Oceanological and Hydrobiological Studies
International Journal of Oceanography and Hydrobiology

Volume 43, Issue 2

ISSN 1730-413X
eISSN 1897-3191

(114–122)
2014

VERSITA

DOI: 10.2478/s13545-014-0123-1
Original research paper

Received: April 03, 2014
Accepted: May 08, 2014

Diatoma polonica sp. nov. – a new diatom (Bacillariophyceae) species from rivers and streams of southern Poland

Małgorzata Bąk[1,*], Horst Lange-Bertalot[1], Jacek Nosek[2], Zofia Jakubowska[2], Małgorzata Kiełbasa[2]

[1]*Palaeoceanology Unit, Faculty of Geosciences, University of Szczecin, ul. Mickiewicza 18, 70-383 Szczecin, Poland*
[2]*Voivodship Inspectorate for Environmental Protection in Krakow, Division in Nowy Sącz, ul. Fabryczna 11, 33-300 Nowy Sącz, Poland*

Key words: Diatoma, Bacillariophyceae, diatoms, new species, southern Poland, rivers and streams

Abstract

Diatoma polonica, a species first observed in samples from the Western Carpathians river systems in southern Poland, is described as a species new to science. The new species status resulted from the fact that the dimensions of cells found did not fit any of the diagnoses given in the literature for the European *Diatoma* taxa established so far. The genus is rather species-poor, even when the entire Holarctic flora is taken into account. The new species is morphologically closest to *Diatoma moniliformis* Kützing, particularly with respect to the vague resemblance of the valve outlines and the presence of a rimportula in each valve pole. Further, more or less similar taxa are *D. tenuis* Agardh, *D. problematica* Lange-Bertalot and *D. mesodon* (Ehrenberg) Kützing, all distinguished, in addition to other specific characteristics, by the rimoportulae regularly present at only one valve pole. Characteristics of *D. polonica* are described and compared with those of other species based on light and scanning electron microscopy.

* Corresponding author: *mabak@univ.szczecin.pl*

INTRODUCTION

As stipulated by the Framework Water Directive, the EU countries (Poland included) are obliged to monitor their waters and assess their quality and ecological state using various indicators, including diatoms. In Poland, this obligation is being fulfilled by biological laboratories of Voivodship Inspectorates for Environmental Protection (VIEP) and their branches. Quite frequently, the inspectorates report problems associated with identification of some relatively rare species, *Diatoma polonica* sp. nov. being a case in point. Morphological characteristics (frustule shape, length, width, and number of striae per 10 µm) of the species place it right between *D. moniliformis* and *D. problematica*, two species frequent in Polish waters, but differing in autecology. SEM examination of the new diatom's morphology indicates that *D. polonica* is a species new to science, fairly common in rivers and streams in the south of Poland. However, analysis of images presenting diatom floras of other regions of Central Europe shows the species to be more widely distributed. Most likely, the species has been ignored in aquatic monitoring or misidentified as representing non-typical forms of *D. moniliformis* or *D. problematica*.

STUDY AREA

The study was carried out in three rivers located in southern Poland, all belonging to the upper Vistula River system: the Dunajec (a right-side tributary of the Vistula), the Kamienica Zabrzeska (the left-side tributary of the Dunajec), and the Ropa (a left-side tributary of the Wisłoka River which itself is a right-side tributary of the Vistula). The general characteristics of the rivers are summarized in Tables 1 and 2.

Table 1

General characteristics of the rivers studied

River	Type	Sampling site	Geographic location		Length (km)	Sampling date	Altitude (m above sea level)	River course	Average depth (m)	Average width (m)	Bottom type
			Latitude	Longitude							
Kamienica Zabrzeska	12	mouth	49.541111°N	20.400833°E	32	9 March 2010	367	meandering	0.5	12	stony
Dunajec	15	Świniarsko	49.597777°N	20.656944°E	247	15 Feb. 2010	286		1.2	80	
Ropa	14	Szymbark	49.630000°N	21.116670°E	79	10 March 2011	300		0.7	20	

Table 2

Water quality characteristics recorded in the studied rivers

River	Temp (°C)	Conductance (μS cm^{-1})	pH	DO (mg l^{-1} O_2)	DOC (mg l^{-1} C)	BOD_5 (mg l^{-1} O_2)	TP (mg l^{-1} P)	Phosphate (mg l^{-1} P-PO_4)	TN (mg l^{-1} N)	Nitrate N (mg l^{-1} N-NO_3)	Ammonia N (mg l^{-1} N-NH_4)	Total hardness (mg l^{-1} $CaCO_3$)	SiO_2 (mg l^{-1})
Kamienica Zabrzeska	0.0	187	8.8	15.6	<1.0	2.3	0.038	0.045	2.1	1.8	0.190	158	4.05
Dunajec	0.0	229	8.4	14.8	1.88	3.4	0.041	0.043	2.1	1.3	0.058	188	4.03
Ropa	1.4	276	8.6	15.8	2.52	2.1	0.025	0.064	1.5	1.1	0.052	114	3.85

