

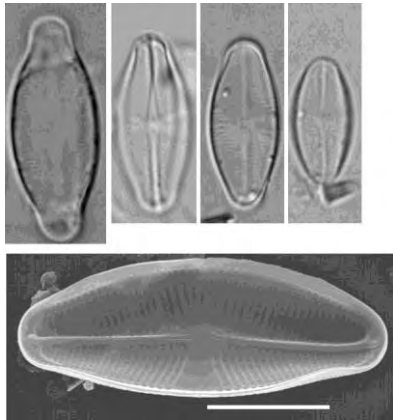
# Biodiversity in high-mountain lakes and other habitats in Poland and Bulgaria: state of knowledge, environmental and taxonomical changes of diatoms

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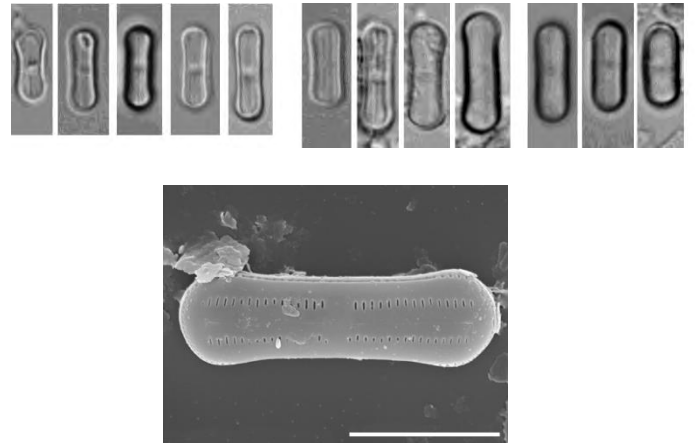


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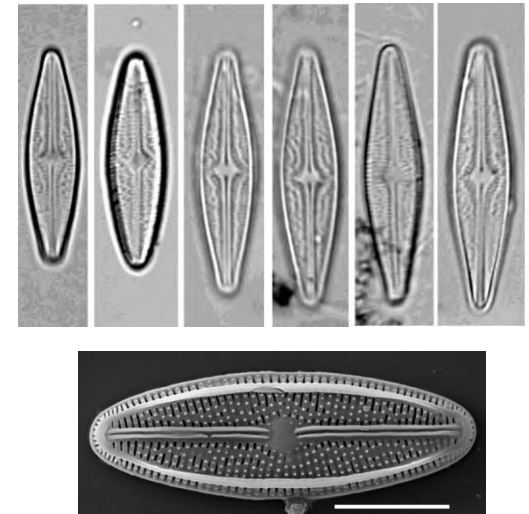
- The majority of high-mountain lakes are relatively small, cold, oligotrophic and dilute
- Due to their location they are often not influenced by anthropogenic nutrient enrichment
- In contrast to lowland lakes mountains lakes often register climate changes directly
- High-mountain lakes are sensitive indicators of past, present and future global change



*Eucocconeis laevis*



*Diadesmis contenta*



*Brachysira brebissonii*

The individual characteristics of the habitats dictate which diatoms live there:

**Altitude.** The higher the habitat, the colder its water and the less organic remains enter it because there is less vegetation in the basin;

**Mineral salts** vary depending on the geology of the basin. The water of the habitat on granite is less mineralised;

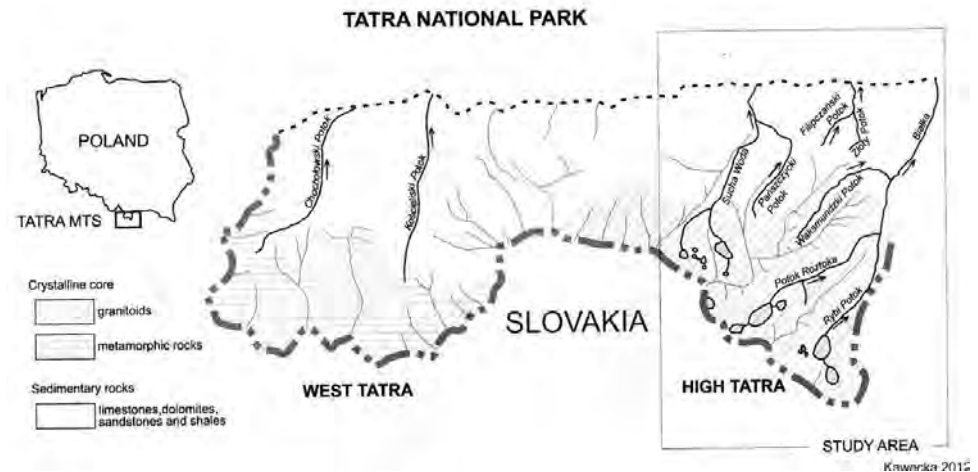
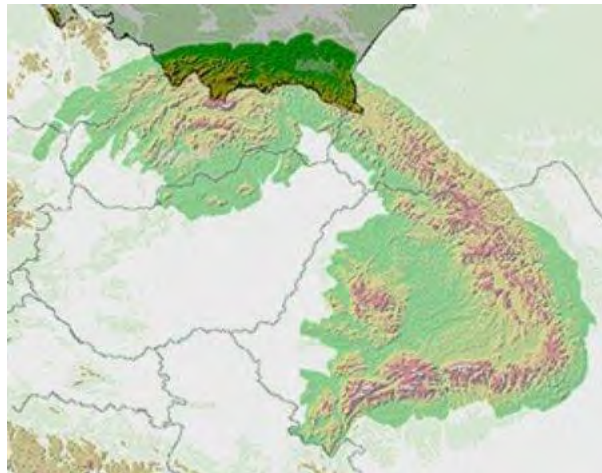


The **size of lakes** can vary from a few square metres to more than 30 hectares in the case of the largest.

# The high-mountain lakes in Poland (Tatra Mts)

The Tatras are the highest mountains in Poland  
(Rysy peak, 2499 m. a.s.l.)

The Tatra Mts are located in the West Carpathians. Their area in Poland is 785 km<sup>2</sup>.



The High Tatra Mts area is built mainly from magmatic rock (granitoids), highly resistant to erosion. The West Tatras area is composed of crystalline metamorphic rock (gneiss and crystalline schists) or sedimentary carbonate rocks (mainly limestone).



## The high-mountain habitats in Poland (Tatra Mts)

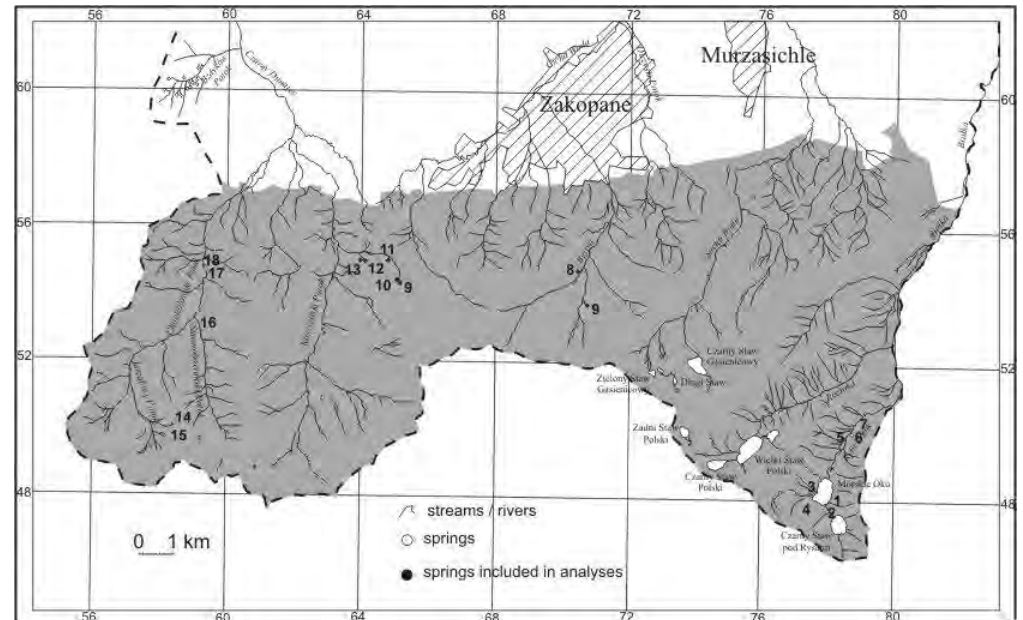
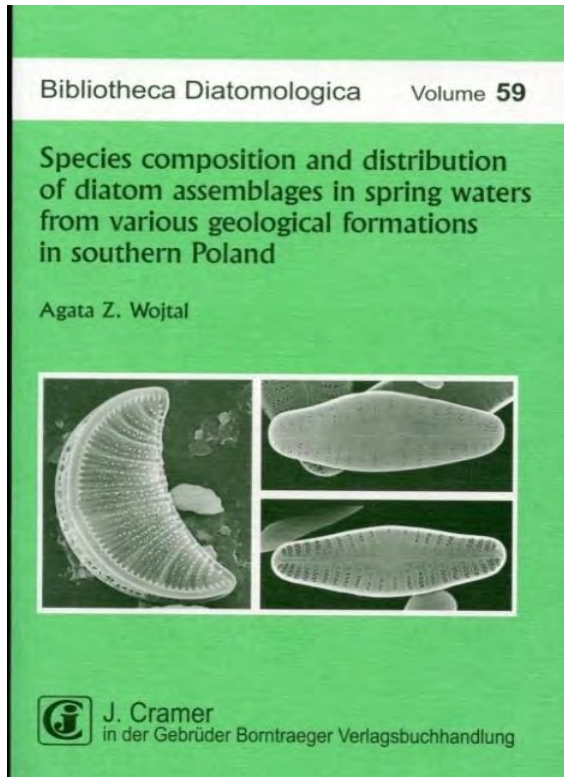
The first data on diatoms were provided by Schumann (1867) and Gutwiński (1909).

Next, many articles about recent diatoms and fossils from Tatra materials were published (e.g., Namysłowski 1922, Wasyluk 1965, Obidowicz 1969, Starmach 1973, Kawecka 1966-2012, Kawecka & Galas 2003, Marciniak 1982, Wojtal 2013, Sienkiewicz & Gąsiorowski 2014, 2016).

They concern diatoms from mountain lakes, streams and springs.

# The high-mountain habitats in Poland (Tatra Mts)

18 springs (Tatra Mts)



‘Impact of invasive alien species on biodiversity and ecosystem services in extreme environments’

# The high-mountain habitats in Poland (Tatra Mts)



In terms of water chemistry the types of springs include dilute (<math><30 \mu\text{S}</math>) (High Tatras), calcium-rich but nutrient-poor (West Tatras).

Most of them are rheocrenes, though some limnocrenes and helocrenes are, too.



The springs vary greatly in their discharge, from small seepages scattered in the High Tatras on granitic bedrock to karstic outflows yielding hundreds of liters of water per second in the West Tatras.

# The high-mountain habitats in Poland (Tatra Mts)

The springs are classified into three groups:

- helocrenes, which are small, numerous, diffuse outflows with swampy zones;
- rheocrenes;
- limnocrenes, including pool springs.

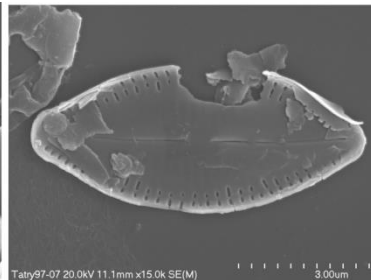
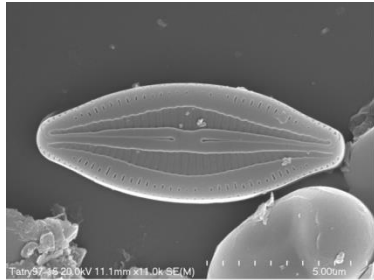
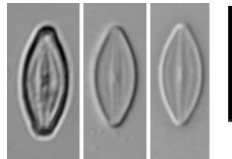


Among freshwater springs, the largest number of species can be found in dilute waters of low alkalinity and ion concentration.

