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Ecology of epipelic diatoms

by

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Abstrakt

Alhough epipelic diatoms play a key role in primary production of many ecosystems, many aspects of their ecology are poorly understood (POULÍČKOVÁ et al., 2008). Diatoms samples of mud sediment were taken from 20 lakes/ponds in Scotland and England, covering a gradient from oligotrophic mountain lakes to eutrophic lowland ponds. In total, 197 diatom taxa were identified. The relationship between lake epipelic diatoms and environmental variables were revealed effectively by use of a multivariate statistical methods using the software package CANOCO for Windows 4.5. The data set was analysed via detrendet correspondence analysis (DCA) and further canonical correspondence analysis (CCA), the species – response curves were modelled using generalized linear models (GLM). Main gradient in species data was described (DCA) and the chemical variables: water depth, area, pH, conductivity, trophy and alkalinity correlated with first axis. Farther the response curves of 13 taxa for pH and conductivity were ascertained (CCA).

Key words: diatoms, epipelon ecology, lakes.

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Abstract

Přestože epipelické rozsivky hraji klíčovou roli v primární produkci většiny ekosystémů, mnohé aspekty jejich ekologie jsou málo známé (POULÍČKOVÁ et al., 2008). Vzorky rozsivek sedimentu byly odebrány ze dvaceti jezer ve Skotsku a Anglii tak, aby byl pokryt gradient od oligotrofních horských jezer až po eutrofní nížinné nádrže. Celkem bylo určeno 197 druhů rozsivek. Vztah mezi epipelickými rozsivkami jezer a faktory prostředí byl popsán za použití statistických metod a programu CANOCO for Windows 4.5. Data byla analyzována za použití detrendované korespondenční analýzy (DCA), následně canonické korespondenční analýzy (CCA), druhově specifické odpovědní křivky byly modelovány použitím generalizovaných lineárních modelů (GLM). Byl popsán hlavní gradient v druhovém složení (DCA) a faktory prostředí: hloubka vody, rozloha, pH, vodivost, trofie a alkalinita byly korelovány s první ordinační osou. Byly sestrojeny odpovědní křivky 13 druhů na pH a vodivost (GLM).

Klíčová slova: rozsivky, epipelon, ekologie, jezera.

Declaration

I, Jiřina Galetová hereby proclaim that I made this study on my own, under the supervision of Doc. RNDr. Aloisie Poulíčková, CSc. and using only cited literature.

In Olomouc, May 7, 2009 ……………………………

signature

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Introduction

Though the epipelic diatoms play a key role in primary production of many ecosystems, many aspects of their biodiversity, ecology and geographical distribusion are slightly known (POULÍČKOVÁ et al., 2009). Many of common epipelic diatoms are described like „cosmopolitan“ (sensu KRAMMER & LANGE – BERTALOT, 1986, 1988, 1991) . POULÍČKOVÁ et al., (2008) alludes to a debate about whether distribution of diatoms are (TELFORD et al., 2007) or not dispersal – limited (FINLAY et al., 2002). FINLAY et al., (2002) described two types of freshwater diatoms: (1) generalists – cosmopolitan diatoms with broad ecological tolerance, and (2) specialists – diatoms with specific requirements, which therefore occur at only few locations. Recent evidence has shown, that traditional diatom morphospecies are often heterogeneous, containing several to many different taxa (POULÍČKOVÁ et al., 2006a). However, ecology of “cryptic“ species is realy unknown.

Epipelon

For algae, there are two principal habitats in aquatic environment: moist or submergent surface – bentic, and open water – planktonic (ROUND et al., 1990). The organisms growing in the bentos have been clasified into subsets. (1) Rhizobentos represents the vegetation rooted in the sediment. (2) Haptobentos (association adnated to solid surface) is divided into epiphyton (growing on other plants), epilithon (growing on rock surfaces), epipsamon (growing on sand grains) and epizoon (growing on animals). (3) Endobentos (community living and boring into solid substrata) includes endolithon and endophyton. (4) Herpobentos (community living on, or moving throught, sediments) is subdivided into **epipelon** (living on the surface of the deposit: mud and sand), endopelon (living and moving within mudy sediments) and endopsamon (living within sandy sediments) (ROUND, 1981).

Epipelon is an greatly widespread community occuring in all waters in regions where sediments accumulate and on to which light penetrates. The species are almost all microscopic and the associations rich and extended (ROUND, 1981). They live on and in the surface layer (several milimetres) of sediment and can not withstand long period of darkness and anaerobic conditions (MOSS, 1977).

Many hundreds of species are involved in the algal association of the epipelon: cyanophytes, chlorophytes, diatoms (chromophytes), desmids and some flagellates (ROUND, 1981). The species composition of the epipelon varies widely between habitats (ROUND, 1981; HINDÁK, 1987). The sediments of streams, lakes, salt marshes, sandy beaches, etc., all have floras of they own, which are often extremely rich in motile pennate diatom species (ROUND et al., 1990). The sediments of lakes arrear to the causal observer as a sterile environment, yet a very rich microscopic epipelic flora lives creeping over and between the silt or sand particles (ROUND, 1981).

Environmental factors

The freshwater bentic communities are influenced by a wide spectrum of biotic and abiotic faktors (solar energy, nutrients, live range, etc.), but also by disturbances (mechanical and chemical) (ROUND, 1981).

Floating plankton in pelagic zone have a primar access to the solar light, whereas the bentic associations in litoral zone to the nutrients releasing by mineralization proces in sediment (WETZEL, 1996). Laboratory test showed that maximal epipelic production rate decreased with water depth and average epipelic production is positively related to average light intensities (VADEBONCOEUR et al., 2000). The decrease of light intensity with water deph is certainly influenced by dispersed particles in water colum, including phytoplankton. High phytoplankton abundance dramatically decreases the depth distribution of bentic algae by shading (POULÍČKOVÁ et al., 2006b).

Another factor of a light distribution along the gradient of depth, can be for example the interaction of wawing and light. Typically, epipelon is associate with the upper lyer of a sediment accordant to a photic zone (HOPKINS, 1963). From experiments modifying the light condition in lakes and reservoirs ensued that a composition of epipelic association and a density are dependent on the light intensity (POULÍČKOVÁ et al., 2006b). Location of microscopic algae in photic zone is established basicaly by their photosynthetic demand. However, the algal cells are also found in depths, even tens centimetres under konpenzation level in afotic, anaerobic zone (GRONTVED, 1962). This phenomenon is attributed to the mechanical processes of sediment (e.g. an agitation evoked by wind). There is a limitation for habitation in the opposite direction of a level, too.

Most diatom taxa are sensitive to UVR because they are unable to efficiently produce photoprotective pigments (ROY, 2000) and they have not good capacity for repair after UVR damage (QUESADA et al., 1997). Diatoms are sensitive to desiccation (MOSISCH, 2001).

The sediments are in motion, continuously moved by water movement and the activites of the animals living on, and in, the sediment. This movement results in the steady sinking of heavy particles, algae including, into the sediment and only algae capable of positive phototactic movement are likely to survive (ROUND, 1981). Most adapted diatom form to this disturbantces appeare pennate diatoms, possessing raphe on both thecas that are motile on the sediment. Non – motile forms (centric, monoraphic diatoms) would be buried in the deposits whenever these were disturbed. They mostly belong to different communities: planktonic (are subsited to the sediment by wave action) or rheophilic (are brought to the lake in the inflows) (ROUND, 1953). In addition, resting stages and settled cells (still capable of photosynthesis) of many planktonic algae can be found in the benthos (SICKO – GOAD et al., 1989).

Diatoms are autotrophic organisms, thus light is one of factors influencing their migration through sediment, but does not have to be the starting impuls for migration (SABUROVA & POLIKAROV..et al., 2003). Migration is often in cirkadial or diurnal rhythm (PALMER et al., 1965). A vertical distribution of diatoms into the sediment is not uniform. SABUROVA & POLIKARPOV (2003) found out that 40% of the diatoms is present in the topmost 2 mm layer and 60% in deep layers of the sediment, with maximum ascertained depth 83 mm in a sand sublayer. Nondividing cells are dominant near the sediment surface and the percentage of dividing cells increases with depth, as well as the occurrence of cytokinetic cells. Migration of epipelic diatoms is mainly regulated by two comprehensive factors: exogennic factors (environmental specifications, e.g. photoperiod) and endogenic faktors (reproduction cycle conected with nutrition needs). The experiment estimated the maximum rate of microalgae movement at 1.7 mm/h.

The chemical and physical variable of lake sediments is probably the cause of differences in composition of bentic algal communities (ROUND, 1953). There is a correlation between nutrients content in sediment and positive movement of some epipelic algae documented, even if a oxygen capacity and a nutrients disolvability is decreasing (REVSBECH et al., 1983). Nutrients represent a basic factor for biomas production,species composition, colonissation rate and primary succession (KITTER et al., 2005). Epipelon have been shown to uptake nutrients from the watercolumn (HAVENS et al., 1999). In backwater have been found specialists, species able to provide nutrients presented in defect concentrations (MOSS, 1973). Epipelic association can be responsible for a substantial proportion of whole-lake primary productivity and are a dynamic component of lake nutrient cycles (AXLER et al., 1996).

SCHÖNFELDER et al. (2002) detected 11 important ecological variables that most independently explain major proportions of the diatom variance among the habitats: DIC (disolved inorganic carbon), TN (total nitrogen), pH, oxygen saturation, disolved iron, SO_4^{2-}, NH^{4+}, soluble reactive silica, maximum water depth, Ca^{2+} or soluble reactive phosphorus. McMASTER et al. (2005) identified maximum depth, $NO_{2-}N+NO_{3-}N$ (nitrite plus nitrate), DOC (disolved organic carbon) and conductivity as the strongest predictor of epipelon abundance in their study. Ponds with high DOC concentrations have generaly more diatoms than ponds with low DOC concentration. Microscopical algae chemically greately affect the chemical components and the nutrient cycling especially some of the minor elements (ROUND, 1981). Diatoms are sensitive to silica being below or close to limiting contrentrations (< 0.5 mg L^{-1}) (McMASTER et al., 2005).

Aims

The present study as a part of the project GACR 206/07/0115 „Diversity, ecological preferences and reproductive biology of freshwater epipelic diatoms“ focus on a evaluation of samples collected from 20 lakes from Great Britan and aims to address the following questions:

1. What is the species composition of epipelic assemblages and a overal diversity of epipelic diatoms in British lakes?
2. What are the ecological preferences of the most common taxa and is there any potential for their use in biomonitoring?

Material and metods

Study sites

The investigated 20 lakes are situated in 2 locations in Grate Britan: England and Scotland (Table 1). The lakes were selected to cover the spectrum from oligotrophic glacial mountain lakes to eutrophic lowland lakes/ponds.The geographical position, and basic morphomertic and hydrological data of the lakes are summarised in Table 2.

Location	Lakes
England	Blake Mere (No. 9), Cole Mere (No. 10), Ellesmere (No. 4), Fenemere (No. 5), Oss Mere (No. 3), Marbury Big Mere (No. 2)
Scotland	Achray (No. 13), Ard (No. 19), Loch of Butterstone (No. 11), Blackford Pond (No. 1), Loch of Clunie (No. 17), Loch of Craiglash (No. 20), Loch of Lowes(No. 16), Lubnaig (No. 18), Lake of Menteith (No. 8), RBG pond (No. 6), Rae Loch (No. 7), Threipmuir Reservoir (No. 14), Loch Venachar (No. 12), Loch Voil (No. 15)

Table 1 Location of lakes
Location: England, Scotland; No.: ordinal number used in following Table 2.

England

Studied 6 lakes are situated in the county of Shropshire, in the Nord - West Midlands region of England, close to the Welsh border (Map 1). Physiographicly, the lakes are part of the Shropshire – Cheshire Plain (below the Plain), well – defined geographical unit, extending from the Mersey estuary to the South Shropshire hills and lying between the Welsh Massif in the west and the Pennines in the east (Ordnance Survay, http://www.ordnancesurvey.co.uk).

Geologicaly, the Plain is an alongated saucer – shaped depresion of mainly carboniferous rocks (limestones, grits, shales and coal measures). However, the solid rocks were mostly overlaid by unconsolidated glacial drift deposited during the Pleistocene ice advances. Ice sheets entered from two main sources: more substantial sheet from the Lake District, south – west Scotland and the lesser one from North Wales (REYNOLDS, 1979).

The distribution of lakes is neither uniform or random, most of them are in distinct local groupings. Major clusters are centered around cities Delamere, Knutsford, Congleton, Ellesmere, Whitchurch and Shrewsbury.

In our case, in Ellesmere group are included: Ellesmere, Blake Mere, Cole Mere; in Whitchurch group lakes Marbury Big Mere and Oss Mere; and lake Fenemere fall into Baschurch group. Mentioned groups are named according to nearest city: Baschurch, Whitchurch and Ellesmere inhered in the middle of the Plain, in areas dominated by sand and gravel drifts (REYNOLDS, 1979).

The factors which contribute to the climate of the Plain are dominated by two components: (1) the proximity of the Plain to the western seaboard, which ensures temperate, humid sub – oceanic conditions throughout most of the year; (2) the position in relation to the Welsh massif, which provides a rain – shadow from westerly winds and eastward – passing fronts. Majority of the lakes have been isolated from streams throughout most of their history. The lakes are, in different extent, fed by mineral – rich ground water flow (REYNOLDS, 1979).

Scotland

Sampled 14 lakes from Scotland are located in 3 areas: (1) county Lanarkshire north of city Glasgow; (2) county Perthshire near cities Dunkeld and Blairgowrie; (3) and near/in the capital city Edinburgh (Ordnance Survay, http://www.ordnancesurvey.co.uk) (Map 2).

. The lakes were formed during the great glaciation by general south – easterly movement of the ice, their bottoms are apparently very irregular. Geologicaly, there are the usual mineral species represented: quartz, felspars, black and white mica, amphibole, pyroxene, magnetite and granite. The deposits are finer grained, in the parts by a inflow of the river there are considerable accumulation of gravel and fine sand.

