

***Luticola grupcei* (Bacillariophyceae) - a new freshwater diatom from Mountain Baba (Macedonia) and Great Smoky Mountains National Park (U.S.A.): comparison with the type material of *L. goeppertiana* (Bleisch) D.G.Mann**

by

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With 67 figures and 1 table

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Abstract: We provide a detailed light and electron microscopy description of *Luticola grupcei* sp. nov. from Mountain Baba, South-Western Macedonia and the Great Smoky Mountains National Park, U.S.A.. The species is characterized by lanceolate valves with shortly protracted ends, length 23–46 µm and breadth 8.5–10.5 µm. The striae are radiate throughout (15–17 in 10 µm) and are composed of coarse areolae (16–20 in 10 µm). There is a single isolated stigma positioned on one side of the rectangular to somewhat panduriform central area. *Luticola grupcei* is morphologically comparable with the widespread, pollution-tolerant *L. goeppertiana* from which the new species differs with respect to shape of the valve ends, striae and areolae density, double row of puncta on the valve mantle, the elongate shape of the stigma as well as ecology. *Luticola grupcei* inhabits high mountain oligotraphentic waters and subaerial habitats contrary to *L. goeppertiana*, which in Macedonia is reported for sites with high organic pollution. The type material of *L. goeppertiana* is used for morphological comparison. Further differences between these two species and related taxa are demonstrated through LM and SEM analyses.

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Introduction

The genus *Luticola* D.G.Mann in Round et al. (1990) was described to accommodate the subgenus *Punctulata* (Grunow) R.M.Patrick [or the first group of the *Naviculae punctatae* sensu Cleve (1895)] after closer examination and re-evaluation of the naviculoid genera (Round et al. 1990). *Luticola* is a fairly small genus; the latest Catalogue of Diatom Names (Fourtanier & Kociolek 2007) lists 63 taxa within this genus, whereas Hustedt (1961–1966) lists 48 in the section *Naviculae punctatae*. *Luticola* differs from *Navicula* Bory sensu stricto with respect to almost every feature of the cell including chloroplast number and arrangement, areola structure, girdle structure and the central stigma (Round et al. 1990). The combination of raphe and pore structure and the presence of a stigma serve as a distinction of this genus from its closest relative, *Diademesmia* Kützing (Bruder 2006). Both genera share a preference for subaerial habitats, and along with some other species like the *Pinnularia borealis* Ehrenberg species complex, *Hantzschia amphyoaxis* (Ehrenberg) Grunow and *Orthoseira rooseana* (Rabenhorst) O'Meara, they are frequently found on damp mosses, rocks, wet walls, soil (Krammer 2000, Van de Vijver et al. 2002, 2006, Lowe et al. 2007) and even in lichens (Lakatos et al. 2004) and air (Phipps & Rosowski 1983). A peculiarity is that *Luticola* can also be found in slightly saline environments, like estuaries, indicating a broad range of tolerance towards water mineral content (Hustedt 1961–1966) and some species even exhibit a high pollution tolerance such as *L. goeppertiana* (Bleisch) D.G.Mann (Van Dam et al. 1994, Gosselain et al. 2005).

Since its creation, *Luticola* has received more attention both in terms of taxonomy and systematics (Lange-Bertalot & Bonik 1978, Denys & De Smet 1996, Kawecka et al. 1996, Van de Vijver et al. 2002, 2006, Metzeltin et al. 2005, Poulíčková 2008, Van de Vijver & Mataloni 2008). However, most of the distribution data are still obtained from various ecological and extreme environments' studies (Van de Vijver & Beyens 1997, Van Kerckvoorde et al. 2000, Sabbe et al. 2003, Cremer et al. 2004) with Hustedt (1961–1966, section *punctatae*) remaining the most comprehensive taxonomic resource and most inclusive compilation of *Luticola* taxa. Nevertheless, several new species have been described recently (Metzeltin & Lange-Bertalot 1998, Van de Vijver et al. 2002, 2006, Metzeltin et al. 2005, Van de Vijver & Mataloni 2008) indicating a higher species diversity especially in the southern hemisphere (Antarctica, Brazil, Uruguay) where some large and distinct taxa seem to be present. Still, the morphological variability of the genus, especially within the more commonly reported taxa like *L. mutica* (Kützing) D.G.Mann, *L. ventricosa* (Kützing) D.G.Mann and *L. goeppertiana* (Bleisch) D.G.Mann, seems to be more cryptic since differences between the taxa are subtle and frequently require a more inclusive approach joining morphometry, ultrastructure and ecology for proper species identification and delineation (Ko-Bayashi 1962, 1963). Two samples from Lake Bolnici I (Mountain Baba) and a sample from the Great Smoky Mountains National Park, both highly abundant in *Luticola* taxa represented very suitable material for a more detailed study and resulted in the proposal of a new species.

Materials and methods

Material from the type locality (temporary Lake Bolnici I) was collected on September 17th, 2006. Lake Bolnici I is a cirque-moraine lake situated at an altitude of 2225 m a.s.l. The basin of the lake is only filled with water during the period of intensive snow-melt from March till May, with the snow-melt and rainfall being the only water source. The maximum water depth during this period is 0.4 m and the average 0.3 m. The rest of the year the lake is almost dry. The diatom material of this lake was collected in the form of dry mosses (as remaining from the water period) from the lake basin. The type material of *L. goeppertiana* (slide No. N15/56 mat. No. RBH1183/E5772, Strehlen, Schlesien) deposited in the Friedrich Hustedt Diatom Collection (BRM) was used for suitable species comparison. *Luticola goeppertiana* was published validly in 1861 as *Stauroneis goeppertiana* Bleisch in Rabenhorst, Die Algen Europas n° 1183 (1861). Bleisch wrote in 1863 that he collected the type material on the walls of a granitic pipe holder on the market place of Strzelin in Poland (former German name: Strehlen, Province of Silesia/Schlesien, Kingdom of Prussia). Additional material of *L. goeppertiana* used for species comparison was collected from River Crna near Skocivir, Macedonia, at an altitude of 566 m a.s.l. At this point the river has a mean water depth of 1.80 m. This material was collected in the form of rock scraping in August, 2006. The *Luticola* valves from Macedonia were compared with a *Luticola*-rich sample found from a collection of dark coloured mucilage on a wet wall along Highway 441 in the Great Smoky Mountains National Park (GSMNP), U.S.A.. Diatom slides were prepared by acid digestion and mounted in Zrax[®]. LM observations were made with a Nikon E-800 microscope and LM microphotographs with a Nikon Coolpix 4500 digital camera. For SEM analyses, cleaned material was dried onto stubs and coated with gold and palladium. SEM micrographs were made with a Cambridge Instruments S4 Stereoscan. Slides were deposited at the Diatom Collection at the Institute of Biology (DCIBS), Faculty of Natural Sciences in Skopje and at the Friedrich Hustedt Diatom Collection in Bremerhaven (BRM).