MATERIALS AND METHODS

Epilithon samples were collected once for each river, during the routine monitoring in late winter in 2010 (in February – Dunajec), and 2011 (in March – Kamienica Zabrzeska and Ropa). On each sampling event, relevant environmental parameters (temperature, conductance, pH, and dissolved oxygen content) were measured with the YSI Professional Plus handheld multiparameter meter. The water was also sampled for laboratory assays of dissolved organic carbon (DOC), biochemical oxygen demand (BOD_5), and contents of total phosphorus (TP), phosphates (Phosphate), total nitrogen (TN), nitrates (Nitrate), ammonia (Ammonia), total hardness (the sum of calcium and magnesium hardness), and silica (SiO_2). The assays were performed according to the Polish Standards used in VIEP laboratories (TOC – PN-EN 1484, 1999; DOC – PN-EN 1484, 1999; BOD_5 – PN-EN 1899-2, 2002; TP – PN-EN ISO 6878, 2006, Phosphate – PN-EN ISO 6878, 2006, TN – CW.21.0, 2010; Nitrate – CW.19.1, 2010, Ammonia – PN-ISO 5664, 2002; Total hardness – CW.39.0, 2010; SiO_2 – CW.41.0, 2010). In the laboratory, diatoms present in the epilithon samples were mounted in a standard manner (Battarbee 1986), viewed with light (Nikon Ecclipse E 600, with a PlanAPO ×100 immersion objective, and 1.4 aperture) and SEM microscopy (Hitachi S-4500), and identified.

RESULTS

Description of *Diatoma polonica* sp. nov. (Figs 1a–w, 2a–f, 5a–h)

Diagnosis differens versus *Diatoma moniliformis* Kützing 1833

Frustula aspectu cinguli rectangularia ita non significanter differentia. Valvae plerumque fortiter vel modice ellipticae interdum aliquid elliptico-lanceolatae (sed numquam lineares cum marginibus rectis). Apices obtuse (nec anguste) rotundati raro paulo protracti subcapitati. Longitudo 12–29 (versus 8–48) μm, latitudo 5–7 (versus 2–4.5) μm. Ratio

