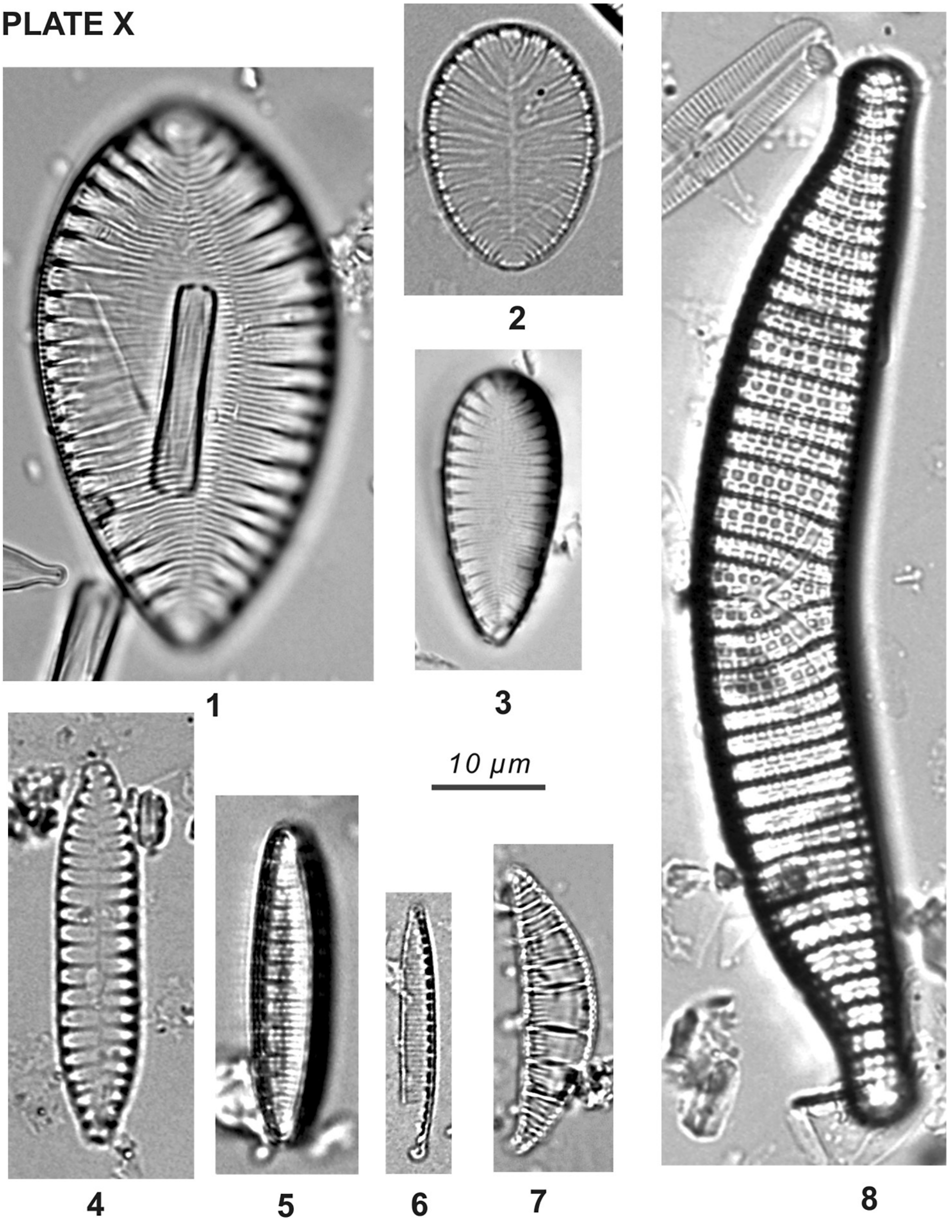


Plate X: 1, *Surirella ovalis*; 2, *Surirella brebissonii*; 3, *S. brebissoni* var. *kuetzingii*; 4, *S. angusta*; 5, *Nitzschia denticula*; 6, *N. perminuta*; 7, *Rhopalodia brebissonii*; 8, *Epithemia adnata* (2, Lekli, Drino river, Tepelena; 3, 8, Çajupi spring, Gjirokastra; 5, Mifoli, Vjosa river, Vlora; 6, Kordhoca, Drino river, Gjirokastra; the rest from Benja thermal springs, Permeti). – Tafel X: 1, *Surirella ovalis*; 2, *Surirella brebissonii*; 3, *S. brebissoni* var. *kuetzingii*; 4, *S. angusta*; 5, *Nitzschia denticula*; 6, *N. perminuta*; 7, *Rhopalodia brebissonii*; 8, *Epithemia adnata* (2, Lekli, Drino Fluss, Tepelena; 3, 8, Çajupi Quelle, Gjirokastra; 5, Mifoli, Vjosa Fluss, Vlora; 6, Kordhoca, Drino Fluss, Gjirokastra; der Rest von Benja Thermalquellen, Permeti).

PLATE X



Literature

Acs E., Földi A., Wetzel C., Vad C., Keve Tihamér K., Dobosy P., Trábert Z., Grigorszky I., Engloner A. & Ector L., 2017b: *Nitzschia austriaca* Hustedt: a characteristic diatom of Hungarian inland saline waters including a morphological comparison with the type material. Phytotaxa 308. 54. 10.11646/phytotaxa.308.1.4.

Acs E., Wetzel C., Buczkó K., Keve Tihamér K., Nagy K., Trábert Z., Foldi A., Pozderka V., Petra W., Heudre D. & Ector L., 2017a: Biogeography and morphology of a poorly known *Sellaphora* species. Fottea, 17. 10.5507/fot.2016.021.

AKM, 2017: Programi kombëtar i monitorimit të mjedisit për vitin 2018. Agjencia Kombëtare e Mjedisit (The National Environmental Monitoring Program for year 2018. The National Environment Agency), Tirana, 104 pp. http://akm.gov.al/assets/pkmm-2018.doc-pdf.pdf