Observations

***Luticola grupcei* A.Pavlov, Nakov & Levkov sp. nov.**

Figs 1–14, 23–35

DESCRIPTION: Valvae rhombico-lanceolatae vel subellipticae apicibus protractis vel rostratis. Valvae in speciminibus maioribus paulo asymmetricae. Longitudo valvae 23–46 μm , latitudo valvae 8.5–10.5 μm . Area axialis angusta ad polos versus gradatim attenuata. Area centralis panduriformis margines valvae non attingens. Stigma solitaria unilateraliter adest. Raphe filiformis, leviter curvata, poris centralibus distinctis declinatis unilateraliter. Striae radiantes distincte punctatae, 15–17 in 10 μm . Puncta comparate crassa, 16–20 in 10 μm .

DESCRIPTION: Valves rhombic lanceolate to slightly elliptical with protracted to rostrate ends, in larger specimens slightly dorsi-ventral asymmetrical. Valve length 23–46 μm and breadth 8.5–10.5 μm . Axial area narrow, continuously tapering towards the valve ends. Central area is a panduriform stauros not reaching the valve margins. Stigma is round, positioned in the middle of the central area. Raphe filiform slightly curved in the central area, proximal raphe endings unilaterally curved to the primary valve side opposite the stigma. Striae, 15–17 in 10 μm are radiate throughout and composed of round coarse areolae 16–20 in 10 μm .

HOLOTYPE: Praep. No. DCIBS Pe104, Figura nostra 4 (Fig. 4).

ISOTYPE: Praep. No. DCIBS Pe104a,b, BRM ZU6/76.

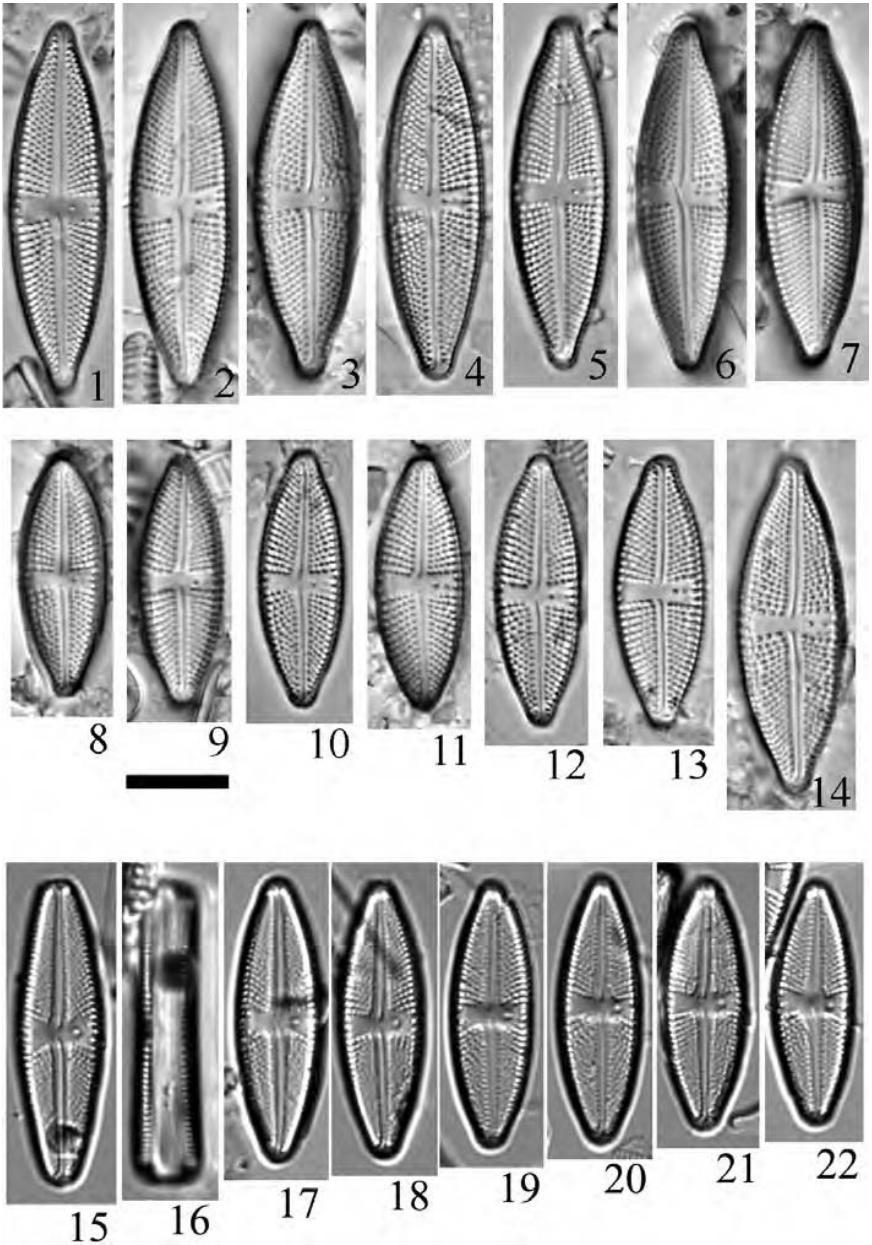
TYPE LOCALITY: Lacus temporarius Bolnici I dictus prope lacum Golemo, Montes Baba Macedonia.

