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Morphological variability of the diatom *Luticola muticopsis* (van Heurck) D.G. Mann in the inland waters of King George Island, South Shetland Islands, Antarctic

ABSTRACT: *Luticola muticopsis* is a characteristic species of polar and subpolar regions. Its morphological variability is not yet precisely described. In the investigated population the cells from capitate to shortened, flat rounded tips were observed. The range of dimensions of specimens was 8.8–40.6 µm × 5.5–17.6 µm, striae 11–22/10 µm; this range considerably exceeded that found in holotype diagnosis.

Key words: Antarctic, South Shetland Islands, King George Island, freshwater diatoms, *Luticola muticopsis*.

Introduction

Luticola muticopsis (syn. *Navicula muticopsis* van Heurck; see Round, Crawford and Mann 1990) is an interesting species characteristic of polar and subpolar regions (Hustedt 1966, Krammer and Lange-Bertalot 1986). The morphological

variability of this species is not yet precisely known. Many varietes and forms have been described by West and West (1911), Carlson (1913), Heiden and Kolbe (1928), Frenguelli (1924), Ko-Bayashi (1963) and Manguin (1964) and revised by Hustedt (1966). Also Ko-Bayashi (1965) observed larger specimens than those in the diagnosis of this species. In this study we are present observations on the morphological variability of *L. muticopsis* occurring in inland waters of King George Island.

Study area

King George Island, the largest in the South Shetland Islands archipelago, is located in the Maritime Antarctic Zone, in the region of wet marine climate. The island is composed of volcanic rocks, and is in 90% covered by ice. Investigations were conducted in the region of Admiralty Bay, where in the area free of persistent ice cover, the *H.Arctowski* Polish Antarctic Station is situated. The average annual air temperature of this area is -1.8°C; in summer (XII–III) the warmest month is January (average +2.3°C), whereas in winter (VI–IX) the coldest month is July (average -7.1°C) (Rakusa-Suszczewski, Miętus and Piasecki 1993).

Materials were collected in Vanishing Creek II, in Vanishing Creek, in Ornithologists Creek, in Petrified Forest Creek and in Coloured Creek (Vanishing Creek II and Coloured Creek were named by the present authors) (Fig. 1). Materials were collected also from water bodies situated in the area of the Polish Antarctic Station. They were: coastal pond and a puddle situated behind the power plant (numbered respectively as pond I and station 15; see Fig. 2 in Kawecka *et al., in press*).

Investigated water bodies originate from melting snow and ice caps, and are ephemeral. Vanishing Creek, Vanishing Creek II and Ornithologists Creek flow through the slopes of the Kasprowy and Jersak massifs, whereas Petrified Forest Creek gathers water from the slopes of Panorama Ridge. Coloured Creek rises from snow beds lying above Blue Dyke hill; it is *ca.* 200 m long; other creeks are longer but do not exceed 1.5 km. The creeks are shallow with the bottom of stones, gravel and sand. Pond I is a shallow water body of muddy bottom.

Few data, on the environmental conditions of the waters investigated are available. During the study period water temperature was: in creeks 0.9–5.8°C, in the pond 7.3–12.0°C and in the puddle 9.2–13.2°C. In Ornithologists Creek pH of the water ranged from 6.6 to 6.9 and, according to Janiec (1992), pH of small standing water bodies amounted to 7.7–9.9. Waters in this area are slightly mineralised and enriched with chloride ions, e.g. in Vanishing Creek the total mineralization amounted to 14.2–45.0 mg l^{-1}, including 12.8–35.8 mg Cl^{-1} (Kozik 1982). In regions of bird colonies and Station buildings waters are enriched with nutrients. Vanishing Creek, Vanishing Creek II and Petrified Forest Creek are not influenced