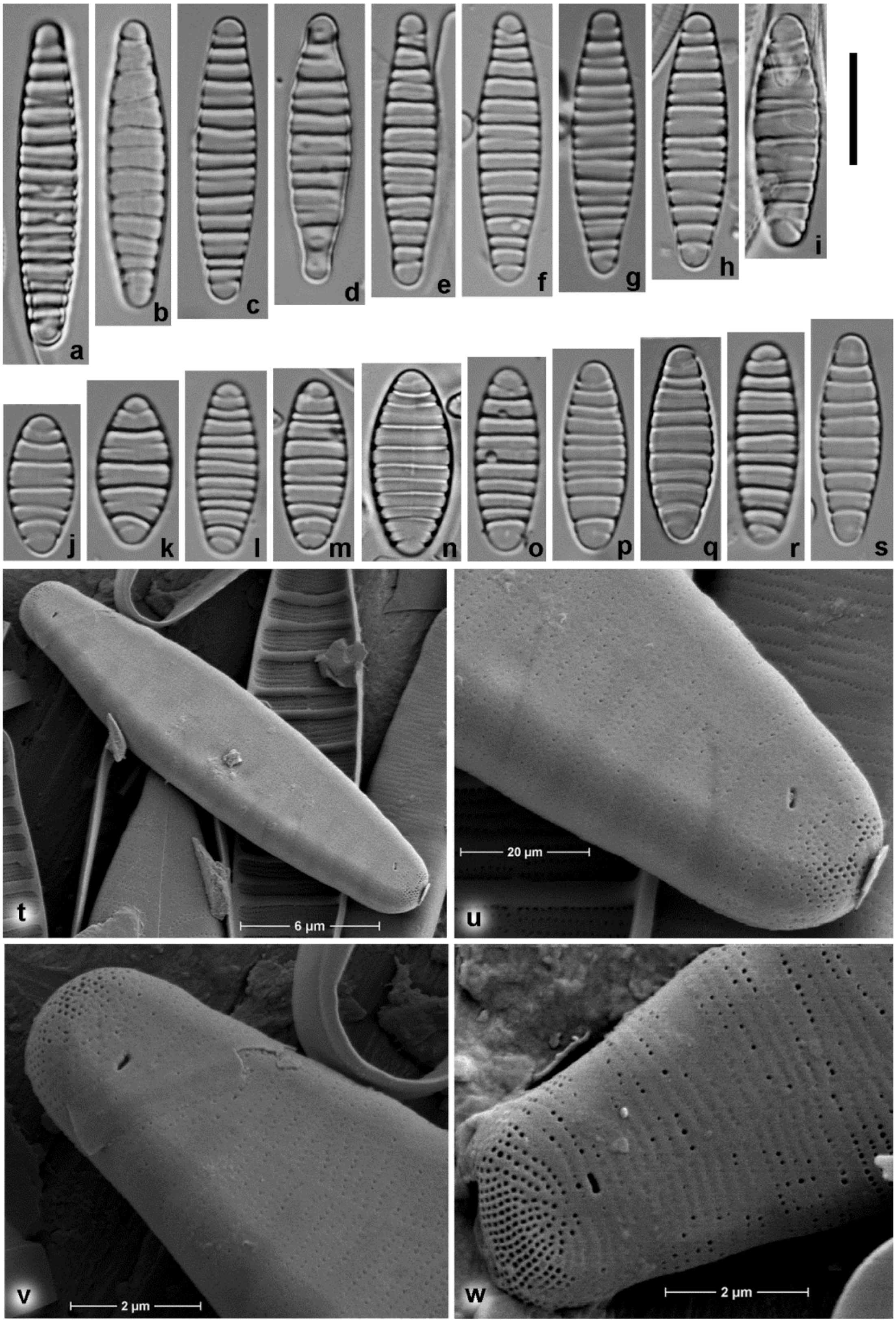

Fig. 1. *Diatoma polonica* sp. nov. from the Western Carpathians (Kamienica Zabrzeska, a small calcium carbonate-rich upland river in southern Poland), (a-s) – LM, (t-w) – SEM, external view (t-v one specimen). Scale bar 10 µm.

longitudo ad latitudinem 1.9–5.4 (nec circiter 3.2–16). Costae primae vel principales 4–8 (versus 7–12) in 10 µm. Costae secundae variabiliter intermissae. Striae transapicales non differentes. Aspectus ultramicroscopicus externus internusque: Rimoportulae binae pro valva sitae in positione subapicali semper distincte in costis secundis interdum prope costam (nec in costis primis).

Holotypes (designated here): Slide no. 18492 in Coll. of Andrzej Witkowski in the Institute of Marine and Coastal Sciences, University of Szczecin (SZCZ), represented by Fig. 1h.

Locus typicus: the confluence of the upland, calcium carbonate-rich, the small Kamienica Zabrzeska River with the Dunajec River, near Zabrzeż (southern Poland).

Etymology: The specific name refers to the country, Poland, where the species was first found in several rivers.

Differential diagnosis vs. *Diatoma moniliformis* Kützing 1833

Frustules rectangular in girdle view, often seen in live phytobenthos (periphyton) samples as zigzag colonies. However, the girdle view is extremely rare in slides of acid-treated material. Valve outlines are predominantly strongly to moderately elliptical, sometimes elliptical-lanceolate (linear specimens with straight margins are absent). Apices are obtusely rounded, rarely slightly protracted subcapitate (vs. narrowly rounded). Length 12–29 (vs. 8–48) µm, breadth 5–7 (vs. 2–4.5) µm. Length-to-breadth ratio 1.9–5.4 (vs. ca. 3.2–16). Primary transapical ribs or bars 4–8 (vs. 7–12) in 10 µm, unevenly spaced. Secondary ribs irregularly intercalated, often not reaching the opposite valve margin. The axial area visible as a hyaline, very narrow line crossing the barely discernible transapical striae. With focusing, a small rimoportula is recognizable at both valve poles.

For internal and external SEM view, see Figs 1t–w and 2a–f. Primary and secondary ribs are clearly differentiated on the internal view by breadth and the amount of accumulated silica. Striae of circular areolae between transapical ribs occur with a density of 40–50 in 10 µm, interrupted by a narrow (1–2 µm wide) sternum. Areola density about 80 in 10 µm. Polar pore fields composed of even more densely spaced radially arranged poroids. Each end of every valve with a bilabiate rimoportula located on the secondary rib next to the apices (not on the primary rib as is typical of *D. moniliformis*). Occasionally, a rimoportula is located at the end of the reduced secondary rib (Fig. 2f) or even directly on the internal valve face (Fig. 2c). The external valve surface is smooth, but features the same pattern of fine structures as the internal surface. Foramina of the rimoportulae are simple transapically orientated slits, often oblique to the apical axis (Figs 1u–w). Marginal spines absent.