TYPE MATERIAL: Dry mosses, collection date: 17.09.2006. DCIBS Accession No. 002967

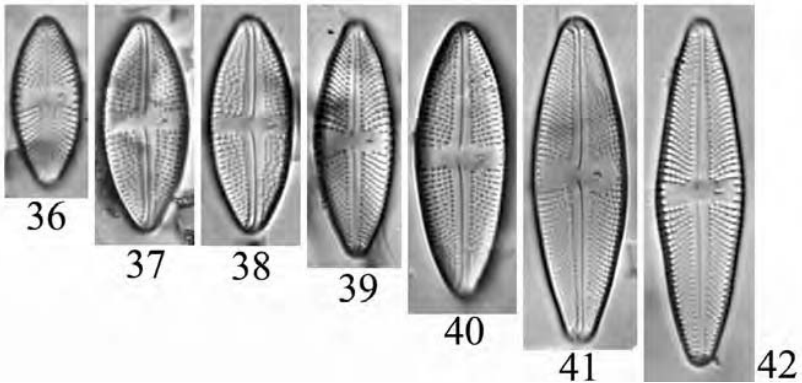
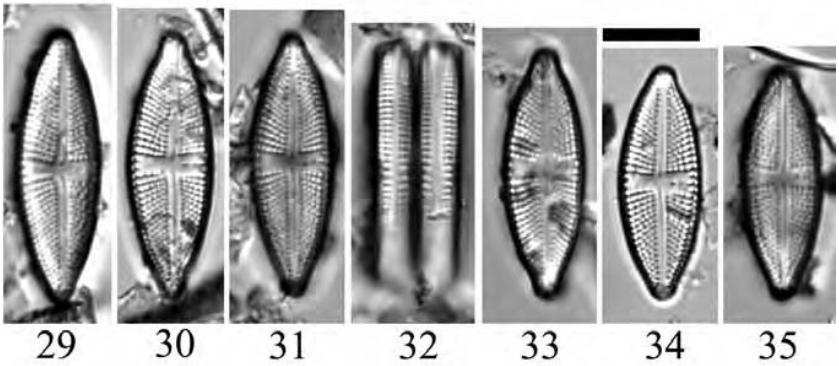
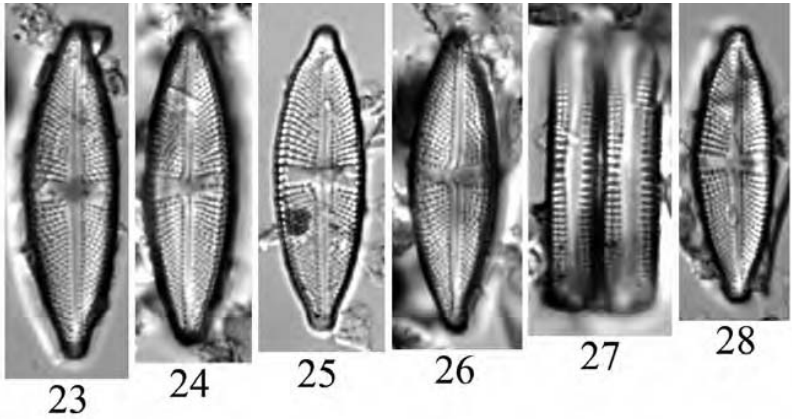
ETYMOLOGY: The name of the species is in honor of Prof. Dr. Ljubco Grupce, for his fundamental achievements in the field of ecology in R. Macedonia.

SCANNING ELECTRON MICROSCOPY: Externally, the valve face is flat, perforated by large, round to elliptical areolae arranged in distinctly radiate striae (Figs 43, 45, 48–50). The valve mantle is perforated by two parallel rows of pores with the same structure as the valve face areolae (Figs 46, 50, 51). Near the valve ends, occasionally, there are three rows of poroids on the valve mantle (Fig. 47). These rows of pores are continuous through the mantle except at the valve apex where they are interrupted by the distal raphe fissure (Figs 47, 53). Each row of two pores on the mantle corresponds with the radiate striae at the valve face (Fig. 50). The opening of each areola is surrounded by a fairly broad hyaline area (Figs 46, 47, 51–53). The linking bars between each interstria on the exterior valve face and mantle appear thicker than the interstriae and are slightly raised (Figs 47, 51, 52). The axial area is narrow, linear or slightly expanded towards the central area (Figs 45, 48, 49). The central area is wide, panduriform (Figs 46, 51, 52), not reaching the valve margins. Near the valve margin there are two single areolae present on the primary valve side and three areolae on the secondary valve side, noticeable in both observed populations (Figs 43, 45, 48–51). In the central area, areolae-like depressions that do not penetrate the valve are present (Figs 43, 45, 46, 48, 49), which are also visible in LM (e.g. Figs 2, 4, 8, 14, 24, 31). The external opening of the stigma in the central area is round or slightly elliptical (Figs 46, 52). The raphe is filiform and straight with tear-drop like proximal endings, bent unilaterally to the primary valve side (Figs 43, 45, 46, 48, 49, 52). The distal ends on the valve face curve to the same direction as the proximal ends (Figs 43, 45, 49) and recurve then to the opposite direction on the apical portion of the valve mantle adopting a question mark resemblance (Figs 47, 53).