North of the city Glasgow in Scotish highland in the Trossachs and Lomond National Park had been chosen lakes from 2 rivers systems: (1) Achray – Venachar on the River Achray Water, (2) Voil – Doine (not sampled) - Lubnaig on the River Black Water. Lakes Achray and Venachar originally formed one sheet of water, recently there is a strip of alluvium between them and the difference in level between them being less than 2 metres. Lakes of second river system formed in post – glacial times one single sheet of water too and later, their subsequent isolation has been due to deposition of sediment. Lake Menteith is situated south of these systems. Lake Ard is located on the River Forth which drains away water from a whole catment area to the sea.

The Threipmuir reservoir is situated at the base of the Pentland hills, about 20 km south - west of the city Edinburgh. Both Blackford pond and RBG pond are situated in Edinburgh, the letter belonging to Royal Botanic Garden in Edinburgh.

Loch Clunie lies in the valley of the Lunan Burn, 5 km west of the city Blairgowrie. Rae Loch lies 2.5 km west of the city Blairgowrie. It lies a 1.5 km east of the Loch of Drumellie into which Rae Loch drains.

Loch of Butterstone, Loch of the Lowes and Loch of Craiglush are a group of three small lochs 3 km to the north - west of city Dunkeld. They lie at the head of the valley of the Lunan Burn, which flows east and south - east to join the River Isla near Coupar Angus.

No.	Lake	Sample	Sampling date	Grid Reference	Alt. (m a.s.l.)	Depth (m)	Area (ha)	Alkal.	pH	Cond. $\mu S.cm^{-2}$	PARMADO	LTDI reeds	LTDI stones	Class
1	Blackford pond	4	121004	NT 253709	75	3	0.6	HA	8.4	331	Sa	77.39	74.96	P
2	Marbury Big Mere	3	211005	SJ560454	78	8.0	10.5	HA	9.2	428	Sa	65.73	69.66	P-M
3	Oss Mere	17	211005	SJ 561440	105	2.9	9.5	HA	9.1	479	Sa	50.73	70.67	P-M
4	Ellesmere	10	211005	SJ407345	98	18.8	46.1	HA	7.5-9.5	272	Sa	52.18	76.63	P-M
5	Fenemere	11	231005	SJ446230	88	2.2	9.4	HA	8	570	Rs	54.03	68.48	P-M
6	RBG pond	19	021204	NT 248752	15	2	0.09	HA	7.5	374	Sa	65.28	64.53	M
7	Rae Loch	18	081204	NO160446	60	4.8	13	MA	n.d.	n.d.	Sa	50.30	58.55	M
8	Lake of Menteith	15,16	290905	NN567009	17	23.5	264	MA	7.04	77	Sa	37.32	50.65	M
9	Blake Mere	5	221005	SJ416337	91	13.5	8.4	HA	7.1-8.2	121	Sa	35.14	50.10	G
10	Cole Mere	8	211005	SJ435329	88	11.5	27.6	HA	7.6-8.3	289	Fe	35.31	48.79	G
11	Loch of Butterstone	6	081204	NO059453	96	7.6	44	MA	8.3	139	Rs	35.99	48.92	G
12	Loch Venachar	22	290905	NN 567062	82	33.8	417	LA	6.69	43.9	Sa	30.45	29.96	G
13	Loch Achray	1	290905	NN 507068	84	29.5	82	LA	6-6.9	31-45	Sa	26.60	38.92	G-H
14	Threipmuir Res.	20,21	111005	NT 169636	253	5	78	MA	n.d.	n.d.	Di	23.76	33.66	G-H
15	Loch Voil	23,24	290905	NN486197	126	30	228	LA	6.68	31.7	Gr	25.87	29.77	G-H
16	Loch of Lowes	12	081204	NO041436	100	16	88	MA	7.54	126	Rs	26.77	43.36	G-H
17	Loch of Clunie	7	081204	NO115437	48	21	54	MA	7.95	198	Sa	28.34	36.68	G-H
18	Lubnaig	13, 14	290905	NN 586 104	123	44,5	249	LA	6,78	48	Gr	n.d.	n.d.	G-H
19	Ard	2	290905	NN 479 017	32	32,6	243	LA	6,63	43,3	Rs	n.d.	n.d.	G-H
20	Loch of Craiglush	9	081204	NO041444	100	13	28	MA	7.54	127	Rs	17.95	23.27	H

Table 2 Geomorphological and environmental charakteristicks of lakes investigated (adjusted according to POULÍČKOVÁ et al., 2008)
Grid reference-UK Ordnance Survey (http://www.ordnancesurvey.co.uk/oswebside/getamap/), Alt. - altitude, Alkal. - alkalinity categories: LA<200 μeq 1^{-1}; MA 200 - 1,000 μeq 1^{-1}; HA > 1,000 μeq 1^{-1}; Cond. – conductivity; PARMADO – Dominant parent material, European Soil Bureau Network (http://eusoils.jrc.ec.europa.eu/Website/eusoils/viewer.htm): Di – diorite, Fl – fluvial clays, silts and loams, Gr – granite, Rs – residual and redeposited loams from silicate rocks, Sa – outwash sand, glacial sand; LTDI reeds/stones – trophic diatoms index based on epiphyton/epilithon, Water quality classes: P – poor, M – moderate, G – good, H – hight; n.d. – no data.

Sampling metods

Samples were taken in November 2004 and 2005 by the supervisor Doc. RNDr. Aloisie Poulíčková, CSc.

Sediment samples were colected using a glass tube, as described by ROUND (1953). One end of a glass tubing (0.5 cm internal bore and 1 m long) was lowered on to the sediment, while the upper end was held above the water surface and closed by the thumb. The tube was then opened and slowely drawn across the sediment and allowed to fill with a mixture of mud and water which was then run into a 100 ml polyethylene bottle. This was repeated until the botle was full.

The bottle was transported to the laboratory. The mud-water mixtures were then poured into plastic boxes and allowed to stand in the dark for at least 5 h. The supernatant was then removed by suction and the mud covered with a lens tissue. Under low-level illumination (~ 5 μmol photons m^{-2} s^{-1}), epipelic algae moved up throught the lens tissue and became attached to cover slips placed on top. Diatoms dried on cover slips were cleaned by heating with 30% H_2O_2 and after washing with deionized water mounted in Naphrax as described preciously by Poulíčková at al. (2008).

Diatoms species were identified using light microscopy according to KRAMMER & LANGE-BERTALOT (1986, 1988, 1991a,b). Relative abundances of individual diatom species were estimated by counting at least 100 valves from each sample. Finaly, the diatom names were standardized according to Index Nominum Algarum (INA) (http://ucjeps.berkeley.edu/INA.html).

Statistical analyses

The diatom – environmental data base was set before numeric analysis. Considering that diatoms samples contain epipelic, planktonic and rheophilic species (Tab 3), only the epipelic and rheophilic species were selected in the data set, whereas planktonic diatoms were excluded. So the original data set consisted of 24 samples from 20 lakes (Tab 2), 176 diatom taxa and 21 environmental variables. Multivariate statistical methods using the software package CANOCO for Windows 4.5 (TER BRAAK & ŠMILAUER, 2002) were used for exploratory analyses of diatom data. The data set was analysed via Detrendent correspondence analysis (DCA) and further Canonical correspondence analysis (CCA) because a prelimilar DCA test indicated that a unimodal approach was appropriate for the study (see results) (LEPŠ & ŠMILAUER, 2003).

It is possible with canonical ordination methods to constrain the species abundance data so that the derived axes are linear functions of the imposed ‘environmental’ parameters.

First, the data set was analysed via DCA. The species data were square – root transformed before analysis. Environmental faktors: alkalinity, altitute, lake surface area, lake depth, trophic diatom index and dominant parental material were detrended by segments before analysis and were correlated with the results of DCA to help with the interpretation of results. Only species with species weight range higher than 10% were sighted on DCA diagram. For testing the significancy of faktors, program NCSS 2007 was used to detect the correlations of samples scores with the first axis. All of the faktors, which being proved correlation with first axis in DCA analysis was used farther. Most of the environmental variables (faktors) had a inflation factor higher than 20, which indicated that there are correlaton among faktors. To detect the relationships between them CCA was used.

The first ordination axis was constrained to only one single environmental variable and the rest of them was deleted. Monte carlo permutation test with 499 permutation was used to test the „biased“ efect of single faktor, still with a influence of relatonships with other faktors, on the diatom data set. Than the first ordination axis was constrained to only one single environmental variable and the rest of faktors was entering to the analysis like covariebles. Monte carlo permutation tested the significance of first ordination axis to get a „clean“ effect of the single faktor (without the effects of covariates). This test for single faktor was repeated by transfering the faktors from covariates group to deleted group and back one by one. The single relationships between faktors were described.

Finaly, CCA was used to identify relationships between species relative abundances in lake sediments and associated water chemistry parameters: pH and conductivity. Species – response curves for diatom species were modelled using generalized linear models (GLM), which were calculated using the Poisson distribution and logit – link function.

Results

In total, 197 diatom taxa were found in mud samples: 176 epipelic, 15 planktonic and 6 rheophylic diatom species (Tab 3). Species richness ranged from 7 to 34 species per lake, the highest being recorded in the lake Clunie and the lowest in the lake Lubnaig. The most frequently observed species were *Navicula cryptocephala* (KÜTZ.) and *Achnanthidium minutissimum* (KÜTZ.) D.B. CZARNECKI. NAVCRY was presented in 20 samples, it was dominant species in 6 samples and the relative abundance varied from 16 to 78%. ACHNMIN was presented in 19 samples, was a dominant species in 3 samples and the relative abundance varied from 23 to 50 %.

In results of the indirect gradient analysis DCA (Fig 1) the first and the second axes of a ordinaton of diatom assemblage explaine 9.6 and 6.2 % of the variance of species data.

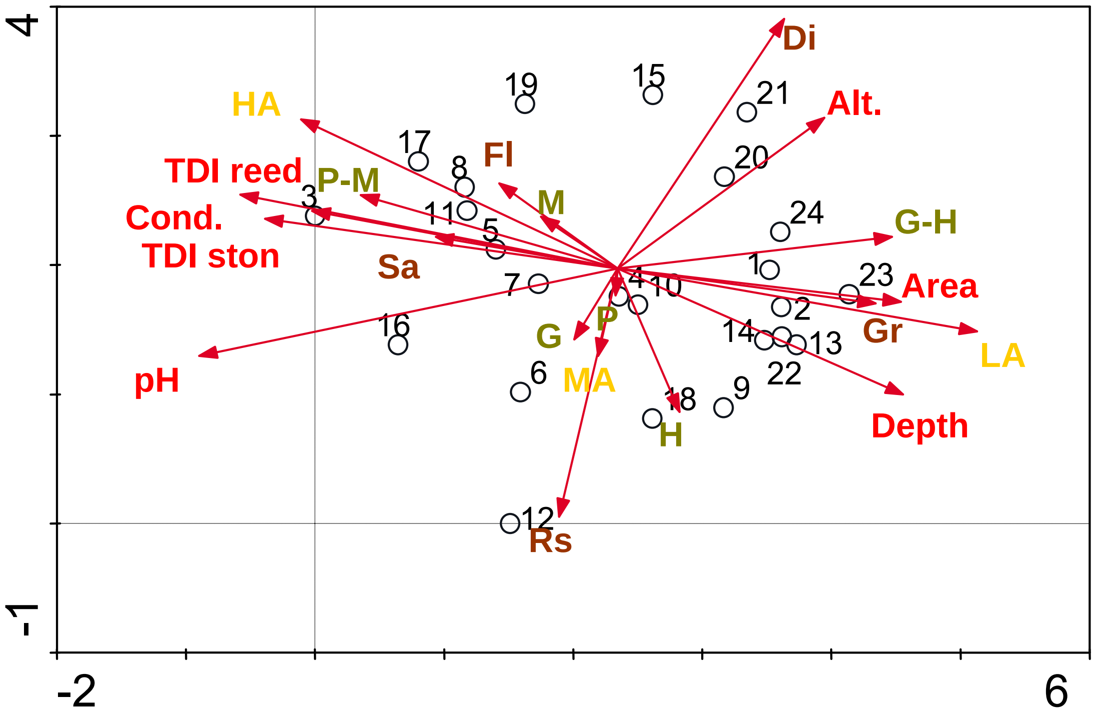

Fig 1 Joint ordination diagram (DCA) of the samples and the supplementary faktors, sample(s)/lake No.:1/13; 2/19; 3/2; 4/1; 5/9; 6/11; 7/17; 8/10; 9/20; 10/4; 11/5; 12/16; 13,14/18; 15,16/8; 17/3; 18/7; 19/6; 20,21/12; 23,24/15. Alt. - altitude, Alkal. - alkalinity categories: LA<200 μeq 1^{-1}; MA 200 - 1,000 μeq 1^{-1}; HA > 1,000 μeq 1^{-1}; Cond. – conductivity; PARMADO – Dominant parent material, European Soil Bureau Network: Di – diorite, Fl – fluvial clays, silts and loams, Gr – granite, Rs – residual and redeposited loams from silicate rocks, Sa – outwash sand, glacial sand; LTDI reeds/stones – trophic diatoms index based on epiphyton/epilithon, Water quality classes: P – poor, M – moderate, G – good, H – hight.

The geomorphologic and environmental charakteristics of lakes (Table 2) were included as supplementary faktors and suggested that the first axis represented the main gradient from lowland lakes in the left part of the diagram to lakes in higher altitute in the right part of the diagram (Fig 1).

In the left part of the diagram (Fig 1) are lowland eutrophic, small and shalow lakes on outwashed sands with higher pH, conductivity and alkalinity. In the middle of the diagram are mesotrophic, middle in area and middle - deep lakes on residual and redeposited lomes with almost neutral pH, middle conductivity and alkalinity. In the right part of the diagram are upland oligotrophic, large and deep lakes on granit with low pH, conductivity and alkalinity.