Distribution: *Diatoma polonica* was found in three upland calcium carbonate-rich rivers: Kamienica Zabrzeska, Dunajec, and Ropa, all belonging to the upper Vistula river system. The distribution of *Diatoma polonica* is not restricted to the Western Carpathians river system. It is very likely that the species was in the past unrecognized by authors monitoring diatoms in other regions of Europe, and was instead mistaken for one of the established taxa. One of us (HL-B) has recently identified *D. polonica* in a sample from lotic waters of Cyprus.

Taxonomical comments: Except for *D. moniliformis* (Figs 3a–v), no other Holarctic *Diatoma* species is actually similar to *D. polonica* (see Williams 1985, 2012). *Diatoma mesodon* (Ehrenberg) Kützing (Fig. 4t–v), with similar outlines, has marginal spines, a single rimoportula per valve, less dense striae (25–35) and transapical ribs (bars) (3–6, but on the average less than 5 in 10 µm). *Diatoma tenuis* Agardh, 1812 (Figs 4a–s, Fig. 5j) is mainly distinguished by clearly capitate ends, the consistently linear valves and a single rimoportula per valve. The highly eutrophilous *Diatoma problematica* Lange-Bertalot, 1993 has, likewise, a single rimoportula and linear rather than elliptical valve outlines. Without doubt, *D. ehrenbergii* Kützing (Fig. 5l) and *D. vulgaris* Bory (Fig. 5i) as well as morphologically related infraspecific taxa will never be confused with *D. polonica* because of their much larger cell size.

DISCUSSION

In the standard diatom literature with identification keys, e.g. Hustedt 1930, Hustedt in Rabenhorst 1931, Patrick & Reimer 1966, Krammer & Lange-Bertalot 1991, Hofmann et al. 2011, the genus *Diatoma* is referred to as a genus with a relatively low number of species, including several synonyms and infraspecific taxa. In diatomological