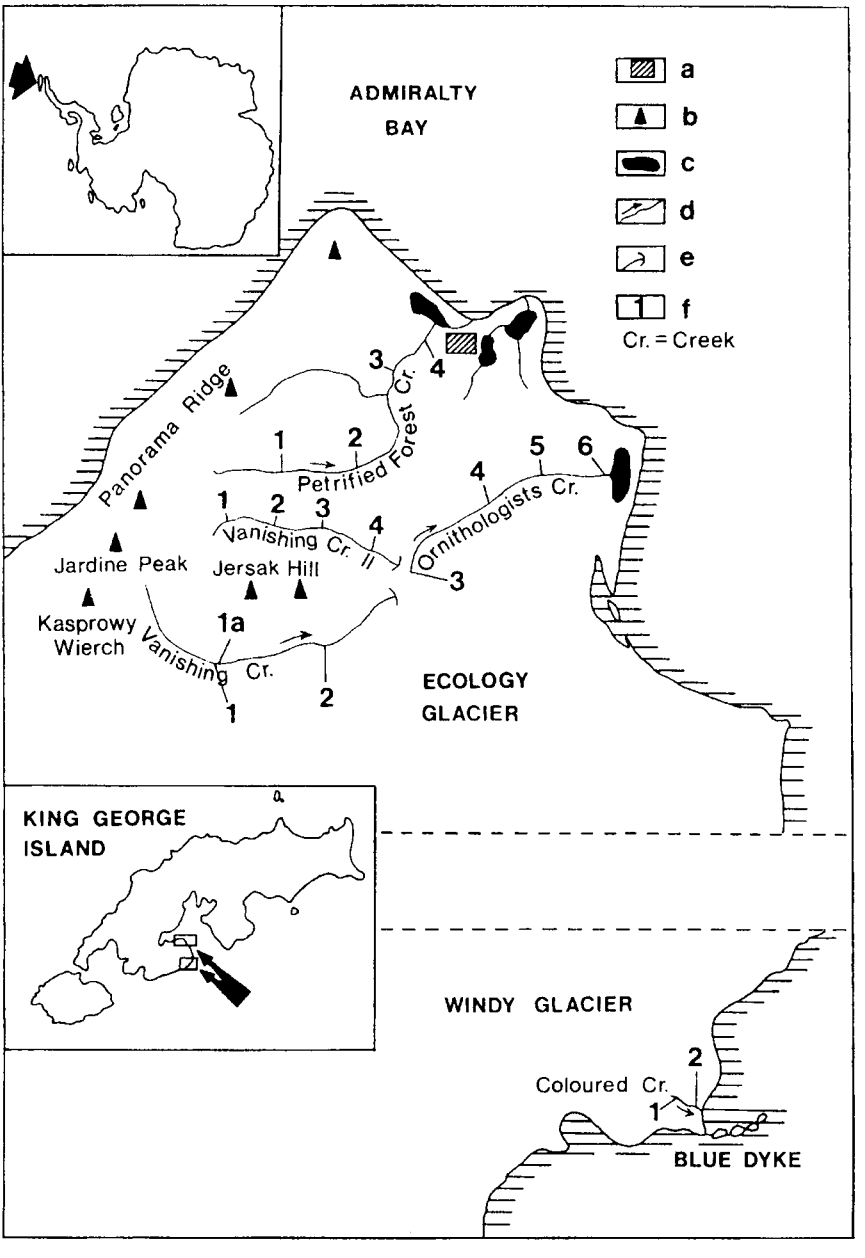

Fig. 1. Localization of sampling stations: a — *Arctowski* Station, b — peaks and hills, c — streams, d — thermokarstic channel swollow holes, e — ponds, f — sampling stations.

by birds, but in the vicinity of central and lower sections of Ornithologists Creek there are penguin rookeries. Coloured Creek is under the influence of old, abandoned penguin rookeries.

Material and methods

Materials were collected by the second author in the Antarctic summer during the XI (1986/87), XIII (1988/89) and XVI (1991/92) Antarctic Expeditions of the Polish Academy of Sciences.

Algae were removed from stones and bottom sediments and preserved in a 4% formalin solution. In the laboratory the material was macerated in a mixture of sulphuric acid and potassium dichromate in the ratio 3:1, then cleaned by centrifugation at 3000 R min^{-1}. Permanent slides were embedded in a synthetic resin ("Pleurax").

Diatoms were counted in 10 microscope fields, and then percentage of organisms in a given community was calculated. Taxa with at least 5% of occurrence were assumed to be numerous, the rest were regarded as scarce. Photographs were taken under scanning electron microscope (JEOL JSM 35CF).