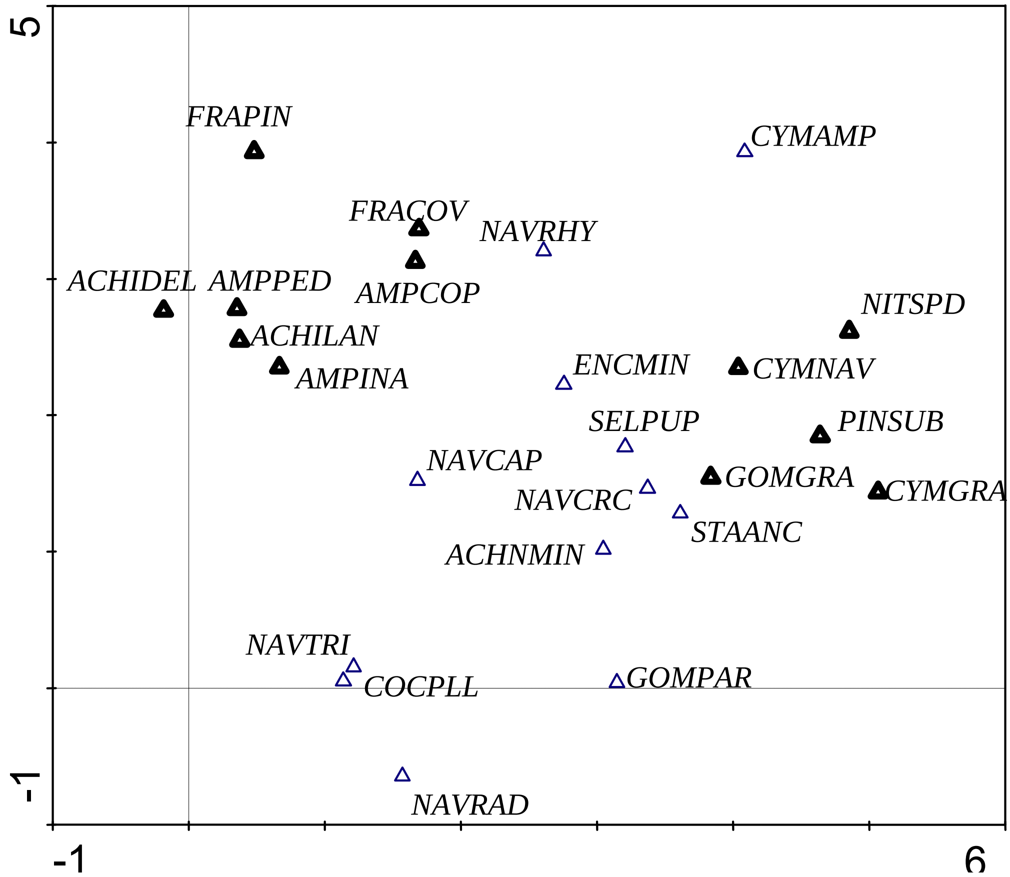

Fig 2 DCA ordination of epipelic diatom species

ACHIDEL - *Achnantheiopsis delicatula*, ACHILAN –*A. lanceolatoides*, ACHNMIN - *Achnanthidium minutissimum*, AMPCOP - *Amphora copulata*, AMPINA - *A. inariensis*, AMPPED – *A. pediculus*, COCPLL - *Cocconeis placentula* var. *lineata*, CYMAMP – *Cymbella amphycephala*, CYMGRA – *C. gracilis*, CYMNAV – *C. naviculiformis*, ENCMIN - *Encyonema minutum*, FRACOV - *Fragillaria construens* var. *venter*, FRAPIN – *F. pinnata*, GOMGRA - *Gomphonema gracile*, GOMPAR – *G. parvulum*, NAVCAP – *Navicula capitata*, NAVCRC - *N. cryptocehala*, NAVRAD – *N. radiosa*, NAVRHY – *N. rhynchocephala*, NAVTRI – *N. trivialis*, NITSPD – *Nitzschia* sp. div., PINSUB – *Pinnularia subcapitata*, SELPUP – *Sellaphora pupula* agg., STAANC – *Stauroneis anceps.*

Samples from lowland eutrophic lakes were characterized by occurence of *Fragillaria pinnata* EHRENB., *Fragillaria construens* var. *venter* (EHRENB.) GRUNOW, *Achnantheiopsis delicatula* (KÜTZ.) LANGE-BERT., *Achnantheiopsis lanceolatoides* (SOVEREIGN) LANGE-BERT. and all *Amphora* spp. (Fig 2). In contrast, epipelic assemblages in oligotrophic upland lakes included *Cymbella gracilis* (EHRENB.) KÜTZ, *Cymbella naviculiformis* AUERSW., *Pinnularia subcapitata* W. GREG., *Nitzschia* sp. div. and *Gomphonema gracile* EHRENB.

The environmental variables (faktors) are correlated with first and second axes. The inflation faktors of 11 of them are greater than 20,00, which predicates correlations among faktors (Tab 4). The depth is negatively correlated with trophic diatom indices TDI reed and TDI ston, which are positively correlated among each other. The area is negatively correlated with pH, which is positively corelated with the conductivity. The alkalinity is negatively corelated with the conductivity.

	Alt.	Depth	Area	pH	Cond.	TDIreed	TDIston
AX1	0.3636	**0.5658**	**0.5433**	**-0.7772**	**-0.7297**	**-0.5897**	**-0.6783**
AX2	0.2201	-0.3113	-0.1397	-0.0438	0.2417	0.1914	0.1903
INLF	62.5851*	46.6982*	18.7914	57.7047*	25.0808*	57.0572*	183.9482*

	HA	LA	MA	G	G - H	H	M
AX1	**-0.6287**	**0.6942**	-0.0207	-0.0682	0.5147	0.1450	-0.1547
AX2	0.3635	-0.2159	-0.1550	-0.1181	-0.0180	-0.2807	0.1171
INLF	164.4783*	14.1213	0.0000	18.3917	46.8693*	42.6865*	62.2911*

	P	P - M	Di	Gr	Fl	Rs	Sa
AX1	0.0017	-0.5006	0.2691	0.4960	-0.2408	-0.0640	-0.3511
AX2	-0.0490	0.2073	0.4128	-0.1364	0.1902	-0.4394	0.1093
INLF	11.5992	0.0000	52.8813*	14.9203	16.2638	11.3817	0.0000

Tab 4 Faktors correlations with first and second axis and their inflation faktor (INLF).
AX1 – first axis, AX2 – second axis, INLF – Inflation faktor, *: INL
F> 20, Alt. - altitude Alt. - altitude, Alkal. - alkalinity categories: LA<200 µeq l^{-1}; MA 200 - 1,000 µeq l^{-1}; HA > 1,000 µeq l^{-1}; Cond. – conductivity; PARMADO – Dominant parent material, European Soil Bureau Network: Di – diorite, Fl – fluvial clays, silts and loams, Gr – granite, Rs – residual and redeposited loams from silicate rocks, Sa – outwash sand, glacial sand; LTDI reeds/stones – trophic diatoms index based on epiphyton/epilithon, Water quality classes: P – poor, M – moderate, G – good, H – hight; **bold writ** – significant correlation .

Species respons to pH

CCA ordination was used for fitting the various regression models that describe the relationship between the relative abundance of a particular diatoms and the gradient of pH. First axis represented pH values and further only the species with a Species Weight Rande > 10 % were used (24 species) for specification of their relationship with pH. The first and the second axes of a CCA ordinaton of diatoms assemblage explain 6.4 and 10.4 % of the variance of species data. To fit the unimodal response curves, Generalized linear model (GLM) with a Poisson distribution and a log link funktion was used.

Null model was fitted to 8 species, which predicates there is any response of the particular species and the gradient of pH. Totaly 15 species response curves were created (Tab 5): 10 of them were statisticaly significant ($P < 0.05$, $P < 0.01$), 5 of them because of low probability lever were rejected. Generalized linear model (GLM) showes 10 statisticly significant species response curves: 4 kvadratic (Fig 3) and 6 linear curves (Fig 4).

	model	b	F - test	P
ACHNMIN	x^2	-56.76	3.31	$0.06^{\dagger}$
ACHIDEL	x	-15.51	13.57	0.001**
AMPINA	x^2	-146	3.94	0.03*
AMPPED	x	-10.03	24.95	0.00006**
COCPLL	x^2	-122.99	24.95	$0.11^{\dagger}$
CYMAMP	x^2	144.44	4.74	0.02*
CYMGRA	x^2	-12372.3	22.48	0.000008**
CYMNAV	x	21.58	19.27	0.0002**
GOMGRA	x^2	-127.54	3.1	$0.06^{\dagger}$
NAVCAP	x	-5.21	3.8	$0.06^{\dagger}$
NAVCRC	x	9.95	10.24	0.004**
NAVRAD	x^2	-766.43	2.43	$0.11^{\dagger}$
NAVTRI	x^2	-186.84	11.73	0.0004**
NITSPD	x	21.58	4.77	0.04*
PINSUB	x	39.7	41.7	0.000002**

Tab 5 The describtion of species responsible curves (pH)

model: x – linear model, x^2 – kvadratic model, b – regresion koeficient, model significance: F - F values, P – probability level: $P > 0.05^{\dagger}$, $P < 0.05$*, $P < 0.01$**, species: ACHNMIN - *Achnanthidium minutissimum*, ACHIDEL - *Achnantheiopsis delicatula*, AMPINA – *Amphora inariensis*, AMPPED – *A. pediculus,* COCPLL - *Cocconeis placentula* var. *lineata*, CYMAMP – *Cymbella amphicephala*, CYMGRA – *C. gracilis*, CYMNAV – *C. naviculiformis*, GOMGRA – *Gomphonema gracile*, NAVCAP – *Navicula capitata*, NAVCRC – *N. cryptocephala*, NAVRAD – *N. radiosa*, NAVTRI – *N. trivialis*, NITSPD - *Nitzschia* sp. div., PINSUB – *Pinnularia subcapita*.

Kvadratic model best describes relationship of 4 species: *Amphora inariensis* (AMPINA), *Cymbella amphicephala*(CYMAMP), *C. gracilis* (CYMGRA) and *Navicula trivialis* (NAVTRI). The optimum, tolerance (width of the species niche) and 0.95 confidence interval were estimated for 3 of them: AMPINA (optimum = 8.09, tolerance = 0.472, confident interval = 7.862 – 8.507), CYMGRA (optimum = 6.71, tolerance = 0.043, confident interval = 6.678 – 6.731) and NAVTRI (optimum = 8.24, tolerance = 0.425, confident interval = 8.038 – 8.579) (Fig 3).

The image of kvadratic curve for species CYMAMP is not ilustrated because of long gradient of species response. The optimum was not estimated, the explicit preferention of lower pH is visual in the left site of the diagram.

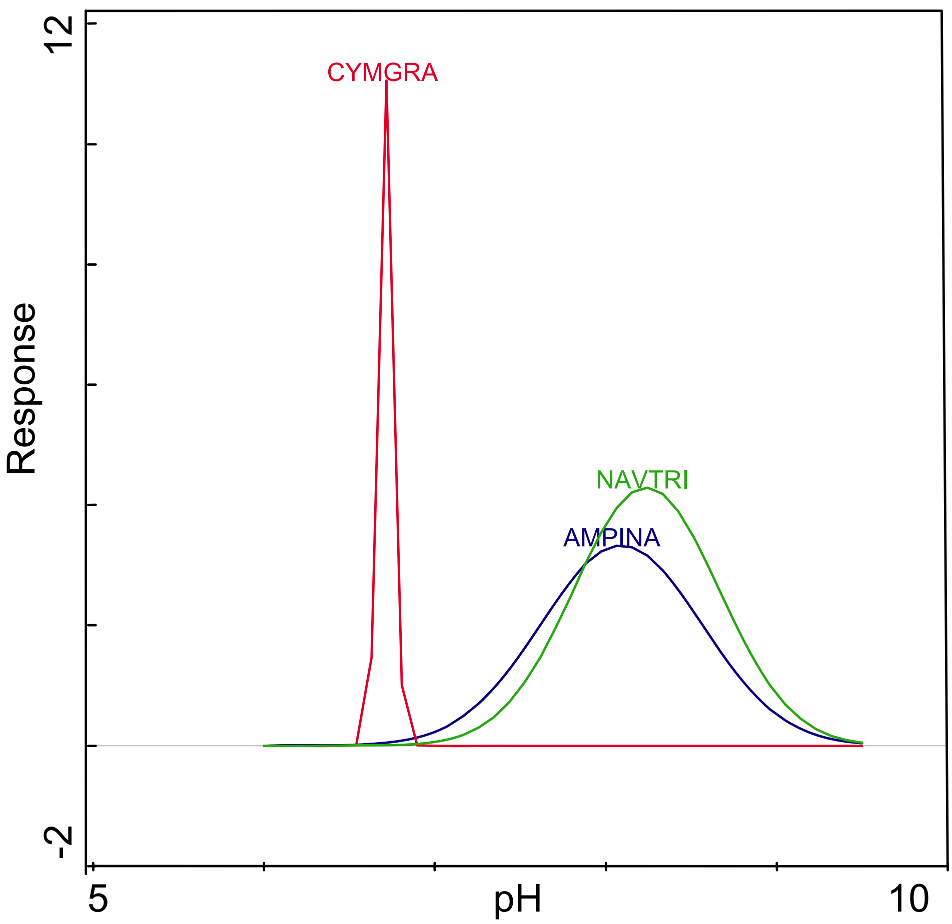

Fig 3 pH: Response kvadratic curves of diatoms, generalized lineral model (GLM). AMPINA – *Amphora inariensis*, CYMGRA - *Cymbella gracilis*, NAVTRI – *Navicula trivialis*.

Linear model best explaine the relationship of 6 species: *Achnantheiopsis delicatula* (ACHIDEL), *Amphora pediculus* (AMPPED), *Cymbella naviculiformis* (CYMNAV), *Navicula cryptocephala* (NAVCRC), *Nitzschia* sp. div. (NITSPD), *Pinnularia subcapitata* (PINSUB). On the left site of the diagram are species prefering lower pH (CYMNAV, NAVCRC, NITSPD, PINSUB), whereas on the right site are species prefering higher pH (ACHIDEL, AMPPED).