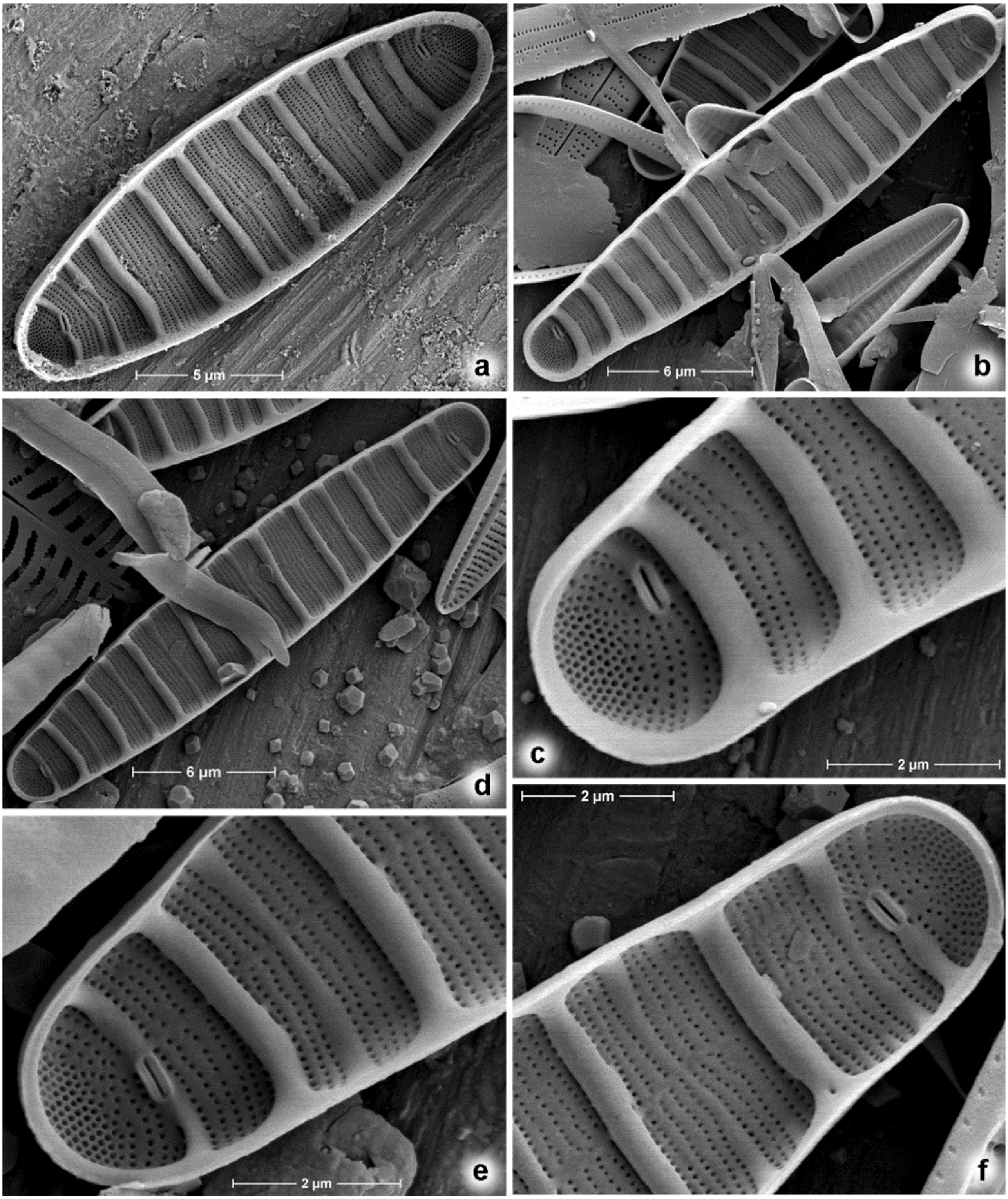

Fig. 2. *Diatoma polonica* sp. nov. from Kamienica Zabrzeska, (a-f) – SEM, internal view (d-f – one specimen).