Results

Dimensions of the cells of *Luticola muticopsis* found in inland waters of King George Island had the following ranges: length 8.8–40.6 µm, width 5.5–17.6 µm, striae 11–22/10 µm, points 20/10 µm. All cells had one isolated stigma in their central part.

Three groups of cells with different morphology could be recognized (Table 1, Pl. 1, Figs 1–13): 1) cells with clearly capitate tips (Figs 1–5); 2) with slightly capitate (Figs 6–9) and 3) with shortened, flat rounded tips (Figs 10–13). *L. muticopsis* cells occurred as a rule in low numbers, however abundant populations were noted in Coloured Creek (02.1987), in Vanishing Creek II (12.1987, station 4) and in the puddle (01/02.1992).

Table 1

Morphological variability of Luticola muticopsis found in inland waters of King George Island.

Investigated waters / shape of tips	Vanishing Creek Vanishing Creek II Ornithologists Creek	Petrified Forest Creek	Coloured Creek	Area of the Polish Antarctic Station: Pond I, puddle near power plant
1. clearly capitate	14-40×5.5-17.6 11-18/10 µm	18.6-37.6×8.3-15.2 11-19/10 µm	20.6-40.6×8.8-15.4 11-18/10 µm	20.6-28.6×7.7-11.6 13-17/10 µm
2. slightly capitate	14.3-29.7×5.5-9.9 14-17/10 µm	14.1-28.2×6.1-11.5 14-20/10 µm	16.5-21.2×7.7-11 13-20/10 µm	16-22.8×8.6-10 15-17/10 µm
3. shortened, flat rounded	11.9-15.4× 5.5-7.7 14-19/10 µm	12.1-13.2×5.5-6.6 17-20/10 µm	13.2-15.4×7.7-8.8 13-16/10 µm	8.8-14.3×6.1-8.0 15-22/10 µm
range of dimension	11.0-40×5.5-17.6 11-19/10 µm	12.1-37.6×5.5-15.2 11-20/10 µm	13.2-40.6×7.7-15.4 11-20/10 µm	8.8-28.6×6.1-11.6 13-22/10 µm

Most of the cells fit the *Luticola muticopsis* diagnosis (Krammer and Lange-Bertalot 1986). However some cells reached larger dimensions. The biggest specimens were found in Coloured Creek (02.1987, station 2), in Vanishing Creek (03.1987, stations 1, 2 and 01.1988, station 2), and in the lower section of Petrified Forest Creek (12.1987, station 4). On the other hand, in the puddle shortened cells prevailed in the population of *L. muticopsis*.

Discussion

The present study showed that there is a considerable morphological variability in *Luticola muticopsis* (Table 1, Pl. 1, Figs 1–13). In the population of the species there were found cells with capitate tips, referring to the description of *Navicula muticopsis* forma *capitata* Carlson (Carlson 1913). Cells with shortened, flat rounded tips corresponding to the description of *Navicula muticopsis* forma *reducta* West *et* West (West and West 1911) were also found. Taxonomic position of these forms has not been decided. Both forms were synonimized by Hustedt (1966) with *L. muticopsis*. However, other authors, *e.g.* Kellogg *et al.* (1980), Oppenheim (1990), Schmidt, Mäusbacher and Müller (1990) have retained the former nomenclature.

According to Krammer and Lange-Bertalot (1986) the dimensions of *L. muticopsis* are: 10–25 × 6–10 μm, striae 15–18/10 μm, points 15–20/10 μm. However, cells were often found with dimensions differing from those given in species diagnosis (Table 1). In the population studied large specimens with capitate tips reaching 40.6 μm in length and 17.6 μm in width, and with usually only 11–13 striae/10 μm, have been worthy of notice. Such big cells of *Luticola muticopsis* were not given in the literature; Ko-Bayashi (1965) also observed large specimens with a wider range of dimensions (8–32 × 6–11 μm, and also with wider range of striae — 10–21/10 μm. In our study these large cells resembled *L. ventricosa* (Kütz.) D. G. Mann (syn. *Navicula mutica* Kütz. var. *ventricosa* Cleve *et* Grunow) and many of them corresponded to its dimensions according to Krammer and Lange-Bertalot (1986): 6–30(40) × 4–9(12) μm, striae 14–20(25)/10 μm, points about 15/10 μm. However, all the investigated cells had isolated stigma in the central part, but not in the extension of middle stria as it is given in the diagnosis of the species.