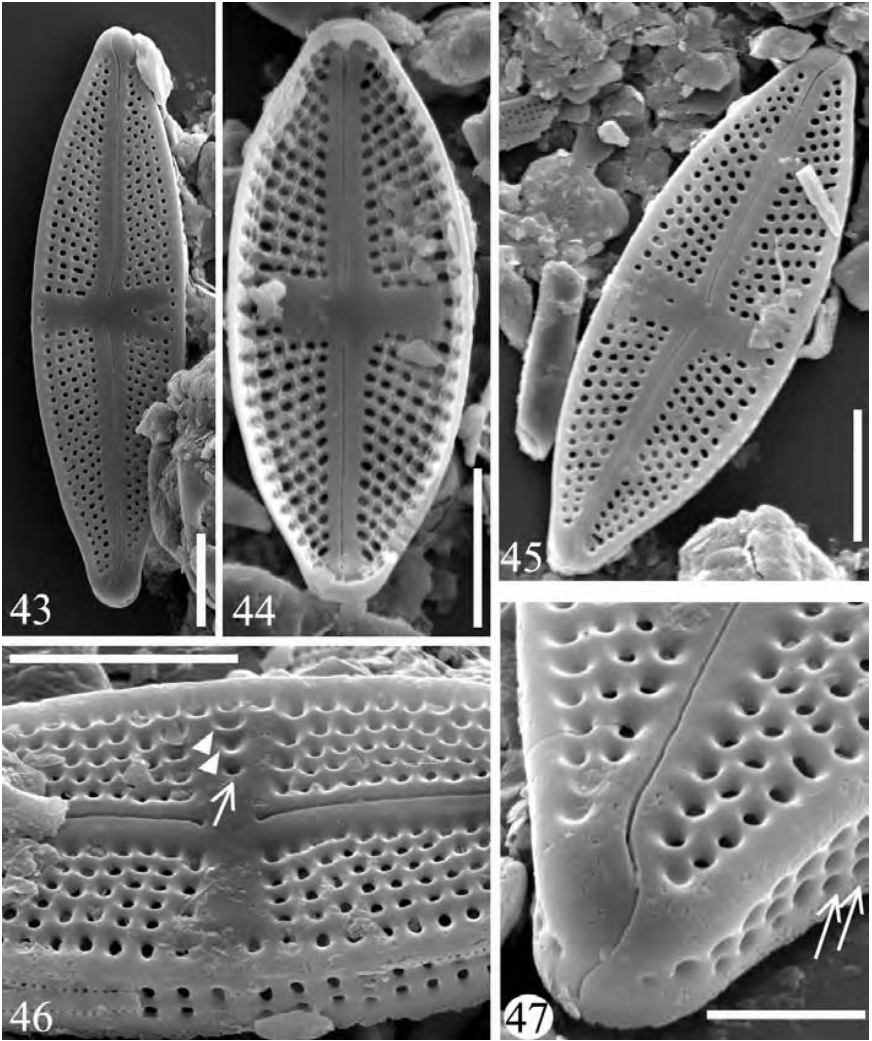
Internally, the ultrastructure of *L. grupcei* is in congruence with the previously described inner view features of *Luticola* (Mayama & Kobayasi 1986, Round et al. 1990, Van de Vijver et al. 2002). The striae are composed of a single row of large, round to elliptical pores (Fig. 44). The interstriae and their linking bars resemble the sternum in thickness and the well developed silification of the linking bars is clearly visible on the interior valve mantle giving it a wave like structure (Figs 44, 54). Sometimes the internal opening of the areolae is outlined by a thin rectangular silica rim (Fig. 44) that is a residue of the hymenes covering almost the entire internal valve surface (Figs 54–58) but was eroded during sample processing (see also Mayama & Kobayasi 1986, Round et al. 1990). The raphe is straight, while the proximal ends are slightly bent towards the secondary valve side (Figs 55, 56). Distally, the raphe system terminates with a slightly raised, but not well-defined helictoglossa (Figs 57, 58). The raphe sternum is wide throughout its length continuing into a well-developed, slightly raised panduriform stauros (Figs 44, 55, 56). Near the mantle, the stauros is perforated by the internal openings of the central marginal areolae (Fig. 44) visible only if the internal thin silica cover is removed. In accordance with this, a specific structure was revealed situated near the internal margin of the stauros opposite the stigma, being a remnant of the connection between the valve and the silica cover (compare Figs 44 and 56). The internal opening of the stigma is located in the central area, near the proximal raphe ends (Figs 55, 56) and has the typical round and lipped structure (Mayama & Kobayasi 1986). The pores on the valve mantle have similar structure to the areolae on the valve face (Fig. 44).



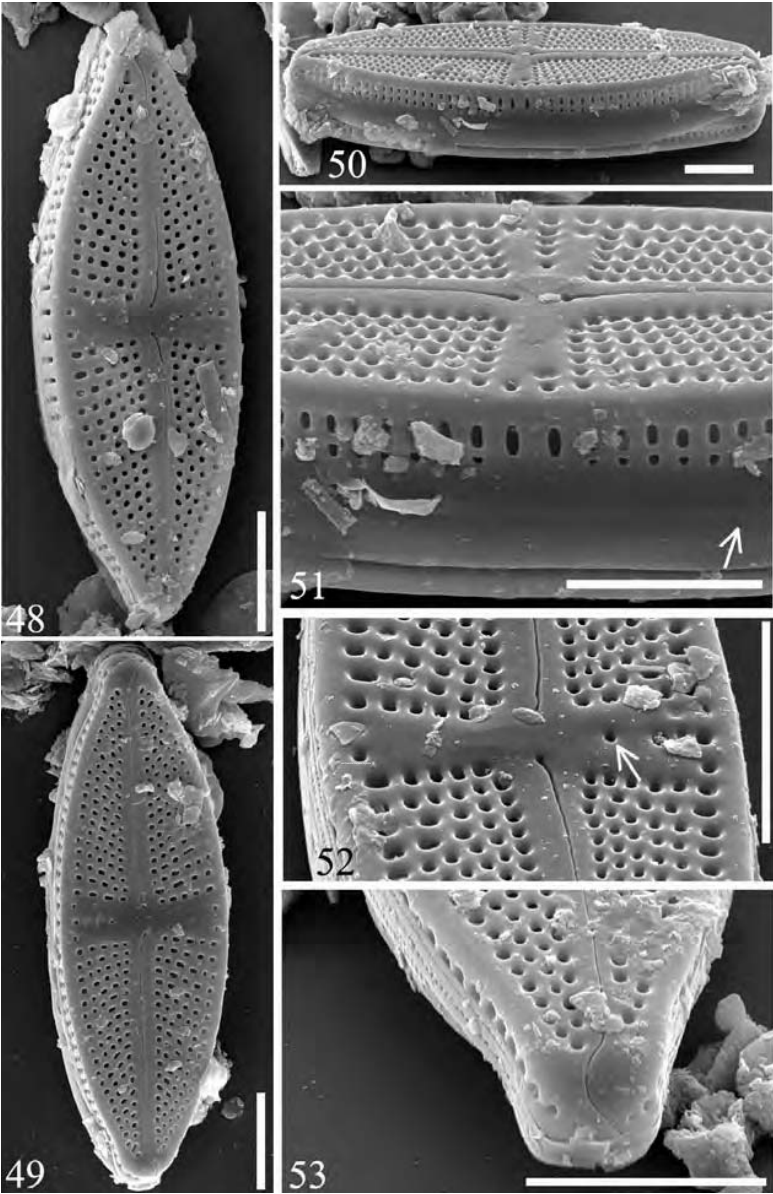
Figs 1–14. *Luticola grupcei* from the type locality (Lake Bolnici I, Baba Mountain, Macedonia), LM. Some specimens in the diminution series are slightly asymmetric to the apical axis. Fig. 4 represents the holotype. Figs 15–22. *Luticola goeppertiana* from the type material, Strehlen, Schlesien (Silesia), Poland, slide No. N15/56 in BRM. Scale bar = 10 μ m.