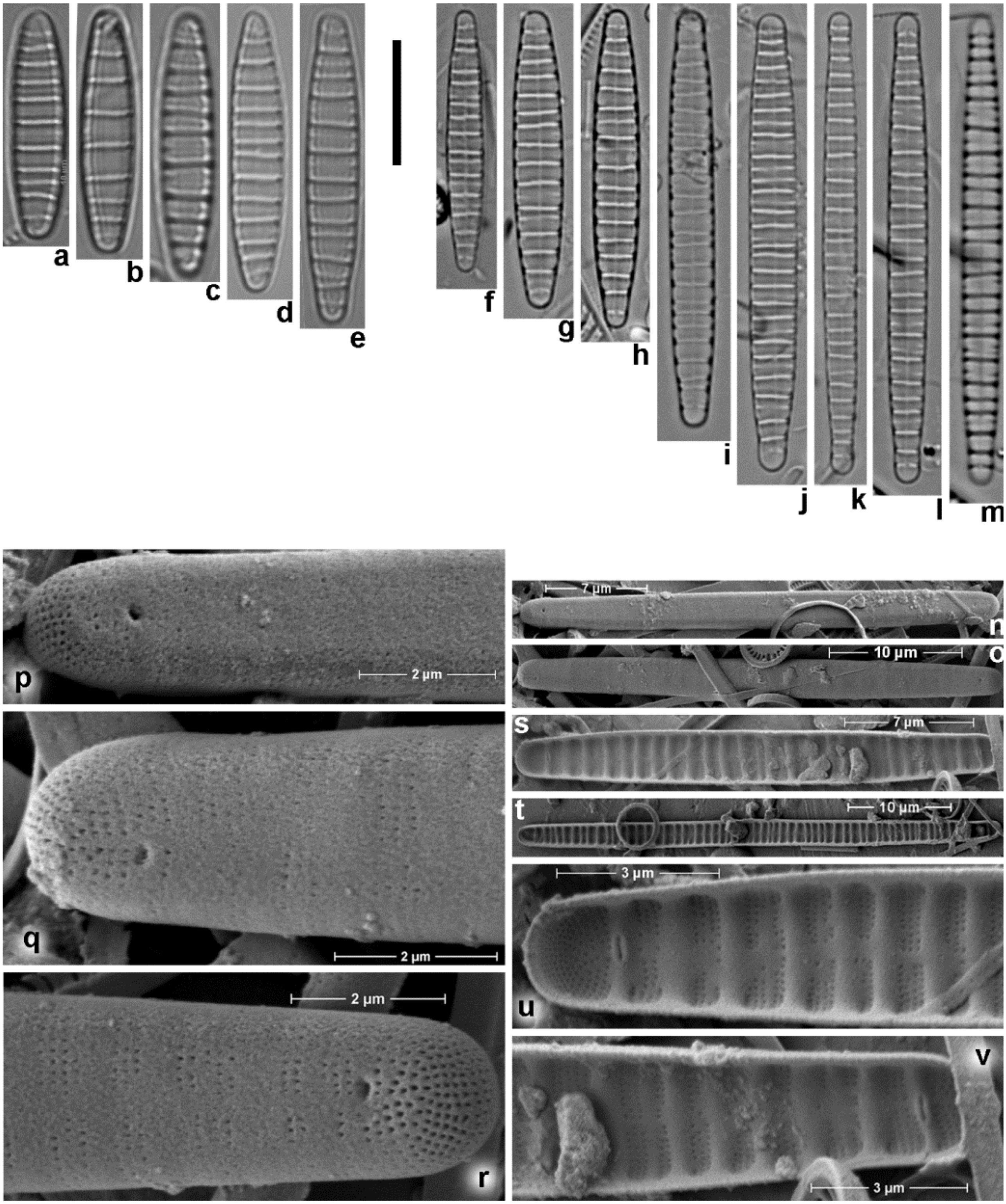

Fig. 3. *Diatoma moniliformis* Kützing. (a-e) – LM, from the same location as *D. polonica* sp. nov., (f-m) – LM and (n-v) – SEM, from southern Germany, (n-r) – SEM, external view, (s-v) – SEM, internal view (o-r and s, u, v – the same specimens). Scale bar 10 µm.

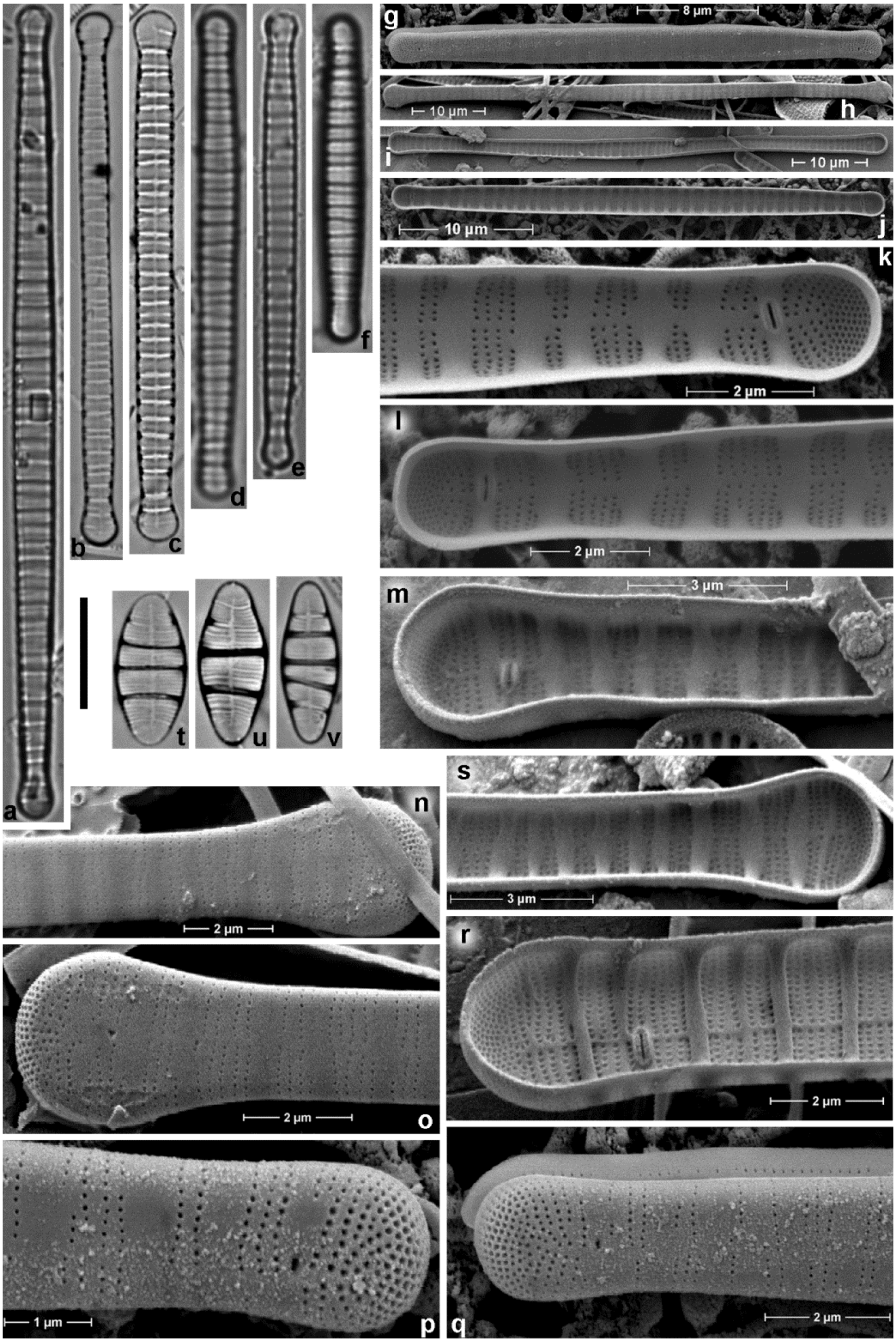

Fig. 4. (a-s) *Diatoma tenuis* Agardh, (t-v) – *D. mesodon* (Ehrenberg) Kützing – all from southern Germany, (a-f) – LM, (g, h, n-q) – SEM external view, (i-l, r, s) – SEM internal view (h, n, o and g, p, q – the same specimens). Scale bar 10 µm.