Carlson R.E. & Simpson J., 1996: A Coordinator's Guide to Volunteer Lake Monitoring Methods. North American Lake Management Society, 1–96. http://dipin.kent.edu/tsi.htm

CEMAGREF, 1982: Étude des méthodes biologiques d'appreciation quantitative de la qualité des eaux. Rapport Q.E. Lyon – Agence de l'Eau Rhône-Medtierrane Corse, 218 pp.

Çullaj A., Hasko A., Miho A., Schanz F., Brandl H. & Bachofen R., 2005: The quality of Albanian natural waters and the human impact (Review article). Environment International 31, 133–146.

Eloranta P. & Kwandrans J., 1996: Testing the use of diatoms and macroalgae for river monitoring in Finland. In Whitton B.A., Rott E. & FriedrichG. (Eds) Use of algae for monitoring rivers. Institut für Botanik, Universität Innsbruck, Innsbruck, 119–125.

EN 13946, 2003: Water quality. Guidance standard for the routine sampling and pretreatment of benthic diatoms from rivers. ISBN 0 580 41960 6, 18 pp. http://standards.mackido.com/en/en-standards24_view_3175.html

EN 14407, 2004: Water quality. Guidance standard for the identification, enumeration and interpretation of benthic diatom samples from running waters. ISBN 0 580 44247 0, 1–16. http://www.standardsdirect.org/standards/standards1/StandardsCatalogue24_view_11733.html

Fidlerová D. & Hlubikova D., 2016: Relationships between benthic diatom assemblages' structure and selected environmental parameters in Slovak water reservoirs (Slovakia, Europe). Knowledge and Management of Aquatic Ecosystems, 27. 10.1051/kmae/2016014.