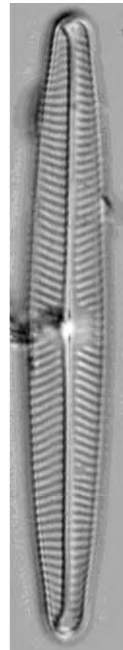
The diatom assemblages may be clearly dominated by one or two species, but the springs differ from each other in dominants. Several diatoms found in these springs are rarely reported and poorly known.

# The high-mountain habitats in Poland (Tatra Mts)

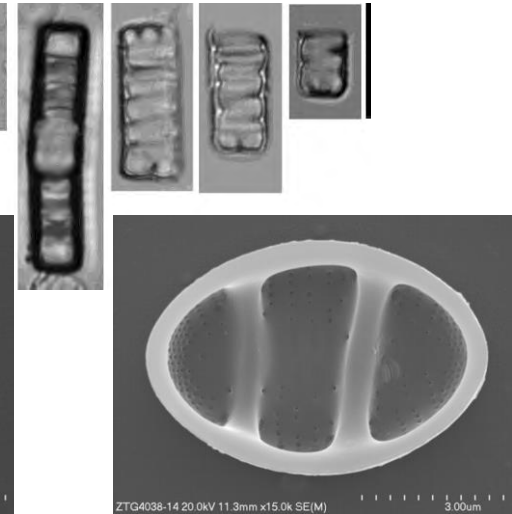
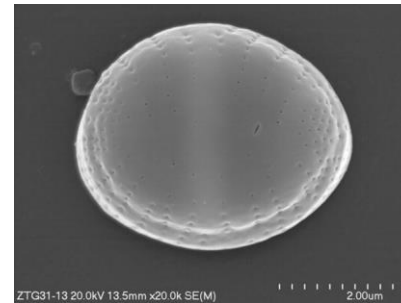
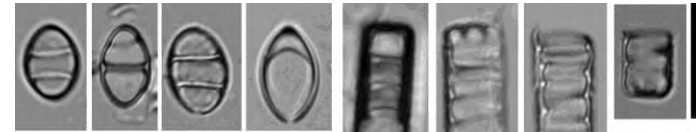
The largest number of poorly known diatoms can be found in springs located in areas least exposed to pollution (e.g., *Diatomella balfouriana*, *Microcostatus krasskei*, *Navicula angusta*, *Psammothidium acidoclinatum*, *P. montanum* and *Tetracyclus rupestris*).



*Microcostatus krasskei*



*Navicula angusta*



*Tetracyclus rupestris*

# The high-mountain habitats in Poland (Tatra Mts)

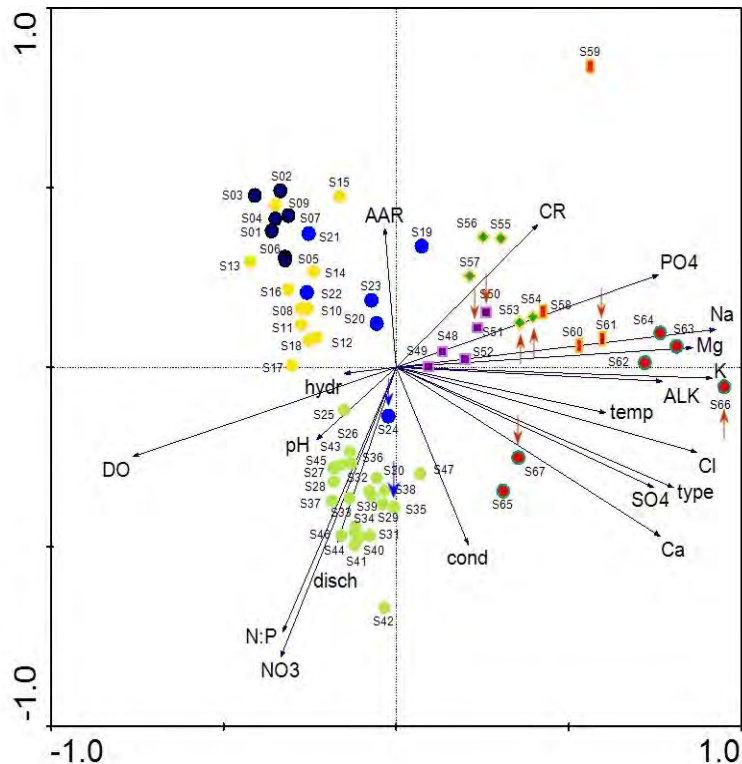


The most important factors shaping species distributions are dissolved oxygen, magnesium, potassium and nitrate concentrations.

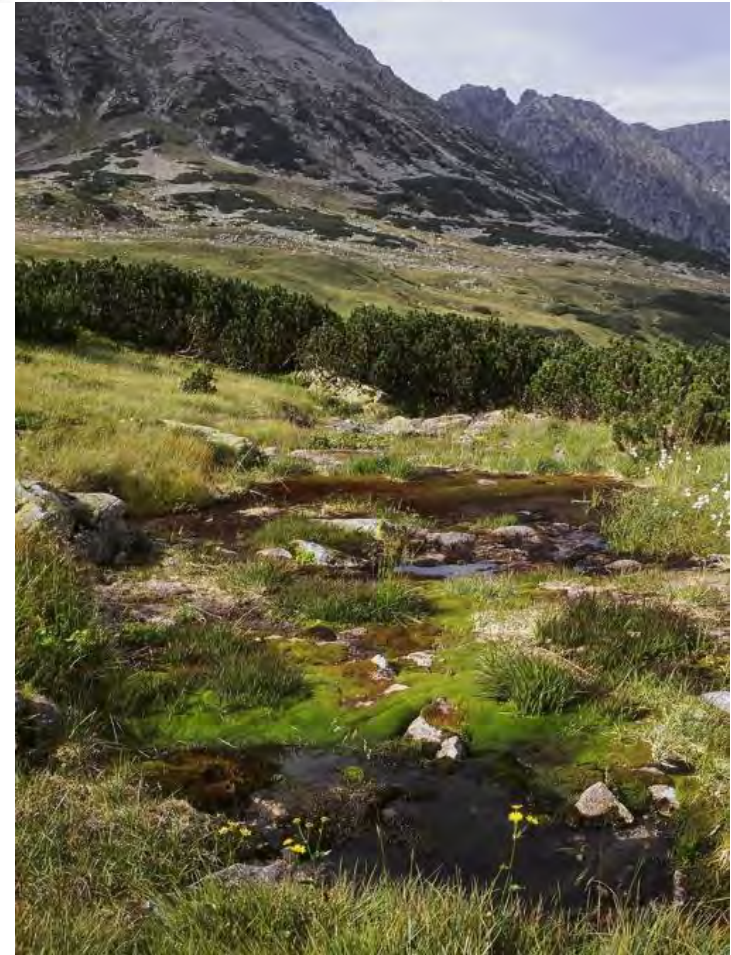
In springs the important factors are specific conductance, water temperature. The most polluted spring habitats are in the Western Tatras and the main threat originates from nitrates.

Even in human-altered areas the springs offer conditions for diatoms regarded as rare.

# Springs from southern Poland

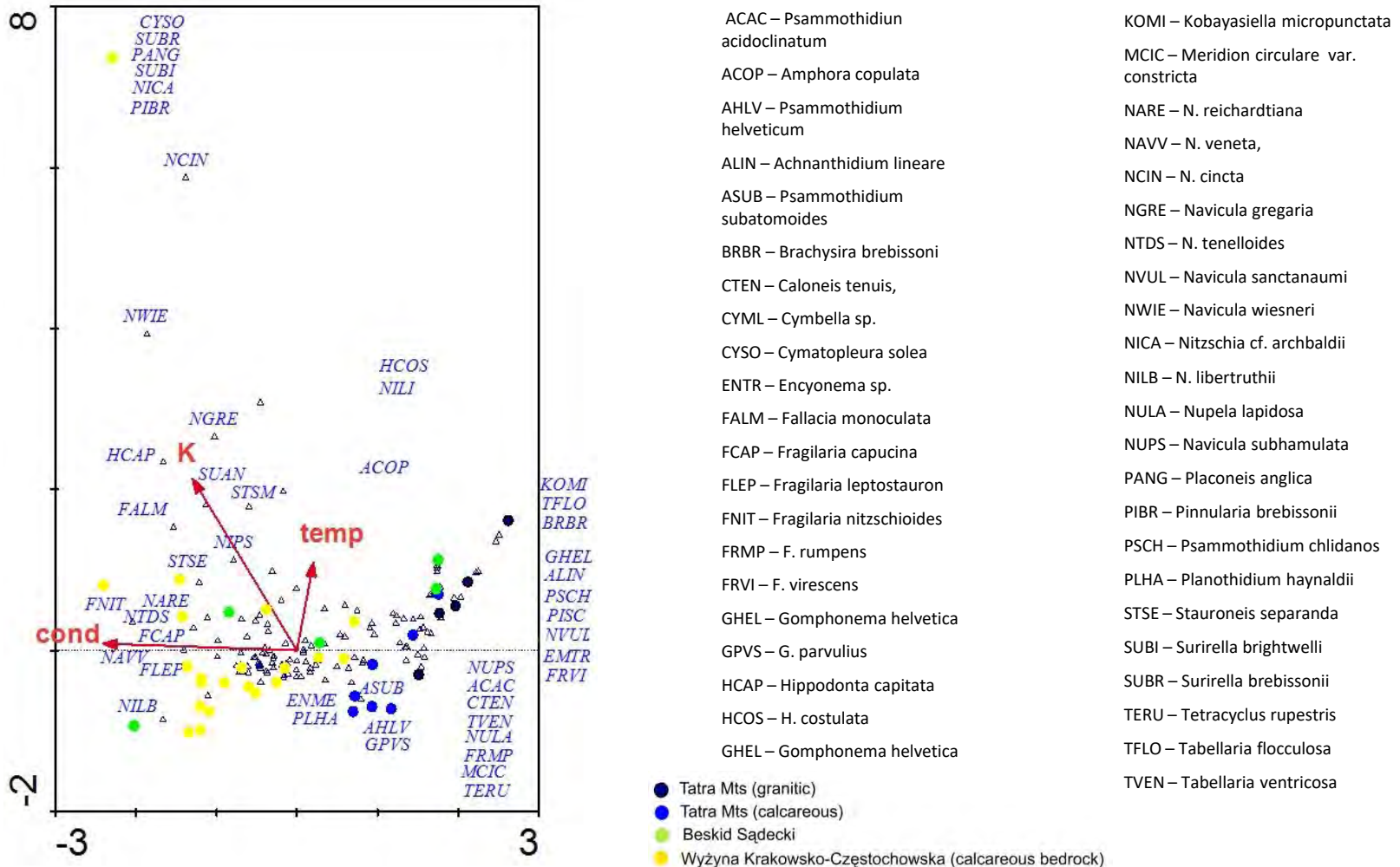


- Tatra Mts (granitic)
- Tatra Mts (calcareous)
- Beskid Sądecki
- Wyżyna Krakowsko-Częstochowska (calcareous bedrock)



PCA ordination biplot (n= 67). The first axis separates samples collected from mineral springs from those of TDS lower than 1000 g per dm<sup>3</sup> and low concentration of specific components. Numbers refer to localities: 48-67 - mineral springs, numbers 1-47 - other springs. Axis 1: 40.2%, Axis 2: 12.2%. 224 taxa of relative abundance ≥ 1%.

# Springs from southern Poland



CCA (n=47) CCA ordination of freshwater springs showing environmental variables identified by forward selection method. Axis 1 explains 6.6% and Axis 2 explains 5.2% of the total variability in the species composition.

More than half of the total variability of the relationship between species composition and environmental variables was explained for the first two axes: 43.3% by Axis 1 and 34.2% by axis 2.