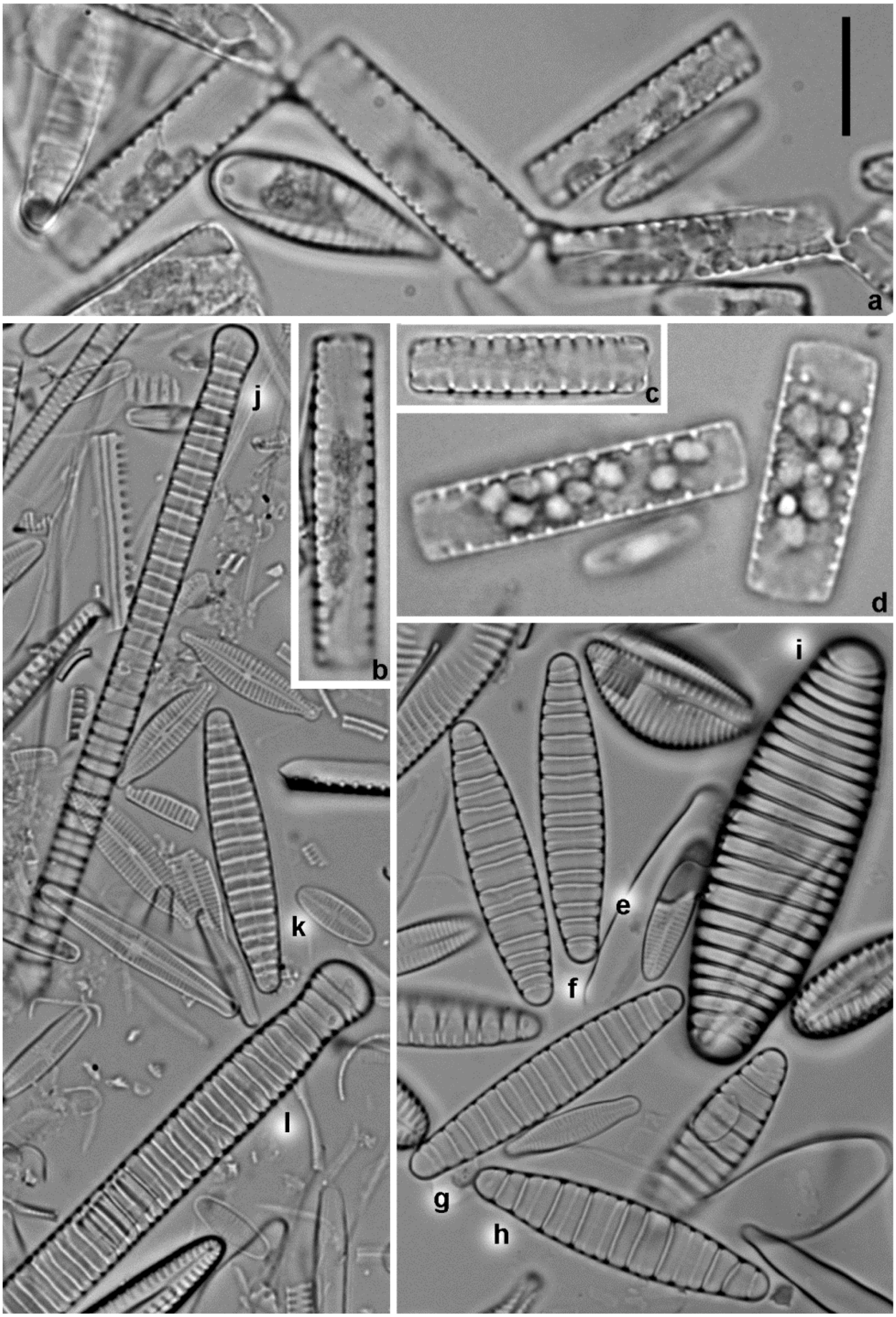

Fig. 5. (a-h) *Diatoma polonica* sp. nov. from southern Poland, LM, (a-d) – untreated cells, (i) – *D. vulgaris*, (j) – *D. tenuis*, (k) – *D. moniliformis*, (l) – *D. ehrenbergii*, (i-l) from southern Germany. Scale bar 10 µm.