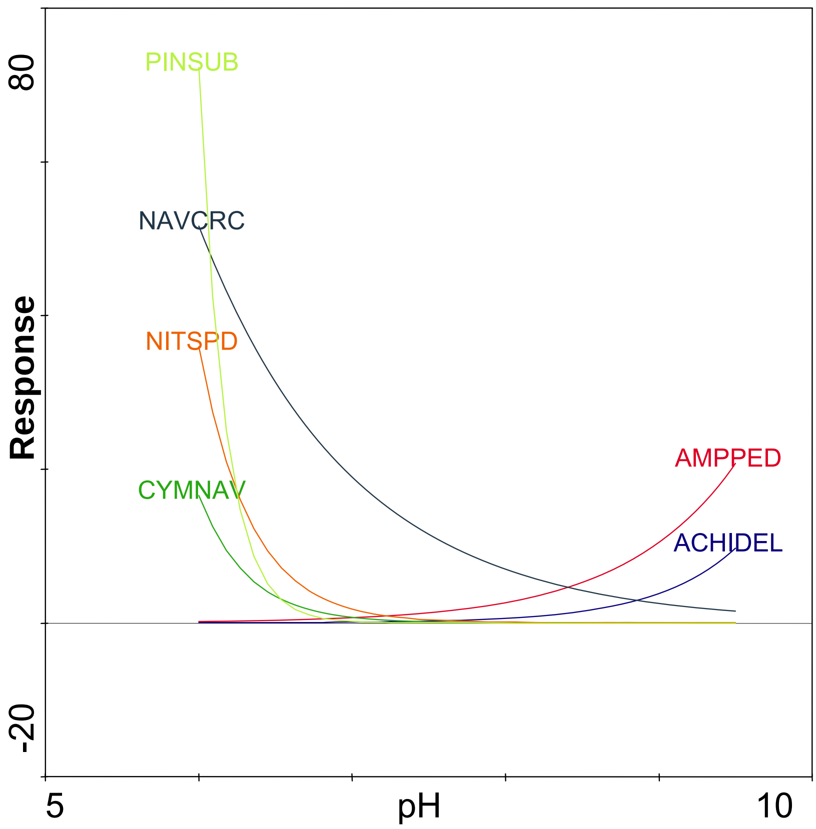

Fig 4 pH: Response linear curves of diatoms, generalized lineral model (GLM). ACHIDEL - *Achnantheiopsis delicatula*, AMPPED – *Amphora pediculus*, CYMNAV – *Cymbella naviculiformis*, NAVCRC – *Navicula cryptocephala*, NITSPD – *Nitzschia* sp. div., PINSUB – *Pinnularia subcapitata*.

Species response to Conductivity

CCA ordination was used for fitting the various regression models that describe the relationship between the relative abundance of a particular diatoms and the gradient of conductivity. First axis represented conductivity and further only the species with a Species Weight Rande > 10 % were used (24 species) for specification of their relationship with conductivity. The first and the second axes of a CCA ordinaton of diatom assemblage explaine 7.1 and 10.4 % of the variance of species data. To fit the unimodal response curves, Generalized linear model (GLM) with the Poisson distribution and the log link function was used.

Null model was fitted to 7 species, which predicates there is any response of the mentioned species and the gradient of conductivity.

	model	b	F - test	P
ACHNMIN	x^2	1.96	8.42	0.002**
ACHIDEL	x	-1.94	5.84	0.02*
AMPCOP	x^2	0.59	18.21	0.00003**
AMPINA	x^2	-1.42	17.89	0.00003**
AMPPED	x^2	-1.39	8.99	0.001**
COCPLL	x^2	-1.47	3.14	0.06†
CYMGRA	x	5.33	18.74	0.0002**
CYMNAV	x^2	2.20	4.54	0.02*
ENCMIN	x	0.10	3.92	0.06†
FRACOV	x	1.02	2.42	0.13†
FRAPIN	x	-0.68	8.60	0.007**
GOMGRA	x^2	-1.89	4.78	0.02*
NAVCAP	x	-0.08	5.87	0.02*
NAVCRC	x	3.48	10.59	0.003**
NAVTRI	x^2	-2.10	2.66	0.09†
NITSPD	x	30.22	99.09	<1 e-6**
PINSUB	x^2	-27.28	23.26	0.000006**

Tab 6 The describtion of species responsible curves (conductivity).

model: x – linear model, x2 – kvadratic model, b – regresion koeficient, model significance: F - F values, P – probability level: P > 0.05†, P < 0.05*, P< 0.01**, species: ACHNMIN - *Achnanthidium minutissimum*, ACHIDEL - *Achnantheiopsis delicatula*, AMPCOP - *Amphora copulata*, AMPINA - *Amphora inariensis*, AMPPED - *Amphora pediculus*, COCPLL - *Cocconeis placentula* var. *lineata*, CYMGRA - *Cymbella gracilis*, CYMNAV – *C. naviculiformis*, ENCMIN - *Encyonema minutum*, FRACOV - *Fragillaria construens* var. *venter*, FRAPIN – *F. pinnata*, GOMGRA - *Gomphonema gracile*, NAVCAP – *Navicula capitata*, NAVCRC – *N. cryptocephala*, NAVTRI – *N. trivialis*, NITSPD – *Nitzschia* sp. div., PINSUB – *Pinnularia subcapitata*.

Totaly 17 species response curves were created (Tab 6): 13 of them were statisticaly significant (P < 0.05, P < 0.01), 4 of them because of low probability level were rejected. Generalized linear model (GLM) showes 11 statisticly significant species response curves: 7 kvadratic (Fig 5) and 4 linear curves (Fig 6).

Kvadratic model best explain the relatioship of *Achnanthidium minutissimum* (ACHNMIN), *Amphora copulata* (AMPCOP), *A. inariensis* (AMPINA), *A. pediculus* (AMPPED), *Cymbella naviculiformis* (CYMNAV), *Gomphonema gracile* (GOMGRA) and *Pinnularia subcapitata* (PINSUB). The optimum and tolerance (width of the species nice) were estimated for PINSUB (optimum = 38.53, tolerance = 5.10), the confident interval was not estimated. The species response curves of ACHNMIN looks like the optimum was found, but the optimum was not estimated. Species GOMGRA and CYMNAV prefer lower conductivity, contrarivise all of *Amphora* spp. prefer higher conductivity.

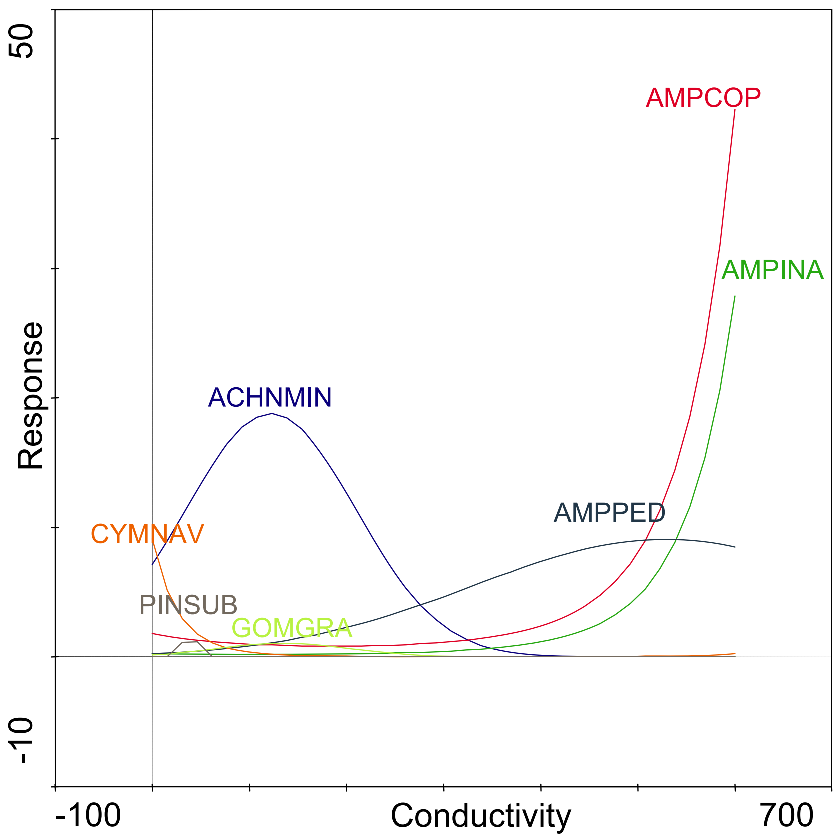

Fig 5 Cond.: Response kvadratic curves of diatoms, generalized lineral model (GLM)
ACHNMIN - *Achnanthidium minutissimum*, AMPCOP - *Amphora copulata*, AMPINA – *A. inariensis*, AMPPED – *A. pediculus*, CYMNAV – *Cymbella. naviculiformis*, GOMGRA - *Gomphonema gracile*, PINSUB – *Pinnularia subcapitata.*

Linear model best explain the relationship of *Achnantheiopsis delicatula* (ACHIDEL), *Cymbella gracilis* (CYMGRA), *Fragilaria pinnata* (FRAPIN), *Navicula capitata* (NAVCAP), *N. cryptocephala* (NAVCRC) and *Nitzschia* sp. div. (NITSPD). The image of linear curve for species CYMGRA and NITSPD are not ilustrated because of long gradient of species response. Optimum was not estimated, both of them prefere lower conductivity, similar NAVCRC. On the right site of diagram are species with higher conductivity preferences (ACHIDEL, FRAPIN and NAVCAP).

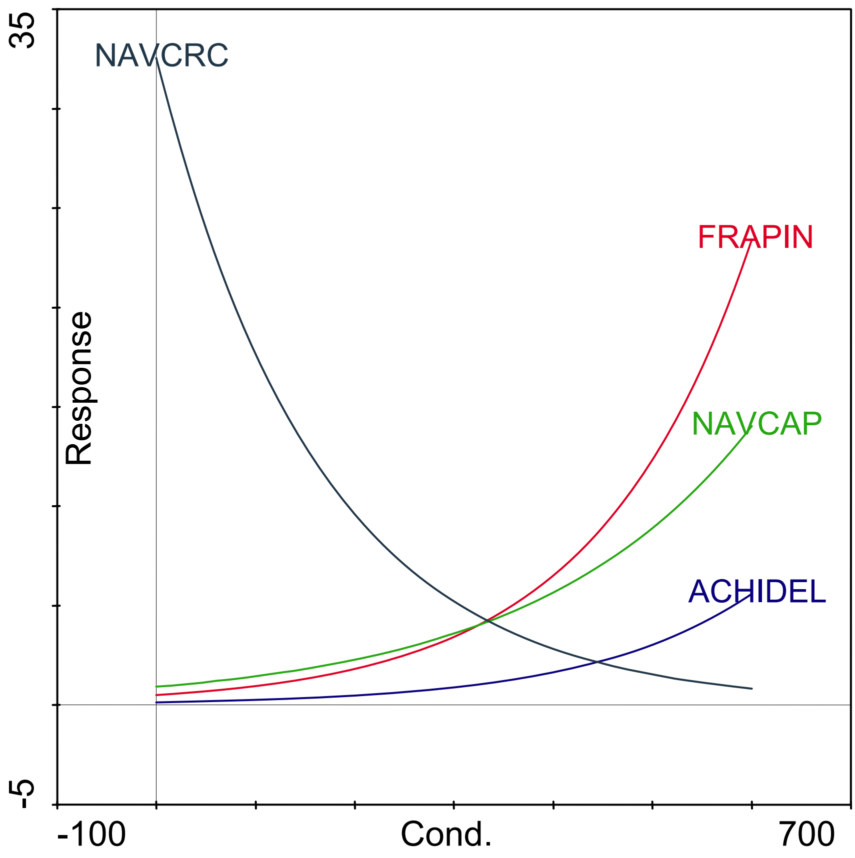

Fig 6 Cond.: Response linear curves of diatoms, generalized lineral model (GLM)

ACHIDEL - *Achnantheiopsis delicatula*, FRAPIN – *Fragilaria pinnata*, NAVCAP – *Navicula capitata*, NAVCRC – *N. cryptocephala*.

Discussion

Diatoms are an abundant, diverse and important component of algal assemblages in freshwater lakes (POULÍČKOVÁ et al., 2004). The composition of diatom communities reflects an entire complex of ecological parametres (VAN DAM, 1982). Diatoms are used for indicaton a quality of water ecosystems, widely used indication systems are based on them: VAN DAM et al. (1994), ROTT (1999), KELLY (1998), SCHÖNFELDER et al. (2002). As most described diatom indices were developed and applied for running waters, applications for lakes are sporadic and in many cases doubtful. However, if you read in a published literature it is explicit, that the ecological preferences of single species are poorly known, or there are not clearly define limits between individual species and many of the common, conventionaly known species are heterogenous. Species komplexes considerably complicate using of indication systems and ecological preferences of individual species are require to be clarify.

My thessis presents pilot study. Based on 20 lakes, it is imposible generalize, samples from several hundred sites would be needed, which is not implementaly within one thessis. Though, my results can refer to species, which are perspective as indicators and to them, for which the taxonomic problems need to be settle. In the following text are confront my findings with literature.

Achnanthidium minutissimum (Fig 7, h – ch)

HINDÁK (1987) refered *Achnanthidium minutissimum* (ACHNMIN) like the species with quite broad ecological amplitude, widely effused, relatively little sensitive to pH, alkalinity and water flowing, subsided in more acid water and in places exposed to stronger flowing. KRAMMER et al. (1991b) described ACHNMIN like species komplex, where for individual species have not been given accurate identification charakteristics. Illustrated intraspecific taxa can be identified with difficulties, especialy in the case of sympatric populations growing on the same locality. ACHNMIN is considered to be cosmopolitan, in middle Europe common species. It looks like ACHNMIN preferes more poluted water, in extreamly clean bog komplexes with lower conductivity and upper parts of rivers was represented poorly.

ACHNMIN is the most widespread bentic diatom.It is a small species, with a undistinguished inside structure and wide shape variability, It was already proofed by

POTAPOVÁ & HAMILTON (2006) that *A. minutissima* is heterogenous and represents a species komplex with ecologically differenciated semicryptic species. Some autors mention even 6 variets with expressively different trofic preferences as well as indication ability (ROTT, 1999). Because it is very often the dominating species (as much as 60% of bentic species composition), it may considerably influence total trofic evaluation (POULÍČKOVÁ personal communication).