Gjini S., Kurteshi K., Vehapi I., Qendro A. & Ismaili M., 2013: Diatoms of river Drino during autumn season 2012 in Gjirokastër (Albania). The 1st International Conference on Research and Educatıon–Challenges Toward the Future (ICRAE2013), 24–25 May 2013, University of Shkodra "Luigj Gurakuqi", Shkodra, Albania, 1–8. http://konferenca.unishk.edu.al/icrae2013/icraecd2013/doc/228.pdf

Gjini S., Qendro A., Kurteshi K. & Ismaili M., 2015: Analysis of diatoms in lake Virua during the summer season of 2011 – Gjirokastër, Albania. The 4th Advanced Research in Scientific Areas, November, 9–13, 2015, Earth and related Environmental sciences, 213–215. eISSN: 2453–6962, cdISSN: 1338-983, 10.18638/arsa.2015.4.1.777. ISBN: 978-80-554-1126-2. www.arsa-conf.com

Grigorszky I., Tihamér Kiss K., Por G., Devai G., Nagy A. S., Somlyai I., Berta C., Duleba M., Trábert Z. & Acs E., 2017: Temperature and growth strategies as the essential factors influencing the occurrence of *Stephanodiscus minutulus* (Kutzing) Cleve & Moller and *Palatinus apiculatus* (Ehrenberg) Craveiro, Calado, Daugbjerg & Moestrup, 167–175. 10.1127/fal/2016/0941.

Guiry M.D. & Guiry G.M., 2018: AlgaeBase. World-wide electronic publication, National University of Ireland, Galway. http://www.algaebase.org; searched on 08 February 2018.

Hoxha B., 2008: Alga mikroskopike nga Lugina e Vjosës (Microscopic Algae from the Vjosa Valley). Master Theses, FNS, UT, 68 pp.

Jaupaj O., 2007: Vlerësim i cilësisë së ujërave të lumenjve shqiptarë mbështetur tek fitobentosi (Assessment of water quality Albanian river based on phytobenthos). Master Theses, FNS, UT, 68 pp.

Kahlert M., Kelly M., Albert R.-L., Almeida S., Bešta T., Blanco S., Coste M., Denys L., Ector L., Fránková M., Hlubikova D., Ivanov P., Kennedy B., Marvan P., Mertens A., Miettinen J., Picinska-Faltynowicz J., Tison-Rosebery J., Tornés E. & Vogel A., 2012: Identification versus counting protocols as sources of uncertainty in diatom-based ecological status assessments. Hydrobiologia 695. 10.1007/s10750-012-1115-z.

Kashta L. & Miho A. 2016: The more frequently occurring macroalgae in Albanian running waters. Buletini i Shkencave Natyrore (BShN), Faculty of Natural Sciences, University of Tirana 21, 31–40. https://sites.google.com/a/fshn.edu.al/fshn/home/botimi-nr-21-viti-2016

Krammer K., 2002: *Cymbella*. In: Lange-Bertalot H. (Ed.), Diatoms of Europe, diatoms of the European inland waters and comparable habitats, Vol. 3, 1–584, incl. 194 pls. A.R.G. Gantner Verlag K.G, Ruggell.

Krammer K. & Lange-Bertalot H., 1986–2001: Bacillariophyceae. Suesswasserflora von Mitteleuropa. Teil 2/1-5; 2/1: 876 pp.; 2/2: 596 pp.; 2/3: 576 pp.; 2/4: 437 pp.; 2/5: 311 pp.. Fischer, Stuttgart-New York.

Kupe L., 2006: Vlerësimi i gjendjes mjedisore të disa habitateve ujore shqiptare mbështetur tek diatometë (Assessment of the environmental state of some Albanian aquatic habitats based on diatoms). PhD theses. FAM, UBT.

Kupe L. & Miho A., 2007: The environmental state of important aquatic habitats in Albania based in algal assessment – A Review. Proceedings of RiverNet Conference, Tirana 15–16 May 2006, 51–65.

Lange-Bertalot H., 2001: *Navicula* sensu stricto. 10 Genera separated from Navicula sensu lato. *Frustulia*. Diatoms of Europe: diatoms of the European inland waters and comparable habitats. Vol. 2 pp. 1–526, 140 pls. A.R.G. Gantner Verlag K.G., Ruggell.

Lecointe C., Coste M. & Prygiel J., 1993: OMNIDIA: Software for taxonomy, calculation of diatom indices and inventories management. Hydrobiologia 269/270, 509–513.