Axis 1:  $p = 0.01$ , Axis 2:  $p = 0.01$

# The high-mountain habitats in Poland (Tatra Mts)

## High Tatra Mts

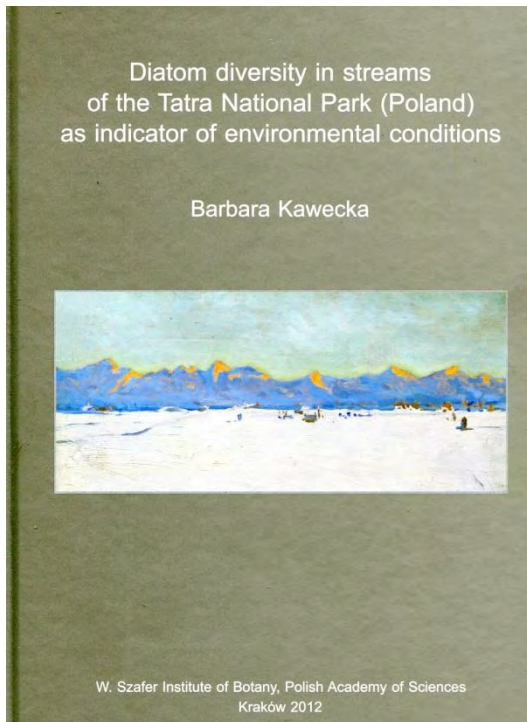
The springs are seepage rheocrenes with low discharge. The slightly acidic to slightly alkaline waters are characterised by low specific conductivity (10-72  $\mu\text{S L}^{-1}$ ) and alkalinity (0.43-0.95  $\text{meq L}^{-1}$ ) but high dissolved oxygen concentrations (8.4-12.1  $\text{mg L}^{-1}$ ). Nutrient and mineral concentrations are low and vary between springs.

## West Tatra Mts

The springs are rheocrenes and helocrenes of different discharge. The range of water pH is broad here, from acidic to alkaline. The water shows low to moderate values for specific conductivity (40-316  $\mu\text{S L}^{-1}$ ) and alkalinity (0.56-3.44  $\text{meq L}^{-1}$ ), and high to very high dissolved oxygen concentration (9-13  $\text{mg L}^{-1}$ ).

Nutrient concentrations are low, and the content of minerals (*e.g.*, calcium, magnesium) varies considerably between springs.

# The high-mountain streams in Poland (Tatra Mts)



Materials from 21 streams (57 sites), collected in 1962-2004

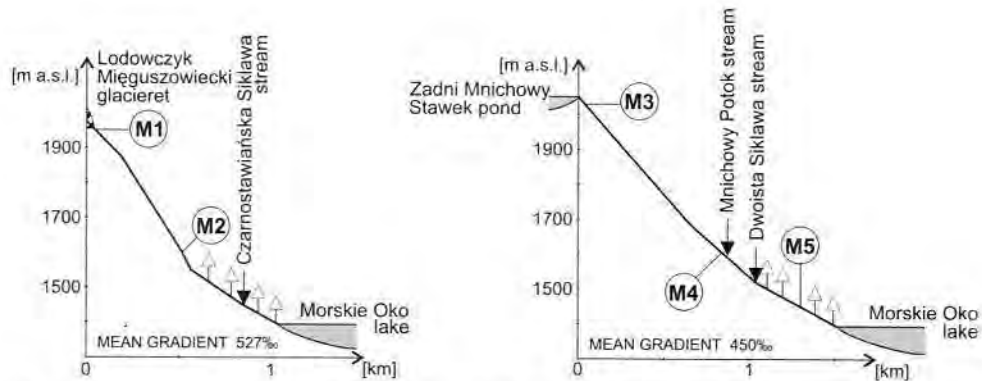
414 diatom taxa were found, mostly oligotraphentic

The diatoms were largely of alpine and subalpine distribution

The most important factors: water chemistry, hydrology

Some localities are eutrophicated (Rybi Potok, Potok Roztoka streams)

# The high-mountain habitats in Poland (Tatra Mts)



SITE	M1		M2		M3		M4		M5	
YEAR	1968	2003	2003	1968	2003	1968	2003	1968	2003	2003
Number of species	61	31	44	55	49	39	29	26		
Diversity index	2.9	2.3	2.2	3.8	1.6	3.8	2.4	2.3		
<i>Achnanthydium minutissimum</i>										
<i>Cocconeis placentula</i> var. <i>euglypta</i>										
<i>Diademsis perpusilla</i>										
<i>Diatoma mesodon</i>										
<i>Encyonema minutum</i>										
<i>Eunotia praerupta</i> sensu lato										
<i>Fragilaria arcus</i>										
<i>Gomphonema minutum</i>										
<i>Meridion circulare</i>										
<i>Planothidium lanceolatum</i>										
<i>Psammothidium helveticum</i>										

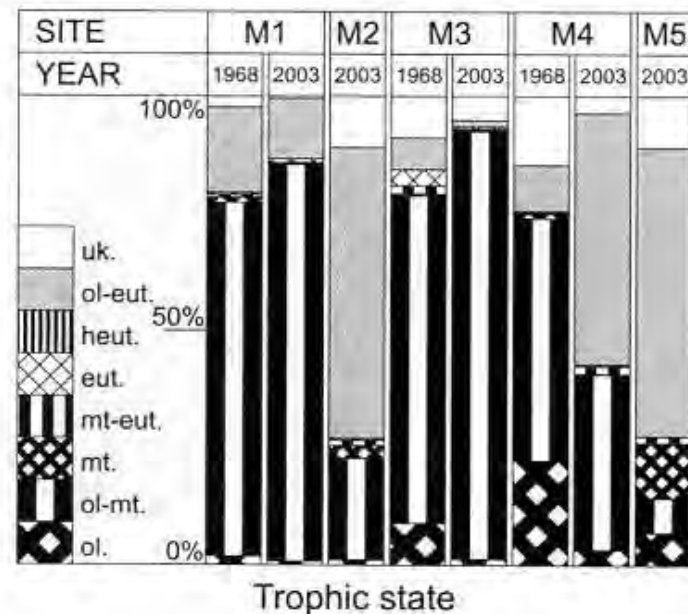
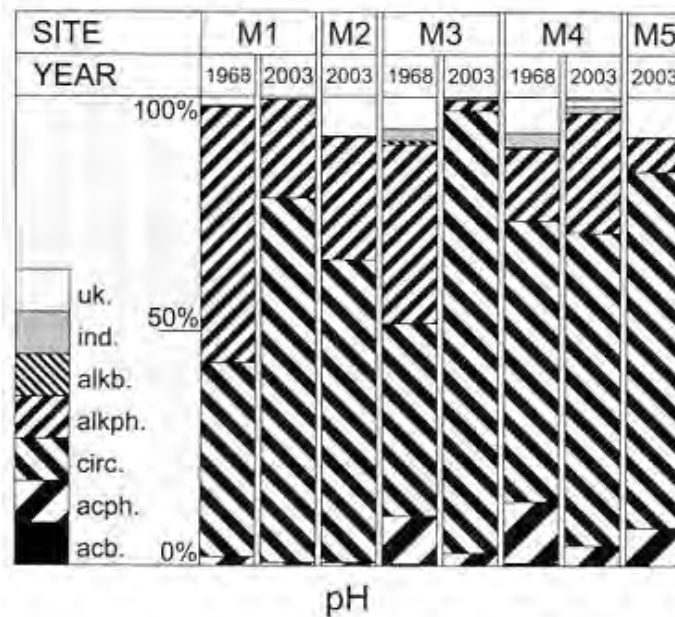
A 200 B

The Mięszowiecki and Zadni Mnichowy Potok streams.

Number of species, diversity index, the most abundant diatoms

Kawecka 2012

# The high-mountain habitats in Poland (Tatra Mts)



Kawecka 2012

The Mięszowiecki and Zadni Mnichowy Potok streams

Relative abundance of diatoms based on pH and trophic state classification system

# The high-mountain habitats in Poland (Tatra Mts)



The most abundant diatoms in Tatra streams:

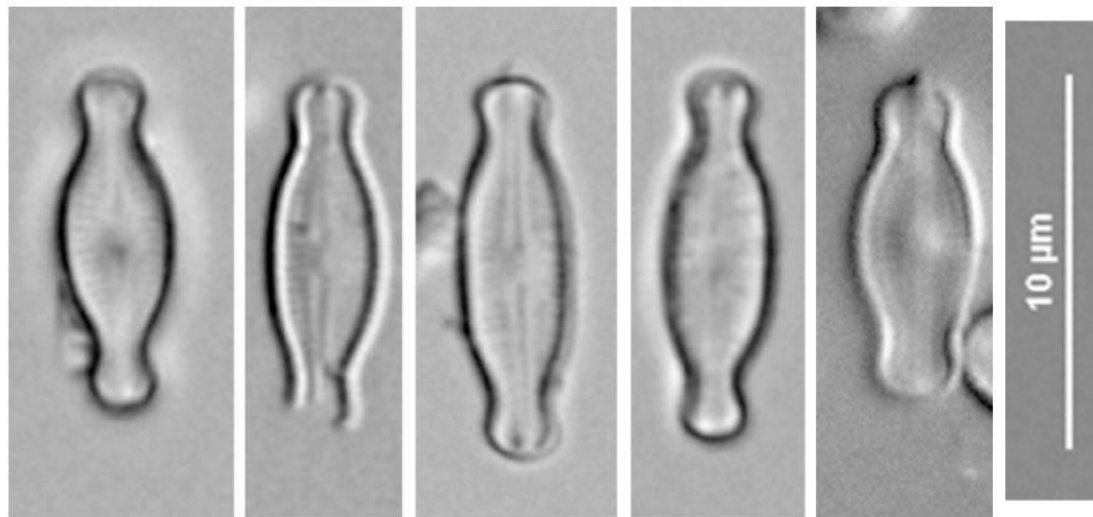
- *Achnanthisidium minutissimum* (expanding diatom, stimulated by human impact Lange-Bertalot & Steindorf 1996)
- *Eunotia exigua* (streams acidification?)
- *Psammothidium marginulatum* (acidophilic diatom of boreo-alpine distribution)
- *Diatoma mesodon* (oligo- $\beta$ -mesotraphentic or mesotraphentic diatom)
- *Tabellaria flocculosa* (oligotraphentic Kawecka 2012, or trophy tolerant Hofmann 1994)
- *Encyonema minutum* (oligo-mesotraphentic diatom)
- *Hannaea arcus* (oligo-mesotraphentic diatom)

But also - *Eolimna minima* (nutrients!), *Navicula cryptocephala* (sewage treatment plant), *Nitzschia palea* (hypereutraphentic,  $\alpha$ -meso- polysaprobic waters).