ACHNMIN was found in 19 samples (Tab 2) and was the most represented diatom in epipelon sampled from 20 investigated lakes. Position of ACHNMIN in the middle of DCA diagram (Fig 2) gives support to the „species komplex" theory. The response curves of ACHNMIN to conductivity (Fig 5) showes preference of lower conductivity, which does not corespondent with opinoin published by KRAMMER et al. (1991b).

Achnantheiopsis delicatula (Fig 7, a)

KRAMMER et al. (1991b) refered *Achnantheiopsis delicatula* like the diatom prefering higher conductivity, occurring in calcite springs from medium to high conductivity (up to conductuvity comparable with bracksh and marine water. ROTT (1999) recorded ACHIDEL like species very rare in appearance, in low abundance, alkalibiont, eutrophic, middle indicatory weight (G = 3 on the scale from 1 to 5). SCHÖNFELDER, E. W. et al. (2002) recorded the pH optimum for ACHIDEL on 7.71, with 0.49 tolerance.

ACHIDEL was represented in epipelon of 4 lakes in lower abundance. This diatom is situated on the left site of the DCA diagram (Fig 2), representing eutrophic lowland lakes with higher conductivity, pH and alkalinity. In CCA analysis was proved significant linear respons of species to pH (Fig 4) and conductivity (Fig 6), with preference to high pH and conductivity. Ascertained informations correspond with opinions published by KRAMMER et al. (1991b) and SCHÖNFELDER et al. (2002) and ROTT (1999).

Amphora copulata (Fig 7, i)

KRAMMER et al. (1986) refered AMPCOP like cosmopolitan, common, occurred in the whole middle Europe. It preferes water with middle level of conductivity, but can be found in waters with higher conductivity too.

ROTT (1999) refered AMPCOP like species: eutrophic – polytrophic acording to TP tolerance, with high indicatory weight for TP (G = 5 on the scale from 1 to 5) and optimum 333 $\mu g l^{-1}$, eutrophic acording to NO_3 – N tolerance, with middle indication weight of NO_3 – N contain, with optimum 2387 $\mu g l^{-1}$, common species in middle abundance, alkalinity tolerant. SCHÖNFELDER et al. (2002) recorded the pH optimum for AMPCOP on 7.69, with 0.65 tolerance. (POULÍČKOVÁ & MANN, in press) demonstrated, that *A. copulata* is species complex with semicryptic species they differ only slightly in their morphology but they are reproductively isolated..

AMPCOP was represented in 14 samples, in middle abundance. On DCA diagram (Fig 2) is this diatom situated on the left site, where are the eutrophic, lowland lakes, with higher conductivity, pH and alkalinity. The species response curves showes the preferences of higher conductivity (Fig 5). Ascertained informations correspond with opinions published by KRAMMER et al. (1991b), SCHÖNFELDER et al. (2002) and ROTT (1999).

Amphora inariensis (Fig 7, j)

KRAMMER et al. (1986) refered AMPINA like the cosmopolitan species of northern – alpine environment, prefering oligosaprobic water with low to middle conductivity. Certainly is AMPINA found in Lappland, in lakes of foothills in Alps and in Yellowstone National Park in USA. ROTT (1999) recorded this diatom like meso – eutrophic acording to TP tolerance, with low ability for indication of TP (G = 1 on the scale from 1 to 5) and optimum 42 $\mu g l^{-1}$, oligo – mesotrophic acording to NO_3 – N toleration, with low indication weight of NO_3 – N contain, with optimum 1099 $\mu g l^{-1}$ and acidophilic, with optimum of NH_4 – N = 153 $\mu g l^{-1}$. This species is common species represented in middle abundance. SCHÖNFELDER et al. (2002) does not make references of this species.

AMPINA was found in 5 studied lakes, in low abundance. On DCA diagram (Fig 2) is this diatom situated on the left side, where are eutrophic, lowland lakes, with higher conductivity, pH and alkalinity. The pH optimum (8.09), tolerance (0.472) and confident interval (7.862 – 8.507) for AMPINA was determined (Fig 3), the preferences of higher conductivity was estimated (Fig 5). The determination of conductivity preference does not correspond to opinion published by KRAMMER et al. (1986).

Amphora pediculus (Fig 7, k – l)

KRAMMER et al. (1986) refered AMPPED like probably a cosmopolitan species occurring in whole middle Europe, abundant in subalpin waters with middle conductivity, but also in other areas with anologous biotops. It is distributed as far as critical contamination (β - α mezosaprob). ROTT (1999) recorded this diatom like eutrophic acording to TP tolerance, with low ability for indication of TP (G = 2 on the scale from 1 to 5) and optimum 136 $\mu g l^{-1}$, oligo – mesotrophic acording to NO_3 – N toleration, with low indication weight of NO_3 – N contain, with optimum 1816 $\mu g l^{-1}$ and alkalinity tolerant, with optimum of NH_4 – N = 99 $\mu g l^{-1}$. It is considered to be realy common species mostly present in hight abundance. SCHÖNFELDER et al. (2002) determinated the pH optimum for AMPPED on 8.18 with tolerance 0.45.

AMPPED was represented in 13 samples in lower or middle abundance. On DCA diagram (Fig 2) is this diatom on the left site representing eutrophic lowland lakes with higher conductivity, pH and alkalinkity. In CCA analysis was proved significant linear respons of species to pH (Fig 4) and conductivity (Fig 6), with preference of higher pH and conductivity. Ascertained informations does not correspond with opinoin published by KRAMMER et al. (1991b) and ROTT (1999), but found pH preferences corresponds with SCHÖNFELDER et al. (2002).

Cymbella gracilis (Fig 7, s)

KRAMMER et al. (1986) refered CYMGRA like the cosmopolitan species abundantly distributed in North Europe and height Alpen, but almost frequent in highlands and rare in lowlands, preferes oligotrophic water with low conductivity. ROTT (1999) refered to this diatom like acidophilic, oligotrophic acording to TP tolerances, with quite hight ability for indication of TP (G = 4 on the scale from 1 to 5), very rare species with low abundance. SCHÖNFELDER et al. (2002) determinated the pH optimum for CYMGRA on 5.26 with tolerance 1.55.

CYMGRA was found in 5 samples in low and middle abundance. On DCA diagram (Fig 2) is this diatom situated on the right site representing oligotrophic upland lakes with lower conductivity, pH and alkalinkity. In CCA analysis was proved significant kvadratic respons of species to pH (Fig 3) and linear to conductivity (Fig 6), with optimum (6.71), tolerance (0.043) and confident interval (6.678 – 6.731) of pH and preferences of lower conductivity. Ascertained informations correspond with opinion published by KRAMMER et al. (1991b), ROTT (1999) and SCHÖNFELDER et al. (2002).

Cymbella naviculiformis (Fig 7, i)

KRAMMER et al. (1986) refered CYMNAV like the cosmopolitan species distributed from lowlands to mountains common, abundant in springs. ROTT (1999) recorded this diatom like cirkumneutral, mesotrophic acording to TP tolerance, with very low ability for indication of TP (G = 1on the scale from 1 to 5), distributed very rare, with low abundance.

CYMGRA was found in 9 samples in low and middle abundance. On DCA diagram (Fig 2) is this diatom situated on the right site presenting oligotrophic upland lakes with lower conductivity, pH and alkalinity. In CCA analysis was proved significant linear response of species to pH (Fig 4) and conductivity (Fig 6), with preference of lower pH and conductivity.

Fragilaria pinnata (Fig 7, aa – ab)

KRAMMER et al. (1986) refered FRAPIN like the cosmopolitan, frequent species. ROTT (1999) recorded this diatom like species meso – eutrophic acording to TP tolerantion, with very low indication weight of TP (G = 1 on the scale from 1 to 5), and optimum 56 $\mu g l^{-1}$, meso – eutrophic acording to NO_3 – N tolerances, with middle indicatory weight of NO_3 – N contain (G = 3 on the scale from 1 to 5), and optimum 1166 $\mu g l^{-1}$, indirect to geochemical parametres, with optimum of NH_4 – N = 153 $\mu g l^{-1}$. FRAPIN is distributed frequently in middle abundance. SCHÖNFELDER et al. (2002) determinated the pH optimum for FRAPIN on 7.89 with tolerance 0.74.

FRAPIN was found in 5 samples in low and middle abundance. On DCA diagram (Fig 2) is this diatom situated on the left site representing eutrophic lowland lakes with higher conductivity, pH and alkalinity. In CCA analysis was proved significant linear response of species to conductivity (Fig 6), with preference of higher conductivity. Ascertained informations correspond with opinion published by KRAMMER et al. (1991b), ROTT (1999) and SCHÖNFELDER et al. (2002).

Gomphonema gracile (Fig 7, ac)

KRAMMER et al. (1986) refered GOMGRA like the cosmopolitan, common in northern Europe and tropics, prefering water with higher conductivity, even brackish water, tolerant to oligosaprobic water, sensitive to organic pollution. ROTT (1999) described this diatom like species being distributed very rare in low abundance. SCHÖNFELDER et al. (2002) determinated the pH optimum for GOMGRA on 7.06 with tolerance 1.36.

GOMGRA was found in 6 samples in low abundance. On DCA diagram (Fig 2) is this diatom situated on the right site representing oligotrophic upland lakes with lower conductivity, pH and alkalinity. In CCA analysis was proved significant kvadratic response of species to conductivity (Fig 5), with preference of lower conductivity.

Navicula capitata (Fig af – ag)

KRAMMER et al. (1986) refered NAVCAP like the cosmopolitan, frequent species with wide ecological niche, for up to brackish water, strictly avoiding water with low conductivity, tolerance to poluted water up to α – mesosaprobic. ROTT (1999) refered this diatom like species eu – politrophic acordong to TP tolerance, with middle indication weight of TP (G = 3 on the scale from 1 to 5), and optimum 397 $\mu g l^{-1}$, NO_3 – N optimum 1166 $\mu g l^{-1}$, alkaliphilic, with optimum of NH_4 – N = 61 $\mu g l^{-1}$. NAVCAPis dustributed frequently in low abundance. SCHÖNFELDER et al. (2002) refered the pH optimum for NAVCAP on 7.55 with tolerance 0.69.

NAVCAP was found in 13 lakes in low abundance and middle abundance (Blackford pond, Fenemere etc.). On DCA diagram (Fig 2) is this diatom situated on the left site representing eutrophic lowland lakes with higher conductivity, pH and alkalinity. In CCA analysis was proved significant linear response of species to conductivity (Fig 6), with preference of higher conductivity. Ascertained informations correspond with opinoin published by KRAMMER et al. (1986), ROTT (1999) and SCHÖNFELDER et al. (2002).

Navicula cryptocephala (Fig 7, ach)

HINDÁK (1987) refered NAVCRC like the common alkalifilic species of backwaters and flowing waters too. KRAMMER et al. (1986) recorded this diatom like cosmopolitan, quite common in middle Europe, prefering waters with low conductivity, up to acidic waters full of decomposed organic detritus. But also is known habitation in non – acidic waters, in upper parts of streams, even in high pollutioned water. ROTT (1999) described this diatom like species eu– polytrophic acording to TP toleration, with high ability for indication of TP (G = 4 on the scale from 1 to 5), and optimum 542 $\mu g l^{-1}$, eu– polyphic to NO_3 – N toleration, with middle indication weight of NO_3 – N contain (3 of 5), and optimum 2198 $\mu g l^{-1}$, alkalibiotic, with optimum of NH_4 – N = 746 $\mu g l^{-1}$. NAVCRC considered to be very frequently in high abundance. SCHÖNFELDER et al. (2002) determinated the pH optimum for NAVCRC on 7.70 with tolerance 0.79. POULÍČKOVÁ et al. (2006) discussed NAVCRC like species komplex, composed probably of species, whose identification based on morphology of frustules is not posible. Species differ in cytology, particularly structure of interphase nucleus, which is possible to observe in fluorescence after DAPI staining. This method is not used by diatomists working in biomonitoring, thus ecological preferences of such pseudocryptic species are not known.

NAVCRC was found in 20 samples and was the most common species found in my study. Position of NAVCRC in the middle of DCA diagram (Fig 2) gives support to the „species komplex“ theory. The response curves of NAVCRC to pH (Fig 4) showes preferences of lower pH and the response curves to conductivity (Fig 5) showes preference of lower conductivity, which corespond with opinion published by KRAMMER et al. (1991b). NAVCRC cannot be considered as a good indicatory species until the individual pseudocryptic species and their ecological preferences will be defined. Some identification method easier, than DAPI staining, should be introduced to diatomists working in biomonitoring.

Navicula trivialis (Fig 7, an)

KRAMMER et al. (1986) refered NAVTRI like the cosmopolitan species, common in middle Europe in waters of very different quality, most often epipelic. This species prefers higher conductivity, up to brackish water, with dessication and pollution tolerance until α – mesosaprobity. ROTT (1999) described this diatom like species eu– polytrophic acording to TP toleration, with low ability for indication of TP (G = 1 on the scale from 1 to 5), alkalophilic, ranged rare in high abundance. SCHÖNFELDER et al. (2002) refered the pH optimum for NAVTRI on 8.16 with tolerance 0.44.

NAVTRI was found in 6 lakes in low and middle abundance. On DCA diagram (Fig 2) is this diatom situated on the left site presenting eutrophic lowland lakes with higher conductivity, pH and alkalinity.The pH optimum (8.24), tolerance (0.425) and confident interval (8.038 – 8.79) for NAVTRI was found (Fig 3). Ascertained informations correspond with opinion published by KRAMMER et al. (1986), ROTT (1999) and SCHÖNFELDER et al. (2002).

Pinnularia subcapitata (Fig 7, ar)

KRAMMER et al. (1986) refered PINSUB like the cosmopolitan species, prefering low conductivity especialy in mountain, but is common in lowland too. ROTT (1999) recorded this diatom like acidophilic, oligotrophic acording to TP toleration, with low ability for indication of TP (G = 2 on the scale from 1 to 5), rare in low abundance. SCHÖNFELDER et al. (2002) refered the pH optimum for NAVTRI on 4.68 with tolerance 0.95.