Levkov Z., Krstic S., Metzeltin D. & Nakov T., 2007: Diatoms of Lakes Prespa and Ohrid, about 500 taxa from ancient lake system. Iconographia Diatomologica 16, 1–613.

Meço M., 2013: Vlerësimi i mëtejshëm i cilësisë biologjike të ujërave sipërfaqësore shqiptare duke u mbështetur te algat silicore (diatome – Bacillariophyceae) (Further assessment of the biological quality of Albanian surface waters based on siliceous algae). Master Theses, FNS, UT, 77 pp.

Meço M., Ndoj E., Nika O. & Miho A., 2014: Vështrim mbi cilësinë biologjike të ujërave sipërfaqësore shqiptare. Buletini i Shkencave Natyrore (BSHN) (An overview of the biological quality of Albanian surface waters. Bulletin of Natural Sciences (BNS)), Faculty of Natural Sciences, University of Tirana: Vol. 18, 49–60. http://buletini.fshn.edu.al/

Miho A., 2014: Overview on Bioquality of Albanian surface waters based on microscopic algae. International Conference on Applied Biotechnology (ICAB-2014), FNS, University of Tirana, 22 September 2014. Book of Proceeding, 11–16.

Miho A., Kashta L. & Beqiraj S., 2013: Between the Land and the Sea – Ecoguide to discover the transitional waters of Albania. Julvin 2, Tiranë, 1–462. ISBN 978-9928-137-27-2. http://www.fshn.edu.al/home/publikime-shkencore

Miho A., Kupe L., Bilero J., Karjalainen S.M. & Jaupaj O., 2010: Cilësia e ujërave në lumenj shqiptarë mbështetur tek Treguesi i Ndjeshmërisë së Ndotjes (IPS). Buletini i Shkencave Natyrore (BSHN), Nr. 10 (Water quality in Albanian rivers based on the Index of Pollution Sensitivity (IPS). Bulletin of Natural Sciences (BNS)), University of Tirana, 63–75.

Miho A., Kupe L., Jaupaj O., Karjalainen S.M., Hellsten S. & Pritzl G., 2008: Overview of Water Quality of Albanian Rivers. The Third International Scientific Conference BALWOIS 2008, Ohrid, Mk, 27–31 May 2008. http://balwois.com/balwois/administration/full_paper/ffp-969.pdf.

Miho A. & Witkowski A., 2005: Diatom (Bacillariophyta) Flora of Albania Coastal Wetlands Taxonomy and Ecology: A Review. Proceedings of the California Academy of Sciences 56, No. 12, 129–145, 1 figure, 2 plates, Appendix.

Miho A., Çullaj A., Hasko A., Lazo P., Kupe L., Schanz F., Brandl H., Bachofen R. & Baraj B., 2005: Gjendja mjedisore e disa lumenjve të Ultësirës Adriatike Shqiptare. / Environmental state of some rivers of Albanian Adriatic Lowland. Tirana University, Faculty of Natural Sciences, Tirana (In Albanian with a summary in English), 1–267. ISBN 99943-681-9-2. http://www.fshn.edu.al/home/publikime-shkencore

Ngjela K., 2016: Cilësia biologjike e ujërave të pellgut të lumit Vjosë mbështetur te algat mikroskopike silicore (diatometë – Bacillariophyceae) (The biological quality of waters of the Vjosa river basin based on the siliceous microscopic algae). Master Theses, FNS, UT, 69 pp.

OECD Ed., 2006: Water Management. Research of the Organization for Economic Co-Operation and Development (OECD). Soil & Water Conservation Society of Metro Halifax (SWCSMH). http://lakes.chebucto.org/TPMODELS/OECD/management.html

Opperman J., Grill G. & Hartmann J., 2015: The Power of Rivers: Finding balance between energy and conservation in hydropower development. The Nature Conservancy: Washington, D.C., 1–52. http://www.hydrosustainability.org/getattachment/ad1b6774-ca2b-40c8-9285-d13a61395370/Nature-Conservancy--The-Power-of-Rivers.aspx

Prifti A., Braho Sh., Sulovari L., Preka F., Çeliku S., Xhomara H., Dano K. & Fusha Gj., 2014: Raporti për Gjëndjen e Mjedisit. Ministria e Mjedisit, Agjencia Kombëtare e Mjedisit (Report on the State of Environment. Ministry of Environment, National Environmental Agency), Tirana, 1–232.