## The high-mountain habitats in Poland (Tatra Mts)

32.8% diatoms are regarded as endangered

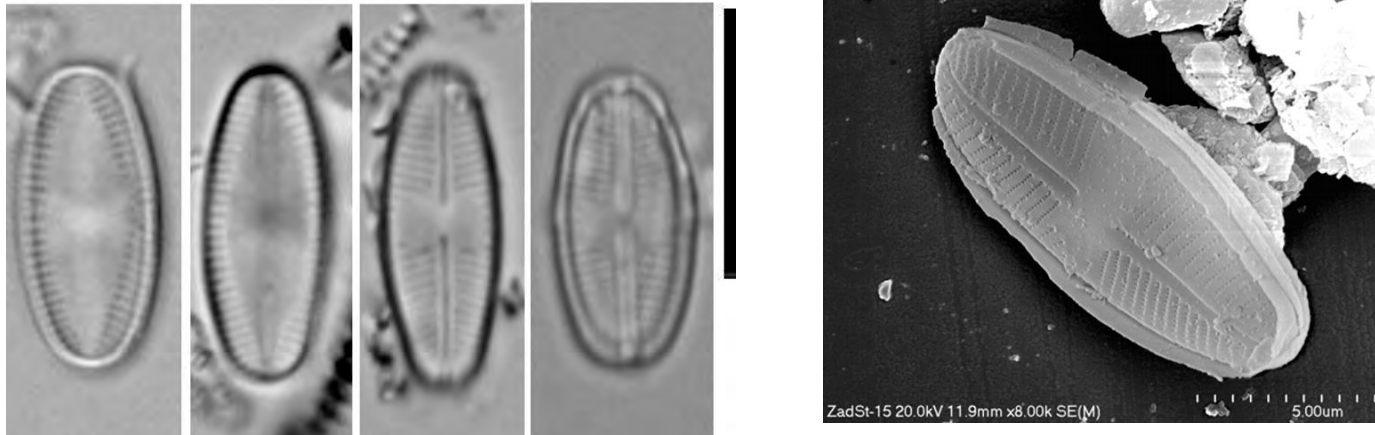
Strongly endangered – *Aulacoseira valida*, *Encyonema elginense*,  
*Eunotia praerupta* var. *bigibba*, *Boreozonacola*  
*pseudosilicula*, *Humidophila schmassmanii*, *Neidiopsis levanderii*



*Humidophila schmassmanii*

# The high-mountain habitats in Poland (Tatra Mts)

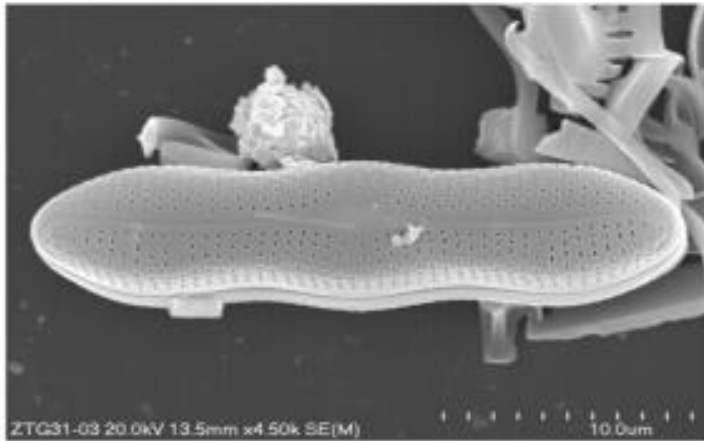
Endangered – 24 taxa, e.g. *Cavinula pseudoscutiformis*, *Encyonema gaeumanii*, *E. hebridicum*, *Eucocconeis flexella*, *Navicula angusta*, *Genkalia digitulus*, *Neidium alpinum*, *Psammothidium didyimum*, *P. marginulatum*.



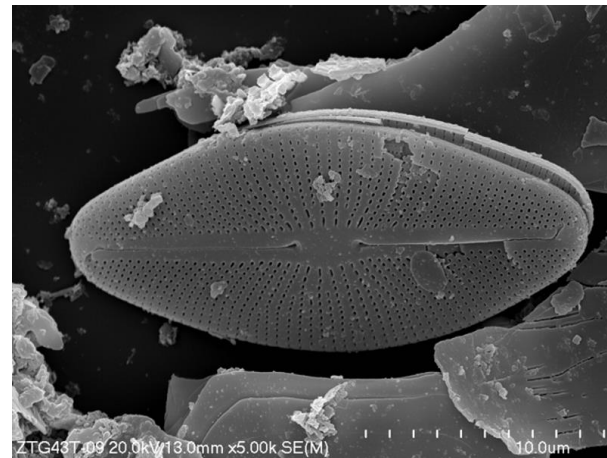
*Psammothidium marginulatum*

# The high-mountain habitats in Poland (Tatra Mts)

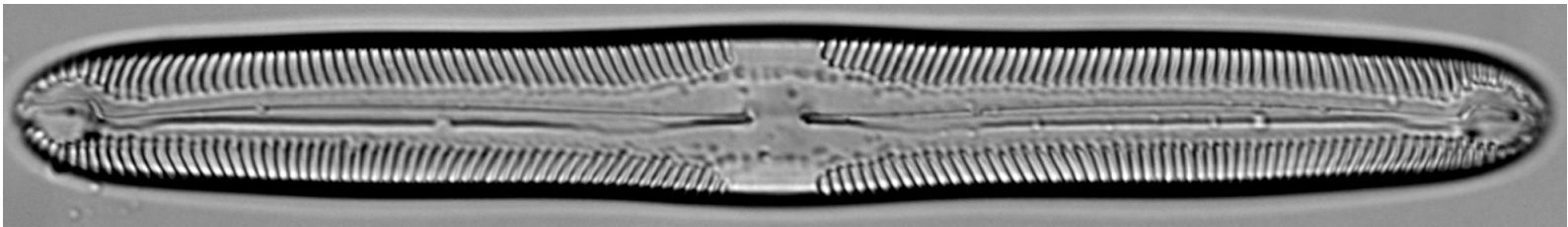
Presumably endangered – 26 taxa, e.g. *Aulacoseira alpigena*, *Caloneis alpestris*, *Cavinula cocconeiformis*, *Pinnularia stomatophora*



Strongly end. *Boreozonacola pseudosilicula*



*Cavinula cocconeiformis*

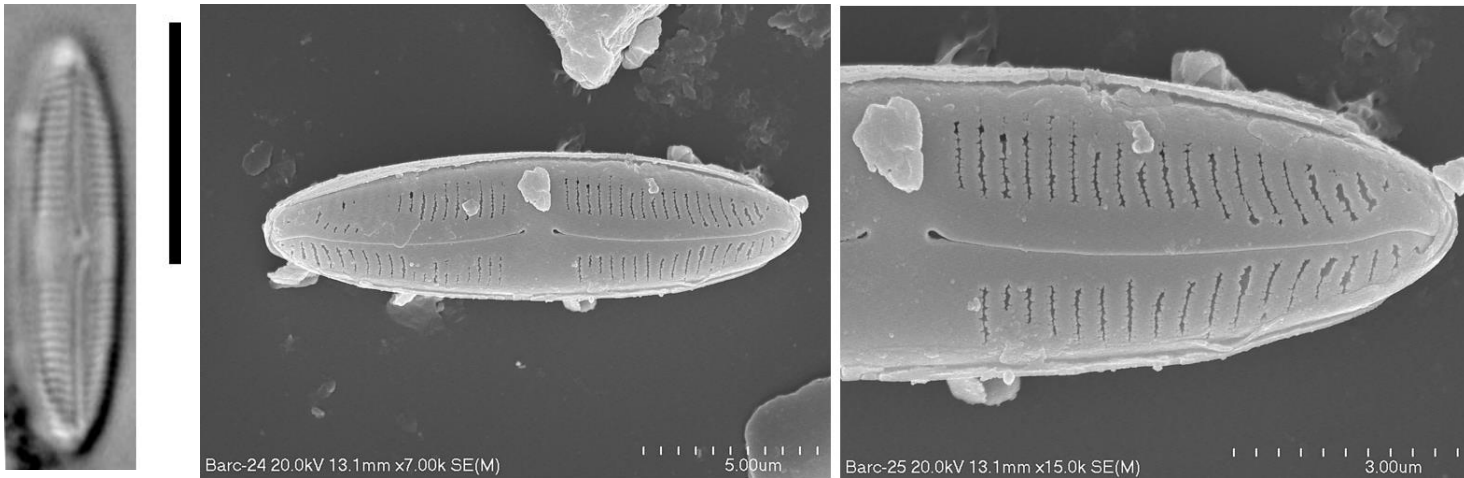


*Pinnularia stomatophora*

'Impact of invasive alien species on biodiversity and ecosystem services in extreme environments'

# The high-mountain habitats in Poland (Tatra Mts)

Rare and Extremely rare – 38 taxa, e.g. *Caloneis vasileyevae*,  
*Chamaepinnularia krookii*, *Pinnularia brevicostata*,  
*Stauroneis agrestis*

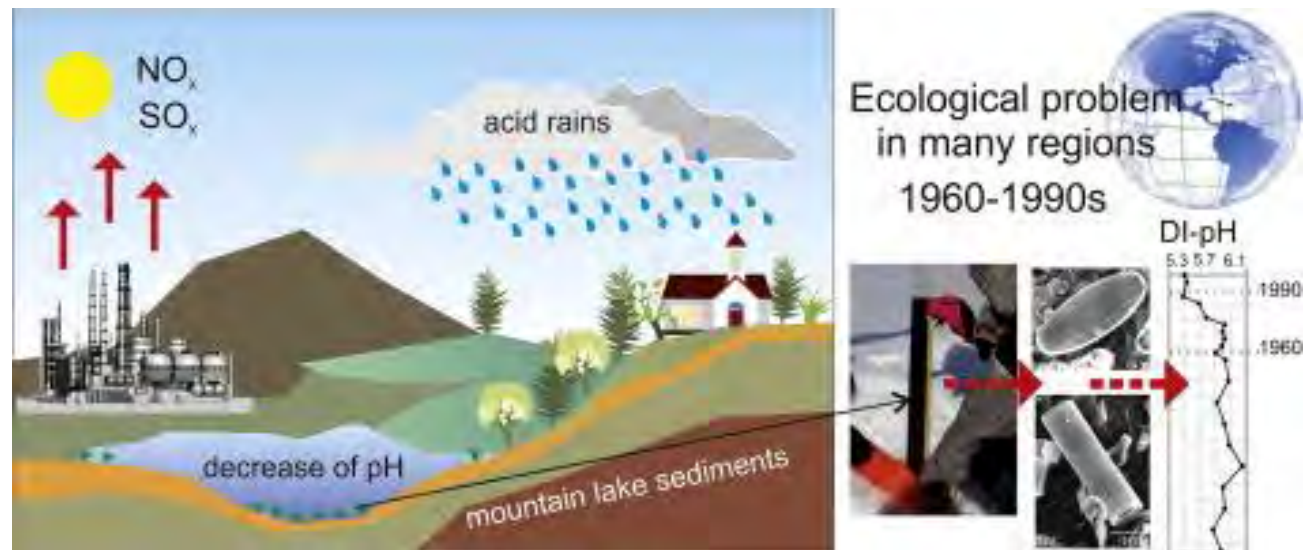


*Caloneis vasileyevae*

# The high-mountain habitats in Poland (Tatra Mts)

The lakes were investigated by:

- Marciniak (1982, 1983 – Przedni Staw lake)
- Kawecka & Galas (2003 – ten lakes)
- Sienkiewicz & Gąsiorowski (2014, 2016 – nine lakes)