literature, the cell dimensions cover, in most cases, wide ranges of values. This may be a reason why the *Diatoma* morphodemes with slender (about 2–7 μm wide throughout the cell cycle) valves did not receive enough attention which would prompt consideration of a new species rather than a discontinuous population. Indeed, Potapova & Snoeijs (1997) observed at two sampling sites two distinct populations and followed them over the entire cell cycle, from the initial cells to the shortest parental ones, in different seasons. These populations from the brackish water of the northern Baltic Sea probably belong to *D. moniliformis,* but differ from *D. moniliformis* present in fresh waters where the species usually occurs; in other words, they differ from the original description based on the observations of freshwater individuals. The difference involves the presence of some cells with exceptionally long (3–80 μm) and broad (2–7.5 μm) valves in the Baltic populations, not encountered in the freshwater populations. However, although longer and broader cells do occur, the mean valve length and breadth remain as given in the original description, i.e. 64.9 and 3.0 μm, respectively. After 15 or 27 months from auxosporulation, the sizes reported were 22–30 μm and about 2.8 μm, respectively. Conspecificity of the populations described by Potapova & Snoeijs (1997) with a freshwater population of the lectotype may be assumed, but has not been confirmed yet. On the other hand, conspecificity of those populations with *D. polonica* can be ruled out. A more subtle problem arises when specimens of morphologically similar but taxonomically different taxa co-occur in samples. This is obviously the case with *D. polonica* which might be mistaken for *D. moniliformis,* unless the position of rimoportulae in the two species is compared using SEM images.

ACKNOWLEDGMENTS

The authors are grateful to Dr. Teresa Radziejewska for helpful comments and linguistic correction of the manuscript.

REFERENCES

Battarbee, R.W. (1986). Diatom analysis. In B.E. Berglund (Ed.), *Handbook of Holocene Palaeoecology and Palaeohydrology* (pp. 527–570). Chichester: John Wiley & Sons Ltd.

Hofmann, G., Werum M. & Lange-Bertalot H. (2011). *Diatomeen im Süßwasser-Benthos von Mitteleuropa.* Koenigstein: A.R.G. Gartner Verlag K.G.

Hustedt, F. (1930). Bacillariophyta (Diatomeae). In A. Pascher (Ed.), *Die Süßwasser-Flora Mitteleuropas* (Vol. 10, 2nd ed.). Jena: Gustav Fischer.

Hustedt, F. (1931). Die Kieselalgen Deutschlands, Österreichs und der Schweiz unter Berücksichtigung der übrigen Länder Europas sowie der angrenzenden Meeresgebiete. In L. Rabenhorst (Ed.), *Kryptogamen – Flora 7* (part II, pp. 1–176). Leipzig: Verlag von Eduard Kummer.

Krammer, K. & Lange-Bertalot H. (1991). Bacillariophyceae, 3. Part. Centrales, Fragilariaceae Eunotiaceae. In H. Ettl, J. Gerloff, H. Heynig & D. Mollenhauer (Eds.), *Süsswasserflora von Mitteleuropa* (Vol. 2(3)), Berlin: Spektrum Akademischer Verlag Heidelberg.

Patrick, R.M. & Reimer C.W. (1966). The *diatoms of the United States exclusive of Alaska and Hawaii* (Vol. 1(13)). Philadelphia: Acad. Nat. Sci.

Potapova, M. & Snoeijs P.J. (1997). The natural life cycle in wild populations of *Diatoma moniliformis* (Bacillariophyceae) and its disruption in an aberrant environment. *J. Phycol.* 33: 924–937. DOI: 10.1111/j.0022-3646.1997.00924.x.

Snoeijs, P. (1993). *Diatoma moniliformis* Kützing 1833. In P. Snoeijs (Ed.), *Intercalibration and distribution of diatom species in the Baltic Sea* (Vol. 1, p. 50). Baltic Marine Biologists Publ. No. 16. Uppsala: Opulus Press.

Williams, D.M. (1985). Morphology, taxonomy and interrelationships of the ribbed araphid diatoms from the genera *Diatoma* and *Meridion* (Diatomaceae: Bacillariophyta). *Bibl. Diatomol.* (Vol. 8). Stuttgart: J. Cramer.

Williams, D.M. (2012). *Diatoma moniliforme*: Commentary, relationships and an appropriate name. *Nova Hedwigia Beiheft* (141): 255–262.