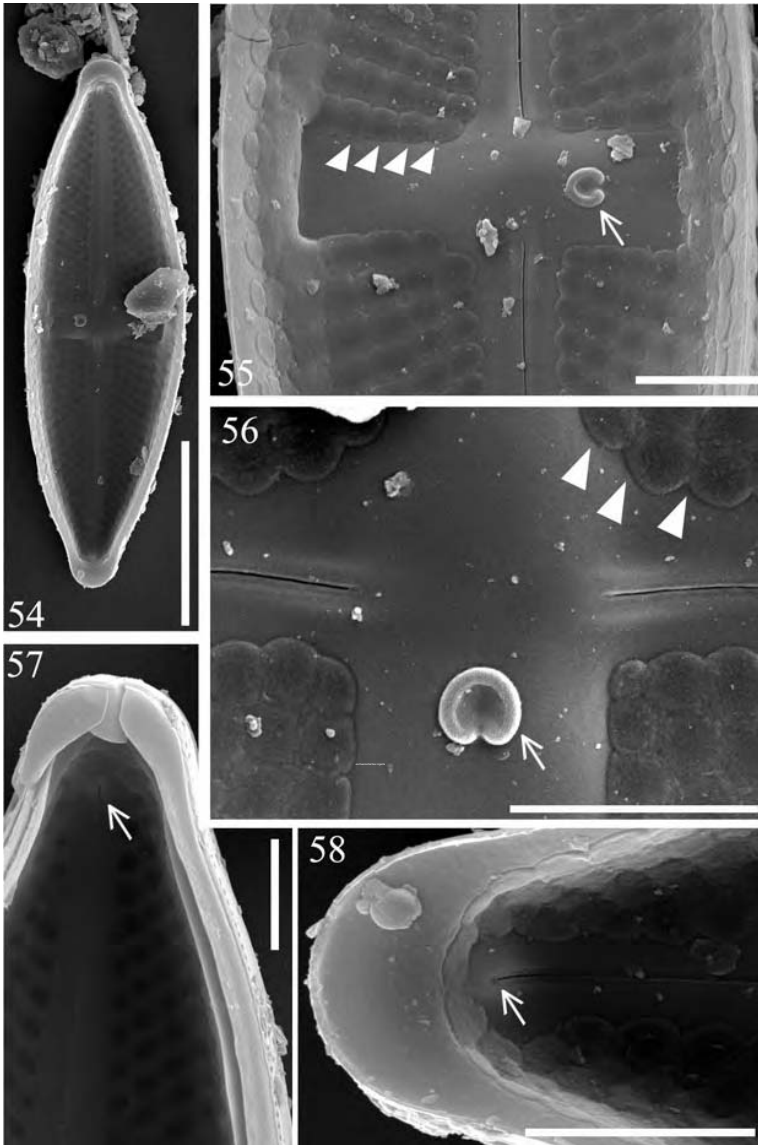
Figs 23–35. *Luticola grupcei* from Great Smoky Mountains National Park, U.S.A., LM. Figs 27, 32. Specimens in girdle view. The two rows of pores on the valve mantle are discernible in the LM. Note the expression of the dorsi-ventral outline even in smaller specimens. Figs 36–42. *Luticola goeppertiana* from River Crna, near Skocivir, south-western Macedonia. Scale bar = 10 μ m.



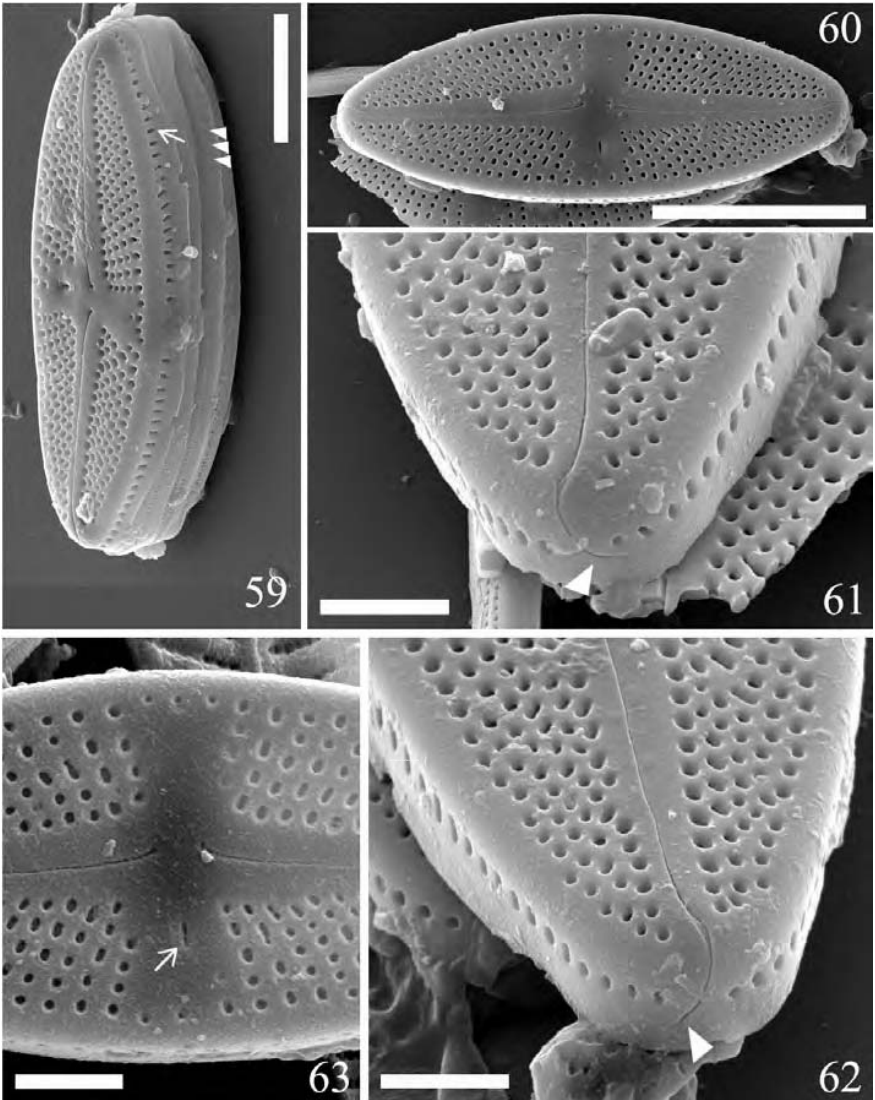
Figs 43–47. *Luticola grupcei* from Lake Bolnici I, SEM. Figs 43, 45–47. External view. Note the slightly asymmetric valve outline (Figs 43, 45) and the double rows of pores on the valve mantle (Fig. 46). Fig. 46. Central portion of the valve exterior clearly depicting the structure of the stigma (arrow) and the areolae-like depressions between the stigma and the marginal areolae (arrowheads). Fig. 47. Apical portion of the valve showing the external distal raphe end. In this specimen, near the apex, three rows of pores are present (otherwise rarely observed character) (arrows). Fig. 44. Internal view. The hymens covering the internal surface of the valve are eroded and represented with rectangular silica rims outlining the oval internal opening of the pores. Scale bars = 5 μm in all figures (except Fig. 47 where the bar is 2 μm).