Sienkiewicz & Gąsiorowski 2016

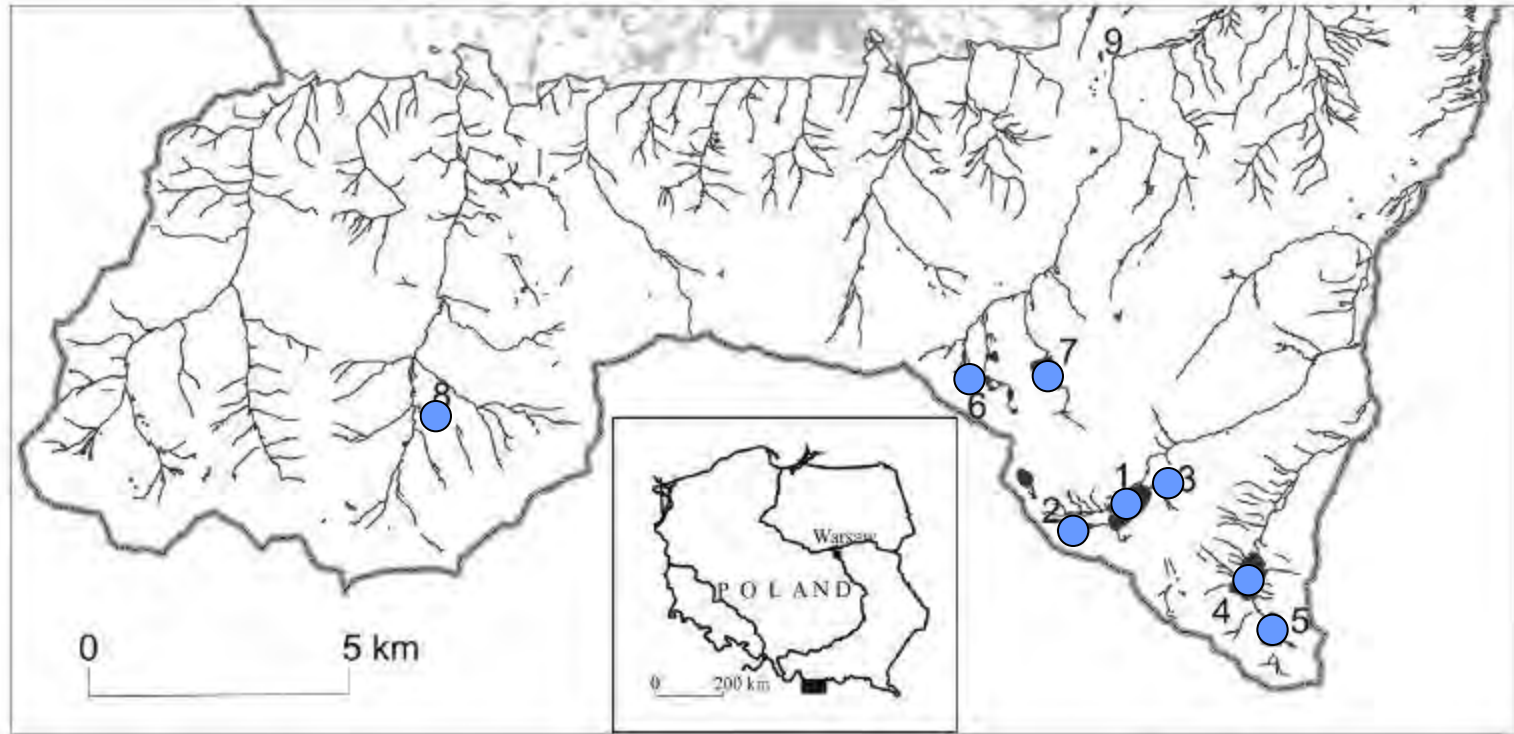
## The high-mountain habitats in Poland (Tatra Mts)

According to Kawecka & Galas (2003) diatoms indicate lack of acidification of most Tatra Mts lakes. In slightly acidified lakes acidophilous *Psammothidium marginulatum* was the most abundant, whereas in the non-acidified lakes circumneutral diatom – *Achnantheidium minutissimum* was dominant.

	pH	Cond.	Alk.	NH <sub>4</sub>	Ca	Mg	SO <sub>4</sub>	NO <sub>3</sub>	Cl	ANC
<b>Slightly acidified</b>										
Zmarzły Gąsienicowy	5.9	15	13	1.9	73	8	43	47	5.0	5
Długi Gąsienicowy	6.2	15	22	3.1	72	7	46	34	4.8	13
Dwoisty Gąsienicowy	5.8	13	8	3.8	61	14	43	31	4.8	20
<b>Non acidified</b>										
Zadni Polski	6.3	24	33	3.0	71	8	38	25	5.2	29
Zadni Gąsienicowy	6.4	18	37	1.9	97	10	46	45	5.1	31
Czarny Gąsienicowy	6.4	17	42	1.6	111	6	47	34	5.3	49
Czarny Polski	6.6	16	69	1.2	88	14	38	14	5.2	59
Wielki Polski	6.7	17	73	1.4	106	10	40	19	3.5	72
Zielony Gąsienicowy	6.7	19	88	1.6	106	13	42	14	4.7	80
Czarny pod Rysami	7.0	28	137	1.0	189	12	57	31	5.3	124

# The high-mountain habitats in Poland (Tatra Mts)

Examination of the paleolimnological record to determine the intensity of acidity changes in lake ecosystems



**Fig. 1 – Location of the study lakes: (1) Wielki Staw Polski (WSP), (2) Czarny Staw Polski (CSP), (3) Przedni Staw Polski (PSP), (4) Morskie Oko (MOK), (5) Czarny Staw pod Rysami (CSR), (6) Zielony Staw Gasienicowy (ZSG), (7) Czarny Staw Gasienicowy (CSG), (8) Toporowy Staw Nizni (TSN), (9) Smreczynski Staw (SME).**

Sienkiewicz, E., Gąsiorowski, M., Limited acid deposition inferred from diatoms during the 20<sup>th</sup> century — A case study from lakes in the Tatra Mountains, *J. Environ. Sci.* (2016)

# The high-mountain habitats in Poland (Tatra Mts)

## Acidity changes in lakes ecosystem

**Table 1 – Selected morphometric and chemical parameters of studied lakes.**

Lake name	Lake code	Location	Altitude (m a.s.l.)	Catchment area (ha)	Lake area (ha)	Max. depth (m)	pH <sup>a</sup> (1993–1994)	pH <sup>b</sup> (1996–1997)	pH <sup>c</sup> (2004)
Zielony Staw Gąsienicowy	ZSG	49°13'44"N 19°59'59"E	1672	33	3.84	15.1	6.3	6.33	6.85
Czarny Staw Gąsienicowy	CSG	49°13'52"N 20°01'05"E	1620	205	17.94	51	6.2	6.09	6.49
Morskie Oko	MOK	49°11'49"N 20°04'12"E	1395	630	34.93	50.8	6.3	6.56	7.13
Czarny Staw pod Rysami	CSR	49°11'20"N 20°04'37"E	1580	179	20.64	76.4	6.8	6.72	7.14
Przedni Staw Polski	PSP	49°12'45"N 20°02'58"E	1668	n.d.	7.71	34.6	6.4	n.d.	7.23
Czarny Staw Polski	CSP	49°12'17"N 20°01'36"E	1722	60	12.7	50.4	6.5	5.51	6.73
Wielki Staw Polski	WSP	49°12'33"N 20°02'27"E	1655	491	34.35	79.3	6.6	6.58	7.03
Smreczyński Staw	SME	49°13'21"N 19°51'52"E	1226	n.d.	0.75	5.3	4.5	n.d.	4.95
Toporowy Staw Niżni	TSN	49°17'00"N 20°01'52"E	1089	~45	0.62	5.7	5.2	5.33	5.57

Sienkiewicz & Gąsiorowski 2016

# The high-mountain habitats in Poland (Tatra Mts)

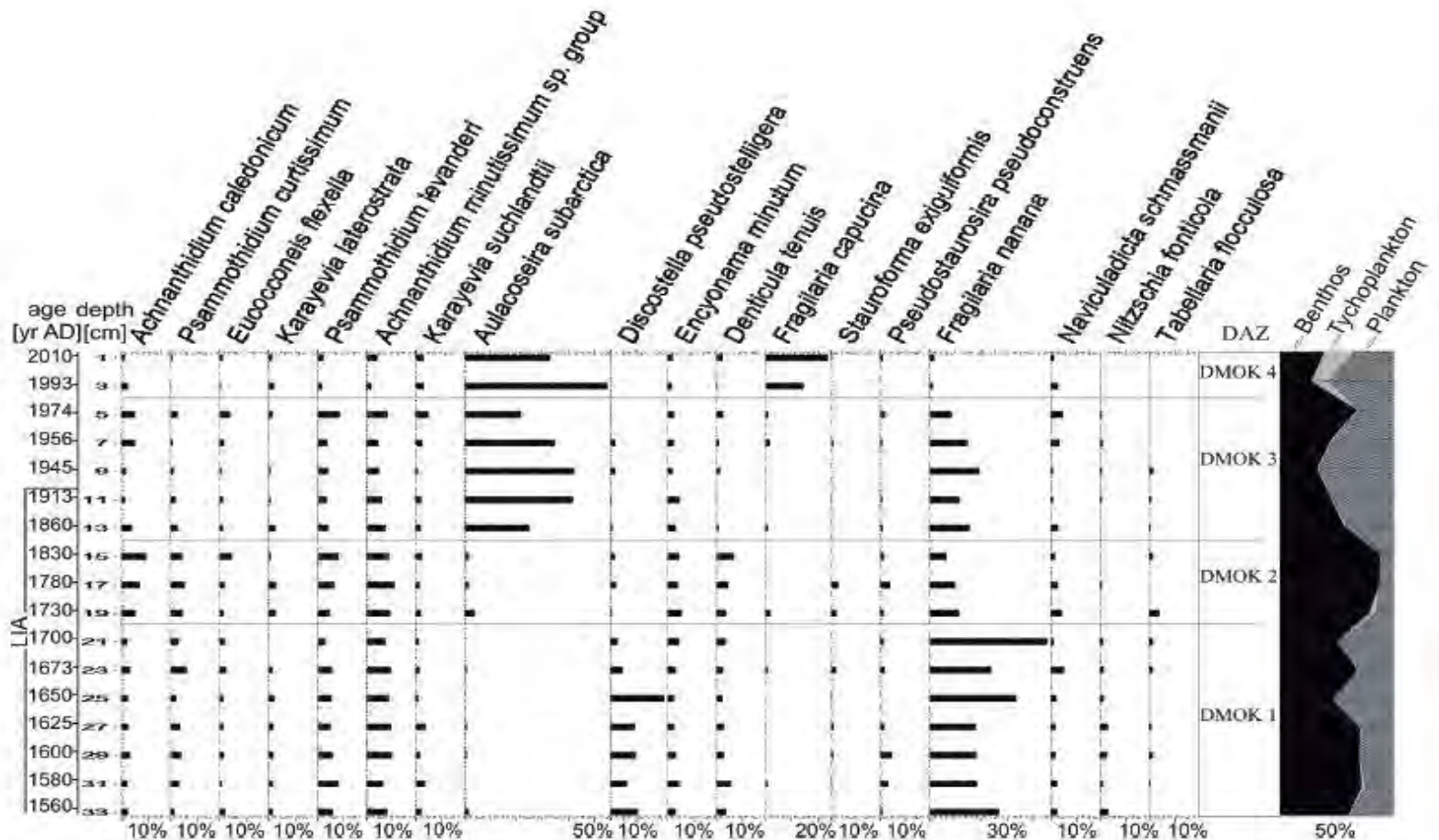
The rate and level of acidification in the oligotrophic Tatra lakes primarily depended on:

- local geology,
- inflow of acidic water from surrounding peat bogs or acidic lakes,
- elevation,
- changes in catchment vegetation as a result of climate changes, e.g., warming, and/or human influences such as acidic deposition originating from combustion of fossil fuels, deforestation, and forest fires, among others.