Rott E., Hofmann G., Pall K, Pfister P. & Pipp E., 1997: Indikationslisten für Aufwuchsalgen in Fließgewässern in Österreich. Teil 1: Saprobielle Indication. Projekt des Bundesministeriums für Land- und Forstwirtschaft, Wasserwirtschaftskataster, 1–80.

Rott E., Pipp E., Pfister P., Van Dam H., Ortler K., Binder N. & Pall K., 1999: Indikationslisten für Aufwuchsalgen in Österreichischen Fließgewässern. Teil 2: Trophieindication. BM f. Land- u. Forstwirtschaft, Zahl 41.034/08-IVA 1/97, Wien, 1–248.

Sejdo I., 2010: Alga mikroskopike nga ujëmbledhës të ndryshëm shqiptarë (Microscopic algae from different Albanian reservoirs). Master Theses, FNS, UT, 48 pp.

Shannon C. E. & Weaver W., 1949: The mathematical theory of commmunication Univ. Illinois Press, Urbana.

WFD, 2000: 2006/44/EC Fish Directive: Directive 2006/44/EC of the European Parliament and of the Council of 6 September 2006 on the quality of fresh waters needing protection or improvement in order to support fish life. Official Journal of the European Union. 264/20-264/31 (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:264:0020:0031:EN:PDF)

Whitton B., 2013: Use of Benthic Algae and Bryophytes for Monitoring Rivers. Journal of Ecology and Environment, 36. 95–100. 10.5141/ecoenv.2013.012.

WWF (Ed.), 2014: Rivers: lifelines of the Dinaric Arc Conservation of the most valuable rivers of South-Eastern Europe. WWF – World Wide Fund for Nature (Formerly World Wildlife Fund), Rome, Italy, 17 pp. http://d2ouvy59p0dg6k.cloudfront.net/downloads/rivers_lifelines_of_the_dinaric_arc_1.pdf

Xhulaj S., 2009: Mbi prodhimtarinë parësore të disa lagunave Adriatike (On the primary production of some Adriatic lagoons). PhD theses. FNS, UT, 198 pp.

Zelinka M. & Marvan P., 1961: Zur Praezisierung der biologischen Klassification der Reinheit fliessender Gewaesser. Arch. Hydrobiol. 37, 387–404.

Received: 2018 07 24

Addresses:

Univ.-Prof. Dr. Aleko Miho, University of Tirana, Faculty of Natural Sciences, Department of Biology. Tirana, Albania. E-mail: aleko.miho@fshn.edu.al

MSc. Klajdi Ngjela, PARR Credit srl, Tirana, Albania.
E-mail: klajdingjela91@gmail.com

MSc. Bledi Hoxha, Protection and Preservation of Natural Environment in Albania (PPNEA). Tirana, Albania. E-mail: b.hoxha@ppnea.org

MSc. Ina Sejdo, Ismail Qemali High School. Tirana, Albania.
E-mail: isejdo@hotmail.com

MSc. Marjol Meço, University of Tirana, Faculty of Natural Sciences, Department of Biology. Tirana, Albania. E-mail: marjol.meco@fshn.edu.al

Zeitschrift/Journal: Verhandlungen der Zoologisch-Botanischen Gesellschaft in Wien. Frueher: Verh.des Zoologisch-Botanischen Vereins in Wien. seit 2014 "Acta ZooBot Austria"

Jahr/Year: 2018

Band/Volume: 155_1

Autor(en)/Author(s): Miho Aleko, Ngjela Klajdi, Hoxha Bledi, Sejdo Ina, Meco Marjol

Artikel/Article: Diversity of diatoms and related quality of free-flowing rivers in Albania (the Vjosa catchment) 107-134