PINSUB was found in 7 samles in low abundance. On DCA diagram (Fig 2) is this diatom situated on the right site representing oligotrophic upland lakes with lower conductivity, pH and alkalinity. In CCA analysis was proved significant linear response of species to pH, prefering lower pH (Fig 4) and kvadratic response to conductivity (Fig 5), with optimum = 38.53 and tolerance = 5.10. Ascertained informations correspond with opinion published by KRAMMER et al. (1986), ROTT (1999) and SCHÖNFELDER et al. (2002).

Conclusion

A total of 24 samples of epipelic diatoms were collected in 20 British lakes, covering gradient from oligotrophic, deep, acidic glacial lakes to eutrophic, shallow, alkalic urban ponds. The results suggest that:

1. A total of 197 diatom species were identified, species richness ranged from 12 to 34 species per lake, which represent a comparable diversity to other substrates (particularly epilithon), commonly used for biomonitoring.

2. Epipelic assemblages were dominated by pennate biraphid (motile) diatoms (173 species), centric diatoms were represented by 16 species, monoraphid and aramid diatoms by 8 species. Oligotrophic lakes can be characterized by the occurrence of *Achnantheiopsis delicatula* (KÜTZ.) LANGE-BERT., *Amphora pediculus* (KÜTZ.) GRUNOW, eutrophic lakes *Cymbella gracilis* (EHRENB.) KÜTZ, *Cymbella naviculiformis* AUERSW., *Pinnularia subcapitata* W. GREG.

3. Epipelic diatom assemblages are related to different ecological variables, particularly water depth, area, pH, conductivity, trophy and alkalinity, and can be used for biomonitoring, after their ecological preferences will be calibrated and taxonomical problems of the species complexes solved.

4. Ecological preferences (pH, conductivity) were calculated for 15 (pH) and 17 (conductivity) common epipelic species, 10 of them can be reccommend for biomonitoring (*Achnantheiopsis delicatula* (KÜTZ.) LANGE-BERT., *Amphora copulata* (KÜTZ.) SCHOENEMAN ET R.E.M. ARCHIBALD, *Amphora inariensis* KRAMMER, *Amphora pediculus* (KÜTZ.) GRUNOW, *Cymbella gracilis* (EHRENB.) KÜTZ, *Fragillaria pinnata* EHRENB., *Gomphonema gracile* EHRENB., *Navicula capitata* EHRENB., *Navicula trivialis* LANGE-BERT, *Pinnularia subcapitata* W. GREG.), 2 of them (*Achnanthidium minutissimum* (KÜTZ.) D.B. CZARNECKI and *Navicula cryptocephala* (KÜTZ.)) are more likely species complexes and need to be solid taxonomically Although the results on these species were significant, for exact calibrations more robust dataset will be necessary (around 100 lakes).

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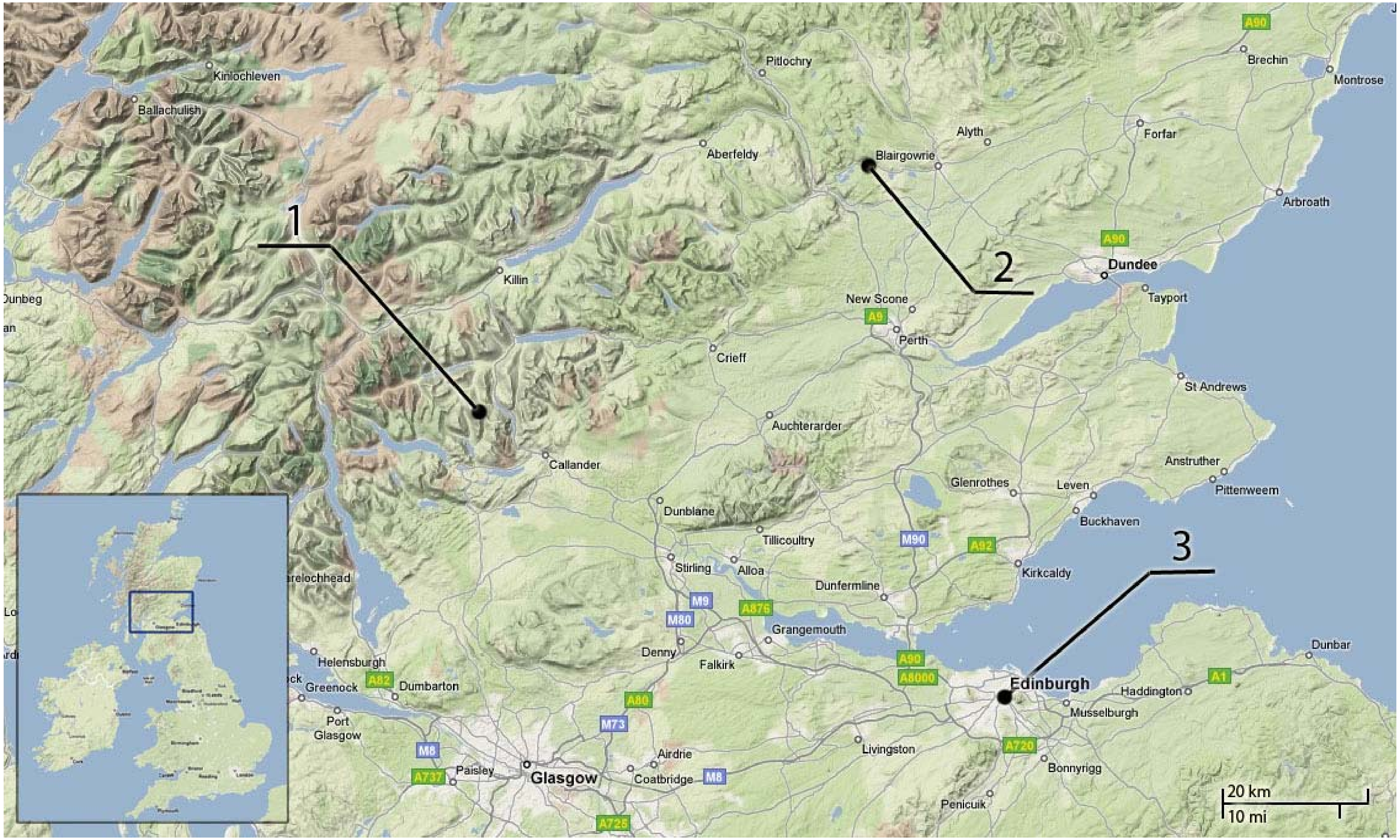
Apendices

Map 1 Sampled area in England (autor Jan Husák)

1 – investigated area

Map 2 Sampled areas in Scotland (autor Jan Husák)



1 – area near city Glasgow, 2 – area near city Blairgowrie, 3 – area near/in city Edinburg

Table 3 The list of species

Taxon	Abbreviation	Samples	Adaptation
Actinocyclus normanii (GREG.) HUST.	ACTNOR	3	E
Achnantheiopsis biporoma (M.H.HOHN&HELLERMAN) LANGE-BERT.	ACHIBIP	21	E
Achnantheiopsis delicatula (KÜTZ.) LANGE-BERT.	ACHIDEL	3, 5, 11, 17	E
Achnantheiopsis dubia (GRUNOW) LANGE-BERT.	ACHIDUB	3	E
Achnantheiopsis frequentissima (LANGE-BERT.) LANGE-BERT.	ACHIFRE	3, 6, 19	E
Achnantheiopsis lanceolatoides (SOVEREIGN) LANGE-BERT.	ACHILAN	5, 7, 8, 10, 11, 15-17	E
Achnantheiopsis pungens (A. CLEVE-EULER) LANGE-BERT.	ACHIPUN	6	E
Achnanthes aperta J.R. CARTER	ACHNAPE	6	E
Achnanthes delicatula subsp. hauckiana (GRUNOW) LANGE-BERT. & RUPPEL	ACHNDEH	11	E
Achnanthes exigua GRUNOW	ACHNEXI	3, 8, 17	E
Achnanthes helvetica (HUST.) LANGE-BERT. &KRAMMER	ACHNHEL	5, 16	E
Achnanthes chlidanos M.H.HOHN& HELLERMAN	ACHNCHLI	13, 15, 21, 22	E
Achnanthes jourseconse HERIB.	ACHNJOU	8, 17	E
Achnanthes lanceolata var. elliptica CLEVE	ACHNLNE	21	E
Achnanthes lanceolata var. *rostrata* HUST.	ACHNLNR	3, 5, 17	E
Achnanthes lemmermannii HUST.	ACHNLEM	16	E
Achnanthes peragalloi BRUN&HERIB.	ACHNPER	6	E
Achnanthes rechtensis L.LECLERCQ	ACHNRECH	15	E
Achnanthes scotica LANGE-BERT.	ACHNSCO	1, 21, 23	E
Achnanthes sp.	ACHNSP	3	E
Achnanthes suchlandtii HUST.	ACHNSUCH	3, 16	E
Achnanthes ventralis (KRASSKE) LANGE-BERT.	ACHNVEN	24	E
Achnanthidium clevei (GRUNOW) D.B. CZARNECKI	ACHDCLE	6, 7, 12, 16	E
Achnanthidium minutissimum (KÜTZ.) D.B. CZARNECKI	ACHDMIN	1, 2, 5-9, 12-16, 18-24	E
Amphora aequalis KRAMMER	AMPAEQ	21	E
Amphora copulata (KÜTZ.) SCHOENEMAN ET R.E.M. ARCHIBALD	AMPCOP	2, 4, 7, 8, 10-12, 15, 17-22, 24	E
Amphora inariensis KRAMMER	AMPINA	4, 7, 8, 16, 17, 22	E
Amphora ovalis (KÜTZ.) KÜTZ.	AMPOVA	1, 5, 7, 8, 10, 11, 20, 21	E
Amphora pediculus (KÜTZ.) GRUNOW	AMPPED	1, 3, 5-8, 11, 15-19, 21	E
Amphora veneta KÜTZ.	AMPVEN	6, 12	E
Anomoeoncis sphaerophora (EHRENB.) PFITZER	ANOSPH	18	E
Asterionella formosa HASSALL	ASTFOR	5, 21	P
Asterionella sp.	ASTSP	3	P
Aulacoseira alpigena (GRUNOW) KRAMMER	AULALP	5	P
Aulacoseira granulata (EHRENB.) SIMONSEN	AULGRA	3, 5-8, 12, 15, 17, 20, 21	P
Aulacoseira lacustris (GRUNOW) KRAMMER	AULLAC	15	P
Aulacoseira sp.	AULSP	21	P
Brachysira vitrea (GRUNOW) ROSS	BRAVIT	9, 13, 23	E
Caloneis molaris (GRUNOW) KRAMMER	CALMOL	7	E
Caloneis silicula (EHRENB.) A. CLEVE	CALSIL	10, 13, 20, 22	E
Cavinula pseudoscutiformis (HUST.) D.G. MANN&A.J. STICKLE	CAVPSE	6, 7, 9, 22, 24	E
Cocconeis disculus (SCHUM.) CLEVE	COCDIS	6, 7, 10	R
Cocconeis placentula EHRENB.	COCPLA	8, 15	R
Cocconeis placentula var. *euglypta* (EHRENB.) CELVE	COCPLE	11, 20, 21	R

Table 3 The list of species (continued)

Taxon	Abbreviation	Samples	Adaptation
Cocconeis placentula var. *lineata* (EHRENB.) CELVE	COCPLL	4-10, 12, 16, 18	R
Cocconeis sp.	COCSP	3	R
Cyclostephanos dubius (FRICKE) ROUND	CYCDUB	11	P
Cyclostephanos invisitatus (M.H. HOHN&HELLERMAN)E.C.THER, STOERMAN&HAK.	CYCINV	18, 19	P
Cyclotella radiosa (GRUNOW) LEMMERM.	CYCRAD	9, 15, 16, 20-22	P
Cyclotella stelligera A. CLEVE&GRUNOW IN VAN HEURCK	CYCSTE	5, 19	P
Cymatopleura solea (BREB.) W. SM.	CYMSOL	4, 10, 15, 19, 20	E
Cymbella affinis KÜTZ.	CYMAFF	9, 18	E
Cymbella amphicephala NAGELI EX KÜTZ.	CYMAMP	10, 20, 24	E
Cymbella caespitosum (KÜTZ.) BRUN	CYMCAE	21	E
Cymbella cistula (HEMPRICH&EHRENB.) KIRCHER	CYMCIS	7, 12, 13, 20	E
Cymbella cuspidata (KÜTZ.)	CYMCUS	12	E
Cymbella descripta (HUST.) KRAMMER&LANGE-BERT.	CYMDES	13, 22, 23	E
Cymbella falaisensis (GRUNOW) KRAMMER&LANGE-BERT.	CYMFAL	13	E
Cymbella gracilis (EHRENB.) KÜTZ	CYMGRA	2, 13, 22, 23	E
Cymbella hilliardii MANGUIN	CYMHIL	2	E
Cymbella hybrida var. *lanceolata* KRAMMER	CYMHYL	3	E
Cymbella lacustris (C.G. AGARDH) A.CLEVE	CYMLAC	18	E
Cymbella naviculiformis AUERSW.	CYMNAV	1, 2, 8, 13, 14, 20-22, 24	E
Cymbella subaequalis GRUNOW	CYMSUA	4	E
Cymbella subcuspidata KRAMMER	CYMSUC	20	E
Cymbella tumidula GRUNOW	CYMTUM	15	E
Diatoma anceps (EHRENB.) KIRCHN.	DIAANC	4, 9	E
Diatoma sp.	DIASP	20	E
Diatoma tenuis C. AGARDH	DIATEN	19, 21	E
Diploneis ovalis (HILSE) A.CLEVE	DIPOVA	7	E
Diploneis parma CLEVE	DIPPAR	20, 21	E
Diploneis puella (SCHUM.) CLEVE	DIPPUE	21	E
Encyonema minutum (HILSE) D.G.MANN	ENCMIN	1, 3, 5, 7, 10, 13, 14, 19-22, 24	E
Encyonema silesiacum (BLEISCH) D.G.MANN	ENCSIL	4, 6, 13, 15, 22	E
Entomoneis ornata (BAILEY) REIMER	ENTORN	20, 21	E
Eoithemia sp.	EOISP	4	E
Eucocconeis laevis (ÖESTRUP) H. LANGE-BERT.	EUCLAE	8	E
Eunotia arcus (EHRENB.) W. SM.	EUNARC	21	E
Eunotia bilunaris (EHRENB.) SCHAARSCHM.	EUNBIL	20	E
Eunotia cf. incisa W. SM.EX W.GREG.	EUNCIN	9	E
Eunotia exigua (BREB.) G.L.RABENH.	EUNEXI	13, 22, 23	E
Eunotia incisa W.SM.EX W.GREG.	EUNINC	6	E
Eunotia sp.	EUNSP	2, 19	E
Eunotia tenella (GRUNOW) (HUST.)	EUNTEN	1	E
Fallacia pygmaea (KÜTZ.) A.J.STICKLE&D.G.MANN	FALPYG	20, 21	E
Fallacia tenera (HUST.) D.G.MANN	FALTEN	7	E
Fragillaria berolinensis (LEMMERM.) LANGE-BERT.	FRABER	15	E
Fragillaria capucina DESM.	FRACAP	6, 9, 20-22	E
Fragillaria cf. leptostauron var. *martyi* (HERIB.) LANGE-BERT.	FRACLM	8	E
Fragillaria construens (EHRENB.) A.GRUNOW	FRACON	6, 8, 9	E