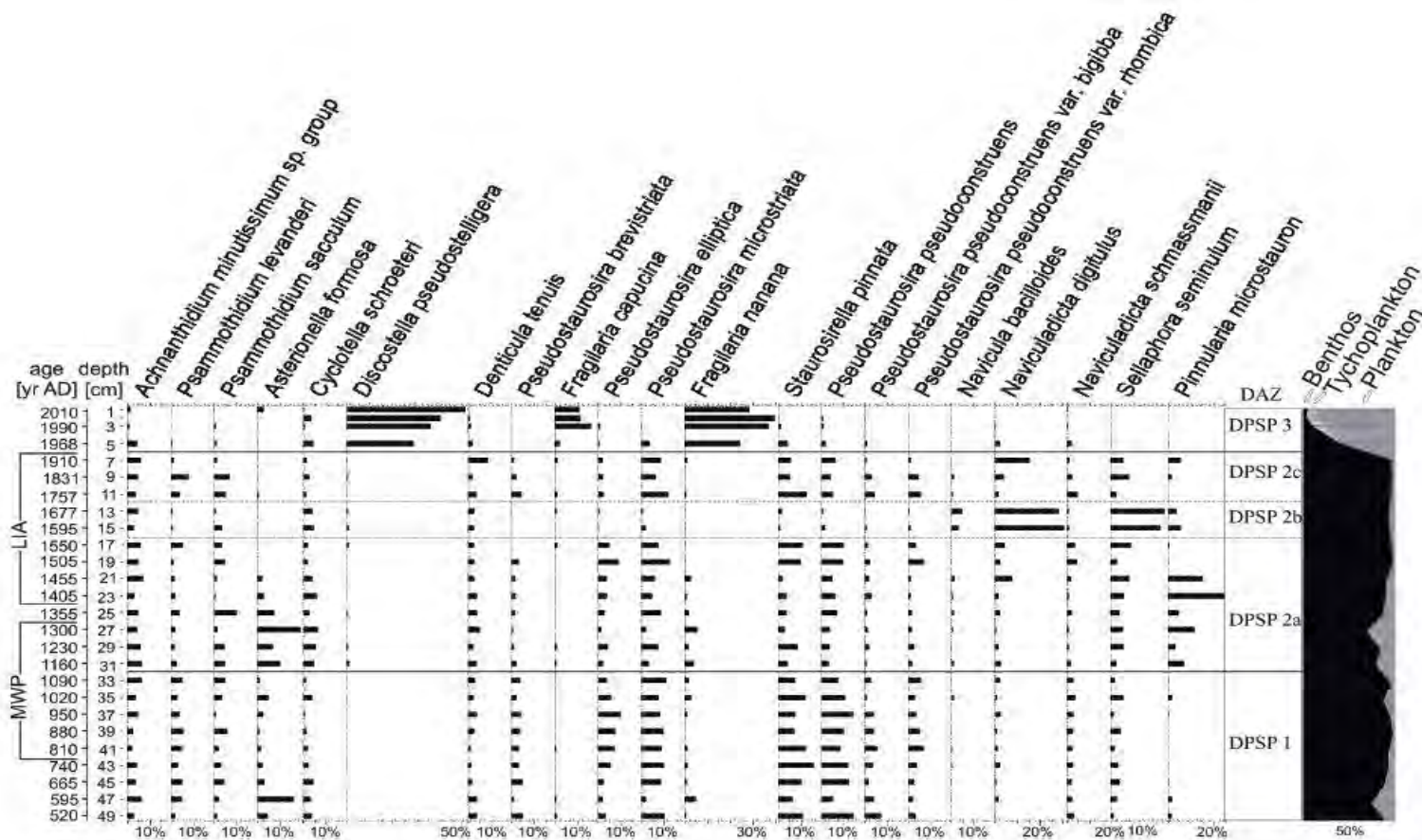
Although deposition of S and N compounds in the High Tatra Mountains was significant, major alterations of diatom assemblages in most lakes did not occur because of the relatively high acid neutralizing capacity during the previous century.

# The high-mountain habitats in Poland (Tatra Mts)

## Trophic status assesment of three high-mountain lakes



Stratigraphy of the most abundant diatoms (species occurring at > 5%) of Morskie Oko Lake (MOK).



Stratigraphy of the most abundant diatoms (species occurring at > 5%) of Przedni Staw Polski Lake (PSP).

Significant alterations in the trophic status of the studied lakes are over the past 50 years. Clear changes from oligotrophy to mesotrophy occurred in the lakes Morskie Oko lake and Przedni Staw Polski.

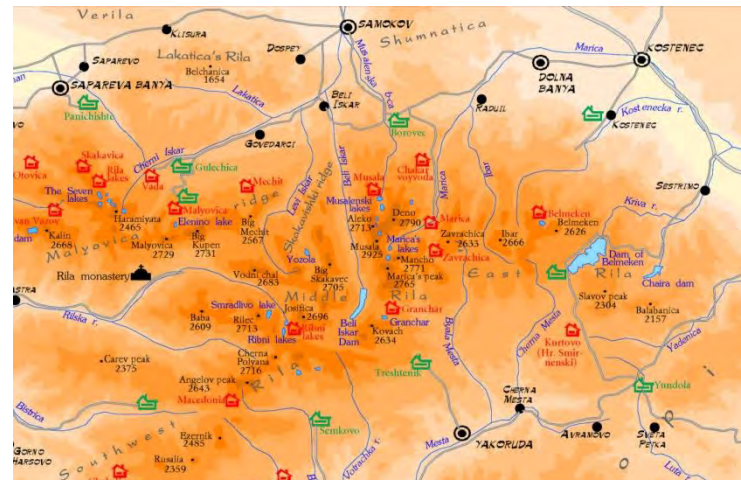
Elwira Sienkiewicz & Michał Gąsiorowski: Changes in the trophic status of three mountain lakes – natural or anthropogenic process? *Pol. J. Environ. Stud.* Vol. 23, No. 3 (2014), 875-892.

# The high-mountain habitats in Bulgaria (Rila Mts)

The Rila Mountains (southwestern Bulgaria) is the highest massif on the Balkan Peninsula (Mousala peak, 2925 m. a.s.l.).

The total area of the range is estimated at about 2393 km<sup>2</sup> (i.e. 2.2 % of the total land area of Bulgaria).

The mountains are made of granite and gneissite rocks and crystalline shales.



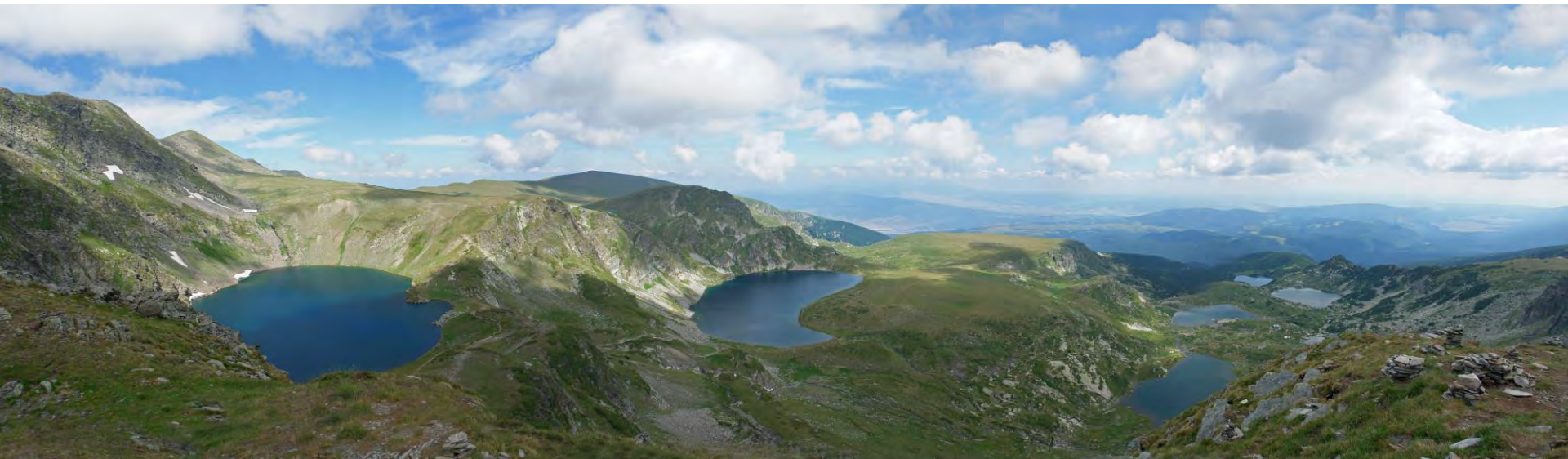
R. Botev

‘Impact of invasive alien species on biodiversity and ecosystem services in extreme environments’

# The high-mountain habitats in Bulgaria (Rila Mts)

Previous diatom studies in the Rila Mts area are mainly focused on taxonomy and floristics (Petkoff 1939; Vodenicharov 1962; Kawecka 1974, 1976).

The recent investigations were focused mainly on lakes evolution and climate changes (Stoyanova et al. 1995, Beshkova 2000, Lotter & Hofmann 2003; Clarcke et al. 2005; Catalan et al. 2009; Ognjanova-Rumenova et al. 2009, 2011; Ognjanova-Rumenova 2012).



# The high-mountain streams in Bulgaria (Rila Mts)

Maljovica stream (Rila – Bulgaria)

Three zones were distinguished  
(difference in altitude when comparison with Tatra Mts is made):

I – altitude c.a. 2600 m a.s.l. – a lot of north-alpine diatoms occur  
and e.g. *Achanthidium minutissimum*, *Caloneis alpinum*,  
(1550-1780 m a.s.l. in Tatras)

II – 1200-2500 m a.s.l. – *Diatoma hyemalis*, *D. mesodon*  
(890-1550 m a.s.l. in Tatras)

III – 1000-1200 m a.s.l. – *Hannaea arcus*, *Fragilaria capucina*,  
*Ulnaria ulna*, *Nitzschia linearis*, *Cymbella affinis*  
(540-890 m a.s.l. in Tatras)

Kawecka B. 1974. Vertical distribution of algae communities in Maljovica stream (Rila – Bulgaria). Pol. Arch. Hydrobiol. 21 (1): 211-228.

# The high-mountain lakes in Bulgaria (Rila Mts)

Climate change according to the Lake Sedmo Rilsko core (Rila Mts, Bulgaria)

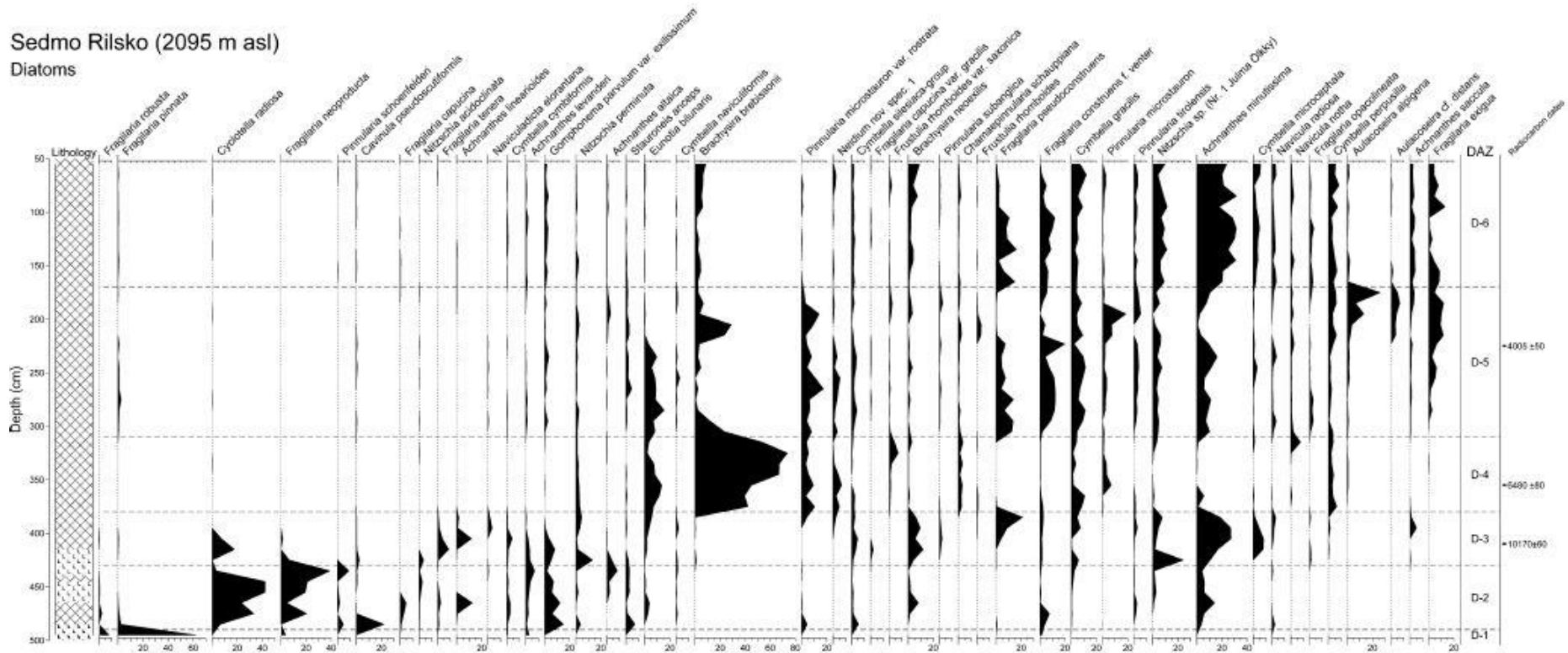
Lotter & Hofmann 2003. The development of the late-glacial and Holocene diatom flora in Lake Sedmo Rilsko (Rila Mts, Bulgaria)