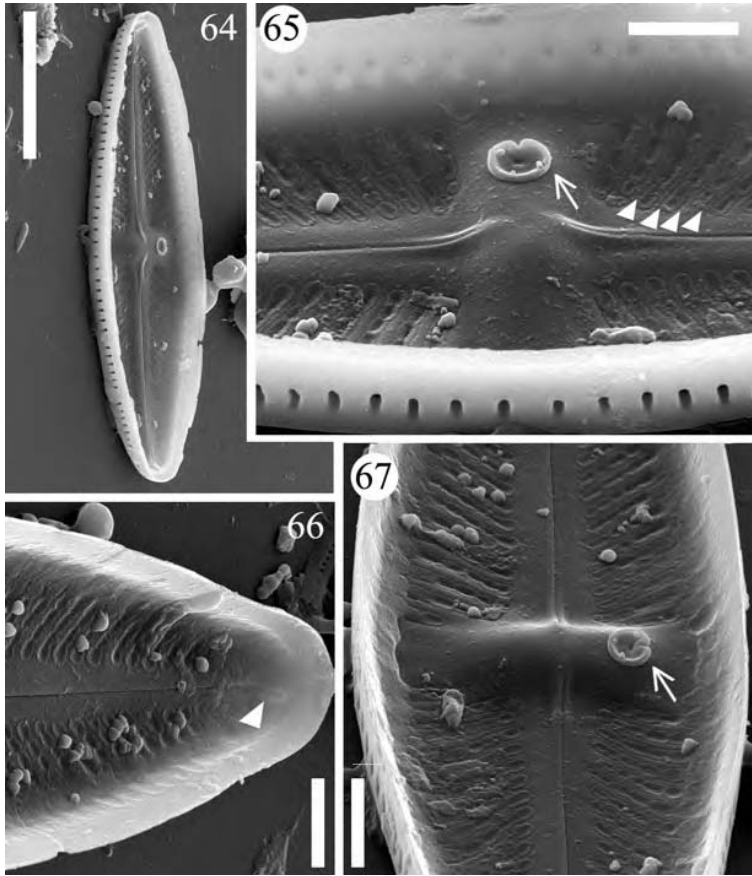
Figs 48–53. *Luticola grupcei* from Great Smoky Mountains National Park, U.S.A., SEM, external view. Figs 48, 49. Whole valves. Note the trans symmetry of the raphe branches. Figs 50, 51. Side view of intact frustule. Note the double rows of pores on the mantle. Valvocopula with a single row of minute pores (arrow). Fig. 52. Close-up of the central area. The external opening of the stigma (arrow) is similar to the poroids. Fig. 53. Detail of the pole. The distal raphe ends are secondarily recurved to the secondary valve side. Scale bars = 5 µm in all figures.



Figs 54–58. *Luticola grupcei* from Great Smoky Mountains National Park, U.S.A., SEM, internal view. Fig. 54 depicts a slightly asymmetrical valve. Figs 55, 56. Details of the panduriform central area. The internal opening of the stigma has the typical structure for this genus as it has been described before (single arrows). Hymens cover almost the entire surface on the inside except for the slightly raised stauros and the longitudinal ribs following the raphe (arrowheads). Figs 57, 58. Details of the interior of the valve poles. Simple internal distal raphe ends and slightly elevated, but not well defined helictoglosae are visible (single arrows). Scale bars = 2 μm in all figures (except Fig. 54 where the bar is 10 μm).



Figs 59–63. *Luticola goeppertiana* from the type material (Strehlen, Schlesien, Accession No. RBH1183/E5772 in BRM), SEM, external view. Fig. 59. Image of the whole valve in side view. Noticeable one row of elliptical areolae on the valve mantle (arrow) and two rows of pores on each girdle band (arrowheads). Fig. 60. Face view of the whole valve. Figs 61, 62. Detailed images of the valve apices on the specimen in Fig. 60. At both poles the raphe ends in second deflection adopting the question mark shape and at the same time interrupting the row of areolae on the valve mantle (single arrowheads). Fig. 63. Magnified image of the central area. Proximally both raphe branches end with a slight deflection into simple tear-drop shape. Note the elongated, slit-like, shape of the stigma (arrow), which is structurally different than the valve-face areolae. Scale bars in Fig. 59 = 5 μm , in Fig. 60 = 10 μm and in Figs 61–63 = 2 μm .



Figs 64–67. *Luticola goeppertiana* from the type material (Strehlen, Schlesien, Accession No. RBH1183/E5772 in BRM), SEM, internal view. Fig. 64. Image of the whole valve. Figs 65, 66, 67. Detail of the central area revealing the proximal ends of the raphe and the structure of the stigma (single arrows). Note the raised stauros and the structure of the thin silica cover of the interior valve face (arrowheads). Fig. 66. Apical portion of the valve with the distal end of the raphe (arrowhead). Scale bars in all images = 2 µm (except in Fig. 64 where the bar is 10 µm).

Discussion

The genus *Luticola* has eight representatives in the diatom flora of Macedonia (Krstic et al. 2006). The majority of these taxa are rare and only *L. goeppertiana* and *L. mutica* appear more frequently in samples. Occasionally, *Luticola* species can be fairly abundant and diatom assemblages in specific, subaerial, acidic or heavily polluted habitats have been found to be comprised of up to 70% of *Luticola* species, such as *L. goeppertiana* in River Crna, *Luticola* sp. in Krcin Mountain and *L. mutica* in River Vardar (pers. observ.).