Table 3 The list of species (continued)

Taxon	Abbreviation	Samples	Adaptation
Fragillaria construens var. *binodis* (EHRENB.) GRUNOW	FRACOB	6, 8, 9, 19	E
Fragillaria construens var. *venter* (EHRENB.) GRUNOW	FRACOV	1-3, 7, 9, 10, 12, 13, 15-17, 19-24	E
Fragillaria leptostauron var. dubia (EHRENB.) HUST.	FRALEP	16, 17	E
Fragillaria leptostauron var. *dubia* (GRUNOW) HUST.	FRALED	6, 7	E
Fragillaria neoprodukta LANGE-BERT.	FRANEO	8	E
Fragillaria pinnata EHRENB.	FRAPIN	3, 8, 17, 19-21	E
Fragillaria sp.	FRASP	7, 10, 16	E
Frustulia rhomboides (EHRENB.) PFITZER	FRURHO	1, 2, 20, 22-24	E
Gomphonema clavatum EHRENB.	GOMCLA	4, 6, 8	E
Gomphonema gracile EHRENB.	GOMGRA	1, 2, 7, 9, 13, 15, 23	E
Gomphonema minutum (C. AGARDH) C. AGARDH	GOMMIN	21	E
Gomphonema parvulum KÜTZ.	GOMPAR	4, 5, 13, 18, 22, 24	E
Gomphonema truncatum EHRENB.	GOMTRU	8, 13, 15, 20-22	E
Gyrosigma acuminatum (KÜTZ.) RABENH.	GYRACU	9, 15, 20, 21	E
Gyrosigma nodiferum (GRUNOW) REIMRER	GYRNOD	7	E
Gyrosigma sp.	GYRSP	1	E
Gyrosigma spencesii (W. SM.) A. CLEVE	GYRSPE	11	E
Hannaea arcus (EHRENB.) R.N. PATRICK	NAVARC	21	E
Karayevia laterostrata (HUST.) J.C.KINGSTON	KARLAT	16	E
Kolbesia ploenensis (HUST.) J.C.KINGSTON	KOLPLO	7	E
Meridion circulare (GREV.) C. AGARDH	MERCIR	20	R
Navicula angusta GRUNOW	NAVANG	13, 17, 23	E
Navicula bacilloides HUST.	NAVBAC	6-8, 21	E
Navicula capitata EHRENB.	NAVCAP	3, 4, 6, 7, 10-12, 15, 17-21	E
Navicula cari EHRENB.	NAVCAR	8, 10, 18	E
Navicula cf. *canoris* M.H. HOHN&HELLERMAN	NAVCCA	3	E
Navicula cf. *meniscus* SCHUM.	NAVCME	11	E
Navicula cincta (EHRENB.) RALFS	NAVCIN	3	E
Navicula clementioides HUST.	NAVCLO	4, 15	E
Navicula clementis GRUNOW	NAVCLS	10, 13	E
Navicula costulata GRUNOW	NAVCOS	13, 20, 21	E
Navicula cryptocephala (KÜTZ.)	NAVCRC	1-3, 5-11, 13, 14, 17-24	E
Navicula cryptotenella LANGE-BERT.	NAVCRT	10, 24	E
Navicula cuspidata (KÜTZ.) KÜTZ.	NAVCUS	1, 4, 19	E
Navicula decussis (ÖESTRUP)	NAVDEC	7, 8, 17	E
Navicula exiqua (GREG.) GRUNOW	NAVEXI	3, 7	E
Navicula gregaria DONKIN	NAVGRE	6, 9, 10, 13	E
Navicula laterostrata HUST.	NAVLAT	10	E
Navicula meniscus SCHUM.	NAVMEN	4, 7, 11, 17	E
Navicula microcari LANGE-BERT.	NAVMIC	10	E
Navicula minuscula var. *bahusiensis* GRUNOW	NAVMIB	3, 11, 17	E
Navicula modica HUST.	NAVMOD	7	E
Navicula oppugnata HUST.	NAVOPP	21	E
Navicula phyllepta KÜTZ.	NAVPHY	6, 10, 13	E
Navicula porifera var. *opportuna* (HUST.) LANGE-BERT.	NAVPOO	20	E
Navicula praeterita HUST.	NAVPRA	13	E

Table 3 The list of species (continued)

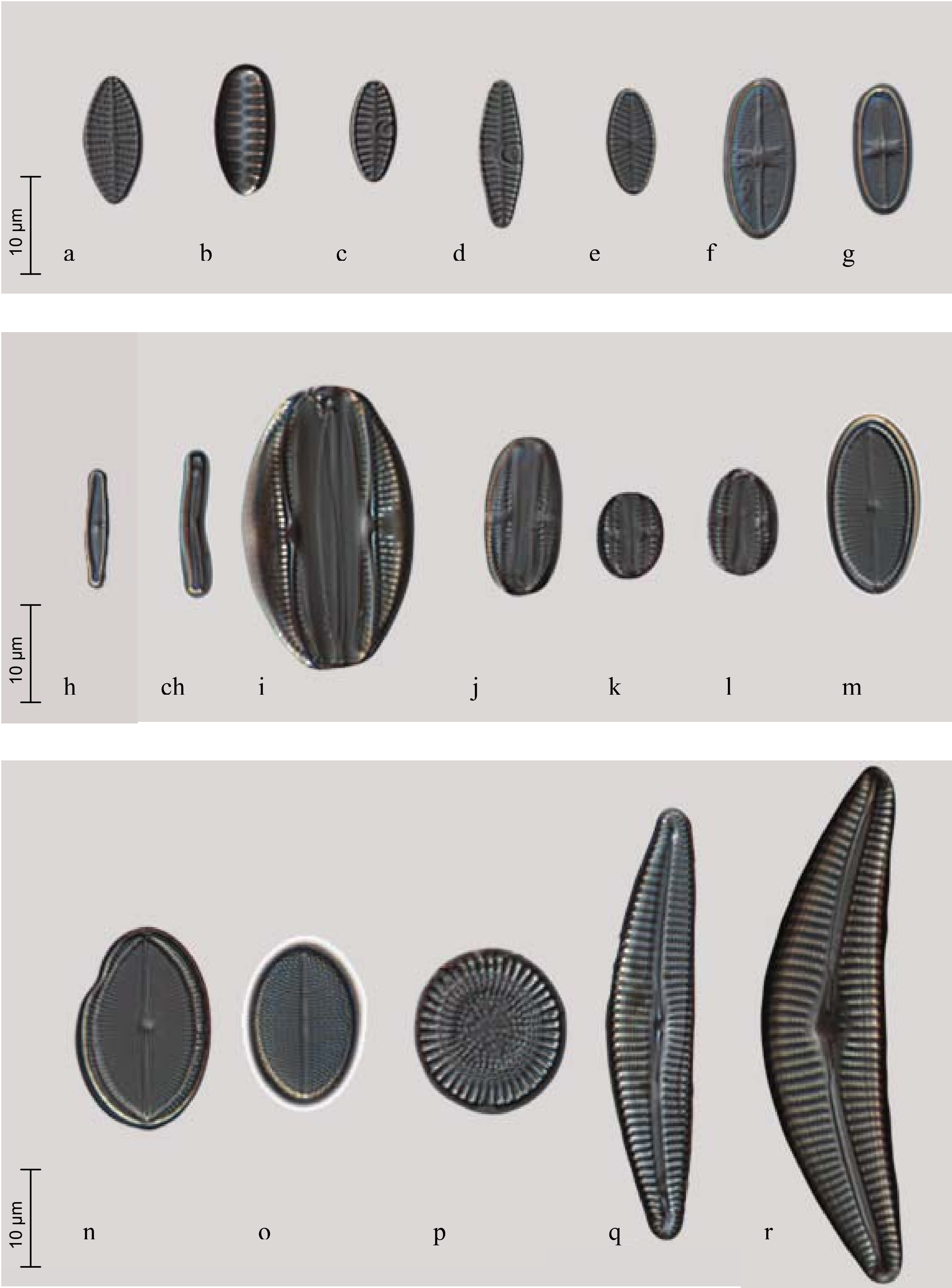
Taxon	Abbreviation	Samples	Adaptation
Navicula pseudanglica LANGE-BERT.	NAVPSE	3, 17	E
Navicula radiosa KÜTZ.	NAVRAD	6, 8, 9, 12, 13, 20, 22	E
Navicula recens (LANGE-BERT.) LANGE-BERT.	NAVREC	3	E
Navicula reinhardtii (GRUNOW) GRUNOW	NAVREI	6	E
Navicula rhynchocephala KÜTZ.	NAVRHY	2, 4, 7, 8, 10, 11, 13, 15, 18-22	E
Navicula scutelloides W. SM.	NAVSCU	3, 8	E
Navicula schoenfeldii HUST.	NAVSCHO	16	E
Navicula similis KRASSE	NAVSIM	1, 3, 5	E
Navicula slesvicensis GRUNOW	NAVSLC	4, 18, 20	E
Navicula splendicula VANLANDINGMAN	NAVSPL	13	E
Navicula trivialis LANGE-BERT.	NAVTRI	3, 4, 6, 7, 10-12	E
Navicula veneta KÜTZ.	NAVVEN	7, 8, 11, 21	E
Navicula viridula (KÜTZ.) EHRENB.	NAVVIR	21	E
Neidium affine (EHRENB.) PFITZER	NEIAFF	1, 13, 20, 21	E
Neidium ampliatum (EHRENB.) KRAMMER	NEIAMP	9, 13, 18, 22	E
Neidium binodeform KRAMMER	NEIBIN	21	E
Neidium bisulcatum var. *subampliatum* KRAMMER	NEIBIS	14	E
Neidium dubium (EHRENB.) A. CLEVE	NEIDUB	4, 6, 10, 17	E
Neidium productum (W.SM.) A. CLEVE	NEIPRO	20	E
Neidium sp.	NEISP	12	E
Nitzschia cf. *flexoides* GEITLER	NITCFL	2, 22	E
Nitzschia recta HANTZSCH IN RABENH.	NITREC	20, 21	E
Nitzschia sigmoidea (NITZSCH) W. SM.	NITSIG	19	E
Nitzschia sp.	NITSP	2, 4, 9, 20, 22	E
Nitzschia sp. div.	NITSPD	1, 23, 24	E
Ophephora olsenii MOLLER	OPHOLS	3, 17	E
Pinnularia acrosphaeria(BREB.) RABENH.	PINACR	13	E
Pinnularia gibba var. *meogongyla* (EHRENB.) HUST.	PINGIM	1	E
Pinnularia interrupta W. SM.	PININT	2, 13, 14, 22	E
Pinnularia major (KÜTZ.) RABENH.	PINMAJ	22	E
Pinnularia microstauron (C. EHRENB.) CLEVE	PINMIC	2	E
Pinnularia nobilis (EHRENB.) EHRENB.	PINNOB	19	E
Pinnularia sp.	PINSP	1, 9, 15	E
Pinnularia subcapitata W. GREG.	PINSUB	1, 2, 13, 21-24	E
Pinnularia viridis (NITZSCH) EHRENB.	PINVIR	20, 22	E
Placoneis gastrum (EHRENB.) MERESCHK.	PLAGAS	4, 9, 10	E
Placoneis hambergii (HUST.) K. BRUDER	PLAHAM	3, 6	E
Placoneis porifera (HUST.) T. OHTSUKA&Y. FUJITA	PLAPOR	6	E
Pleurostaurum obtusum (LAGERST.) PERAG.	PLEOBT	22, 24	E
Psammothidium bioretii (H.GERM.) L. BUKHT.&ROUND	PSABIO	16, 20, 24	E
Rhoicosphenia abbreviata (C.AGARDH) LANGE-BERT	RHOABB	10	E
Sellaphora bacillum (EHRENB.) D.G. MANN	SELBAU	10, 11	E
Sellaphora laevissima (KÜTZ.) D.G. MANN	SELLAE	2, 5, 15, 21	E
Sellaphora pupula agg. KÜTZ. MERESCHK.	SELPUP	1, 2, 4, 6, 7, 9-11, 13-15, 17-22, 24	E
Stauroneis acuta W. SM.	STAACU	15	E
Stauroneis anceps EHRENB.	STAANC	2, 7, 13, 22	E

Table 3 The list of species (continued)