The oldest zones are characterized by peryphytic, alkaliphilous to circumneutral diatoms (*Fragilaria* s.l.).

c.a. 8800 years ago a conspicuous change to acidobiontic *Brachysira brebissonii* was noted – stabilization of soils in the catchment and decrease of alkalinity

c.a. 6350 years ago the abundance of *B. brebissonii* decreased and erosional input increased slightly (higher alkalinity)

# The high-mountain lakes in Bulgaria (Rila Mts)



Lotter & Hofmann 2003

‘Impact of invasive alien species on biodiversity and ecosystem services in extreme environments’

# The high-mountain lakes in Bulgaria (Rila Mts)

The monitoring of lakes – Sulzata, Okoto, Bubreka and Bliznaka

**Table 1. Geography and morphometry characteristics of the Rila Mountains lakes studied.**

Lake	Latitude N Degrees	Longitude E Degrees	Altitude* m a.s.l.	Catchment area* $10^5 \text{ m}^2$	Water surface area* $10^4 \text{ m}^2$	Water volume* $10^3 \text{ m}^3$	Maximal depth* m
Sulzata	42.19750	23.31028	2535	1.8	0.7	15	4.5
Okoto	42.19964	23.30584	2440	3.6	6.8	860	37.5
Bubreka	42.20556	23.30678	2282	5.6	8.5	1170	28.0
Bliznaka	42.20122	23.31497	2243	21.0	9.1	590	27.5

Ognjanova-Rumenova, N., Y. Presolska, I. Botev. 2006. Abundance and species composition of diatoms and invertebrates in the cirque Sedemte ezera cirque, Rila Mts. (Southwest Bulgaria). - *Phytologia Balcanica*, 12, 1: 25-36.

# The high-mountain lakes in Bulgaria (Rila Mts)

25.6% of diatoms were classified as “nordic-alpine” and 10% as boreal

High dominance frequency, e.g. *Achnantheidium minutissimum*, *Eucoconeis flexella*, *Encyonema minutum*, *Staurosira construens*, *S. venter*, *Tabellaria flocculosa*

More than 8% planktonic and euplanktonic species: *Aulacoseira alpigena*, *Discostella ocellata*, *Cyclostephanos dubius*, *Actinocyclus normanii*, *Asterionella formosa*, *Ulnaria ulna* and *U. danica*

Water chemistry is a very important factor for diatom composition (alkalinity and concentration of  $\text{Ca}^{2+}$  have statistically significant positive correlation ( $R = 0.97$ ,  $P < 0.0004$ ))

The substrate roughness of the littoral influences the diatom species composition

# The high-mountain lakes in Bulgaria (Rila Mts)

In the study (EMERGE), 235 lakes in several European ranges were investigated with the following specific aims:

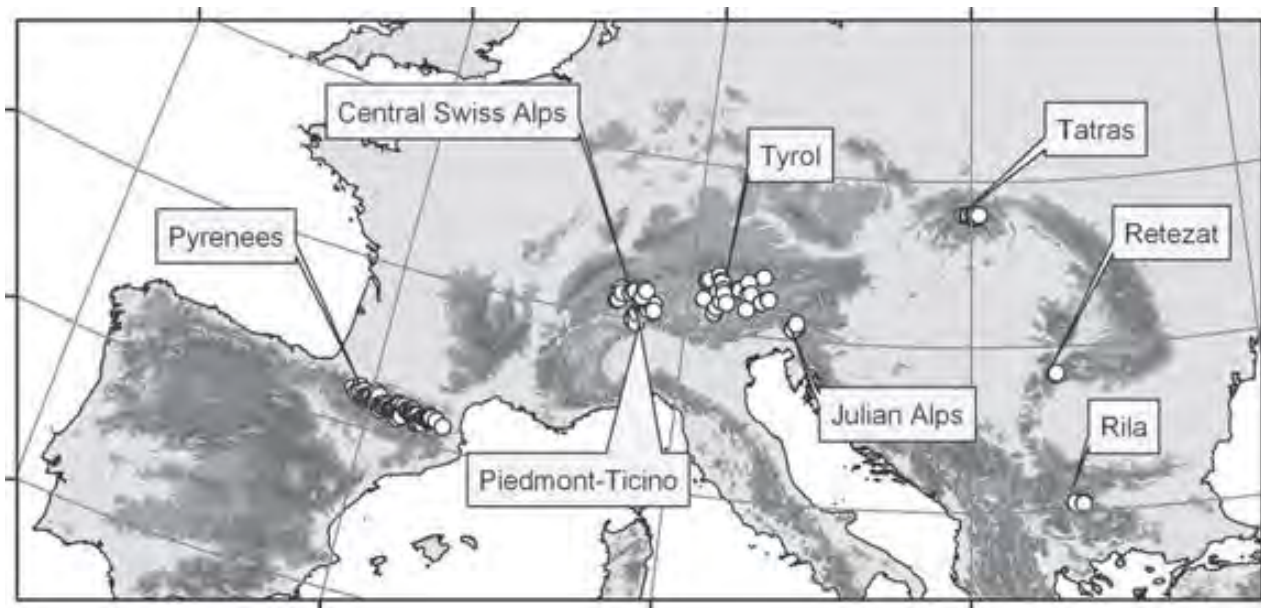
- to analyse the patterns of community assemblage in several groups of phylogenetically related species
- to identify the main environmental variables explaining the species assemblages
- to investigate the commonalities among taxonomic groups from which ecological thresholds could be defined

Catalan et al. 2009. Ecological thresholds in European alpine lakes. *Freshwater Biology*, 54.

# The high-mountain lakes in Bulgaria (Rila Mts)

There is not a single environmental lake typology discriminating alpine biota.

Diatoms mainly respond to water chemistry, rotifers to lake size, chydorids and planktonic crustaceans to ice-cover duration and chironomids to a set of trophic and dynamic variables.



Catalan et al. 2009. Ecological thresholds in European alpine lakes.  
Freshwater Biology, 54.

# The high-mountain lakes in Bulgaria (Rila Mts)

Ognjanova-Rumenova, N., I. Botev. 2008. Use of diatoms as indicators of human impact and climate changes in Bulgarian high mountain lakes. In: Global Environmental change: Challenges to Science and Society in Southeastern Europe, Conference Book, 19-21 May 2008, Sofia.

Ognjanova-Rumenova et al. 2009a. Environmental changes in the Rila Mountains, South - western Bulgaria, as recorded by the sediments of a remote lake. *Advanc. Limnol.* 62.

Ognjanova-Rumenova et al. 2009b. Benthic diatom flora in relation to chemical and physical factors in high mountain lakes in the Rila Mountains (Southwestern Bulgaria). *Advanc. Limnol.*, 62.

Ognjanova-Rumenova et al. 2011. Using sediment diatom assemblages in the assessment of environmental changes in high-altitude lakes, Rila Mts, Bulgaria. *Phytol. Balcanica* 17(2).

# The high-mountain lakes in Bulgaria (Rila Mts)

Ognjanova-Rumenova & Botev 2008

27 benthic samples from nine lakes:

- Okoto, Bubreka, Sulzata, Bliznaka (in the Sedemte Ezera cirque),
- Alekovo, Ledeno, Karakashevo (in Mousalenski cirque),
- Dolno Marichino, Gorno Marichino (in Marishki cirque).

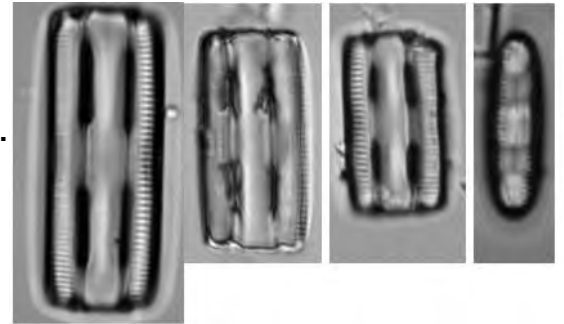
Shannon-Wiener  $H' = 2.70-4.50$

The most important factors determining the taxonomic diversity of diatom assemblages are:

- alkalinity
- pH
- conductivity

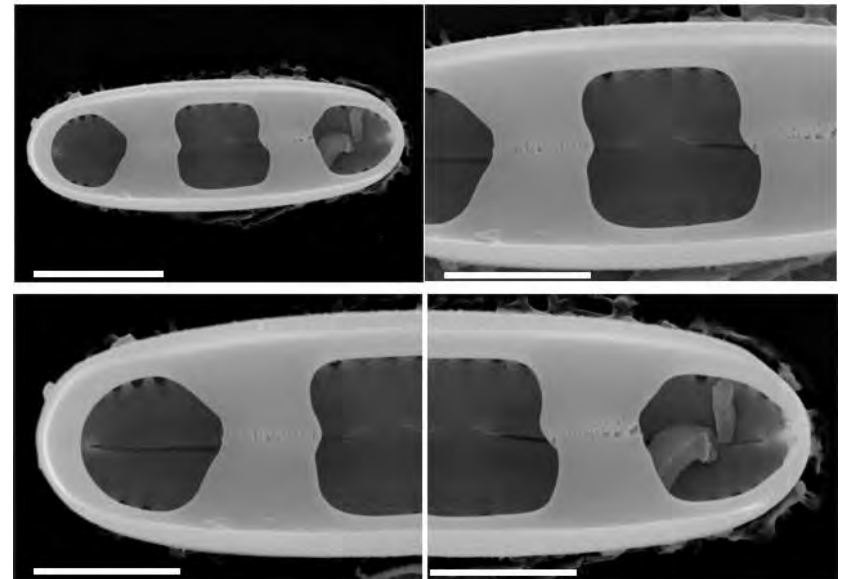
# The high-mountain lakes in Bulgaria (Rila Mts)

Ognjanova-Rumenova 2012. Diversity, distribution and ecology of diatoms from nine high Mountain lake Rila National Park (Bulgaria). Proceedings International Conference Ecology – Interdisciplinary Science and Practice. Sofia, 25 – 26 October 2012.