Small cells with shortened, flat rounded tips are also worthy of notice. Perhaps these cells could assumed to be a dwarf form of *L. muticopsis* modified by environmental conditions. Such shortened cells in the *L. muticopsis* population prevailed, *e.g.* in the puddle in the area of Polish Antarctic Station in a habitat of unstable severe conditions, which are characteristic of astatic water bodies. The effect of diatom cells dwarfing was observed also in high-mountain creeks pararelly with increasing altitude, which may be attributed to worsening of environ-

mental conditions (Kawecka 1969, 1974 a, b). On the other hand the cells with shortened, flat rounded tips resemble *Luticola cohnii* (Hilse) D. G. Mann and many of them corresponded to its dimensions according to Krammer and Lange-Bertalot (1986): 10–30 × 6–12 μm, striae 15–20/10 μm, points 15–20/10 m. This similarity may suggest close affinity of *Luticola muticopsis* and *L. cohnii*. Such a possibility has been suggested already by Krammer and Lange-Bertalot (1986), and it was confirmed by Mann (in Round, Crawford and Mann 1990) who has transferred *Navicula muticopsis*, *N. cohnii*, as well as *N. mutica* to newly created genus *Luticola*. Further investigation on taxonomy of *Luticola muticopsis* should be based on algal cultures and, may be, on genetic analysis.

In Antarctica *Luticola muticopsis* occurs in various habitats. It lives mainly in freshwater: both in stagnant (Fukushima 1962, Hirano 1965, Baker 1967, Pankow *et al.* 1987, Oppenheim 1990, Schmidt, Mäusbacher and Müller 1990, Wassel and Håkansson 1992, Kawecka *et al.*, *in press*), and in running waters (Seaburg *et al.* 1979, Kawecka and Olech 1993). However, it was also found in saline ponds and lakes (West and West 1911, Karasawa and Fukushima 1977, Broady 1989). The present as well as former investigations (Kawecka and Olech 1993, Kawecka *et al.*, *in press*) showed that *L. muticopsis* occurs both in extremely oligotrophic waters and also those enriched with nutrients by bird colonies. West and West (1911) found *L. muticopsis* in a site very rich in nutrient, on the ground of a penguin rookery.

Geographical distribution of *L. muticopsis* is poorly known. It is believed by many authors to be a characteristic species of Antarctica (West and West 1911, Ko-Bayashi 1965, Hustedt 1966, Pankow *et al.* 1987, Pankow, Haendel and Richter 1991). It was recognized even as an endemic Antarctic species (Fukushima 1962, Goldman, Mason and Wood 1972, Watanuki and Karasawa 1975, Kellogg *et al.* 1980). However, this view contradicts Hirano (1965), Pankow *et al.* (1987) and Kramer and Lange-Bertalot (1986) who have mentioned it also from other continents.