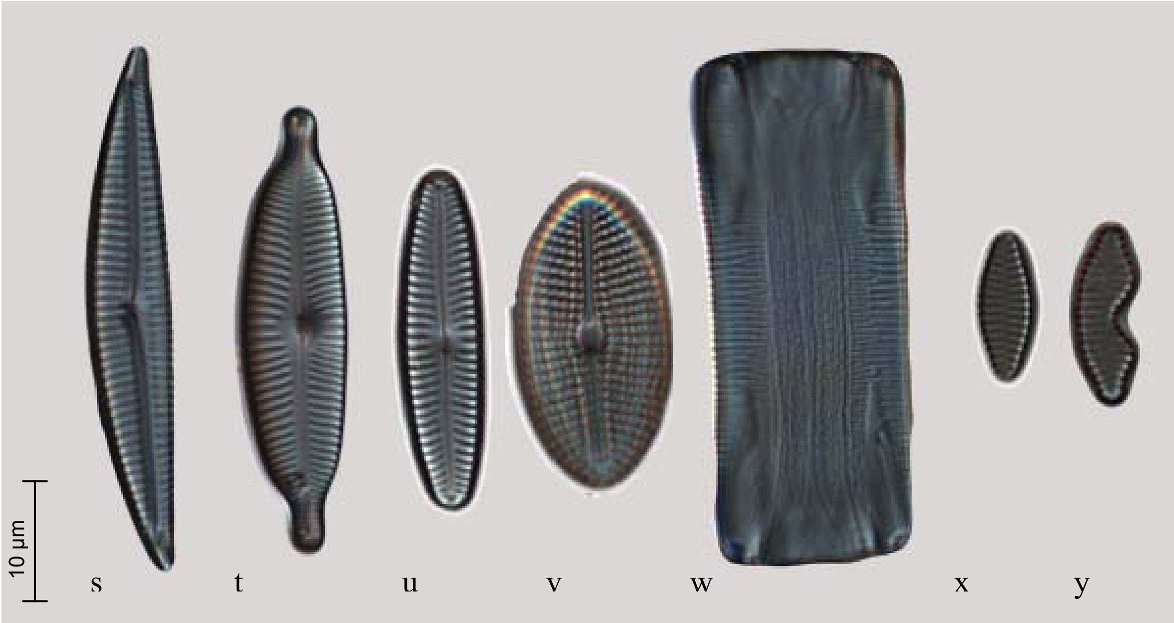
Taxon	Abbreviation	Samples	Adaptation
Stauroneis kriegeri PANT.	STAKRI	5	E
Stauroneis phoenicenteron (NITZSCH) EHRENB.	STAPHO	9, 19, 20, 22	E
Stauroneis smithii GRUNOW	STASMI	20-22	E
Stenopterobia delicatissima (LEWIS) BRÉB.	STEDEL	2	E
Stephanodiscus invisitus M.H.HOHN&HELLERMAN	STEINV	16	P
Stephanodiscus medius HAK.	STEMEN	3	P
Stephanodiscus minutus GRUNOW EX CLEVE&V. MÖLLER	STEMIN	15	P
Stephanodiscus minutus J.PANT.	STEMIT	7	E
Stephanodiscus minutus STOERMEN&H. HLKANSSON	STEMIU	6, 17, 21	P
Surirella amoena J. PANTOCSEK	SURAMO	7	E
Surirella amphioxys W. SM.	SURAMP	2	E
Surirella brebissonii KRAMMER&LANGE-BERT.	SURBRE	13, 2	E
Surirella cf. *angusta* KÜTZ.	SURCAN	2	E
Surirella linearis W. SM.	SURLIN	21, 23	E
Tabellaria flocculosa (W.ROTH) KÜTZ.	TABFLO	2, 3, 5-7, 9, 13-15, 18,20-24	P

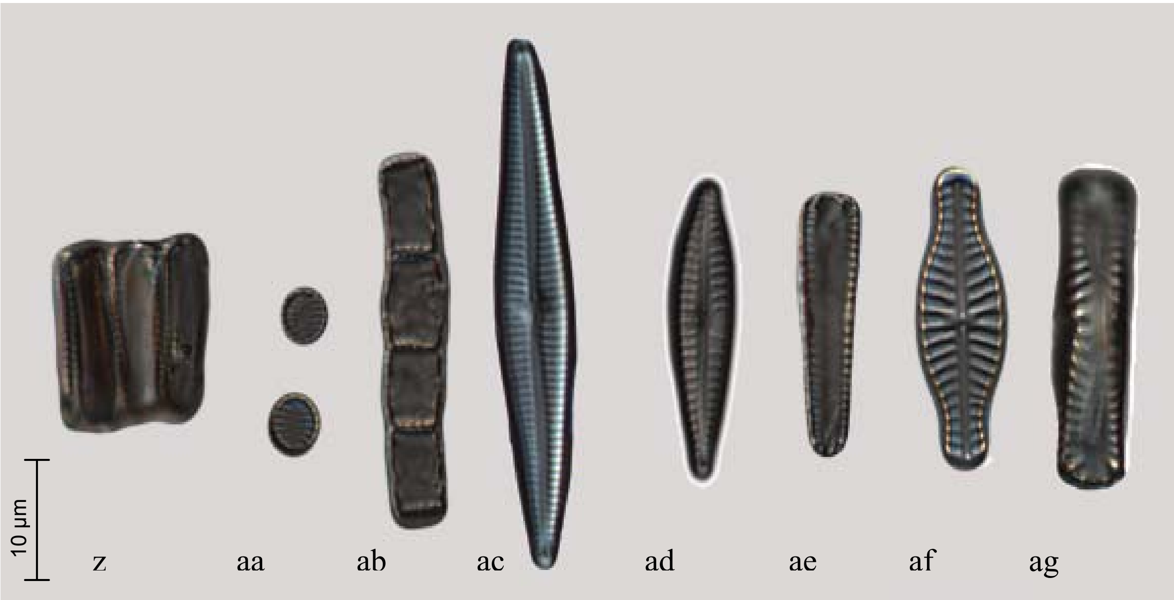
Adaptation: E – epipelic, P – planktonic, R – rheophylic diatom.

Fig 7 The photos of species

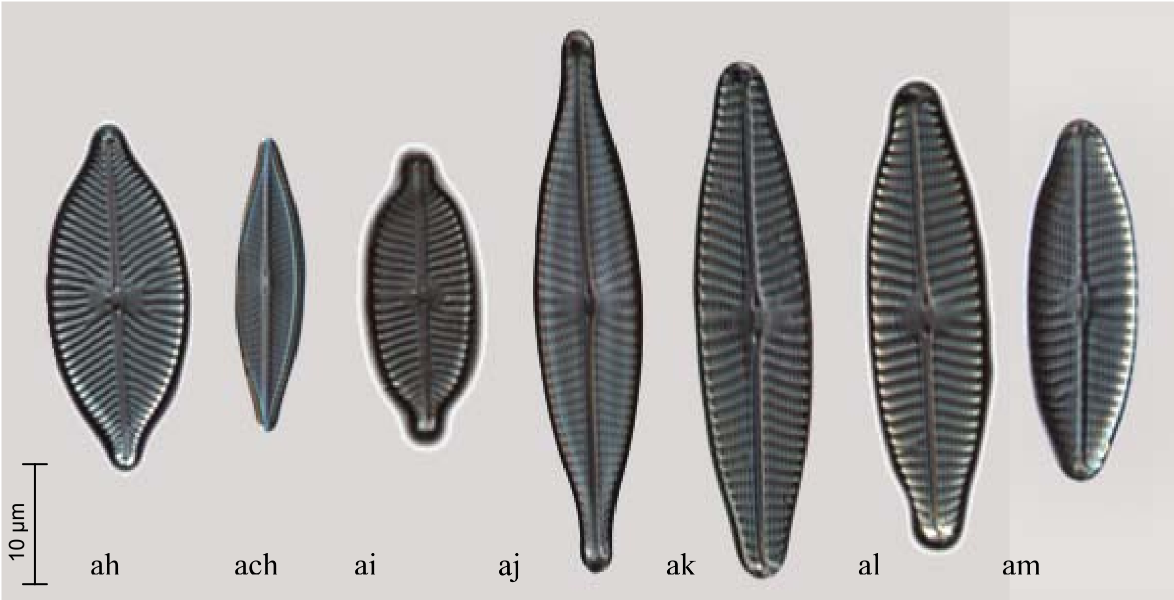


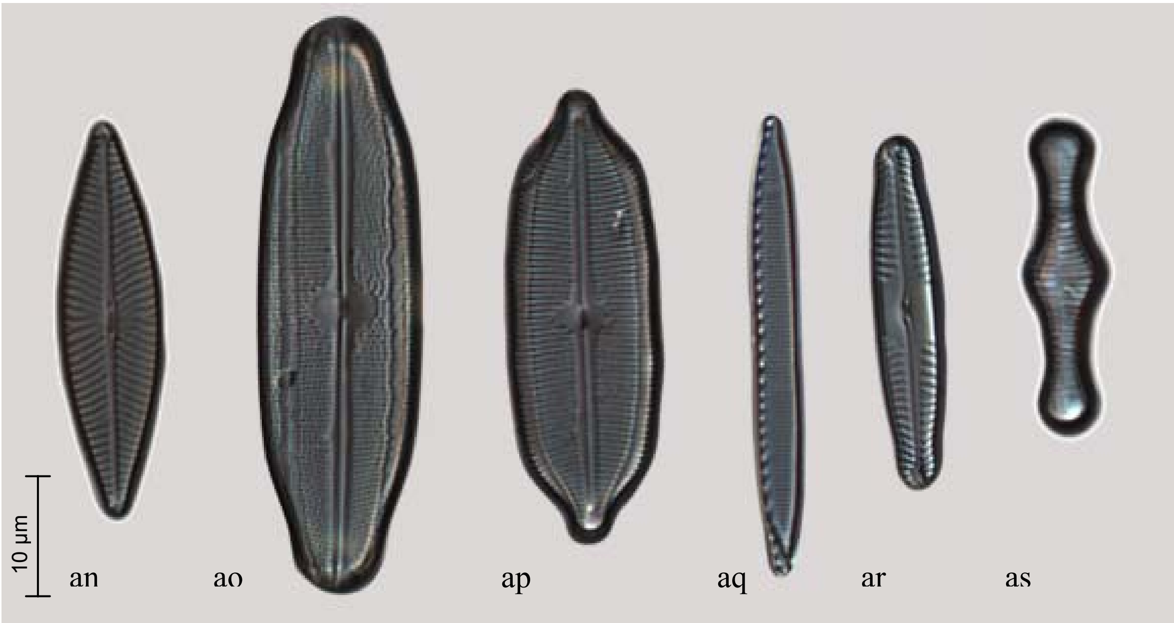
a – *Achnantheiopsis delicatula*, b – Fragilaria sp., c – e *Achnantheiopsis frequentissima*, f – g *Achnanthes chlidanos*, h – ch *Achnanthidium minutissimum*, i - *Amphora copulata*, j - *Amphora inariensis*, k – l *Amphora pediculus*, m - *Cocconeis placentula* var. *euglypta*, n – o *Cocconeis placentula* var. *lineata*, p - *Cyclostephanos dubius*, q - *Cymbella affinis*, r - Cymbella cistula.



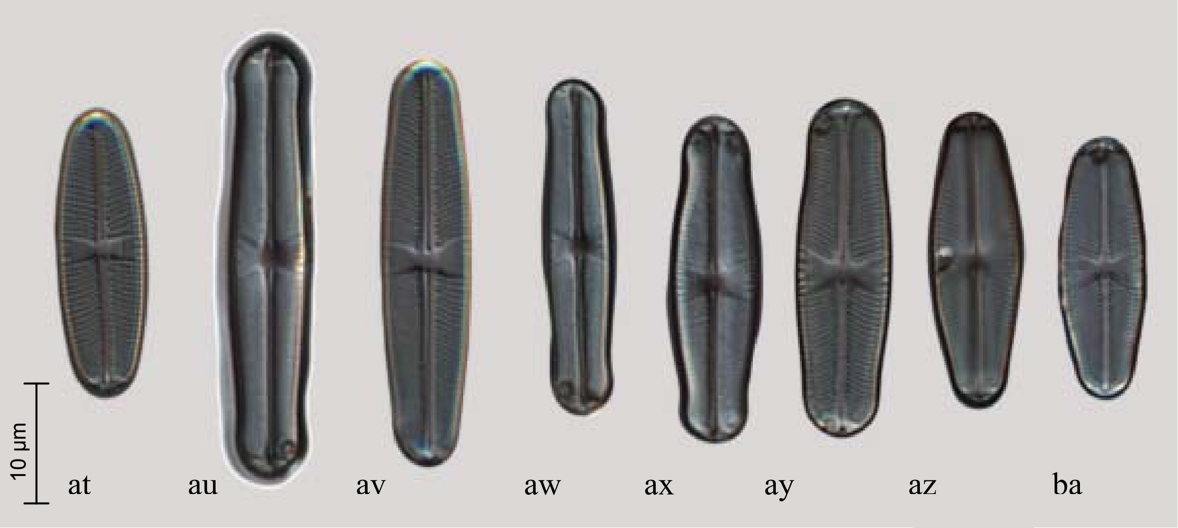


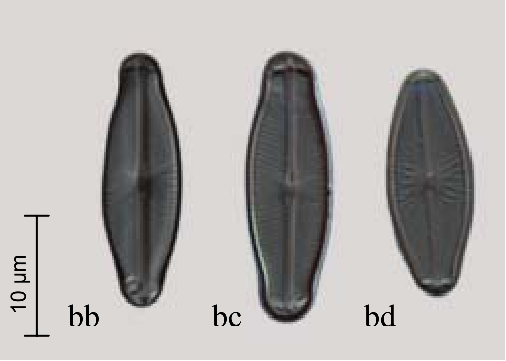
s - *Cymbella gracilis*, t - *Cymbella naviculiformis*, u - *Cymbella subaequalis*, v - *Diploneis ovalis*, w - *Eunotia* sp., x – z *Fragillaria construens* var. *venter*, aa – ab *Fragillaria pinnata*, ac - *Gomphonema gracile*, ad – ae *Gomphonema parvulum*, af – ag *Navicula capitata*.





ah - *Navicula clementis*, ach - *Navicula cryptocephala*, ai - *Navicula* sp., aj - *Navicula rhynchocephala*, ak – am *Navicula slesvicensis*, an - *Navicula trivialis*, ao - *Neidium ampliatum*, ap - *Neidium dubium*, aq – *Nitzschia* sp. div., ar - *Pinnularia subcapitata*, as – *Tabelaria floculosa.*





at - *Sellaphora bacillum*, au – bd *Sellaphora pupula* agg.