Luticola grupcei can be easily distinguished from the three other *Luticola* taxa at the type locality by morphological features (valve outline, shape of the valve ends and also valve length and breadth). *Luticola acidoclinata* Lange-Bertalot has small elliptical valves (Lange-Bertalot & Metzeltin 1996), with simple distal raphe endings that do not continue on the valve mantle, which is perforated by a single row of areolae. *Luticola mutica* has an elliptical outline with bluntly rounded ends clearly different from our new taxon. In relation to this, the symmetry of the raphe and the organization of the axial and central area are quite similar with *L. grupcei*. *Luticola cohnii* (Hilse) D.G.Mann also possesses an elliptical outline and unprotracted ends but differs considerably with respect to the shape of the proximal raphe ends that after the initial deflection to the primary side secondarily bend towards the middle of the stauros. Furthermore, both *L. mutica* and *L. cohnii* have a single row of pores on the valve mantle. In any case, *L. grupcei* can be readily identified and distinguished from the rest of the *Luticola* taxa present in the type locality based on the overall morphology as seen in the LM (valve shape, valve ends, morphometric data). Ultrastructure only confirms the separate identities of these species.

The valves of *L. grupcei* are lanceolate and have short but clearly protracted to subcapitate ends. This feature is opposed to *L. goeppertiana* where sometimes shorter cells have slightly offset ends (Figs 22, 37) that are otherwise more or less bluntly rounded and not protracted (Figs 15–22, 36–42). Additionally, *L. goeppertiana* has a rhombic (in larger specimens) (Figs 15, 42) to broadly elliptical (in smaller specimens) (Figs 36–38) valve outline. Nevertheless, smaller specimens of *L. grupcei* (Figs 8, 9) resemble *L. goeppertiana* in valve outline. Another distinctive feature in LM is the coarse structure of the areolae of *L. grupcei* and the number of marginal areolae in the central area on the primary valve side. In all of the specimens of *L. grupcei* examined, the number of marginal areolae was two and in the case of *L. goeppertiana* three or more. Additionally, *L. goeppertiana* has a higher striae density (17–21 in 10 µm versus 15–17 in 10 µm in *L. grupcei*).

The ultrastructure of *L. goeppertiana* compared to *L. grupcei* reveals a flat valve face perforated by fine areolae composing the radiate striae (Figs 59, 60). The valve mantle is perforated by one row of elliptical pores (Fig. 59) alongside the valve length. These pores are round at the apical portion of the mantle (Fig. 62) where this row is interrupted by the distal raphe endings. The interstriae and their linking bars resemble the thickness of the rest of the valve. In the central area, near the valve margin on the primary valve side (opposite the stigma), there are usually three to four strongly shortened striae comprised of one or few areolae (Figs 59, 60). The number of shortened striae (composed by single areolae, marginally positioned) on the secondary valve side is always three (Figs 59, 60). The external opening of the stigma is always slit-like (Figs 59, 60, 63). The proximal raphe ends are tear drop-like shaped (Fig. 63), while distally the raphe fissures possess the same question mark curvature as in *L. grupcei* (Figs 61, 62). Internally both raphe ends are simple, slightly raised proximally and with a small helictoglossa distally (Figs 64–67). The entire internal valve surface of *L. goeppertiana* is also covered with a thin silica structure, comparably different from the one in *L. grupcei* (compare Fig. 65, arrowheads and Fig. 55, arrowheads). This thin silica structure follows the pattern

of striation in both species, in relation to which, it covers the entire stria along with the interstria surface in *L. grupcei* and in *L. goeppertiana* it is restricted to the stria surface, only. In addition to this, the internal structure of the stigma in the former (Fig. 56, arrow) appears thicker than the one in *L. goeppertiana* (Fig. 65, arrow).

The remarkable feature in *L. grupcei* is that the mantle is perforated by two parallel rows of large round pores (Figs 46, 50, 51) as opposed to *L. goeppertiana* (Fig. 59) that has only one row (see also Mayama & Kobayasi 1986). Two rows of pores are present in *L. naviculoides* J.R.Johansen (= *N. mobiliensis* var. *minor* R.M.Patrick), nevertheless the pores are much smaller and densely spaced (Mayama & Kobayasi 1986). It seems that a porous valve mantle is a fairly constant character in *Luticola*, but the number of the rows can vary between one like in *L. claudiae* Metzeltin, Lange-Bertalot & García-Rodríguez (Metzeltin et al. 2005, pl. 84: fig. 6) to four as in *L. hilgenbergii* Metzeltin, Lange-Bertalot & García-Rodríguez (Metzeltin et al. 2005, pl. 88: fig. 8).

Luticola grupcei can be distinguished from *L. mitigata* (Hustedt) D.G.Mann (Rumrich et al. 2000, pl. 62: fig. 1, Metzeltin & Lange-Bertalot 1998, pl. 87: fig. 12) by the more protracted valve ends, the wider axial area and the elliptical exterior opening of the stigma (which can be identified in LM) found in *L. mitigata* (see also Table 1). *Luticola incoactoides* Lange-Bertalot & Rumrich (Rumrich et al. 2000, pl. 61: figs 1–4) is similar in valve outline to *L. grupcei*. This taxon can be separated by its slightly subcapitate valve ends, its larger central area and the finer structure of the areolae. The striae density of *L. incoactoides* (20–21/10 μm) is higher than in *L. grupcei* (15–17/10 μm) while the valve length and breadth are larger in *L. grupcei* (23–46 μm compared to 18–25 μm and 8.5–10.5 μm compared to 7–8 μm , respectively). In addition to this, the SEM images clearly show the differences in both the proximal and distal external raphe ends, as well as the expression of the ridge structure on the valve face/mantle junction and the number and shape of the pores along the mantle.

The similarity of *L. grupcei* with *L. dismutica* (Hustedt) D.G.Mann (Metzeltin & Lange-Bertalot 1998, pl. 87: figs 22–24) is reinforced by the coarse structure of the areolae visible in LM and the elliptical valve outline. The clear truncated valve ends of *L. dismutica* represent a differential character. *Luticola* spec. cf. *dismutica* (Hustedt) D.G.Mann as in Metzeltin et al. (2005, pl. 79: figs 1–7) also resembles *L. grupcei* in valve outline but is differentiated from it in the form of the valve ends which are more broadly rounded, the larger extension of the central area towards the valve margins and the number of single marginal areolae opposite the stigma in the central area.