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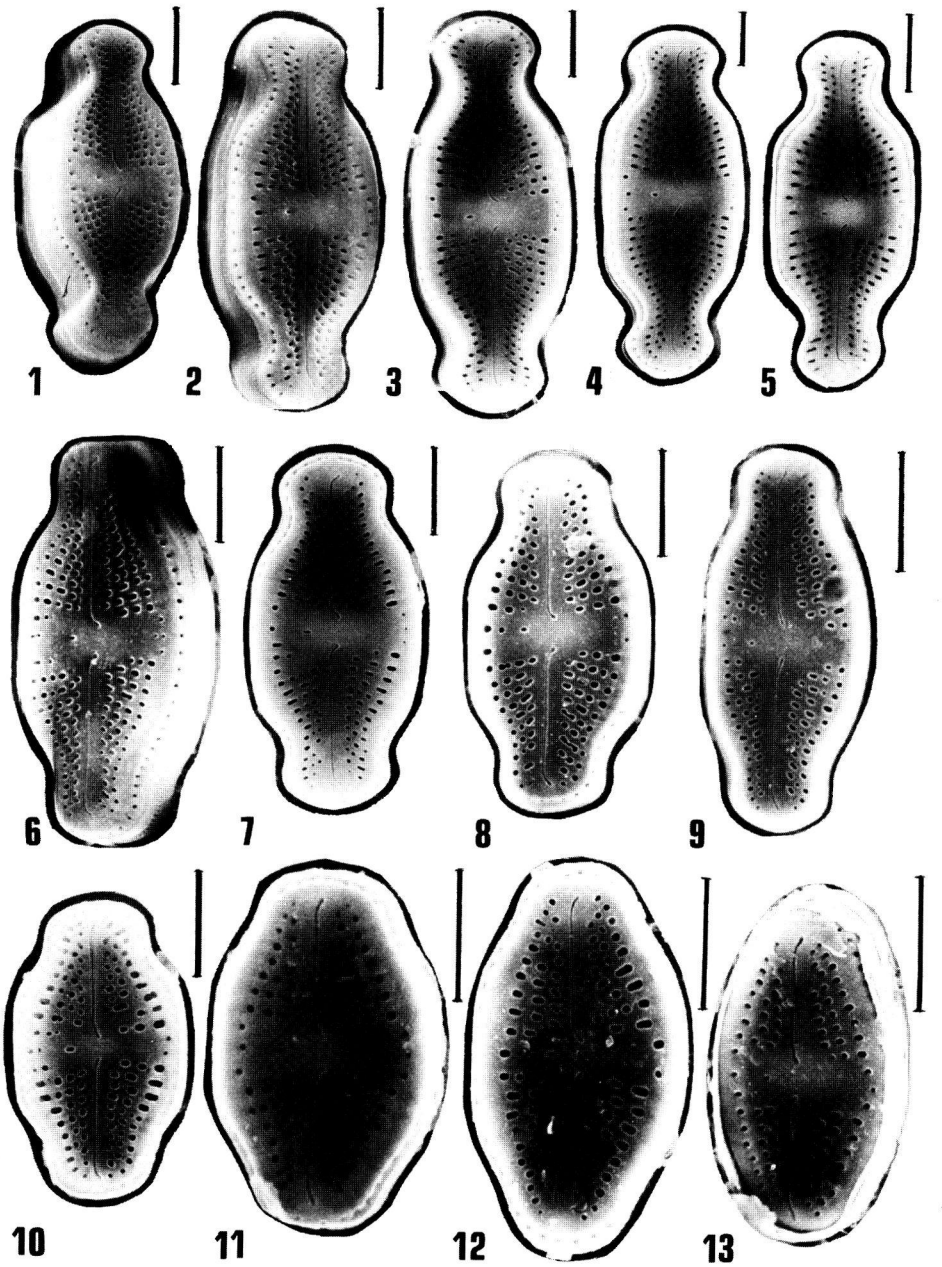
Streszczenie

Luticola muticopsis (syn. *Navicula muticopsis*) jest gatunkiem charakterystycznym dla obszarów polarnych i subpolarnych. Występuje w szerokim zakresie warunków środowiskowych. Okrzemka ta jest spotykana zarówno w wodach stojących, jak i płynących, słodkich oraz słonawych, oligotroficznych i zeutrofizowanych, a także na glebie w rejonach pingwinisk.

Wykazuje dużą zmienność morfologiczną, której zakres nie jest dokładnie poznany. W populacjach gatunku występujących w wodach śródlądowych wyspy King George (potoki oraz stawek i kałuża na terenie Stacji im. *H. Arctowskiego*) spotykano komórki o różnym kształcie końców, od główkowatych, poprzez formy pośrednie, aż do krótkich, płasko zaokrąglonych (tab. 1, rys. 1–13). Komórki posiadały wymiary: 8.8–40.6 × 5.5–17.6 µm, prążków 11–22/10 µm (tab. 1) i wiele z nich odbiegało od wymiarów podanych w diagnozie gatunku (wg Krammer and Lange-Bertalot 1986).



SEM photographs:
1–5. *Luticola muticopsis* with clearly capitate tips, 6–9. *Luticola muticopsis* with slightly capitate tips, 10–13. *Luticola muticopsis* with shortened tips. Scale bars 5 μm.