## Red List of diatoms from Rila Mts

- E1 (threatened with extinction) – four taxa
- E2 (strongly endangered) – six taxa
- E3 (endangered) – 16 taxa
- R (extremely rare taxa) – four taxa
- G (supposed to be endangered) – 25 taxa
- V (taxa believed likely moved into endangered group) – 35 taxa



*Diatomella balufouriana*

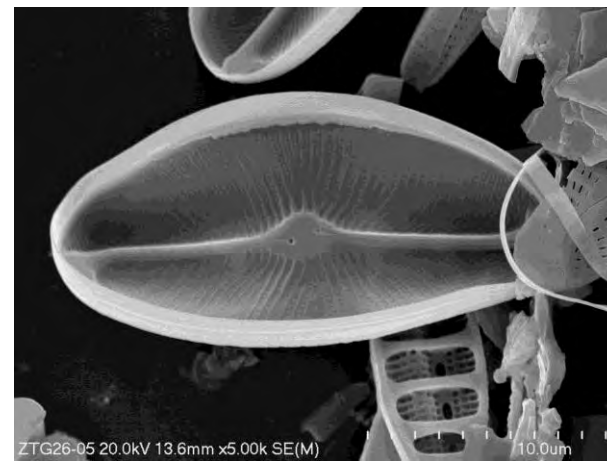
# The high-mountain lakes in Bulgaria (Rila Mts)

Threatened with extinction – *Eunotia faba*, *E. pseudopectinalis*,  
*Rossithidium nodosum*, *Navicula detenta*

Strongly endangered – *Aulacoseira valida*, *Boreozonacola pseudosilicula*,  
*Eunotia arcus*, *E. monodon*, *E. praerupta* var. *bigibba*, *E. serra*  
var. *tetraodon*

Endangered – e.g., *Eucoconeis flexella*, *Genkalia digitulus*,  
*Psammothidium marginulatum*

Extremely rare taxa – *Karayevia suchlandtii*, *Pinnularia brevicostata*, *P.*  
*stomatophora*, *Pseudostaurosira brevistriata*



*Eucoconeis flexella*

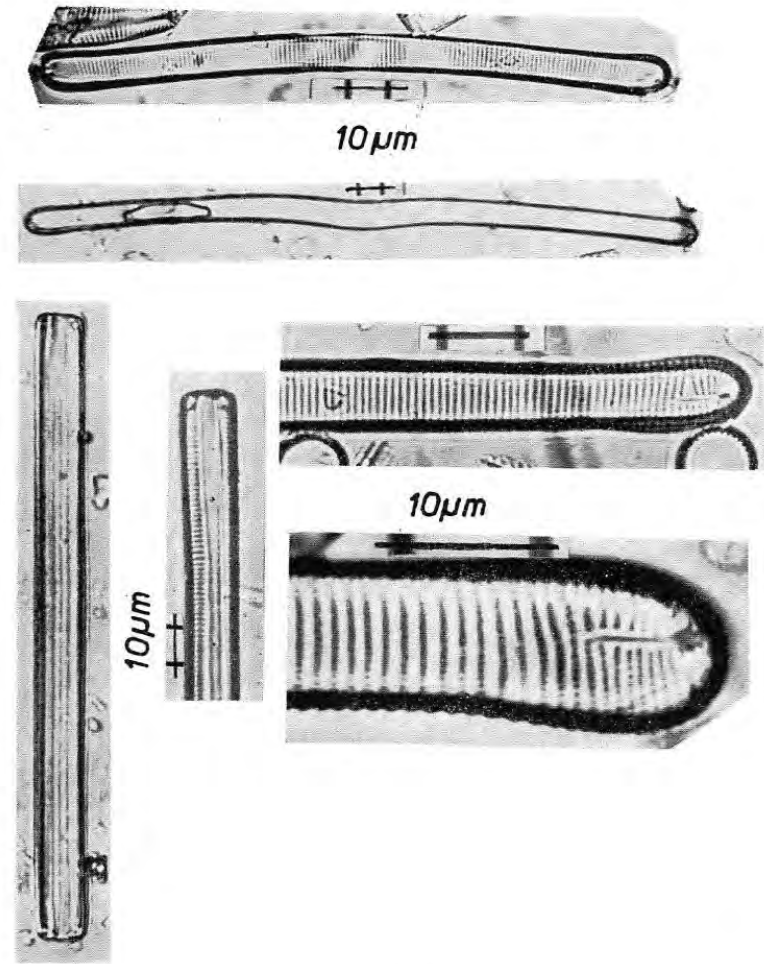
‘Impact of invasive alien species on biodiversity and ecosystem services in extreme environments’

# The high-mountain streams in Bulgaria (Rila Mts)

In 1976 Kawecka described new variety of *Eunotia flexuosa* – *E. flexuosa* var. *rilensis*.

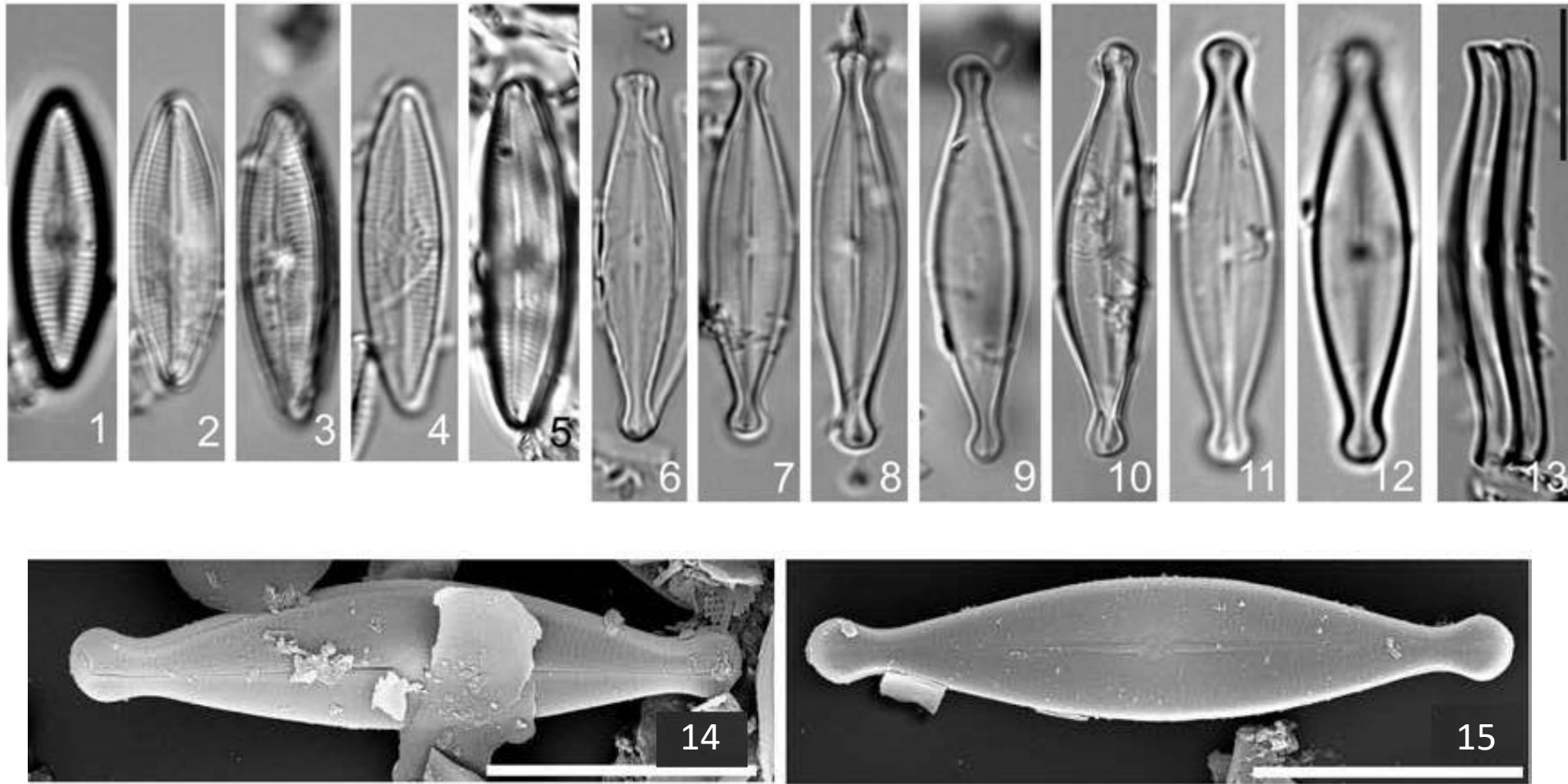
This diatom was found in Maljovica stream, at an altitude of 2400-1750 m a.s.l.).

Rheophilous environment on a wide terrace crossing the slope is its *locus typicus*.

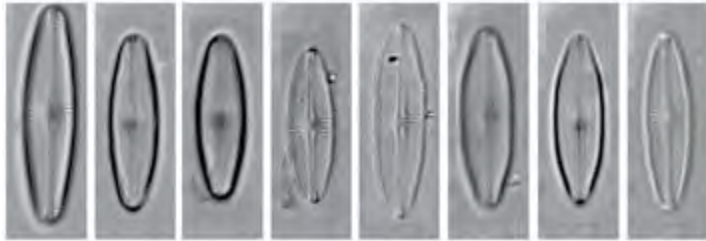


Ryc. 1. *Eunotia flexuosa* (Bréb.) Kütz. var. *rilensis* n. var.

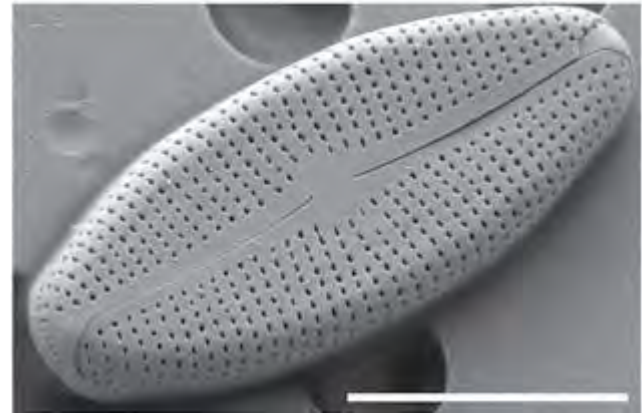
*Nupela lapidosa* (1-5) and *N. marvanii* (6-15) from Tatra Mts



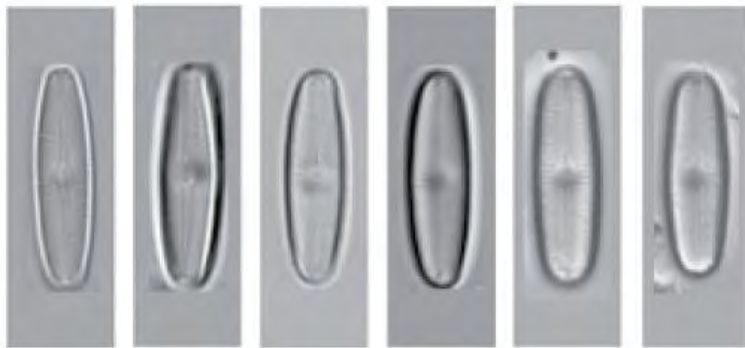
Wojtal A. Z. 2009. *Nupela marvanii* sp. nov., and *N. lapidosa* (Krasske) Lange–Bertalot in Poland with notes on the distribution and ecology of the genus *Nupela* (Bacillariophyta). *Fottea* 9(2): 233–242.



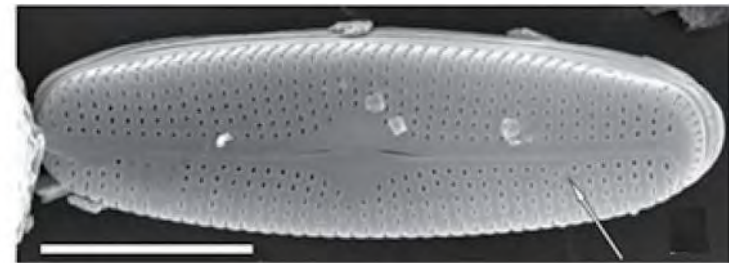
*Genkalia digitulus*



*Genkalia digitulus*



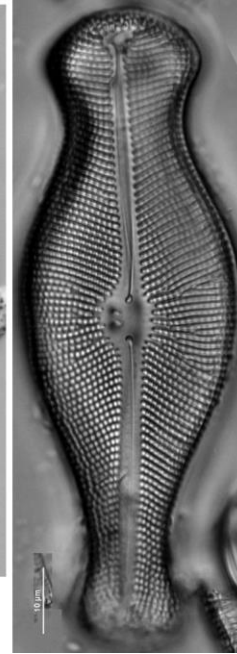
*Genkalia boreoalpina*



*Genkalia boreoalpina*

Wojtal, Ognjanova–Rumenova, Wetzel, Hinz, Piątek, Kapetanovic, Ector & Buczkó 2014. Diversity of the genus *Genkalia* (Bacillariophyta) in boreal and mountains lakes – taxonomy, distribution and ecology. *Fottea*, Olomouc, 14(2): 225–239

Thank you for your attention!



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