A more peculiar feature is that there appears to be some heterogeneity in the distal raphe ends that sometimes can be recurved to the secondary valve side (Figs 47, 53, 61, 62) in which case the raphe ends are dissimilar much like in some species of *Placoneis* (Cox 1987, 2003, Levkov et al. 2007) or *Navicula reinhardtii* (Grunow) Grunow (Mann 1999, Edlund et al. 2006). Trans-symmetry in raphe branches seems to be present throughout the genus *Luticola* although the distal ends curvature is quite variable, ranging from simple deflection to the secondary side to a full question

Table 1. Main differential characters of *Luticola grupcei* and its most similar taxa.

| | Valve length (µm) | Valve breadth (µm) | Striae density/10µm | No. of marginal areolae opposite the stigma | Valve ends | No. of mantle rows of areolae | External opening of the stigma | Valve face/mantle junction ridge | Reference |
|---|-------------------|--------------------|---------------------|---|----------------------------|-------------------------------|--------------------------------|----------------------------------|--|
| <i>L. grupcei</i> sp. nov. | 23-46 | 8.5-10.5 | 15-17 | 2 | protracted | 2 (3) | round | absent | this study |
| <i>L. goeppertiana</i> (Bleisch) D.G. Mann | 17.6-29.9 | 6.8-8.2 | 17-21 | ≥3 (2) | rounded, not protracted | 1 | slit-like | absent | this study |
| <i>L. goeppertiana</i> (Bleisch) D.G. Mann | 10-65 (144) | 6-15 (36) | 18-24 | ≥3 | rounded, not protracted | ? | slit-like | ? | Krammer & Lange-Bertalot (1986): pl. 62: figs 1, 2 |
| <i>L. mitigata</i> (Hustedt) D.G. Mann | 25-35 | 7-10 | 16-20 | 4 | clearly protracted | ? | slit-like | ? | Hustedt (1961-66): fig. 1596; Round et al. (1990); Rumrich et al. (2000): pl. 62: fig. 1; Metzeltin & Lange-Bertalot (1998): pl. 87: fig. 12 |
| <i>L. incoactoides</i> Lange-Bertalot & Rumrich | 18-25 | 7-8 | 20-21 | 3 | slightly subcapitated | 1 | round | present | Rumrich et al. (2000): pl. 61: figs 1-4 |
| <i>L. dismutica</i> (Hustedt) D.G. Mann | 15-44 | 6-11 | 16-20 | 3 | truncated | ? | round | ? | Hustedt (1961-66): fig. 1600; Round et al. (1990); Metzeltin & Lange-Bertalot (1998): pl. 87: figs 22-24 |
| <i>L. spec. cf. dismutica</i> (Hustedt) D.G. Mann | 18.6-25.3 | 6.6-8.6 | 16-20 | 3-4 | rounded | ? | round | ? | Metzeltin et al. (2005): pl. 79: figs 1-7 |

mark shape where the terminal fissures finally bend to the secondary side at the valve mantle (Figs 47, 53, 61, 62, see also Mayama & Kobayasi 1986, figs 10, 36). In some taxa, e.g. *L. claudiae* and *L. incoactoides*, the terminal fissures are absent, resulting in a much reduced raphe system that ends at the valve face resembling the raphe of the chain forming *Diademsis* taxa (Werum & Lange-Bertalot 2004, Van de Vijver et al. 2006). Another feature that has previously been recorded as a characteristic of other genera is the occlusion of both the valve face and mantle areolae of *L. uruguayensis* Metzeltin, Lange-Bertalot & García-Rodríguez by delicate foramina lips (Metzeltin et al. 2005, pl. 232: figs 1, 2A). This delicate structure is also present in *L. higleri* Van de Vijver, Van Dam & Beyens, but restricted only to the mantle pores (Van de Vijver et al. 2006, figs 33-38).

A small number of taxa within the genus, *L. uruguayensis* (Metzeltin et al. 2005, pl. 232: figs 1, 2A), *L. incoactoides* (Rumrich et al. 2000, fig. 61: 1–4), *L. higleri* (Van de Vijver et al. 2006, figs 37, 38) possess a well developed ridge structure at the valve face/mantle junction associated with one row of elliptical pores at the valve mantle. This combination of characters is not constant, since the ridge structure in *L. hilgenbergii* (Metzeltin et al. 2005, pl. 88: fig. 8) is combined with round shaped valve mantle areolae and the elliptical valve mantle pores in *L. peguana* (Grunow) D.G.Mann (Metzeltin et al. 2005, pl. 232: figs 3, 4) are not associated with a ridge structure. In addition, observations reveal LM visibility of the internal “longitudinal canal-like structure” of taxa possessing a well-developed valve face/mantle junction ridge. This canal like structure is formed by the thin internal silica cover and the interior valve face as it is clearly shown by Mayama & Kobayasi (1986), but has been misidentified with the longitudinal canal of the genus *Neidium* Pfitzer (Round et al. 1990, Van de Vijver et al. 2006) where the canal is a tubular structure within the valve wall (Sims & Paddock 1979, Round et al. 1990).

The type locality of *L. grupcei* is a temporary shallow lake that is dry during most of the vegetative season, being covered with water only in the intensive snow-melt period (March-May) (Vasilevski 2006). The diatom assemblage inhabiting this habitat is dominated by *Pinnularia borealis* Ehrenberg, *P. microstauron* (Ehrenberg) Cleve, *P. rabenhorstii* Krammer, *Eunotia diodon* Ehrenberg sensu lato, *Diademsis perpusilla* (Grunow) Lange-Bertalot, *Neidium ampliatum* (Ehrenberg) Krammer sensu lato, *Orthoseira roeseana* (Rabenhorst) O’Meara and *Encyonopsis falaisensis* (Grunow) Krammer. This assemblage is a combination of both aerophilous (*P. borealis*, *O. roeseana*, *D. perpusilla*) and acidophilic (*E. diodon* sensu lato, *P. microstauron*, *S. anceps* Ehrenberg sensu lato) taxa (Levkov et al. 2005). Although the pH of the lake itself is not known, the post-glacial lakes present in the vicinity of the type locality are acidic (pH = 4–5, Vasilevski 2006) and have a typical acidophilous diatom composition represented by the dominance of taxa like *Aulacoseira distans* (Ehrenberg) Simonsen, *Eunotia* spp., *Frustulia saxonica* Rabenhorst, *Brachysira brebissonii* R.Ross and *Tabellaria flocculosa* (Kützinger) Roth.

Luticola grupcei was also found in mucilage on a wet wall in the GSMNP, U.S.A. The type locality in Macedonia is a temporary lake, which in some ways has similar ecological aspects with respect to those of a wet wall where moisture is intermittent, if not limiting and nutrients are low. This suggests that this species may be common

in low pH environments with variable moisture levels, including subaerial habitats. Since populations of *Luticola* are seldom dominant and often occupy poorly explored microhabitats (subaerial low pH sites) we feel that the genus *Luticola* contains many more undescribed species.

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